US005640768A

United States Patent [19]

Teramachi

[11] **Patent Number: 5,640,768**

[45] **Date of Patent: Jun. 24, 1997**

[54] **PRODUCTION METHOD FOR A LINEAR BEARING**

[75] Inventor: **Hiroshi Teramachi**, Tokyo, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **369,477**

[22] Filed: **Jan. 6, 1995**

Related U.S. Application Data

[62] Division of Ser. No. 50,374, Jul. 16, 1993, Pat. No. 5,380,099.

[30] **Foreign Application Priority Data**

Sep. 19, 1991 [JP] Japan 3-266962

[51] **Int. Cl.^{6}** **F16C 33/00**

[52] **U.S. Cl.** **29/898.03**; 264/242; 264/318; 384/45

[58] **Field of Search** 29/898.03; 264/242, 264/318, 336, 248, 296; 384/45; 72/340

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,025,995	5/1977	Thompson	29/898.03
4,515,416	5/1985	Teramachi .	
4,527,841	7/1985	Teramachi .	
4,551,895	11/1985	Teramachi	29/898.03
4,615,569	10/1986	Hirata .	
4,654,940	4/1987	Hidano	29/898.03
5,076,713	12/1991	Morita .	
5,295,748	3/1994	Yamazaki	29/898.03 X

FOREIGN PATENT DOCUMENTS

61-147815	7/1986	Japan .
2-43521	3/1990	Japan .
3-48417	10/1991	Japan .

Primary Examiner—Carl J. Arbes

Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

It is an object of the present invention to provide a linear bearing which is easy to manufacture and has sufficient mechanical strength, and its production method. A slider **1** guides a table or other movable bodies along a rail **2** and includes a thin ball plate **6** in which load ball channels **61** are formed to move balls **5** therein, and a thin mounting plate **7** adapted to secure the movable body. A molding material **8** such as resin or die cast alloy is molded to insert the ball plate **6** and the mounting plate **7** thereinto. The rail **2** is made of a metallic material **2** whose surface is hardened to a predetermined level when subjected to plastic deformation. During plastic deformation, the ball channels **23** are hardened to a predetermined level.

5 Claims, 11 Drawing Sheets

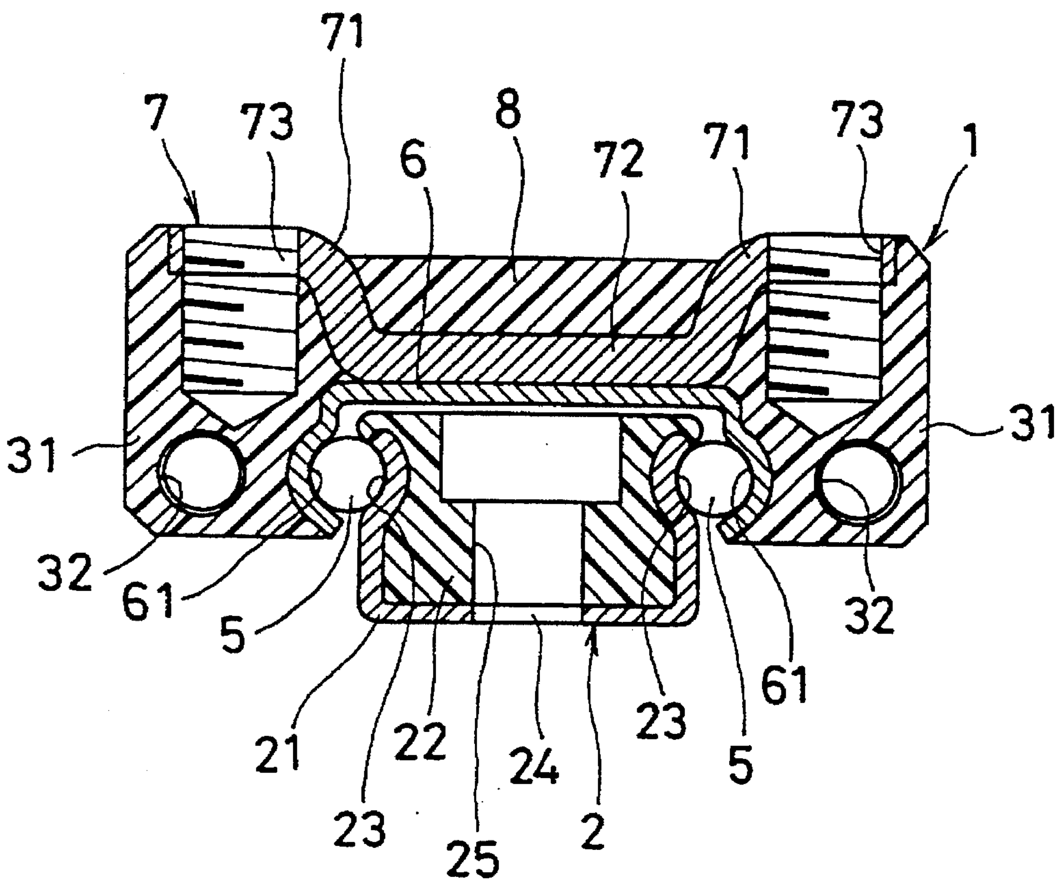


FIG. 1

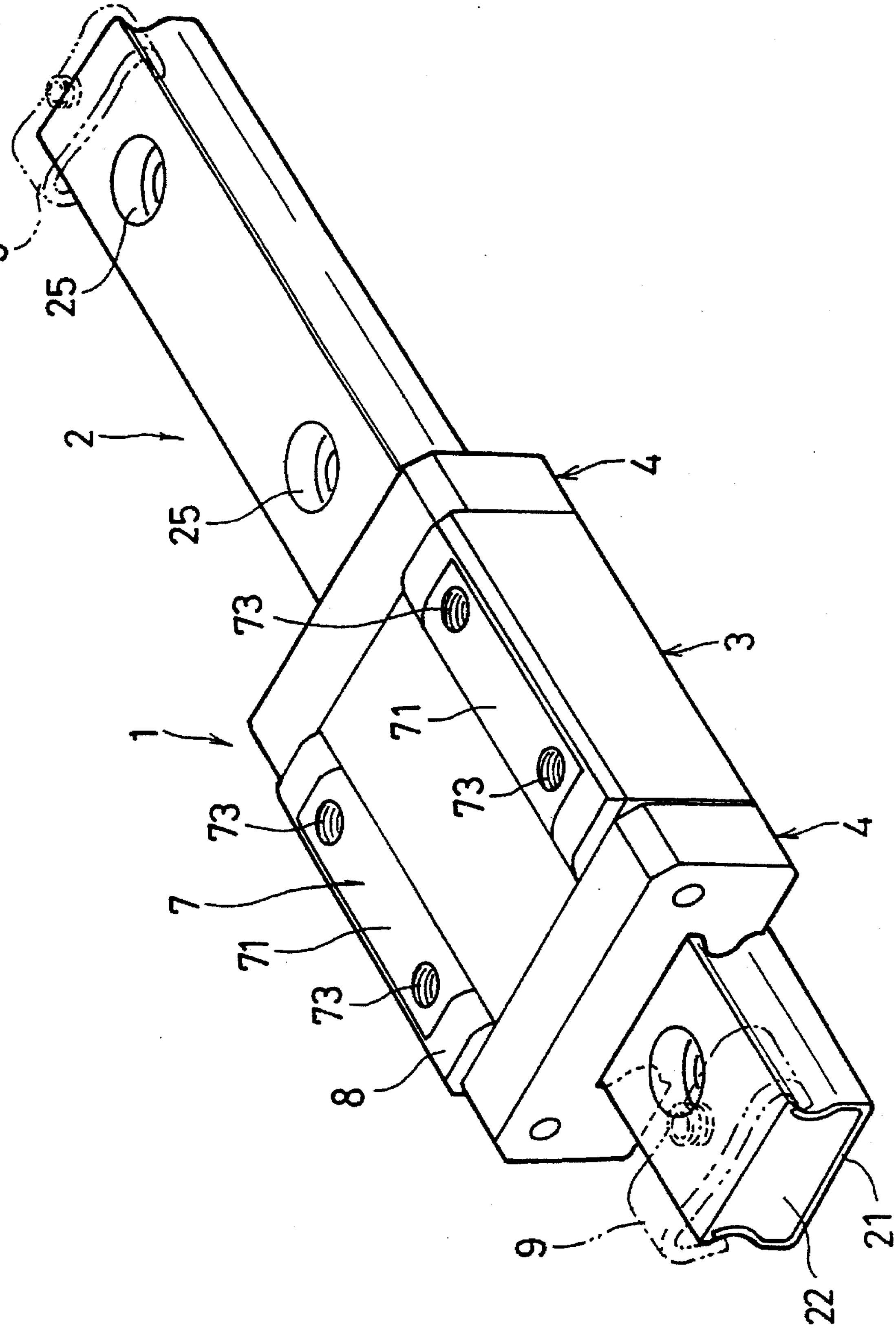


FIG. 2

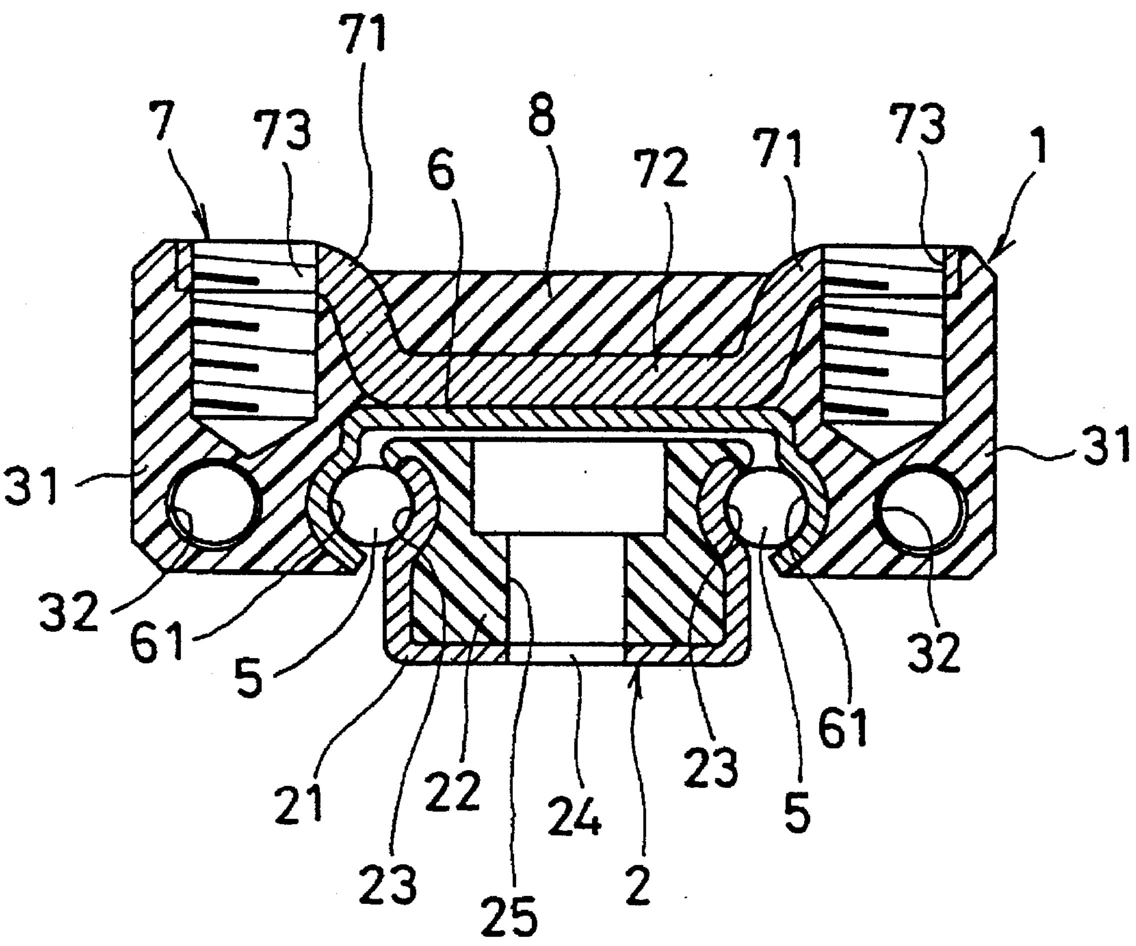


FIG. 3

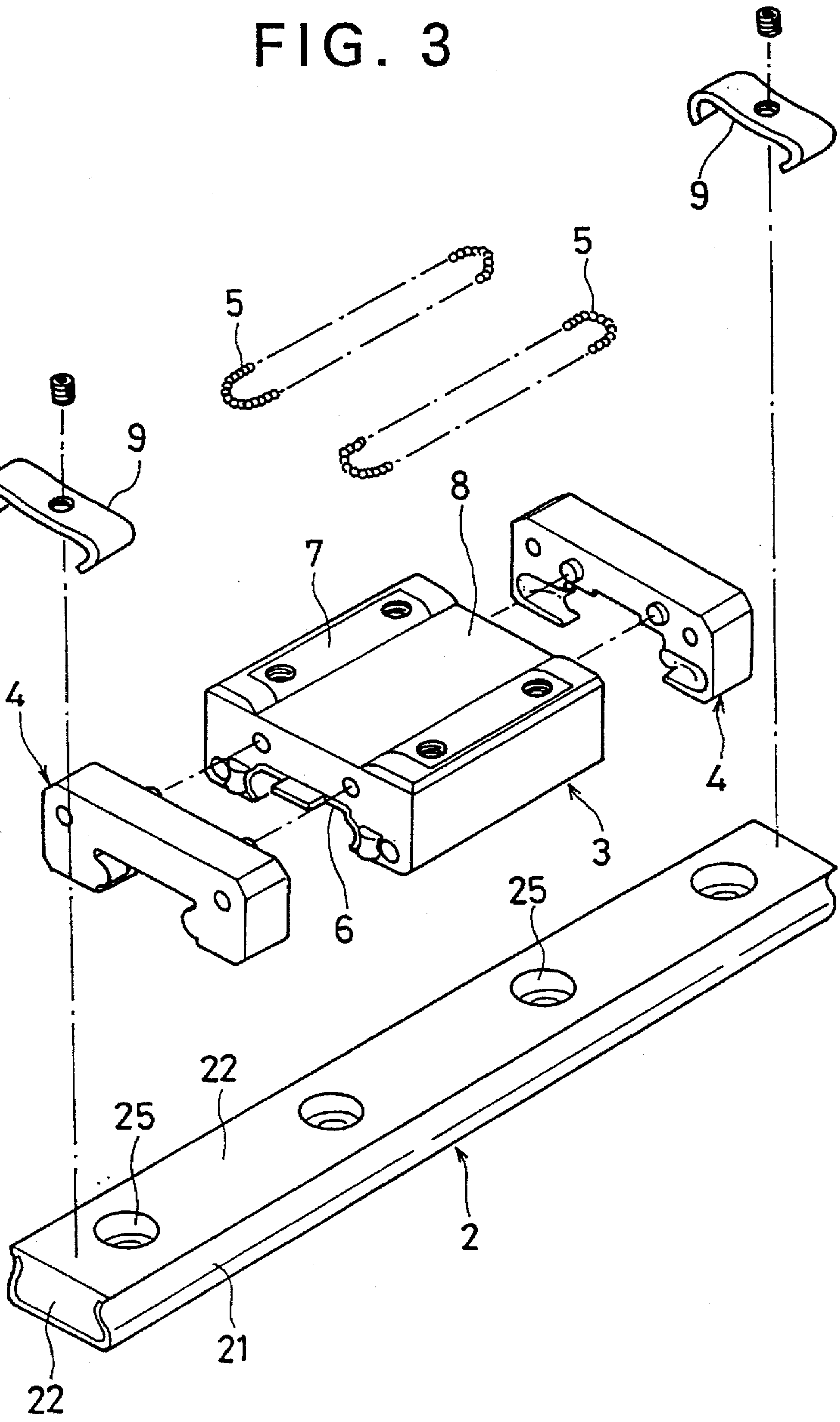


FIG. 4

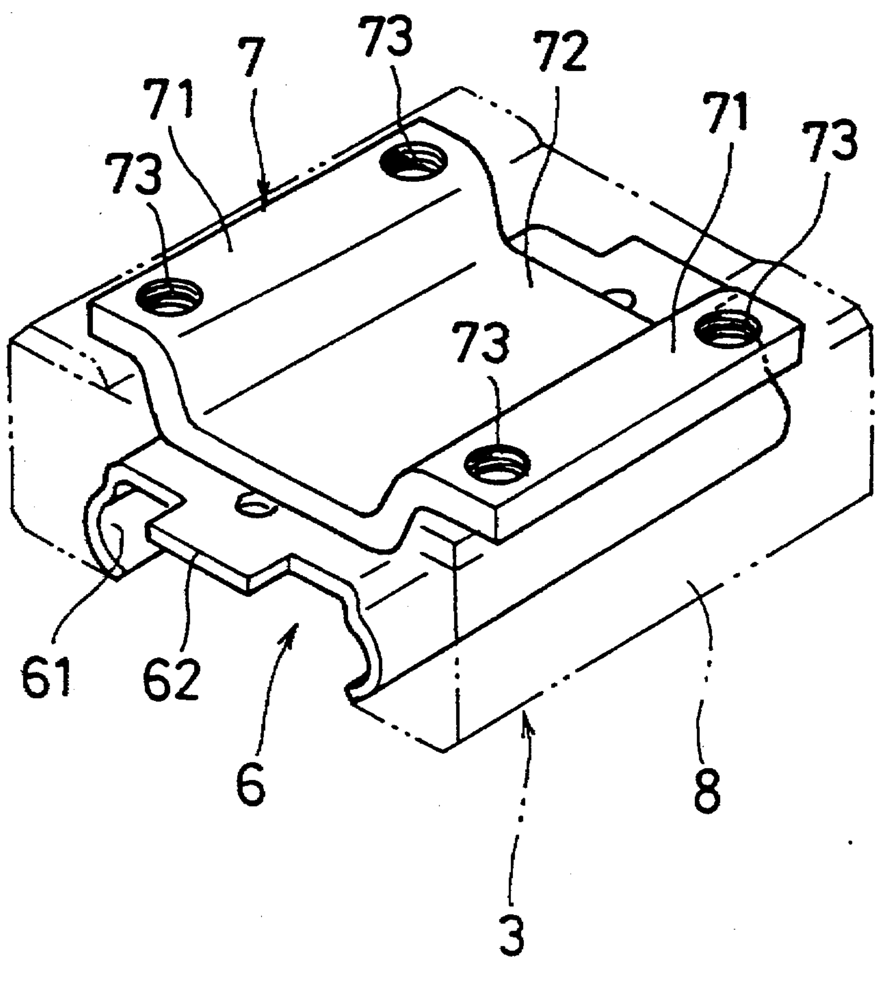


FIG. 5

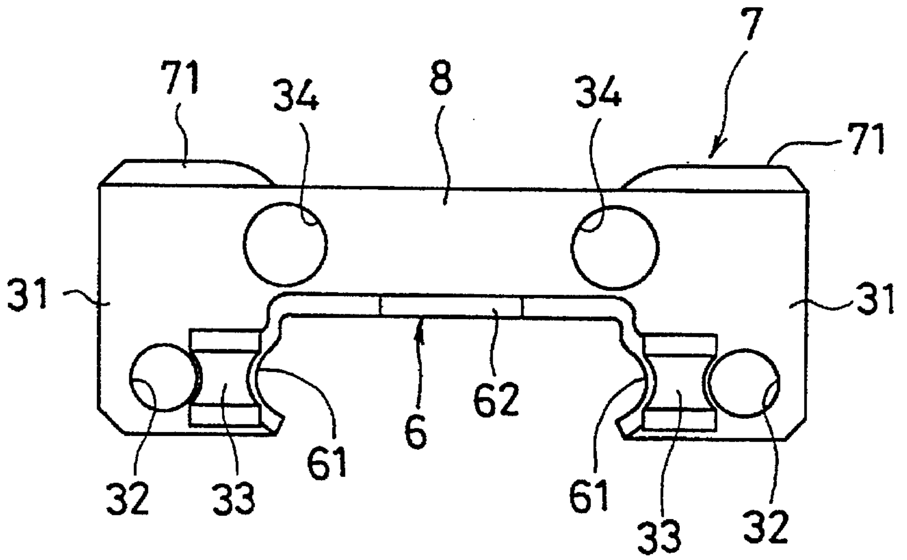

7
71
34
8
34
71
31
31
62
6
61
61
32
33
33
32

FIG. 6

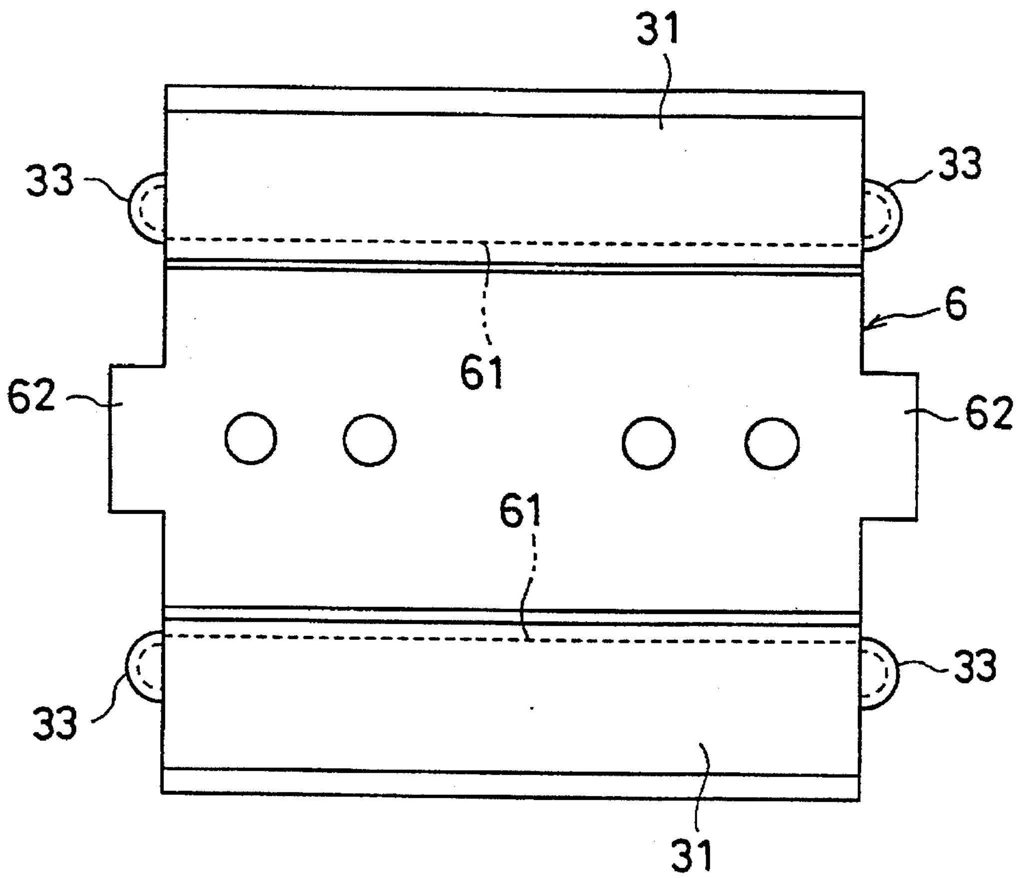

31
33
33
6
61
62
62
61
33
33
31

FIG. 7

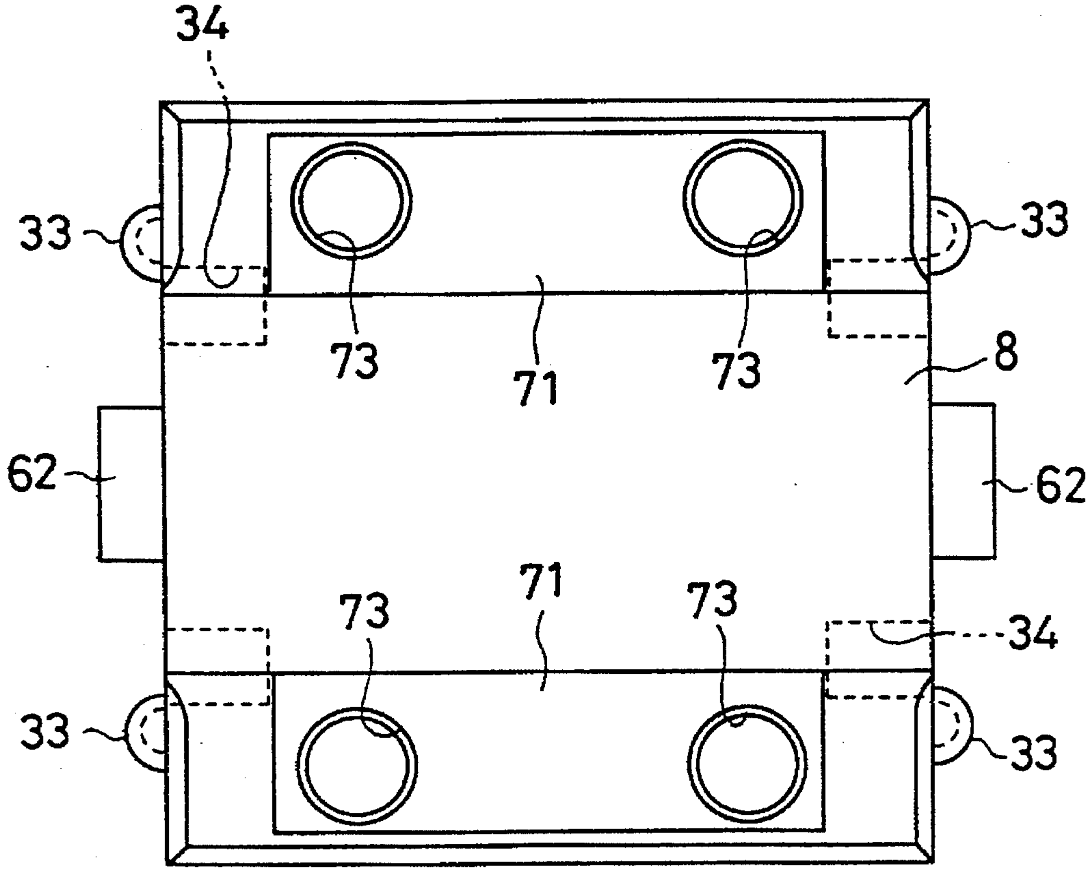


FIG. 8

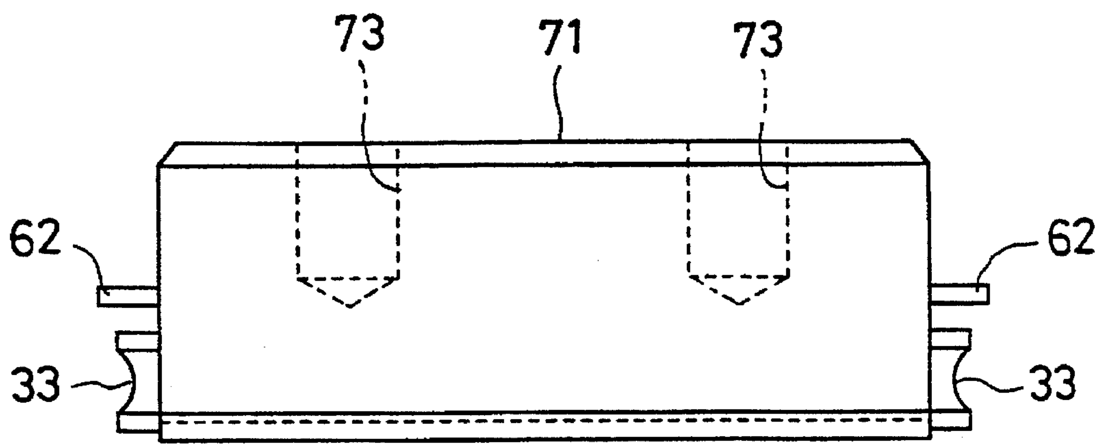


FIG. 9

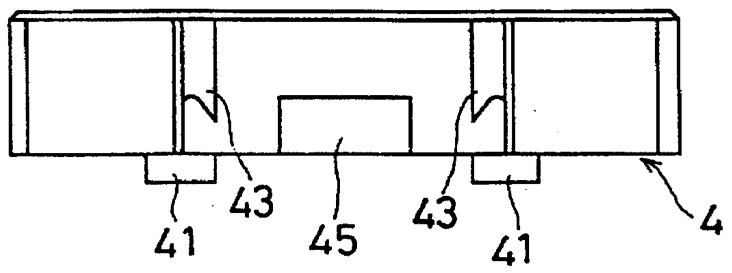


FIG. 10

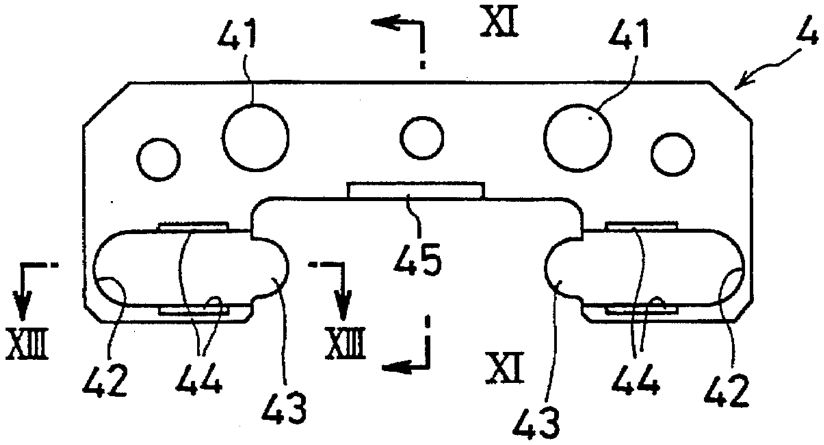


FIG. 11

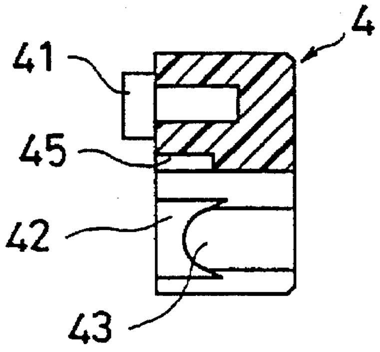


FIG. 12

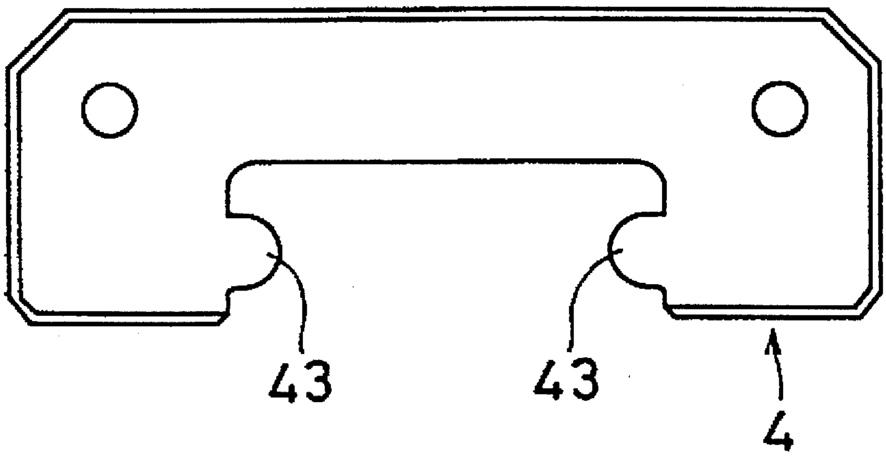


FIG. 13

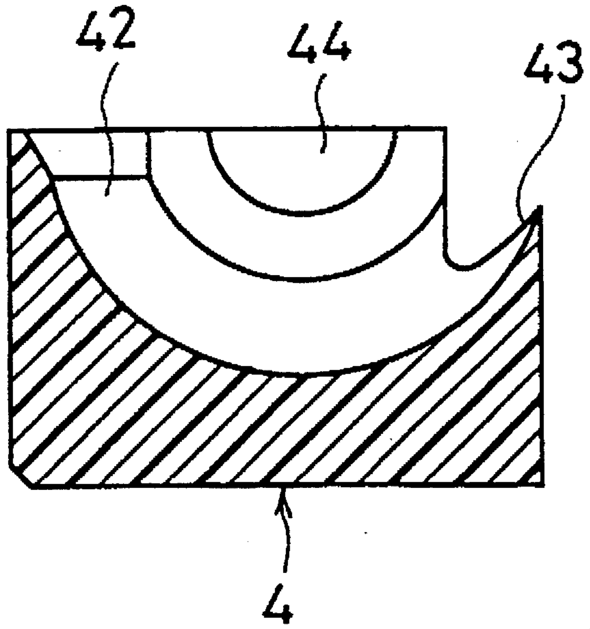


FIG. 14

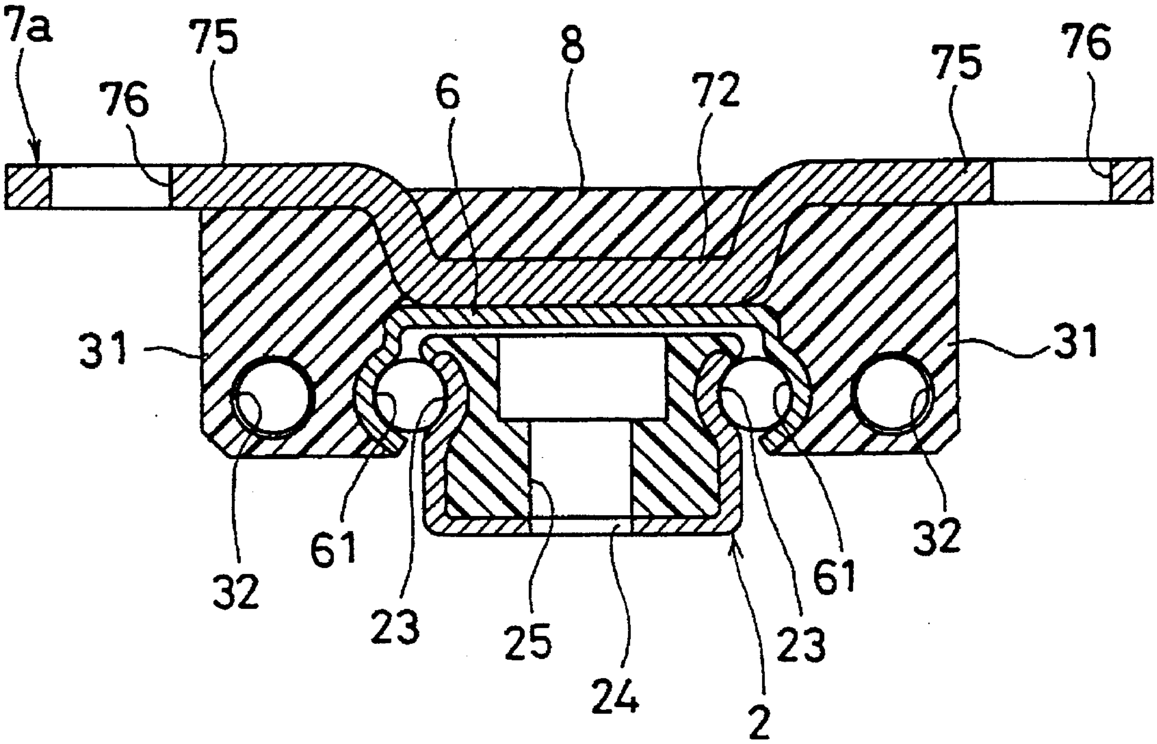


FIG. 15

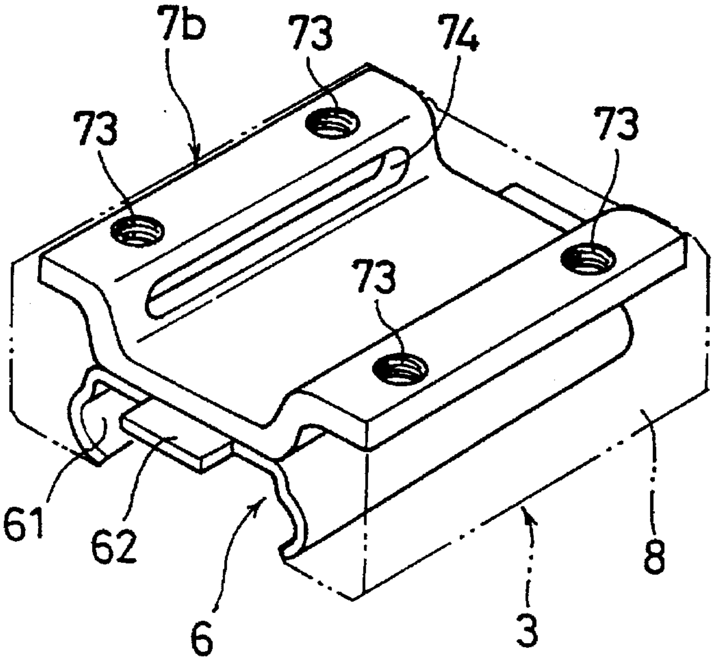

7b
73
74
73
73
73
73
61
62
6
3
8

FIG. 16

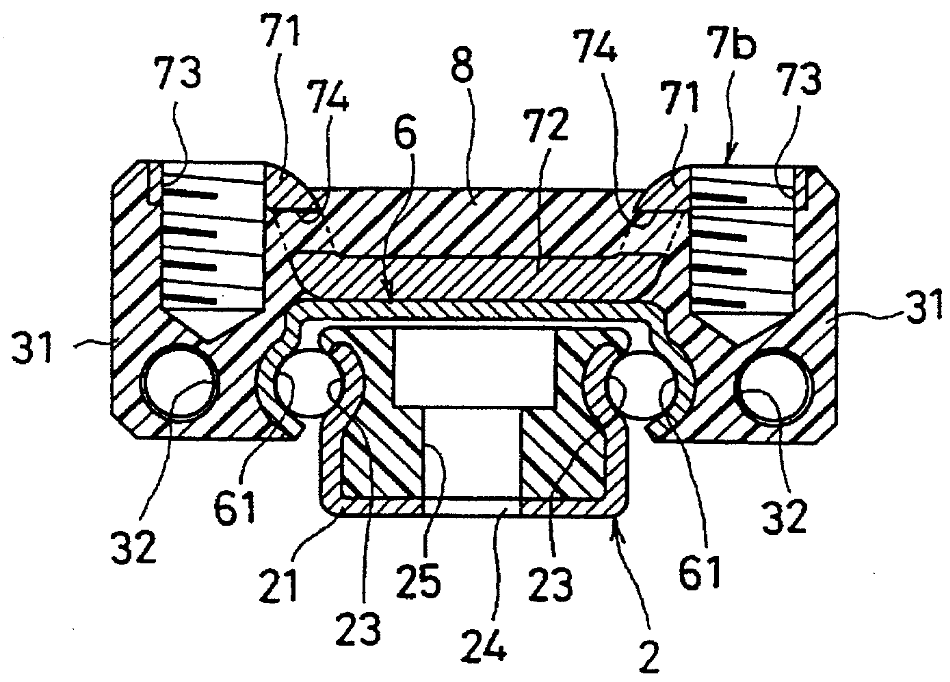
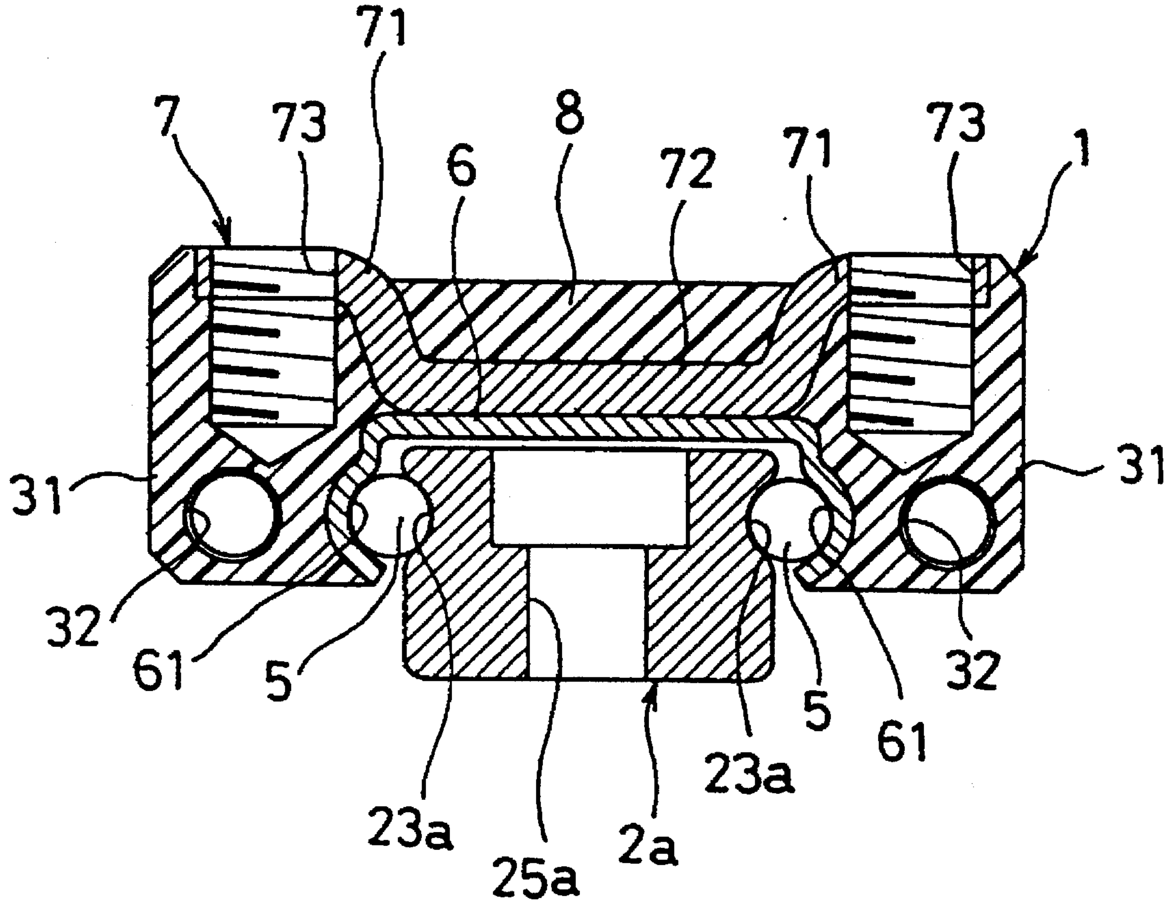

73
71
74
8
6
72
74
7b
71
73
31
31
32
61
21
23
25
24
23
2
61
32

FIG. 17



PRODUCTION METHOD FOR A LINEAR BEARING

This is a divisional application of application Ser. No. 08/050,374, filed Jul. 16, 1993, now U.S. Pat. No. 5,380, 099.

TECHNICAL FIELD

The present invention relates to a linear bearing for guiding movable bodies such as tables for use in various machine tools or industrial robots along a straight bed or stationary element.

BACKGROUND ART

This kind of linear bearing comprises a rail having ball channels in which balls are moved and secured to a bed or stationary element, and a slider having load ball channels cooperating with the ball channels to sandwich a multiplicity of balls and adapted to guide a table or movable body along the rail.

The slider has a function such that the load of the movable body is applied directly thereto. Under the circumstances, if the slider is deformed, the movable body is displaced relative to the base to which the rail is mounted. This presents a problem that the movable body can not be guided accurately on a straight line. The slider body to which the movable body is secured must have high rigidity.

To thid end, the slider conventionally has a slider body formed from a metal block made, for example, of bearing steel. The slider body is made by first cutting a rectangular metal block to a predetermined shape, then, forming nonload ball bores and tapping bolt holes for securement of a movable body, and finally, carburizing a portion of the slider body and cutting and lapping that portion of the slider body to form load ball channels.

However, where a slider body is made from a metal block made, for example, of bearing steel, such a metal block must be machined in various ways. This production method is thus cumbersome.

It is necessary to accurately and smoothly cut the slider body at a predetermined angle to form load ball channels. However, it is difficult to accurately contact a grinder or other cutting tools when the slider body has a complicated shape. This deteriorates the accuracy of load ball channels.

There is proposed a slider body made from materials other than metal block. A thin metal plate has load ball channels and is molded, at its outer periphery, of epoxy concrete or synthetic resin (see Japanese utility model publication No. 48417/91).

According to this proposal, load ball channels can be readily and accurately formed by pressing or ball burnishing the thin metal plate. Also, the slider body can readily be machined to a complicated shape. This slider body can be more economically made than those formed by machining metal blocks.

However, the proposed slider body is less in rigidity than those made from metal blocks since it is like a metal plate with load ball channels attached to a block made of synthetic resin. The slider body is thus susceptible to deformation or breakage when substantial load is exerted from a movable body.

A slider must have a mounting portion for securement of a movable body. Movable bodies have various shapes and are, therefore, secured to the slider in various ways. The mounting portion may be in the form, for example, of a flange as an extension of the slider. Under the circumstances, linear bearing manufacturers are required to provide sliders with various mounting portions to meet user's need. Its manufacture is, however, rather cumbersome. Thus, there is a need for sliders which allow for ready securement of movable bodies in various ways and which are economical to manufacture.

Conventionally, a rail is formed by drawing a metal block to have a predetermined cross section, carburizing a portion of the metal block, and cutting or lapping that portion to form ball channels. This production method is as cumbersome as that of the slider. Another problem is that the surface of the rail where balls are moved is susceptible to crack.

There has recently been proposed a rail which includes a thin metal plate in which ball channels are formed by press, and synthetic resin inserted within the metal plate (see Japanese laid-open utility model publication No. 43521/90). However, to give ball channels predetermined hardness, it is necessary to treat the metal plate with TUFFTRIDE or thermally treat the metal plate such as quenching to harden the surfaces of the ball channels on which balls are moved. This treatment is also cumbersome and does not improve the fragility of the surfaces on which balls are moved.

DISCLOSURE OF THE INVENTION

In view of these problems, it is an object of the present invention to provide a linear bearing which is easy to manufacture and has high mechanical strength, and its production method.

In order to achieve the object, the present invention provides a slider for a linear bearing which comprises a thin ball plate having load ball channels, and a thin mounting plate having mounting portions to which a movable body is secured, characterized in that the ball plate and the mounting plate are integrated together by molding a molding material such as resin or die cast alloy.

According to such technical means, the slide can be formed by injection or extrusion molding synthetic resin within which the ball plate and mounting plate are inserted, or by die casting an alluminum or zinc alloy. This allows for ready production of the slider having various shapes such as an inclined C-shape or L-shape. The shape of the ball plate may thus be altered in response to the shapes of a slider. Also, the number and angle of load ball channels formed in the ball plate may be changed as necessary.

The mounting plate may take any shape so far as it has mounting portions to secure a table or other movable bodies. However, it is necessary for the mounting plate to have high rigidity according to its shape and material since the load of a movable body is applied locally to the mounting plate.

Further, nonload ball channels can be any means applicable to the existing linear bearings so far as it can bring balls up at ends of the load ball channels. In the present invention, for example, the slider includes nonload ball bores extending in parallel to the load ball channels. End caps may be attached to front and rear ends of the slider to provide a communication between the load ball channels and the nonload ball bores. Alternatively, ball tubes may be inserted in the slider to provide a communication between opposite ends of the load ball channels.

The present invention has for its purpose to reduce the number of production steps and the production cost. It is therefore preferable to form part of the nonload all channels during insert molding process.

The mounting plate is integrated in the slider by insert molding, but the molding material such as resin surrounds the mounting plate, only. The mounting may be separated from the slider when substantial load is exerted on the mounting plate. To more firmly integrate the mounting plate in the slider, an adhesive agent may be applied to the mounting plate prior to insert molding. Alternatively, the ball plate and the mounting plate may be projection welded or riveted together. However, the use of these means results in an increase in the number of production steps and is not preferable as the purpose of the present invention is to reduce the production cost.

Therefore, the mounting plate preferably has a fixed portion which is embedded in the molding material during insert molding. This results in a decrease in the number of production steps simply by changing the shape of the mounting plate. The fixed portion may be in the form of pawls provided at opposite ends of the mounting plate. Alernatively, recesses may be formed centrally in the mounting plate.

Where the mounting plate has a fixed portion, the fixed portion preferably has an axial length less than that of the ball plate or has through openings. This prevents separation of the molding material covering the fixed portion from the molding material surrounding the ball plate and thus ensures firm integration of the mounting plate with the ball plate.

The present invention also provides a rail for use in a linear bearing to achieve the foregoing object.

A first rail is made of a metallic material which has such a characteristic that its surface hardness is increased when subjected to plastic deformation. The ball channels have predetermined surface hardness when the rail is plastically deformed to a predetermined shape.

With these technical means, the rail is pressed or rolled to a predetermined shape where the rail is made from a thin metal plate. At that time, the surface of the ball channels is hardened to a predetermined level. The rail is drawn to a predetermined shape where the rail is made from a metal block. During drawing process, the surface of the ball channel is hardened to a predetermined level.

The surface hardness required for the ball channels may vary depending on the material of balls and the load to be exerted on the slider, but is normally at least H_RC35. With this production method, the greater the deformation during plastic deformation, the greater the hardness of the ball channel surface on which balls are moved. Thus, where the rail is made, for example, by drawing process, the surface hardness of the ball channels can be adjusted by changing the volume as drawn by a dice.

The same production method is applicable to the ball plate of the slider. The surface of the load ball channels can be hardened to a predetermined level simply by pressing or rolling a thin metal plate to a predetermined shape.

To achieve the foregoing object, a second rail is made from a metal rod and includes ball channels which is subjected to quenching and subzero (or deep freezing) treatment.

With these technical means, the fragile metallic system is improved during quenching process to effectively prevent crack which may occur in the ball channels upon repeated application of loads.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a linear bearing according to a first embodiment. FIG. 2 is a sectional view of the linear bearing according to the first embodiment. FIG. 3 is an exploded view, in perspective, of the linear bearing according to the first embodiment. FIG. 4 is a perspective view of the linear bearing according to the first embodiment, part of which is taken away to show the structure of a slider body. FIG. 5 is a front view of the slider body of the linear bearing according to the first embodiment. FIG. 6 is a bottom plan view of the slider body of the linear bearing according to the first embodiment. FIG. 7 is a top plan view of the slider body of the linear bearing according to the first embodiment. FIG. 8 is a side view of the slider body of the linear bearing according to the first embodiment. FIG. 9 is a bottom plan view of an end cap of the linear bearing according to the first embodiment. FIG. 10 is a rear view of the end cap of the linear bearing according to the first embodiment. FIG. 11 is a sectional view taken along the line XI—XI of FIG. 10. FIG. 12 is a front view of the end cap of the linear bearing according to the first embodiment. FIG. 13 is a sectional view taken along the line XIII—XIII of FIG. 10. FIG. 14 is a sectional view showing a modified form of the slider of the linear bearing according to the first embodiment. FIG. 15 is a perspective view of a linear bearing according to a second embodiment, part of which is taken away to show the structure of a slider. FIG. 16 is a sectional view of the linear bearing according to the second embodiment. FIG. 17 is a sectional view of the linear bearing according to the first embodiment, showing a modified form of a rail.

BEST MODE FOR CARRYING OUT THE INVENTION

A linear bearing and its production method of the present invention will now be described with reference to the accompanying drawings.

FIGS. 1 and 2 show a linear bearing according to a first embodiment of the present invention. The linear bearing generally includes a rail **2**, ad a slider **1** movable along the rail **2**. FIG. 3 is a disassembled view of the slider **1** which includes a slider body **3** having a substantially inclined C-shape and extending over the rail **2**, and a pair of end caps **4** coupled to front and rear ends of the slider body **3**. The slider **1** is mounted on the rail through balls **5** which endlessly circulate in the slider **1**.

As shown in FIG. 4, the slider body **3** includes a channel-like ball plate **6**, and a mounting plate **7** having mounting portions **71** for mounting a movable body (not shown). The ball plate **6** and the mounting plate **7** are integrally formed together by a synthetic resin **8** (for example, "TorayCA").

The ball plate **6** is made of stainless steel or other metal (for exmple, SUS430) and shaped by a press. Opposite inner surfaces of the ball plate **6** form load ball channels **61** which cooperate with ball channels **23** of the rail **2** to sandwich the balls **5**. Positioning projections **62** extend axially from opposite ends of the ball plate **6** to position the end caps. The load ball channels **61** are quenched and then, subzero treated. This treatment hardens the load ball channels **61** to increase its resistance to wear and stabilizes the metallic system of the load ball channels **61** to improve its fragility.

Alternatively, a metal sheet whose surface hardness can be increased when subjected to plastic deformation may be pressed or rolled to a predetermined shape. It is then plastically deformed to harden the surface of the load ball channels **61** to a predetermined level. Such a metal sheet which can be used in this process is, for example, austenite SUS304. The surface hardness of the load ball channels **61** is less than H_RC10 prior to pressing and increased to H_RC35 to 40 after it has been pressed. This method eliminates a need for heat treatment and results in lower production cost.

The mounting plate **7** is formed also by pressing a sheet metal made, for example, of stainless steel and having a thickness slightly greater than that used for the ball plate **6**. The mounting plate **7** includes a recess or fixed portion **72** embedded in the synthetic resin **8** and located between a pair of mounting portions **71**. The mounting portions **71** are tapped to form bolt holes **73** for threading engagement with bolts (not shown) of a movable body. The axial length of the mounting plate **7** is shorter than that of the ball plate.

The slider body **3** is formed by insert molding the ball plate **6** and the mounting plate **7**. FIGS. **5** to **8** show the slider body **3** after it is insert molded.

As is clear from these figures, the ball plate **6** is wrapped by synthetic resin and is not separated from the slider body **3** in any direction. The mounting portions **71** of the mounting plate **7** extend outwardly from the surface of the slider body **3**. The fixed portion **72** of the mounting plate **7** is embedded in the synthetic resin **8**. The mounting plate **7** is thus not separated from the slider body **3** in any direction. During insert molding, part of nonload ball bores is defined in the slider body **3** to provide a connection between ends of the load ball channels to circulate the balls **2** therethrough. Specifically, the slider body **3** has legs **31** in which ball bores **32** through which nonload balls are moved are defined in parallel relationship to the load ball channels **61**. Semicircular return guides **33** are formed in front and rear end surfaces of the slider body **3** to direct the balls **5** from the load ball channels **61** and the ball bores **32** and vice versa. Positioning holes **34** are defined during insert molding to receive projections **41** of the end caps **4**.

The slider body **3** is formed substantially during the insert molding process. Finally, the mounting portions **71** of the mounting plate **7** which extend outwardly from the surface of the slider body **3** is abraded to provide a reference surface.

The end caps **4** coupled to front and rear ends of the slider body **3** are injection molded of synthetic resin. Semicircular ball return channels **42** are formed in the inner sides of the end caps **4** and form part of the nonload ball channels. As shown in FIGS. **9** to **13**, the ball return channels **42** provide a connection between the load ball channels **61** of the slider body **3** and the ball bores **32**. Tongues **43** extend from ends of the end caps **4** to bring the balls **5** up from the load ball channels **61**. Also, seats **44** are provided centrally in the ball return channels **42** to receive return guides **33** of the slider body **3** when the end caps **4** are coupled to the slider body **3**. This facilitates guidance of the balls **5** through the ball return channels **42**.

The end caps **42** are adhesively attached to the slider body **3**. To ensure accurate attachment of the end caps **4** to the slider body **3**, the end caps **4** have recesses **4** to receive projections **62** of the ball plate **6**, and projections **41** to fit into the positioning holes **43** of the slider body **3**.

As shown in FIGS. **2** and **3**, the rail **2** includes a channel-like rail plate **21** made by pressing, and a synthetic resin **22** inserted in the rail plate **21** during molding process. A pair of ball channels **23** are formed in opposide outer sides of the rail plate **21** during pressing process. Also, through holes **24** are formed in the base along the length of the rail plate **21**. Bolt holes **25** are formed during insert molding process and correspond to the through holes **24**. In this embodiment, the slider **1** has no ball retainer. To avoid accidental removal of the slider **1** from the rail **2** and disengagement of the balls **5** from the load ball channels **61**, stoppers **9** are attached to opposite ends of the rail **2**.

The surface of the ball channels **23** are hardened to a predetermined level completely in the same manner as the load ball channels **61** of the ball plate **6**. After the rail has been pressed, the ball channels **23** are quenched and then, subzero treated. Alternatively, a metal sheet made of austenite SUS304 may be pressed or rolled to a predetermined shape to thereby increase the surface hardness of the ball channels **23** to a predetermined level.

When the slider **1** is in use, the balls **5** are placed in the nonload ball channels composed of the ball return channels **42** of the end caps **4** and the ball bores **32** of the slider body **3**. The balls **5** are also placed between the ball channels **23** of the rail **2** and the load ball channels **61** of the slider body **3**. A movable body is then secured to the mounting portions **71** which extend outwardly from the upper surface of the slider **1**.

A substantial part of the slider **1** is formed of synthetic resin **8**. However, part of the mounting plate **7** which has high regidity is embedded in the synthetic resin **8** to be integral with the slider body **3**. This mounting plate **7** serves as a reinforcing element for the slider body **3** to increase the rigidity of the slider body **3**. Thus, the slider body **3** is free from deformation or breakage if substantial load is exerted.

The mounting plate **7** and the slider body **3** are integrally formed during insert molding of the slider **3**. A change in shape of the mounting plate **7** results in a corresponding change in shape of the slider.

FIG. **14** shows a modification of the slider body **3** as insert molded. The slider body includes a mounting plate ***7a*** which has wider mounting portions than those of the mounting plate **7**, and bolt holes **76**.

According to this embodiment, while the ball plate **6** and other elements are commonly used, a variety of mounting plates **7** can be employed to provide a variety of sliders. Thus, various types of sliders can economically and readily be fabricated according to user's need.

In the foregoing embodiment, the axial length of the mounting plate **7** is less than that of the ball plate **6** so that the synthetic resin **8** which covers the fixed portion **72** of the mounting plate **7** are safely joined to the synthetic resin **8** which surrounds the ball plate **6**. As an alternative, the axial length of the mounting plate **6** may be identical to that of the slider body **3**. In such a case, slots or through openings **74** may be formed in the fixed portion **72** as shown in FIG. **15**.

FIG. **16** is a sectional view showing a second embodiment of the slider **1** wherein a mounting plate ***7b*** has the through openings **74**. As is clear from FIG. **16**, the synthetic resin **8** which covers the fixed portion **72** of the mounting plate **7** through the through openings **74** is safely joined to the synthetic resin **8** which surrounds the ball plate **6**. This embodiment also allows for firm integration of the mounting plate ***7b*** with the slider body **3**.

In this embodiment, the ball plate **6** is pressed, but the load ball channels **61** are not abraded. However, the load ball channels **61** may need be abraded when the plate **6** per se is made of a material which does not provide a smooth surface.

The rail **2** in which the slider **1** of this embodiment is assembled may be made by pressing a metal sheet. As shown in FIG. **17**, a matal block may be drawn to form a rail ***2a*** of a predetermined shape. In such a case, ball channels ***23a*** of the rail ***2a*** are quenched and then, subzero treated after it has been drawn so as to increase resistance to wear and improve the fragility of the ball channels ***23a***.

To reduce the cost of manufacturing the rail ***2a***, a block made of austenite SUS304 may be drawn to a predetermined shape. The rail ***2a*** is plastically deformed to thereby increase the surface hardness of the ball channels ***23a*** to a preetermined level.

INDUSTRIAL APPLICABILITY

As described above, according to a linear bearing and its production method of the present invention, a slider is formed by integrating a high rigid mounting plate with a ball plate by the use of molding material such as resin or die cast alloy. The slider thus made is highly rigid even if molding material is relatively flexible. It is therefore possible to provide a linear bearing which has high mechanical strength.

Also, according to a linear bearing and its production method of the present invention, a rail is plastically deformed to a predetermined shape to thereby harden a ball channels. This eliminates a need for heat treatment of the ball channels. It is therefore possible to provide a linear bearing which has high mechanical strength and is economical to manufacture.

Further, according to a linear bearing and its production method of the present invention, when a rail is quenched to harden ball channels, subzero treatment is subsequently effected to alter metallic system to improve the fragility of the rail. The ball channels are thus free from crack. It is therefore possible to provide a linear bearing which has high mechanical strength.

I claim:

1. A method of producing a linear bearing, said linear bearing comprising a rail having ball channels, and a slider having load ball channels cooperating with said ball channels to sandwich a multiplicity of balls and guiding a table or movable body secured to said slider along said rail, said method comprising the steps of

forming a thin ball plate having load ball channels, forming a thin mounting plate having mounting portions to which the movable body is secured, and integrally molding said ball plate and said mounting plate to provide said slider.

2. A method of producing a linear bearing according to claim 1, wherein part of nonload ball channels through which nonload balls are circulated are formed when said ball plate and said mounting plate are integrated together during insert molding process.

3. A method of producing a linear bearing according to claim 1, wherein said ball plate is made from a metal sheet whose surface hardness is increased when subjected to plastic deformation, and said load ball channels are hardened to a predetermined level while said ball plate is subjected to plastic deformation.

4. A method of producing a linear bearing, said linear bearing comprising a rail having ball channels, and a slider having load ball channels cooperating with said ball channels to sandwich a multiplicity of balls and guiding a table or movable body secured to said slider along said rail, said method comprising the steps of

providing a metallic material whose surface hardness is increased when subjected to plastic deformation, and plastically deforming said metallic material to form said rail and harden said ball channels to a predetermined level.

5. A method of producing a linear bearing, said linear bearing comprising a rail having ball channels, and a slider having load ball channels cooperating with said ball channels to sandwich a multiplicity of balls and guiding a table or movable body secured to said slider along said rail, said method comprising the steps of

forming ball channels in said rail, quenching said ball channels, and then, subzero treating (or deep freezing) said ball channels.

* * * * *

US005277498A

United States Patent [19]

Kawaguchi

[11] Patent Number: 5,277,498

[45] Date of Patent: Jan. 11, 1994

[54] LINEAR GUIDE DEVICE

[75] Inventor: Takahiro Kawaguchi, Tokyo, Japan

[73] Assignee: THK Co., Ltd., Tokyo, Japan

[21] Appl. No.: 809,508

[22] PCT Filed: May 16, 1991

[86] PCT No.: PCT/JP91/00646

§ 371 Date: Mar. 23, 1992

§ 102(e) Date: Mar. 23, 1992

[87] PCT Pub. No.: WO91/18219

PCT Pub. Date: Nov. 28, 1991

[30] Foreign Application Priority Data

May 21, 1990 [JP] Japan 2-130965

[51] Int. Cl.^{5} F16C 29/06; F16H 27/02

[52] U.S. Cl. 384/45; 74/89.15

[58] Field of Search 384/43, 44, 45; 74/89.15

[56] References Cited

U.S. PATENT DOCUMENTS

4,632,573 12/1986 Itoh .... 384/45 X
4,674,893 6/1987 Teramachi .... 384/43 X
4,932,279 6/1990 Kasuga .... 384/45 X
4,934,202 6/1990 Hikita et al. 74/89.15
4,983,049 1/1991 Lecomte 384/45
5,074,160 12/1991 Kusuga .... 384/45 X
5,076,713 12/1991 Morita 384/45

FOREIGN PATENT DOCUMENTS

443098 8/1991 European Pat. Off. 384/45
58-34225 2/1983 Japan .
84421 5/1985 Japan .
11207 3/1987 Japan .
200016 9/1987 Japan .

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] ABSTRACT

A linear guide device which comprises a track bed having a substantially rectangular section opened at one side and is provided at its inner surfaces with rolling surfaces for rolling members; and a bearing block which has load rolling surfaces cooperating with the rolling surfaces to hold the rolling members therebetween and moves in a hollow portion of the track bed in accordance with rotation of a feed screw shaft engaging the bearing block. The bearing block is formed of a block body, rolling aperture forming plates and covers which are jointed together to entirely form ball circulation paths through which no-load balls circulate. Therefore, a long bearing block can be facilely manufactured, and thus a number of the rolling members can be increased for achieving the linear guide device having a large maximum allowable load and a compact configuration.

1 Claim, 10 Drawing Sheets

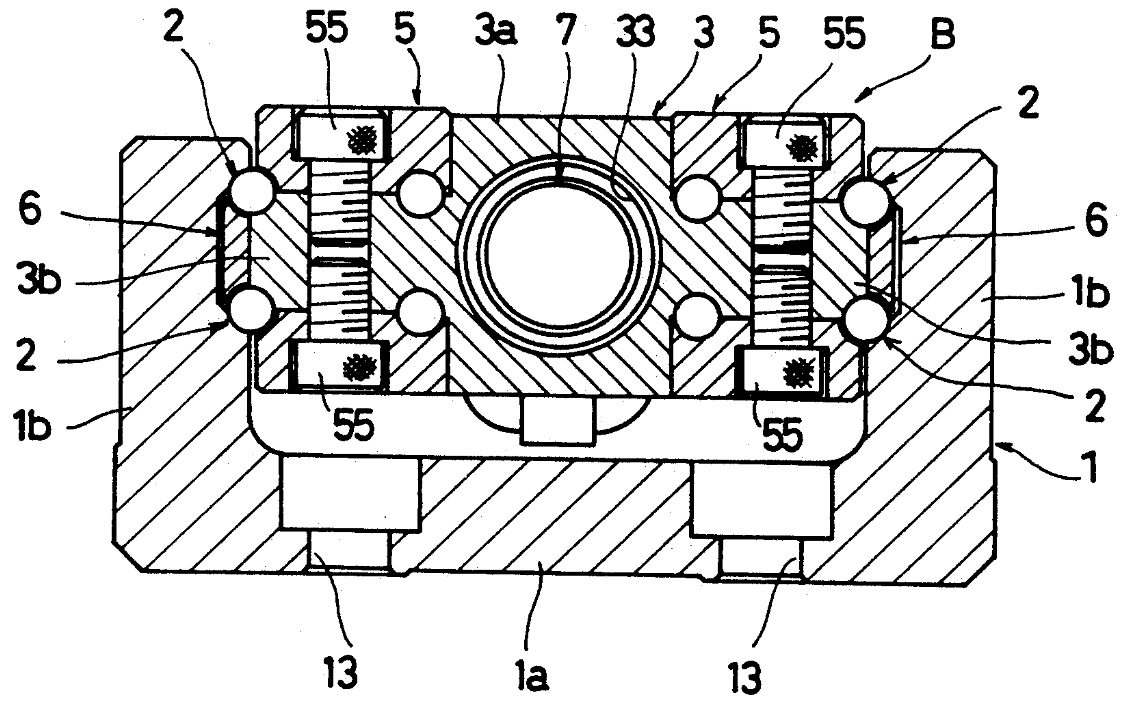
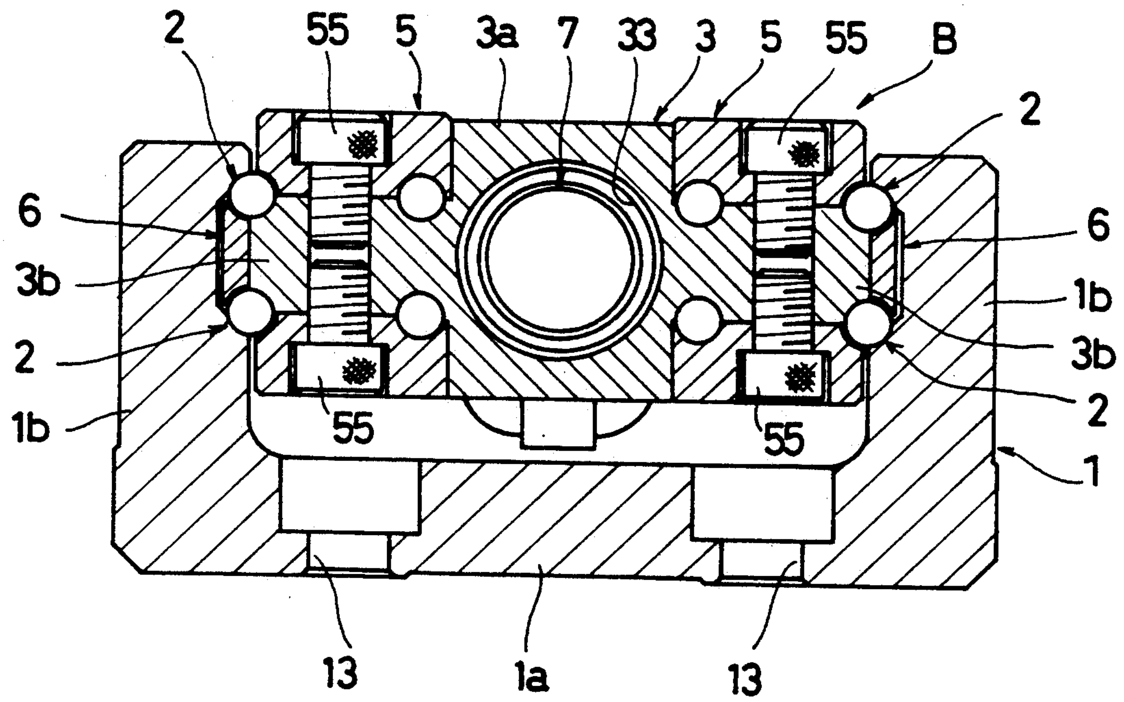


FIG. 1



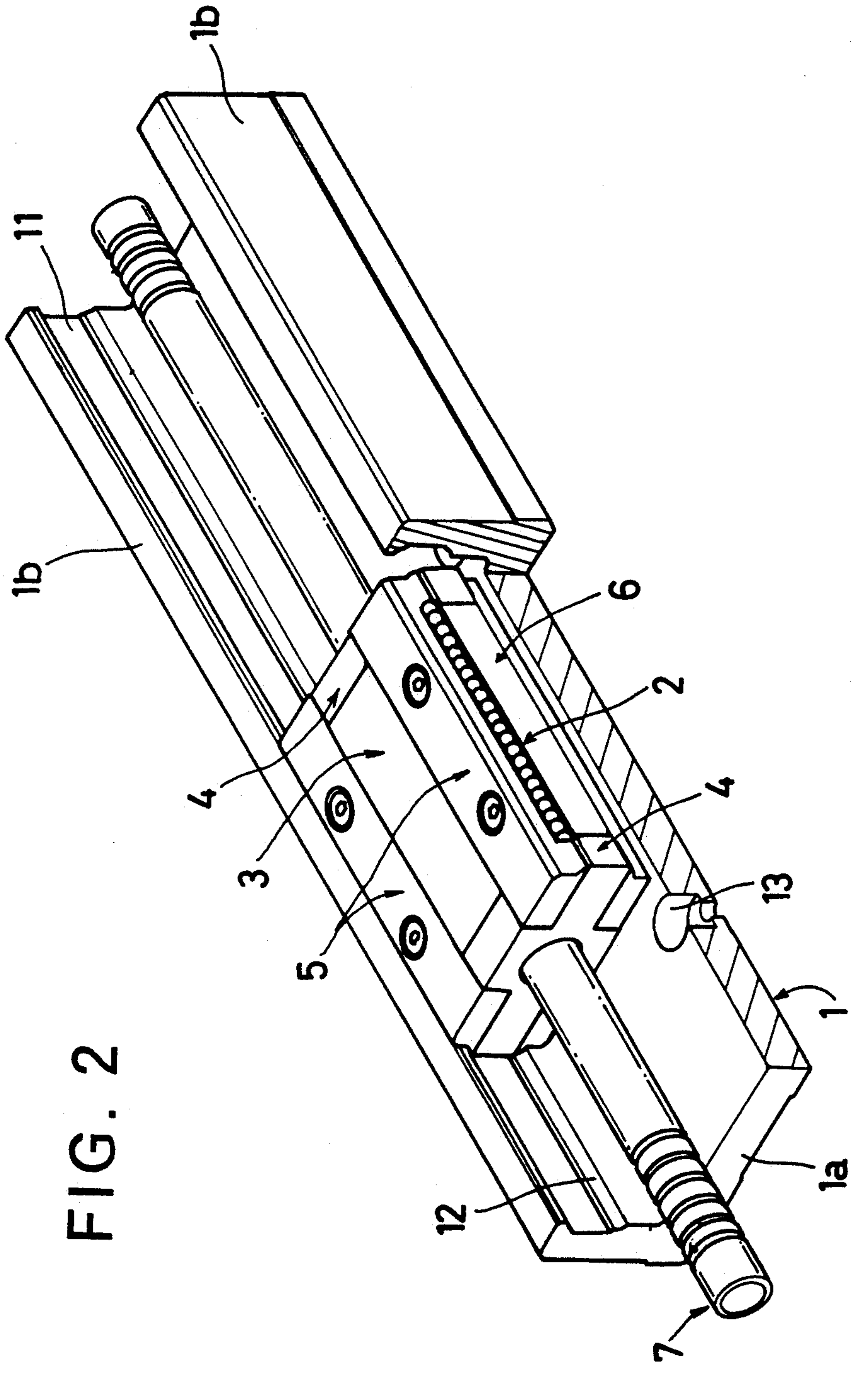


FIG. 2

FIG. 3

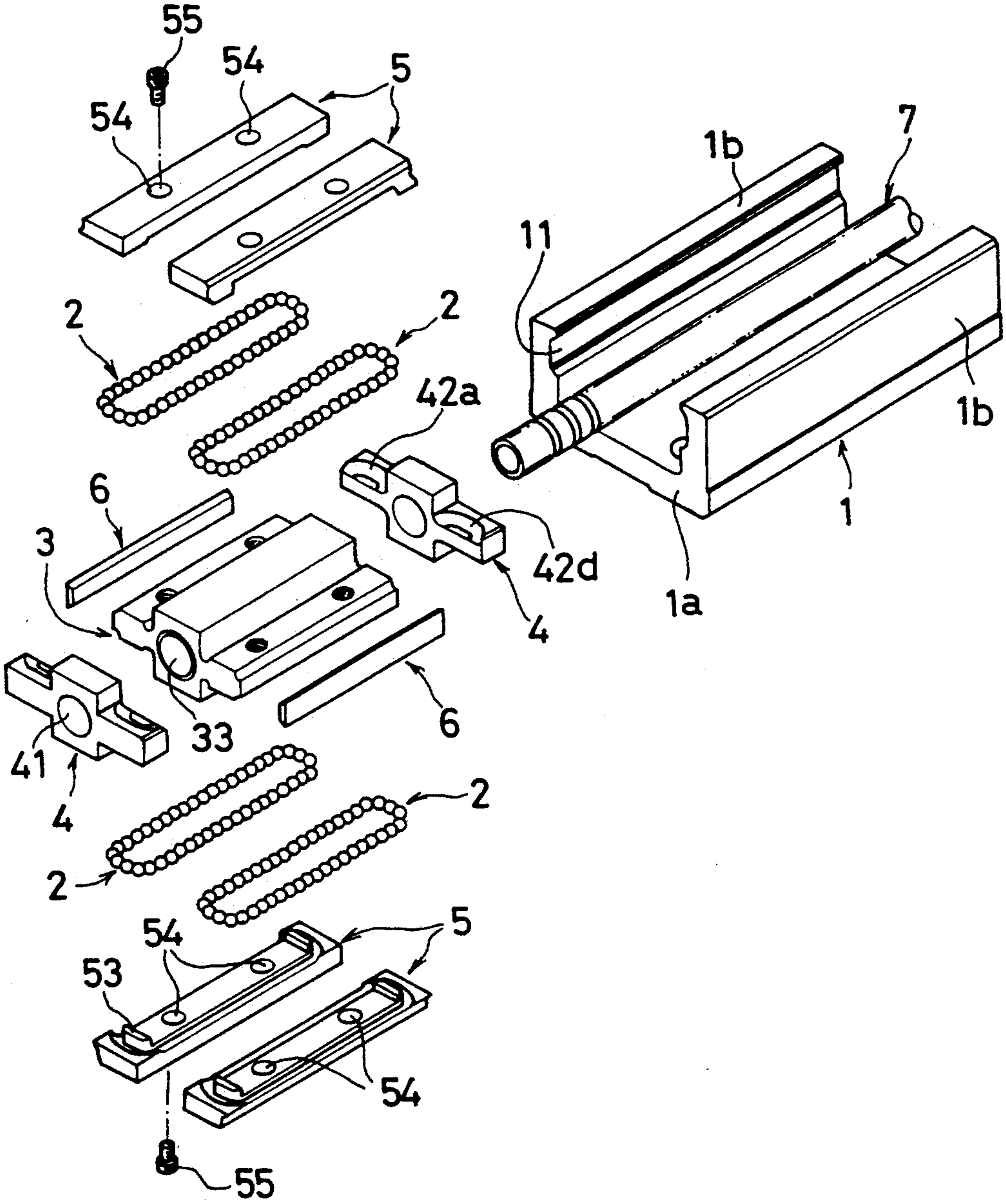


FIG. 4

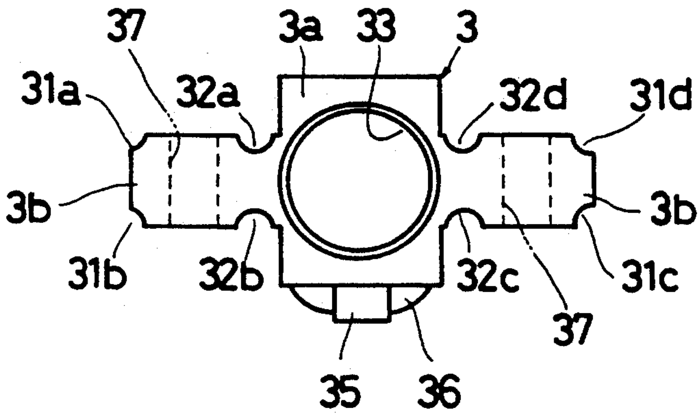

37
3a
33
3
31a
32a
32d
31d
3b
3b
31b
32b
32c
31c
37
35
36

FIG. 5

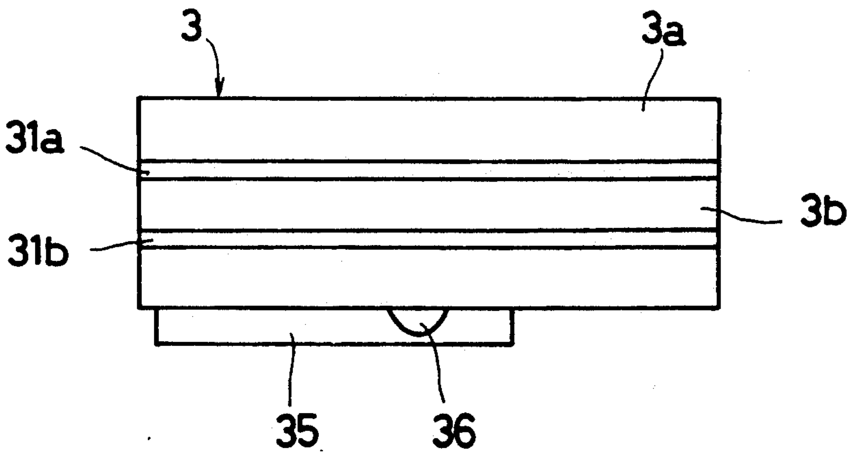

3
3a
31a
3b
31b
35
36

FIG. 6

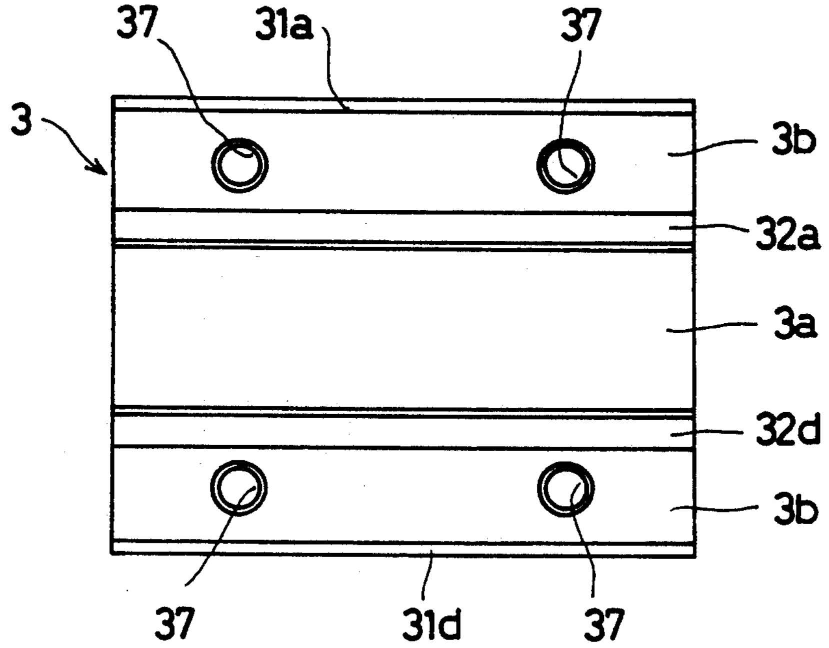

37
31a
37
3
3b
32a
3a
32d
3b
37
31d
37

FIG. 7

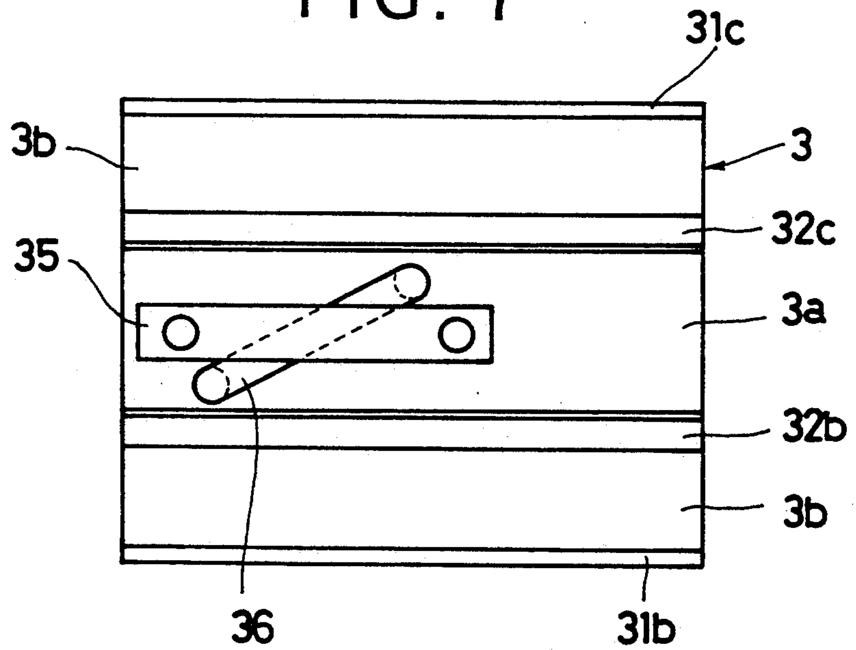

31c
3b
3
32c
35
3a
32b
3b
36
31b

FIG. 8

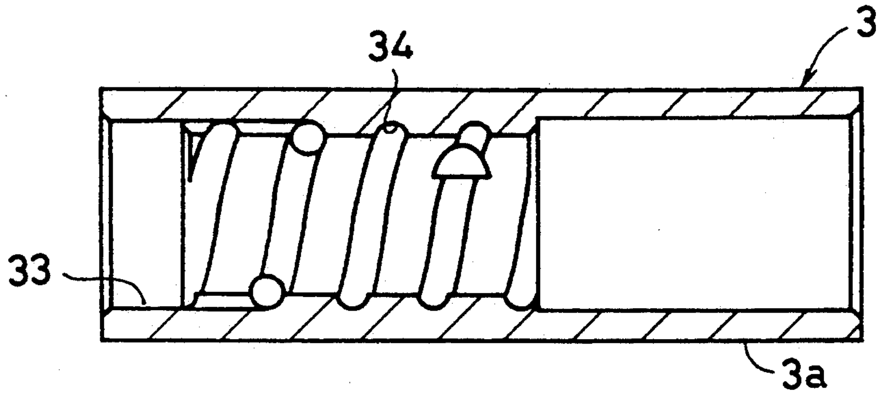


FIG. 9

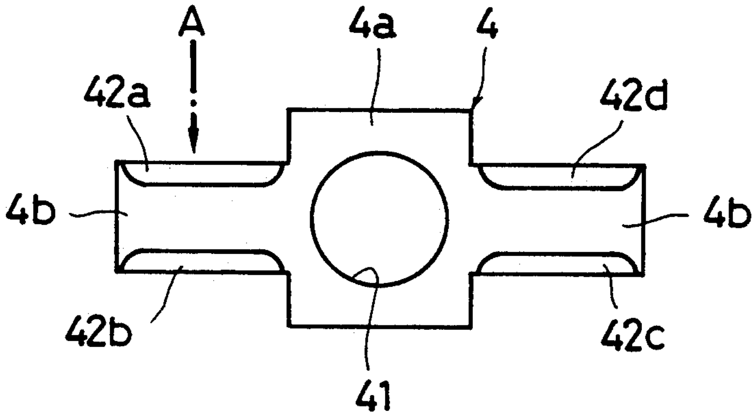


FIG. 10

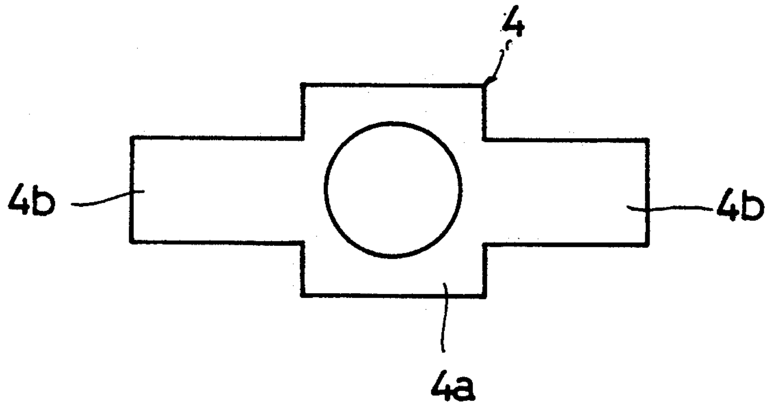


FIG. 11

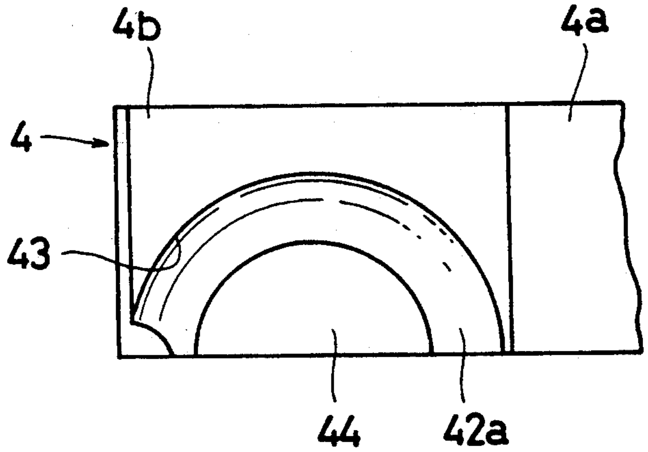


FIG. 12

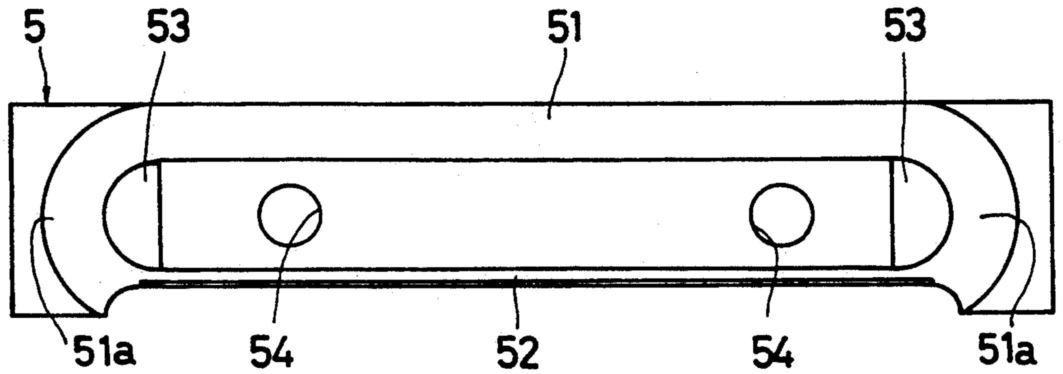


FIG. 13

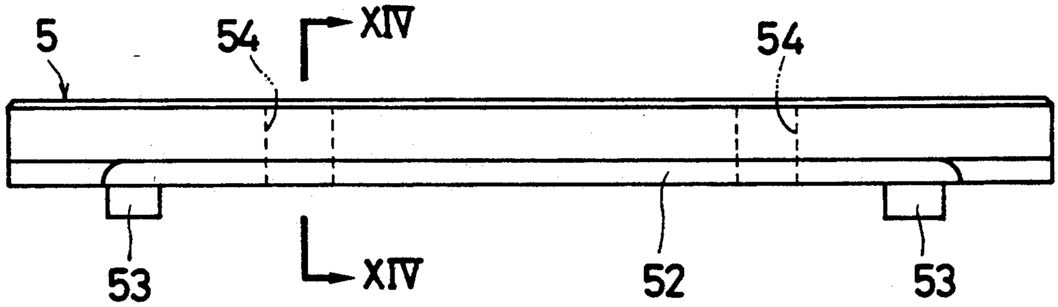
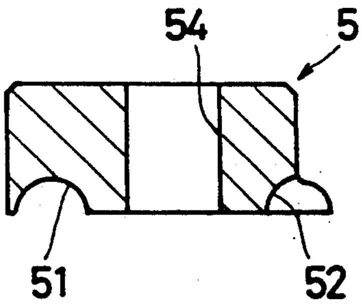


FIG. 14



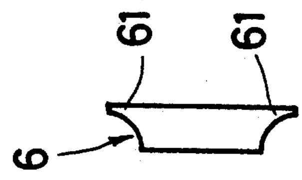


FIG. 16

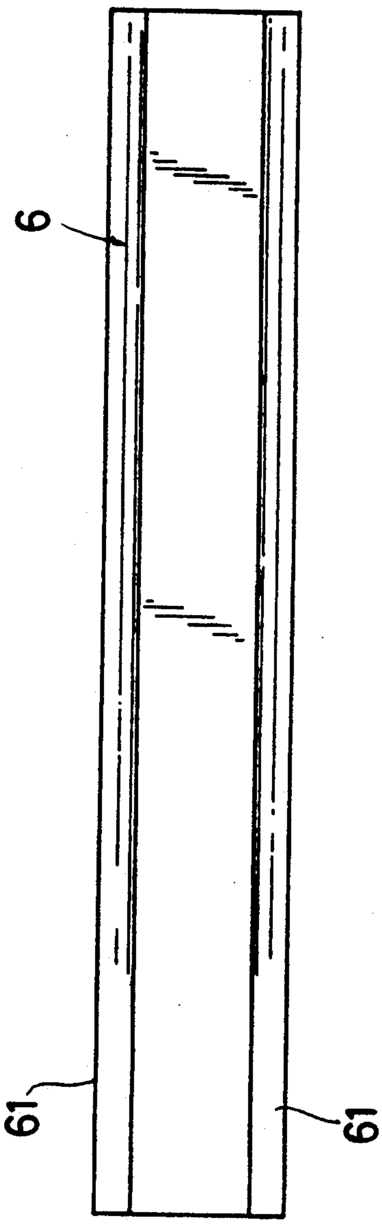
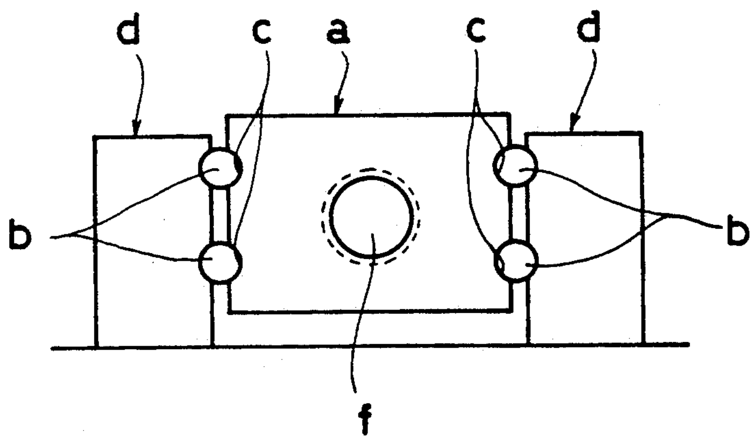


FIG. 15

FIG. 17 (Prior Art)



LINEAR GUIDE DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a linear guide device used, for example, in a linear motion component of a machine tool or an industrial robot.

2. Description of the Related Art

A linear guide device of a type described above has been disclosed in Japanese Laid-Open Patent publication No. 62-200016. Specifically, as shown in FIG. 17, a bearing block (a) (which will be called merely a "block") is provided at its opposite side surfaces with load ball grooves (c) in which balls (b) rolls. A pair of track beds (d) is disposed with the block (a) therebetween. The beds (d) are provided with ball rolling grooves opposed to the load ball grooves (c). The balls (b) held between the load ball grooves (c) and the ball rolling grooves support the block (a) so that the block (a) may be movable along the track beds (d).

A screw shaft (f) of a feed screw mechanism is engaged with a central portion of the block (a), so that the screw shaft (f) may be rotated to move the block (a) along the track beds (d).

According to this linear guide device, since the bearing block for supporting a movable member such as the table is constructed integrally with the feed screw mechanism for applying a driving force for the linea motion to the movable member, a compact construction of the device can be achieved, and a height of the movable member can be minimized, which enables a stable motion.

However, with respect to the bearing block of the linear guide device described above, opposite ends of each load ball groove must be connected by a ball circulation path so as to guide or introduce the balls from a termination end of the load ball groove to a start end of the load ball groove again.

In the prior art, the ball circulation path is generally formed of a no-load ball rolling aperture, which is formed in the block to correspond to each load ball groove, and ball return paths, each of which connects an end of the ball load groove and an end of the no-load ball rolling aperture.

However, the no-load ball rolling aperture is a very small aperture having a diameter only slightly larger than that of the ball, and thus it is difficult to form a long no-load ball rolling aperture by drilling. Therefore, machining of the no-load rolling aperture restricts increase of a length of the block, and thus restricts the length of the load ball groove.

Generally, in a bearing which employs rolling members such as balls for bearing the motion between two objects, a maximum allowable load may be increased by 1 increasing sizes of the rolling members, or 2 increasing numbers of the rolling members which rolls on the load rolling groove. However, the latter can be hardly applied to practical products because the lengths of the load ball grooves are restricted due to the above described reason.

The present invention is devised in view of the above problems. It is an object of the invention to provide a linear guide devide, which allows easy formation of no-load rolling apertures for rolling members and has a large maximum allowable load and a small sizes.

SUMMARY OF THE INVENTION

In order to achieve the above objects, a linear guide device of the invention comprises: a track bed which has a substantially rectangular section opened at one side and is provided at its inner surfaces with rolling surfaces for rolling members; and a bearing block which has load rolling surfaces cooperating with said rolling surfaces to hold the rolling members therebetween and moves in a hollow portion of the track bed in accordance with a degree of rotation of a feed screw shaft engaging the bearing block, wherein said bearing block has a block body which includes a ball-nut portion engaging the feed screw shaft, a pair of bearing portions projected from the ball-nut portion and the load rolling surfaces formed at ends of the bearing portion, said bearing block further includes a rolling aperture forming plate which cooperates with the bearing portions to form the no-load rolling apertures for the rolling members, and covers which are engaged with front and rear end surfaces of the block body, and said covers form return paths for the rolling members which connect the load rolling surfaces and the no-load rolling apertures, respectively.

According to the embodiment of the invention described above, the load rolling surfaces formed on the bearing block may be appropriately varied with respect to its configurations including a number of the surfaces and a contact angle thereof to the rolling members, provided that the load rolling surfaces can bear the load applied to the block, and that the variation does not apply the load to the screw shaft engaging the block body.

In a construction in which the no-load rolling apertures are formed by the bearing portions of the block body and the rolling aperture forming plates engaging them, the apertures may be formed by no-load rolling grooves provided in the block body and closed or covered with the rolling aperture forming plates, or conversely, may be formed by the no-load rolling grooves provided in the rolling aperture forming plates engaging the block body.

Further, the rolling members used in the invention may be appropriately selected from balls, rollers and others.

According to the above embodiment, since the no-load rolling apertures in the bearing block are formed by attaching the rolling aperture forming plates to the block body, the no-load rolling apertures can be facilely manufactured by forming grooves for receiving the rolling members in one or both of the members, which facilitates manufacturing of the long bearing.

Since the bearing block is formed by attaching the rolling aperture forming plates and the covers to the block body, the block body may have a vertically and laterally symmetrical configuration which allows manufacturing of the long body by drawing.

Further, since the rolling aperture forming plate forms one side of the no-load rolling aperture, collision noises of the rolling members during rolling thereof in the no-load rolling apertures can be sufficiently prevented by employing plates made from resin.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross section illustrating a first embodiment of a linear guide device according to the invention;

FIG. 2 is a perspective view with a certain part cut away;

FIG. 3 is an exploded view illustrating components of a linear guide device according to the first embodiment;

FIGS. 4–7 are an elevation, a side view, a top view and a bottom view illustrating a block body, respectively;

FIG. 8 is a longitudinally sectional view illustrating a ball-nut portion of the block body;

FIGS. 9 and 10 are a front view and a rear view of a cover;

FIG. 11 is a view taken along an arrow A in FIG. 9;

FIGS. 12 and 13 are a rear view and a side view illustrating a rolling aperture forming plate;

FIG. 14 is a cross section taken along line XIV—XIV in FIG. 13;

FIGS. 15 and 16 are a side view and an elevation of a ball retainer; and

FIG. 17 is a cross section illustrating a linear guide device of the prior art.

DESCRIPTION OF THE REFERENCE NUMERALS

DESCRIPTION OF THE REFERENCE NUMERALS			
1:	track bed	2:	ball (rolling members)
3:	block body	3a:	ball-nut portion
3b:	bearing portion	4:	cover
5:	rolling aperture forming plate	12:	rolling surface
7:	screw shaft		
31a~31d:	load ball grooves (load rolling surface)		
B:	bearing block (block)		

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A linear guide device of the invention will be described in greater detail with reference to the accompanying drawings.

FIGS. 1 and 2 illustrate a first embodiment of the linear guide device of the invention, which is basically formed of a track base or bed 1 having a substantially rectangular section opening at one side and fixed to, e.g., a bed, a substantially rectangular bearing block B (will be also called as a "block") engaging a screw shaft 7 of a feed screw mechanism for moving in a concave portion of the track bed 1, and a plurality of balls 2 or rolling members which bear loads between the block B and the track bed 1 during rolling therebetween.

The block B is formed of, as shown in FIG. 3, a block body 3 engaging the feed screw shaft 7, covers 4 attached to front and rear end surfaces of the block body 3, rolling aperture forming plates 5 engaging four corners of the block body 3, and a pair of ball retainers 6 engaging side surfaces of the block body 3.

The block body 3 includes, as shown in FIGS. 4–7, a ball-nut portion 3*a* engaging the screw shaft 7 and a pair of bearing portions 3*b*, and thus has a section similar to a cross. Each bearing portion 3*b* is provided at corners or edges with a pair of load ball grooves 31*a* and 31*b*, or 31*c* and 31*d*, in which the balls 2 rolls. No-load ball grooves 32*a*–32*d* for circulating the balls which roll from ends of the load ball grooves 31*a*–31*d* are formed at corners between the bearing portions 3*b* and the ball-nut portion 3*a*. Each bearing portion 3*b* is provided with tapped bolt apertures 37 into which attaching bolts 55 are screwed for attaching the rolling aperture forming plates 5.

The ball-nut portion 3*a* engaging the screw shaft 7 is provided with, as shown in FIG. 8, a through aperture 33 having a diameter slightly larger than the screw shaft 7 and a rolling groove 34 which is formed at a portion of the through aperture 33 and corresponds to a spiral ball rolling groove on the screw shaft 7. Further, a return tube 36 is fixed to the ball-nut portion 3*a* by a holder member 35 to form a circulation path. Pre-loads are applied to balls (not shown) disposed between the screw shaft 7 and the block body 3 for increasing the accuracy of motion of the block B.

Since the block body 3 thus constructed has a vertically and laterally symmetrical configuration, it can be manufactured by drawing without utilizing conventional machining such as cutting. Specifically, the block body 3 can be manufactured in such a manner that the drawing is applied to a steel member to form the above sectional shape and then polishing for the load ball grooves 31*a*–31*d* and drilling for the through apertures 33 are applied to it. According to this manufacturing method, block bodies 3 having intended lengths can be facilely manufactured by appropriately cutting the drawn steel member into pieces.

The cover 4 has a sectional shape similar to a cross, as shown in FIGS. 9 and 10, and includes a base 4*a* and a pair of arms 4*b* projected therefrom. The cover 4 is formed by injection molding of synthetic resin. The base 4*a* is provided with a through aperture 41 into which the screw shaft 7 is inserted. Each projected arm 4*b* is provided at its opposite side surfaces with ball return grooves 42*a*–42*d* for connecting the load ball grooves 31*a*–31*d* on the block body 3 and the corresponding no-load ball grooves 32*a*–32*d* to each other (see FIG. 11). In FIG. 11, a numeral 43 indicates one of projections for scooping and guiding the balls 2, which roll from the load ball grooves 31*a*–31*d*, into the ball return grooves 42*a*–42*d*. A numeral 44 indicates one of positioning seats for bearing the guide projections 53 which will be described later and are provided in the rolling aperture forming plates 5.

The rolling aperture forming plates 5 are manufactured by injection molding of synthetic resin, similarly to the covers 4. As shown in FIGS. 12–14, the plates 5 each are provided at one surface with ball circulation grooves 51 corresponding to the no-load ball grooves 32*a*–32*d* on the block body 3 and the ball retrn grooves 42*a*–42*d* on the covers 4. Also, the plates 5 each are provided at one side edge with a ball retaining groove 52 which connects to the ball circulation groove 51 and corresponds to the load ball groove 31*a*–31*d* of the block body 3. Further, inside return portions 51*a* of the ball circulation paths 51, the guide pieces 53 are projected for positioning the plates 5 with respect to the block body 3 or the covers 4. In an assembly of the block B, each pair of the guide pieces 53 engage the front and rear end surfaces of the bearing portion 3*b* for positioning the block body 3, and rest on the positioning seats 44 of the covers 4 for positioning the covers 4. Numerals 54 indicate penetrated apertures through which attaching bolts 55 are inserted for attaching the plates 5 to the block body 3.

The ball retainer 6 is a rod-like member having a nearly trapezoid shape, as shown in FIGS. 15 and 16, and has a width so determined that a gap between the projected end 61 of the retainer 6 attached to the block body 3 and the ball retaining groove 52 on the rolling aperture forming plate **5** may be smaller than the diameter of the ball **2**, whereby the balls **2** are prevented from disengaging from the load ball grooves **31***a*–**31***d* when the block B is removed from the track bed **1**.

The track bed **1** has a nearly rectangular shape opened at one side and includes a fixing portion **1***a* fixed to a basic member such as a bed, and a pair of support portions **1***b* projected from the opposite ends of the fixing portion **1***a* for supporting the block body **3**. Each supporting portion **1***b* is provided at its inner surface with a groove **11**, and the grooves **11** are provided at their upper and lower corners with ball rolling grooves **12***a*–**12***d* opposed to the load ball grooves **31***a*–**31***d* of the block body **3**, respectively. A numeral **13** indicates one of bolt holes into which fixing bolts for fixing the track bed **1** are inserted.

In the construction described above, the bearing block B is assembled by attaching the covers **4** to the front and rear end surfaces of the block body **3** by screws (not shown), attching the four rolling aperture forming plates **5** to the bearing portions **3***b* of the block body **3** and attaching the ball retainers **6** to the side surfaces of the bearing portions **3***b* by screws (not shown).

Therefore, in the illustrated embodiment, the no-load ball rolling apertures corresponding to the load ball grooves **31***a*–**31***d* is formed of the no-load ball grooves **32***a*–**32***d* on the block body **3** and the ball circulation grooves **51** on the rolling aperture forming plates **5** opposed thereto. Further, the ball return paths which connect the no-load ball rolling apertures and the load ball grooves **31***a*–**31***d* are formed of the ball return grooves **42***a*–**42***d* on the covers **4** and the ball circulation grooves **51** on the plates **5** faced thereto.

In this construction, the no-load ball grooves **31***a*–**31***d* are facilely formed by applying milling to the block body **3** and the ball return grooves **42***a*–**42***d* and the ball circulation grooves **51** are facilely formed by the injection molding of the covers **4** and the rolling aperture forming plates **5**, respectively. Therefore, even in the long block B, the no-load ball rolling apertures can be facilely and accurately formed.

Since the balls **2** are covered with the plates or covers **4** made from the synthetic resin while they are rolling the ball circulation paths, noises which may be caused by circulation of the balls can be reduced.

According to the linear guide device of the invention, as described hereinabove, the no-load rolling apertures can be facilely formed by machining the grooves for receiving the rolling members in the block body and/or the rolling aperture forming plates, so that the long bearing block can be facilely manufactured, and thus the number of the load rolling members can be increased to obtain the linear guide device having an increased maximum allowable load and a compact configuration.

Since the block body having an intended length can be manufactured by cutting a drawn member, the productive efficiency can be increased and the costs can be reduced.

Further, owing to the rolling aperture forming plates made from resin, the collision noises of the rolling members during rolling in the no-load apertures can be minimized, and thus the linear guide device having a small operation noise can be obtained.

What is claimed is:

1. A linear guide device comprising:

a track bed having a substantially rectangular section open at one side and provided at its inner surfaces with rolling surfaces for rolling members; and

a bearing block having load rolling surfaces cooperating with said rolling surfaces to hold the rolling members therebetween and moving in a hollow portion of the track bed in accordance with a degree of rotation of a feed screw shaft engaging the bearing block, wherein

said bearing block has a block body which includes a ball-nut portion engaging the feed screw shaft, a pair of bearing portions projecting from both sides of the ball-nut portion and the load rolling surfaces formed at corners or edges of the bearing portion, and, thus constructed, having a vertically and laterally symmetrical configuration.

said bearing block further including four rolling aperture forming plates engaged with upper and lower sides of said bearing portions, and cooperating with the bearing portions to form no-load rolling apertures for the rolling members, and covers which are engaged with front and rear end surfaces of the block body, and

said covers forming return paths for the rolling members which connect the load rolling surfaces and the no load rolling apertures, respectively.

* * * * *

US005184898A

United States Patent [19]

Kito

[11] **Patent Number: 5,184,898**

[45] **Date of Patent: Feb. 9, 1993**

[54] **BALL RETAINER FOR LINEAR BEARINGS**

[75] Inventor: **Fusao Kito**, Yamanashi, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **884,345**

[22] Filed: **May 18, 1992**

[51] **Int. Cl.**[5] **F16C 29/06**

[52] **U.S. Cl.** **384/43**

[58] **Field of Search** 384/43–45

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,204,717	5/1980	Ernst et al.	384/43
4,206,951	6/1980	Ernst et al.	384/43
4,339,157	7/1982	Olschewski et al.	384/43
5,051,001	9/1991	Jacob	384/43

FOREIGN PATENT DOCUMENTS

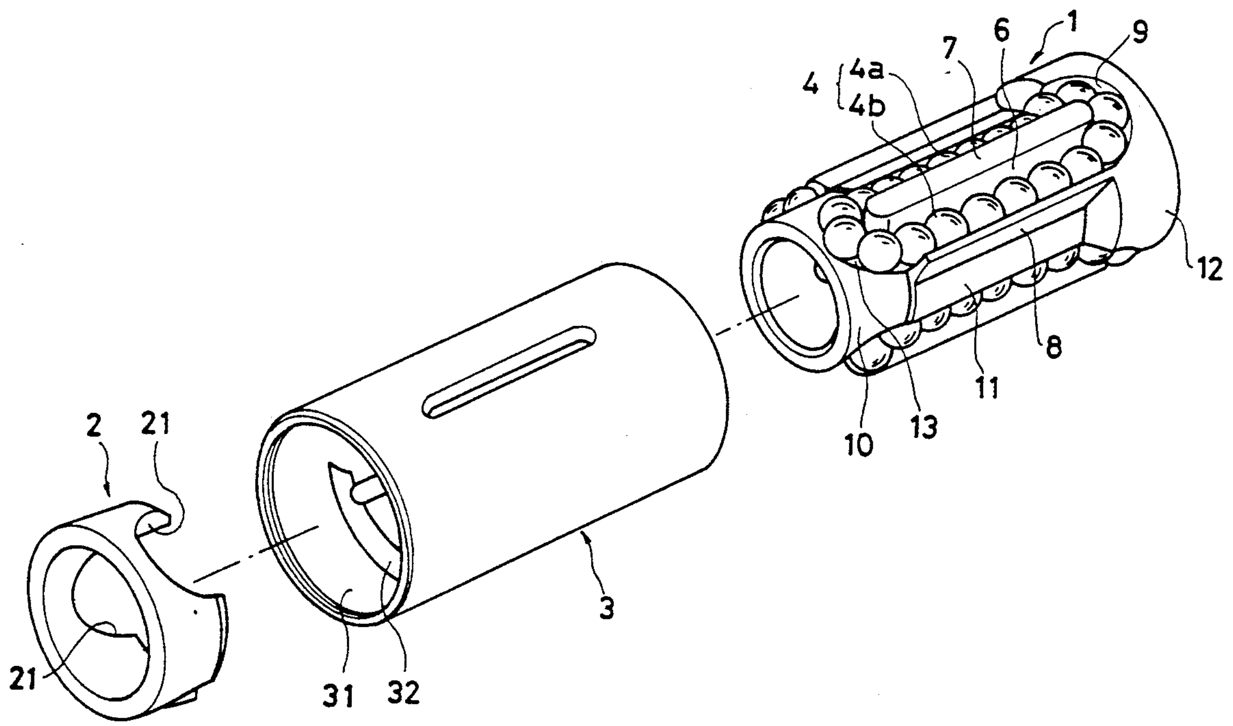
62-33140	8/1987	Japan .
63-6507	2/1988	Japan .

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

A ball retainer to be used in a linear bearing of a ball bush, a ball spline or the like. The ball retainer is formed with endless ball guide races for guiding balls smoothly and can be easily assembled in a bearing outer cylinder. The ball retainer is constructed to comprise: a retainer body fitted in a hollow portion from one opening of the bearing outer cylinder which moves linearly around a bearing shaft; and an annular piece fitted in the hollow portion from the other opening. The ball retainer is characterized in that its outer shape is configured with the inner shape of the bearing outer cylinder when the annular piece is fixed on the leading end portion of the retainer body.

2 Claims, 8 Drawing Sheets



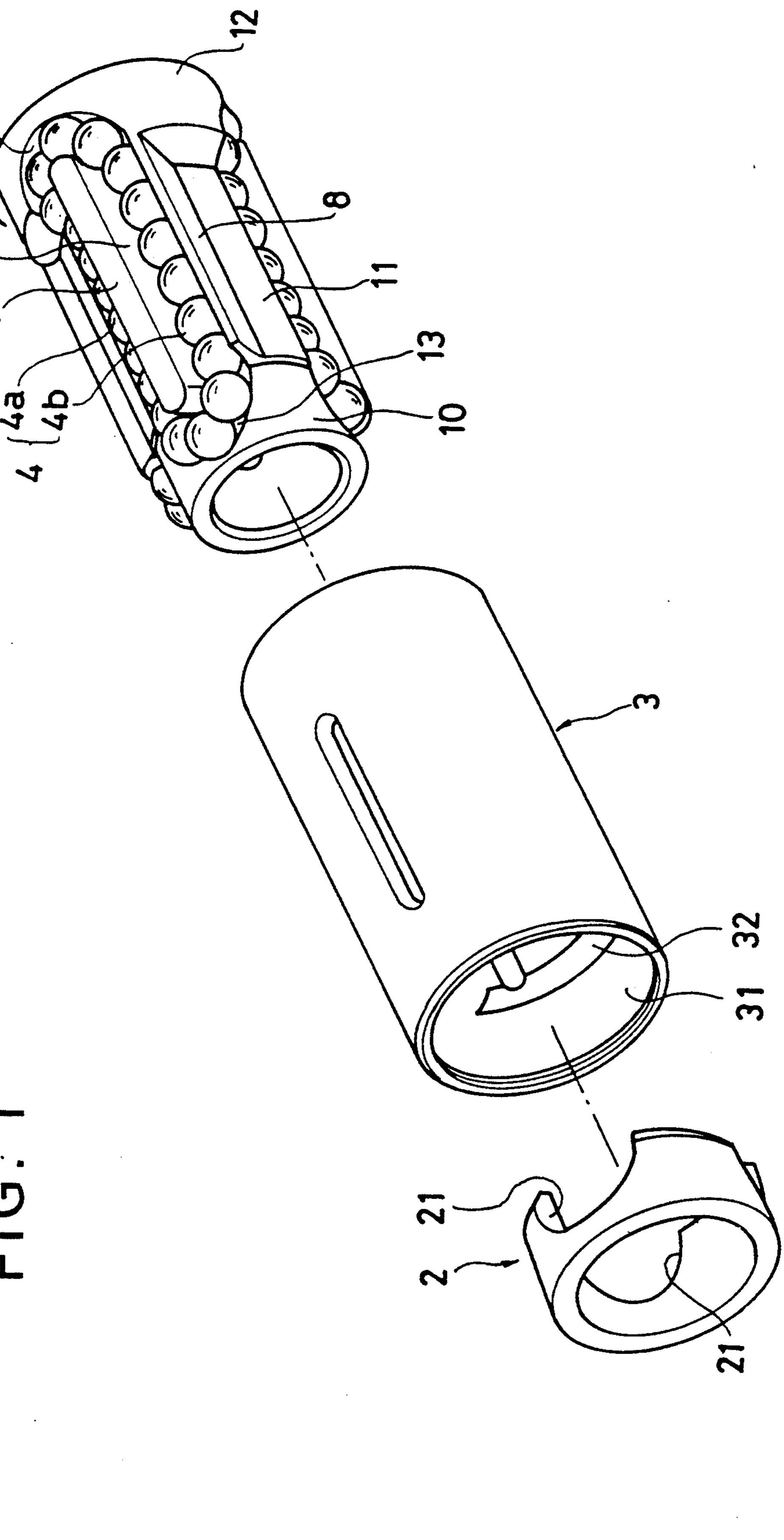


FIG. 1

FIG. 2

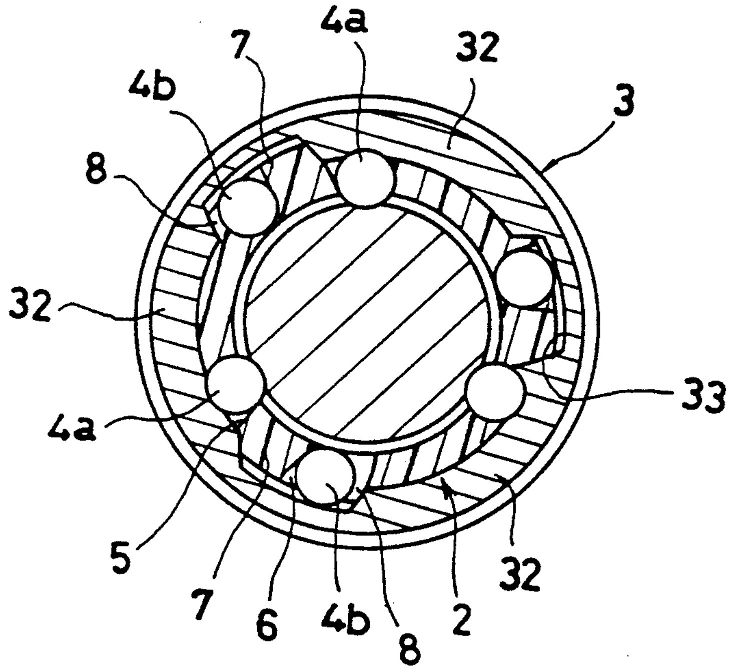


FIG. 3

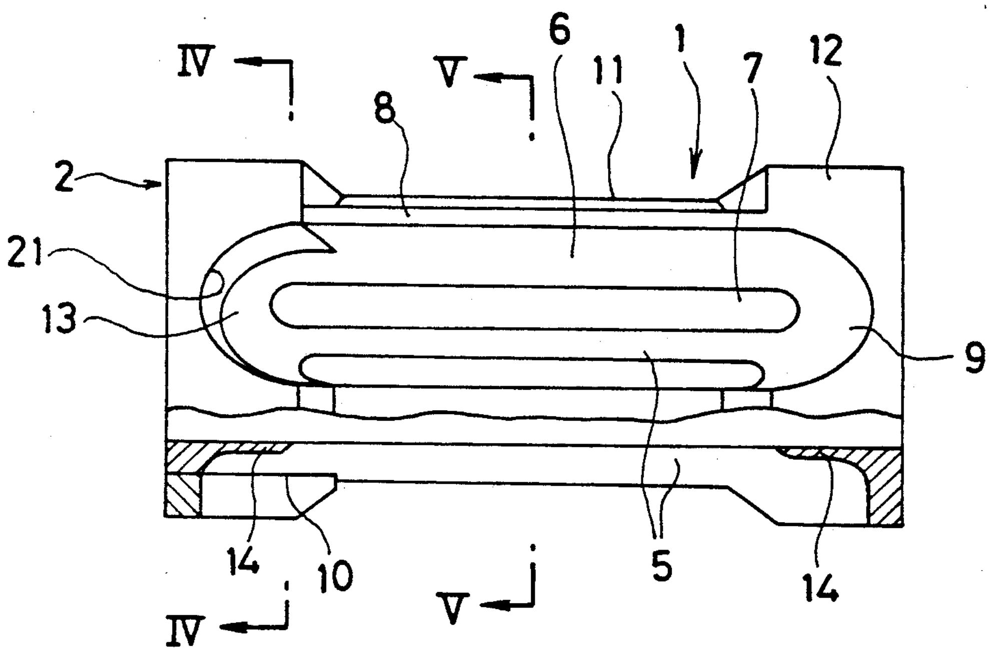


FIG. 4

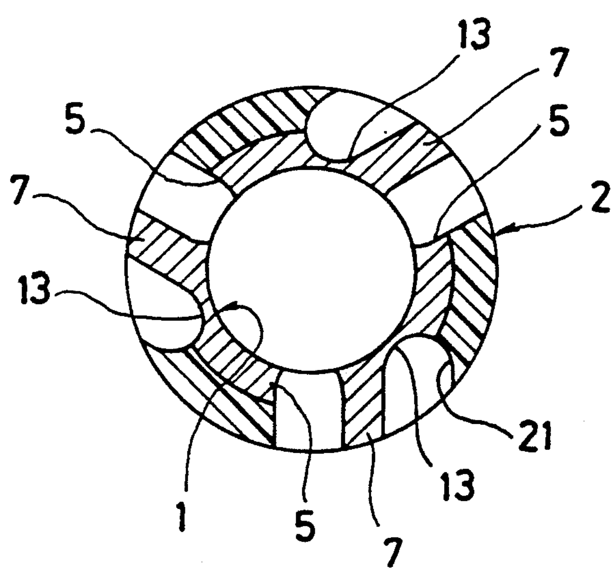


FIG. 5

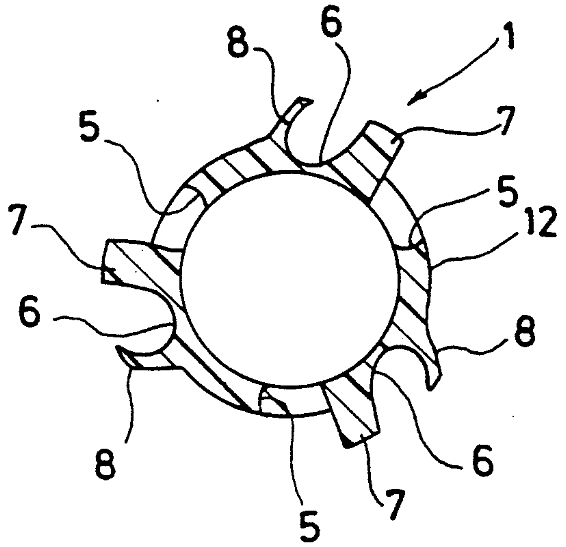


FIG. 6

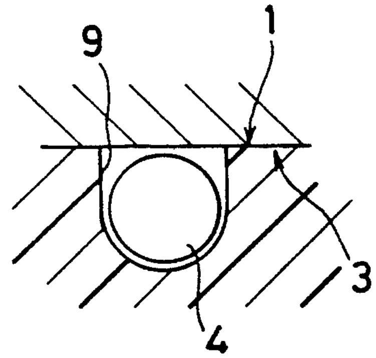
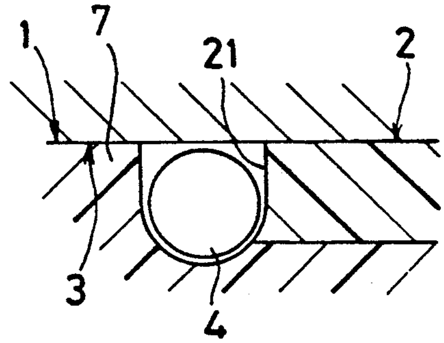


FIG. 7



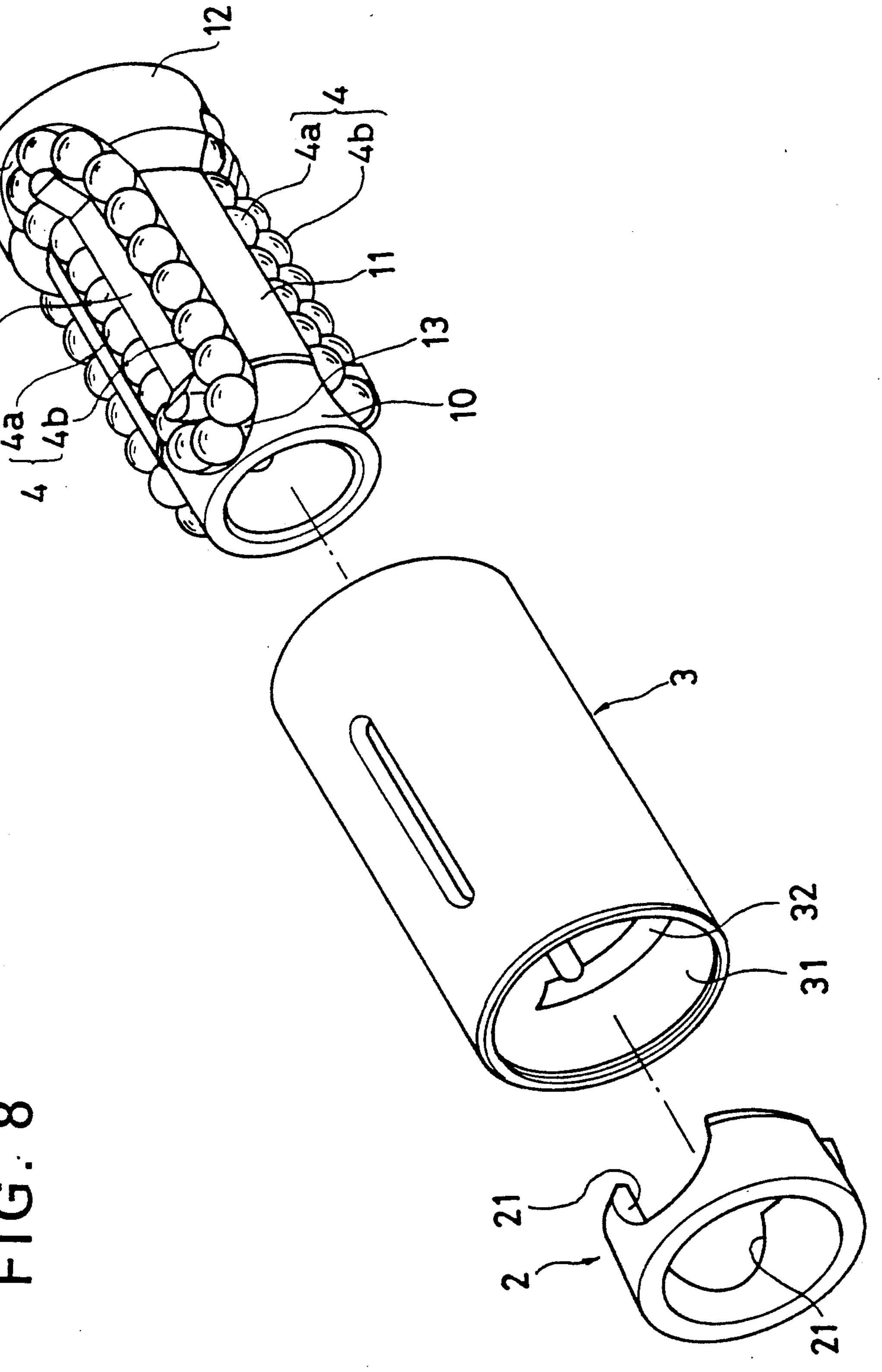


FIG. 8

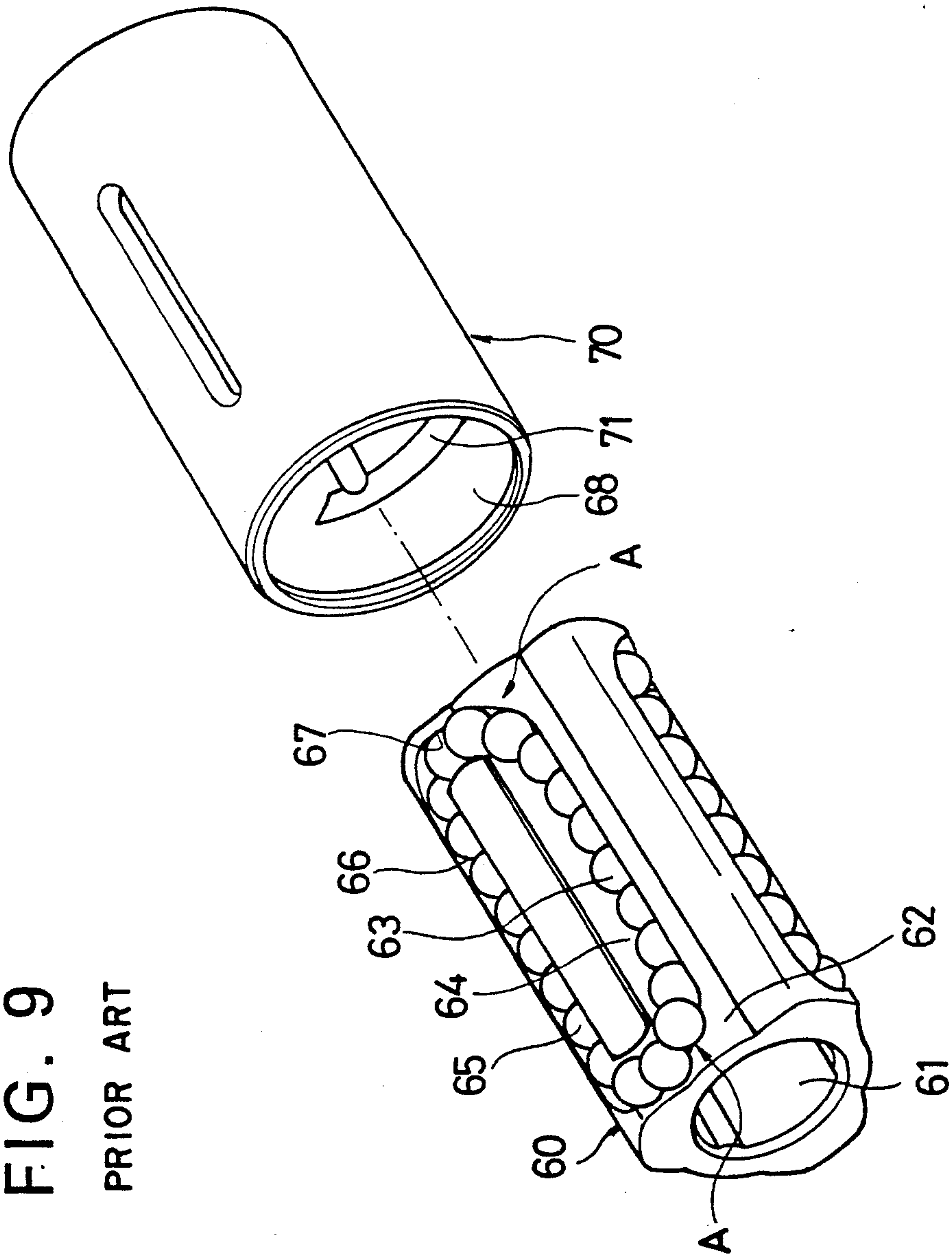


FIG. 9
PRIOR ART

FIG. 10 PRIOR ART

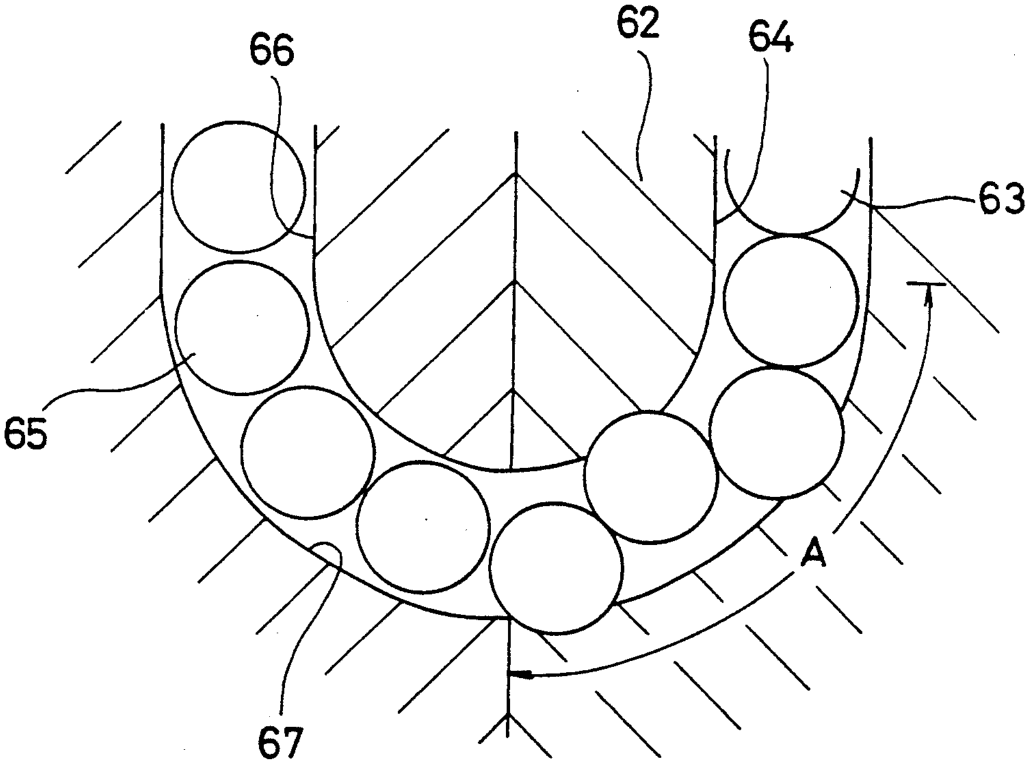


FIG. 11

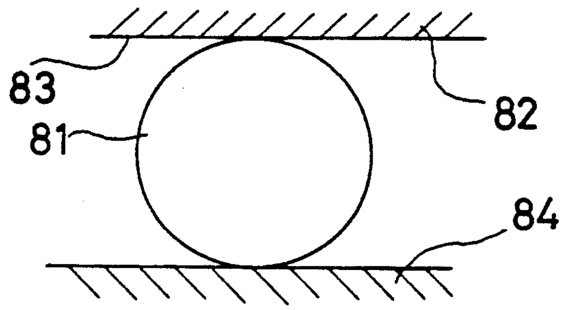
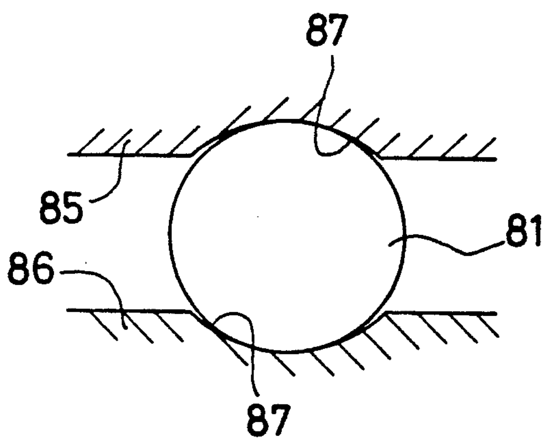


FIG. 12



BALL RETAINER FOR LINEAR BEARINGS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a ball retainer adapted to be used in a linear bearing of a ball spline, a ball bush or the like for retaining and arraying balls held between a bearing outer cylinder and a bearing shaft and, more particularly, to an improvement in the shape of the ball retainer for circulating the balls smoothly.

2. Description of the Prior Art

The ball retainer of this kind generally known in the prior art is exemplified by a ball retainer **60** of a ball spline, as shown in FIG. **9**.

This ball retainer **60** is molded into a generally cylindrical thin shape having a hollow portion **61**, in which a spline shaft (although not shown) is loosely fitted. Specifically, the ball retainer **60** is formed in its outer circumference **62** with a plurality of endless ball guide races, each of which is composed of: elongated loaded ball guide races **64** for rolling loaded balls **63** held between a spline outer cylinder **70** and the spline shaft; unloaded ball guide races **66** for loading unloaded balls **65**; and ball turning races **67** for connecting the loaded ball guide races **64** and the unloaded ball guide races in communication. Moreover, this ball retainer **60** is fitted for use in the hollow portion of the spline outer cylinder **70** after its endless ball guide races have been arrayed with the loaded balls **63** and the unloaded balls **65**.

Considering the assembly efficiency of the ball spline, the ball retainer thus constructed and used is integrally injection-molded of a synthetic resin and is assembled with the spline outer cylinder **70** by inserting it into the hollow portion from one opening of the spline outer cylinder **70**.

Incidentially, this spline outer cylinder **70** has its inner circumference divided into: a loaded ball region for holding the loaded balls **63** together with the spline shaft; and a pair of ball scoop regions **68** positioned axially adjacent to the loaded ball region. The loaded ball region is formed axially of the spline outer cylinder **70** with a plurality of ridges **71** for holding the loaded balls **63** between themselves and the spline shaft. On the other hand, the aforementioned ball scoop regions **68** are formed to have such an equal internal diameter that the loaded balls **63** are released in the ball scoop regions **68** from the clearances between the aforementioned ridges **71** and the spline shaft.

In order to fit the integrally molded ball retainer **60** in the hollow portion of the spline outer cylinder **70**, therefore, the shape of the outer circumference of the ball retainer **60** has to be configured with the sectional shape of the loaded ball regions formed with the ridges **71**. For this reason, the ball retainer **60** is given an axially uniform sectional shape (as shown in FIG. **9**).

However, this sectional shape raises the following disadvantages. At first, if the ball retainer **60** has its sectional shape made identical to that of the load ball regions, the aforementioned ball turning races **67** are partially (as indicated at A in FIG. **9**) shallowed so much that the rolling runs of the unloaded balls **65** are liable to grow unstable. Since, moreover, the ball turning races **67** correspond to the ball scoop regions **68** of the spline outer cylinder **70**, clearances are established between the spline outer cylinder **70** and the ball retainer **60** in the ball scoop regions **68** to make unstable the rolling runs of the unloaded balls **65** in the aforementioned A portions.

As a result, at the time of the high-speed or vertical movements of the spline outer cylinder **70**, the unloaded balls **65** are liable to come out of the ball turning races **67** so that they interfere with each other, as shown in FIG. **10**, to clog the ball turning races **67**. Thus, there rises another problem that the balls cannot circulate any more.

SUMMARY OF THE INVENTION

The present invention has been conceived to solve such problems and has an object to provide a ball retainer which has endless ball guide races capable of guiding balls smoothly along predetermined tracks and which can be easily assembled with a bearing outer cylinder.

In order to achieve the above-specified object, according to the present invention, there is provided a ball retainer fitted in the hollow portion of a bearing outer cylinder, which can move linearly around a bearing shaft, for retaining and arraying balls held between the bearing outer cylinder and the bearing shaft, which retainer comprises: a retainer body including: a smaller-diameter portion adapted to be fitted in a loaded ball region of the bearing outer cylinder, which is formed with a plurality of axially extending ridges for holding said balls together with the bearing shaft; a larger-diameter portion formed at one end of the smaller-diameter portion and so fitted in a ball scoop region of the bearing outer cylinder adjacent to the loaded ball region that it is axially retained by the ridges; and a leading end portion formed at the other end of the smaller-diameter portion to have a diameter equal to or smaller than that of the smaller-diameter portion for forming a clearance with the inner circumference of the bearing outer cylinder in another ball scoop region of the bearing outer cylinder, the smaller-diameter portion being formed in its outer circumference with loaded ball guide races and unloaded ball guide races corresponding to loaded ball rolling faces and unloaded ball races, which are formed in the inner circumference of the bearing outer cylinder, the larger-diameter portion and the leading end portion being formed in its outer circumferences with ball turning races for connecting the loaded ball guide races and the unloaded ball guide races in communication; and an annular piece formed with semicircular cut portions corresponding to the ball turning races and fixed on the outer circumference of the leading end portion of the retainer body for occupying the clearance between the leading end portion and the inner circumference of the bearing outer cylinder.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, advantages and features of the present invention will become apparent from the following description to be made with reference to the accompanying drawings, in which:

FIG. **1** is an exploded perspective view showing the state, in which a ball retainer according to a first embodiment of the present invention is assembled;

FIG. **2** is a section showing the assembled state of the ball retainer according to the first embodiment;

FIG. **3** is a side elevation showing the ball retainer according to the first embodiment;

FIG. **4** is a section taken along line IV—IV of FIG. **3**;

FIG. **5** is a section taken along line V—V of FIG. **3**;

FIG. 6 is a section showing a ball turning race in a larger-diameter portion of a retainer body;

FIG. 7 is a section showing the ball turning race in a seat of the retainer body;

FIG. 8 is an exploded perspective view showing an assembled state of a ball retainer according to a second embodiment of the present invention;

FIG. 9 is an exploded perspective view showing the assembled state of the ball retainer of the prior art;

FIG. 10 is an enlarged view for explaining the problems in the ball retainer of the prior art;

FIG. 11 is a section showing a ball contacting state in a ball bush, to which the ball retainer of the present invention can be applied; and

FIG. 12 is a section showing a ball contacting state in a ball spline, to which the ball retainer of the present invention can be applied.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A ball retainer in a linear bearing in accordance with the present invention will be described in detail in the following with reference to the accompanying drawings.

FIG. **1** is an exploded perspective view showing a ball retainer of a ball spline, to which the present invention is applied. This ball retainer is constructed to include a retainer body **1** fitted in the hollow portion of a spline outer cylinder **3** (as will be shortly referred to as the "outer cylinder") from one opening of the same, and an annular piece **2** fitted in the hollow portion from the other opening of the outer cylinder **3**.

First of all, the retainer body **1** is composed of: a smaller-diameter portion **11** fitted in a loaded ball range of the outer cylinder **3**; a larger-diameter portion **12** formed to extend from one end of the smaller-diameter portion **11** and fitted in a ball scoop region **31** of the outer cylinder **3**; and a leading end portion **10** formed to extend from the other end of the smaller-diameter portion **11** and positioned in the ball scoop region **31** of the outer cylinder **3**. The retainer body **1** is injection-molded of a synthetic resin to have a substantially equal total length as that of the outer cylinder **3**.

FIG. **5** shows a section of the aforementioned smaller-diameter portion. This smaller-diameter portion **11** is formed with: loaded ball guide races **5** of elongated window shape for guiding loaded balls **4*a*** between the outer cylinder **3** and the spline shaft (although not shown); and unloaded ball guide races **6** for rolling unloaded balls **4*b***. These two guide races **5** and **6** are partitioned by islands **7**, and the unloaded ball guide races **6** are formed at their one sides with banks **8**, which face the islands **7** and extend from the larger-diameter portion **12**, for enclosing and guiding the unloaded balls **4*b*** rolling in the unloaded ball guide races **6**. As shown in FIG. **1**, moreover, those islands **7** and the banks **8** are fitted in unloaded ball races **33** which are formed between a plurality of ridges **32** of the outer cylinder **3**. Moreover, the loaded ball guide races **5** are formed at their two ends with tongues **14** for scooping the loaded balls **4*a*** having rolled in said races **5** up to ball turning races **9** and **13**.

As shown in FIG. **6**, on the other hand, the aforementioned larger-diameter portion **12** is formed with the deeper ball turning races **9** for wrapping and guiding the unloaded balls **4*b*** like the aforementioned unloaded ball guide races **6**. Each of the ball turning races **9** connects one end of the loaded ball guide race **5** and one end of the unloaded ball guide race **6** in communication.

Moreover, the aforementioned leading end portion provides a seat having its outer circumference fitting the aforementioned annular piece **2** therein. This leading end portion **10** is formed with the ball turning races **13** for connecting the loaded ball guide races **5** and the unloaded ball guide races **6** in communication.

On the other hand, the annular piece **2** is a ringshaped member having its internal diameter for fitting the outer circumference of the leading end portion **10** therein. The annular piece **2** is formed, as shown in FIG. **1**, with semicircular cut portions **21** which correspond to the ball turning races **13** formed in the leading end portion **10** of the retainer body **1**. The cut portions **21** are provided in the number corresponding to the ball tracks and arranged at an equal distance.

Moreover, the ball retainer thus constructed according to the present embodiment is assembled with the outer cylinder by fitting the retainer body in the hollow portion from one opening of the outer cylinder, by fitting the annular piece **2** in the hollow portion from the other opening, and by fixing the annular piece **2** on the leading end portion **10** of the retainer body **1**.

FIG. **6** shows the behavior, in which the unloaded ball **4*b*** is rolling in the ball turning race **9** formed in the larger-diameter portion **12**. The unloaded balls **4*b*** are completely sealed by both the ball turning races **9** formed in the retainer body **1** and the outer cylinder **3** so that they can roll smoothly in the ball turning races **9** without coming out of these races **9**. On the other hand, the ball turning races **13** formed in the leading end portion **10** are made deep and defined, as shown in FIGS. **4** and **7**, by the islands **7** of the retainer body **1** and the cut portions **21** of the annular piece to have sections identical to those of the ball turning races **9** shown in FIG. **6**. As a result, the unloaded balls **4*b*** to roll in the ball turning races **13** can roll smoothly in the ball turning races **13** without coming out these races **13**.

Thus, in the ball retainer of the present embodiment, the deep ball circulating tracks for connecting the two ends of the loaded ball guide races **5** in communication are completed, when the annular piece **2** is fixed in the retainer body **1**, so that the unloaded balls **4*b*** scooped up from the load ball guide races **5** can circulate smoothly.

Next, FIG. **8** shows a second embodiment of the present invention.

This embodiment takes a structure substantially similar to that of the foregoing first embodiment. Since the smaller-diameter portion **11** of the retainer body **1** is cut by a lathe, it has its center portion of the islands **7** and its banks **8** cut away.

As a result, the unloaded ball guide races **6** are made shallow, but the ball turning races **9** and **13** are made deep like the first embodiment so that the balls **4** can be arrayed in the predetermined tracks and smoothly guided from the loaded ball guide races **5** to the unloaded ball guide races **6**.

Here in FIG. **8**, the components similar to those of FIG. **1** are designated at the common reference numerals, and their descriptions will be omitted.

In the first and second embodiments thus far described, moreover, the description is directed to the case, in which the present invention is applied to the ball spline having three ball tracks, but the present invention can also be applied to any ball spline irrespective of the number of ball tracks.

Incidentally, the linear bearing, to which the present invention can be applied, is a bearing for bearing the relative linear movements between the cylindrical bearing outer cylinder and the bearing shaft by holding a plurality of balls circulating endlessly inbetween. This bearing is exemplified by: a ball bushing in which a ball **81** can bear a load while contacting in point-to-point relation with a loaded ball rolling face **83** formed on the inner circumference of a baring outer cylinder **82** and the outer circumference of a bearing shaft **84**, as shown in FIG. **11**; and a ball spline in which the ball **81** can bear the load while contacting in point-to-point relation with a bearing outer cylinder **85** and a shallow loaded ball rolling face **87** formed on a bearing shaft **86** and can transmit the rotational torque acting between the two members.

According to the structures thus far described, the ball retainer is assembled by fitting the retainer body in the hollow portion of the bearing outer cylinder from one opening of the same and by fitting the annular piece from the other opening, so that its shape can be completely contoured with the shape of the hollow portion of the bearing outer cylinder. As a result, the ball turning races connecting the loaded ball guide races and the unloaded ball guide races are made deep throughout their lengths so that the balls can roll smoothly in array within the ball turning races. As a result, the balls are prevented from coming out of the predetermined track in the ball turning races and from clogging the races so that their circulations can be smoothed to achieve the smooth sliding movements of the bearing outer cylinder.

What is claimed is:

1. A ball retainer fitted in the hollow portion of a bearing outer cylinder, which can move linearly around a bearing shaft, for retaining and arraying balls held between said bearing outer cylinder and said bearing shaft, comprising:

a retainer body including: a smaller-diameter portion adapted to be fitted in a loaded ball region of said bearing outer cylinder, which is formed with a plurality of axially extending ridges for holding said balls together with said bearing shaft; a larger-diameter portion formed at one end of said smaller-diameter portion and so fitted in a ball scoop region of said bearing outer cylinder adjacent to said loaded ball region that it is axially retained by said ridges; and a leading end portion formed at the other end of said smaller-diameter portion to have a diameter equal to or smaller than that of said smaller-diameter portion for forming a clearance with the inner circumference of said bearing outer cylinder in another ball scoop region of said bearing outer cylinder, said smaller-diameter portion being formed in its outer circumference with loaded ball guide races and unloaded ball guide races corresponding to loaded ball rolling faces and unloaded ball races, which are formed in the inner circumference of said bearing outer cylinder, said larger-diameter portion and said leading end portion being formed in its outer circumference with ball turning races for connecting said loaded ball guide races and said unloaded ball guide races in communication; and

an annular piece formed with semicircular cut portions corresponding to said ball turning races and fixed on the outer circumference of the leading end portion of said retainer body for occupying the clearance between said leading end portion and the inner circumference of said bearing outer cylinder.

2. A ball retainer according to claim **1**, wherein the loaded ball guide races of the smaller-diameter portion of said retainer body are formed at their two ends with tongues for scooping up the loaded balls having rolled therein to said ball turning races.

* * * * *

(19) Bundesrepublik Deutschland
Deutsches Patent- und Markenamt

(10) **DE 11 2004 000 900 T5** 2006.04.27

(12) # Veröffentlichung

der internationalen Anmeldung mit der
(87) Veröffentlichungs-Nr.: **WO 2004/106770**
in deutscher Übersetzung (Art. III § 8 Abs. 2 IntPatÜG)
(21) Deutsches Aktenzeichen: **11 2004 000 900.6**
(86) PCT-Aktenzeichen: **PCT/JP2004/007100**
(86) PCT-Anmeldetag: **25.05.2004**
(87) PCT-Veröffentlichungstag: **09.12.2004**
(43) Veröffentlichungstag der PCT Anmeldung
in deutscher Übersetzung: **27.04.2006**

(51) Int Cl.[8]: ***F16F 15/04*** (2006.01)
F16C 29/04 (2006.01)
F16F 15/02 (2006.01)
B23Q 1/40 (2006.01)

(30) Unionspriorität:
2003-155351 30.05.2003 JP
2004-148908 19.05.2004 JP

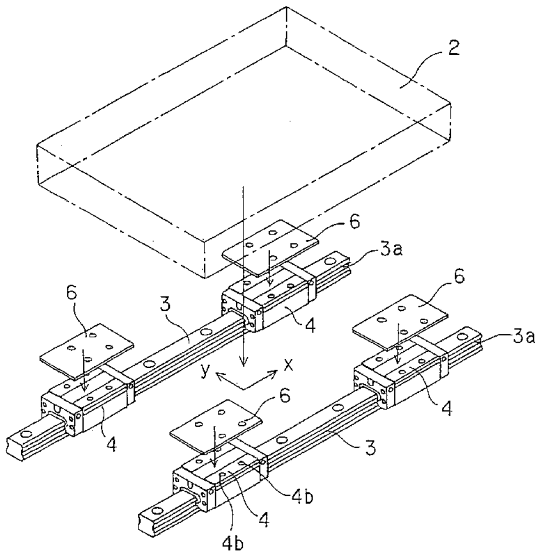
(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Viering, Jentschura & Partner, 80538 München

(72) Erfinder:
Michioka, Hidekazu, Tokio/Tokyo, JP; Iida, Katsuya, Yamanashi, JP

(54) Bezeichnung: **Dämpfungsstruktur und Bewegungsführungsvorrichtung, die in die Dämpfungsstruktur einbezogen ist**

(57) Hauptanspruch: Dämpfungsstruktur mit einer Mehrzahl von dünnen Metallschichten und einer Mehrzahl von dünnen Dämpfungsschichten mit jeweils einem Young-Modul, der sich von dem der Metallschicht unterscheidet, wobei die Metallschicht und die Dämpfungsschicht eine nach der anderen wechselweise derart laminiert sind, dass sie eine Gesamtdicke der Dämpfungsstruktur von nicht mehr als 1,0 mm schaffen.



Beschreibung

Gebiet der Erfindung

[0001] Die vorliegende Erfindung betrifft eine Dämpfungsstruktur, die eine Schwächungs- oder Dämpfungsfunktion hat, und insbesondere eine Dämpfungsstruktur für die Anwendung der Dämpfungsfunktion bei einem Führungssystem zum Führen einer Relativbewegung eines Tisches in Bezug auf eine Basis.

Stand der Technik

[0002] Es ist ein Führungssystem zum Führen eines Tisches in Bezug auf eine Basis bekannt. Ein solches Führungssystem weist eine Laufschiene, die an der Basis montiert ist, und einen bewegbaren Block auf, der an dem Tisch montiert ist, um entlang der Laufschiene verschiebbar zu sein. Um eine sanfte Gleitbewegung des bewegbaren Blocks in Bezug auf die Laufschiene sicherzustellen, sind Wälzkörper, wie Kugeln, Rollen oder dergleichen, die eine Wälzbewegung durchführen, zwischen der Laufschiene und dem bewegbaren Block angeordnet.

[0003] Wenn der Tisch nach der Bewegung des Tisches unter Verwendung eines Antriebsmechanismus, wie einer Kugelumlaufspindel, rapide gestoppt wird, wird der Tisch in dessen Vorlaufrichtung in Schwingungen oder Vibrationen versetzt. In einem Falle, wo ein Führungssystem in eine Werkzeugmaschine, eine Teilmontagemaschine, eine Halbleiter/Flüssigkristall-Herstellungsvorrichtung und so weiter eingebaut ist, muss eine Bedienperson mit der Durchführung einer Arbeit an dem Führungssystem warten, bis die Schwingung oder Vibration aufhört, und dementsprechend ist es notwendig, die Schwingung abzuschwächen oder zu dämpfen.

[0004] In einem herkömmlichen Führungssystem wird, um die Schwingung des Tisches zu dämpfen, ein Vorbelastungsverfahren angewendet, bei welchem eine innere Belastung auf einen Wälzkörper ausgeübt wird. Zum Beispiel sind Wälzkörper mit jeweils einem Außendurchmesser, der größer als ein Spalt zwischen einer in der Laufschiene ausgebildeten Wälzkörperlaufrille und einer Wälzkörperlaufrille des bewegbaren Blocks ist, zwischen der Laufschiene und dem bewegbaren Block angeordnet. wenn die innere Belastung auf den Wälzkörper ausgeübt wird, ist der Reibungswiderstand groß, der zu einem Zeitpunkt aufhört, wenn der Wälzkörper in der Wälzkörperlaufrille abrollt, und somit wird eine Bewegungsstabilität verbessert. Ferner kann die Schwingungs-(Vibrations-) Energie in Wärmeenergie umgewandelt werden, wodurch die Schwingung gedämpft wird.

Probleme, die mit der Erfindung zu lösen sind

[0005] Jedoch wird gemäß der oben genannten Struktur durch Ausüben der inneren Belastung auf den Wälzkörper ein Widerstand zu einem Zeitpunkt erhöht, wenn der bewegbare Block in Bezug auf die Laufschiene gleitet, und infolgedessen wird die nutzbare Lebensdauer des Wälzkörpers verkürzt.

[0006] Zwischenzeitlich ist auch als eine erdbebenfeste Struktur zum Schützen eines Gebäudes vor Erdbeben eine laminierte Gummistruktur bekannt, die zwischen dem Gebäude und dessen Grundstruktur angeordnet ist. Eine solche laminierte Gummistruktur ist aus Eisenplatten und Gummis gebildet, welche wechselweise laminiert sind, und die laminierte Gummistruktur hat eine hohe Steifigkeit gegen eine senkrechte Belastung und wird in horizontaler Richtung verformt, wodurch eine große Schwächungs-(Dämpfungs-) Funktion geschaffen wird.

[0007] Jedoch hat die herkömmliche laminierte Gummistruktur im Allgemeinen eine nicht so große Dicke (Höhe), zum Beispiel von 10 bis 20 mm, welche nicht für deren Montage in einem Führungssystem geeignet ist, das eine geringe Größe erfordert. Darüber hinaus ist entsprechend einer solchen Höhe das Verformungsmaß der laminierten Gummistruktur infolge der horizontalen Belastung (d.h. der Scherkraft) groß. Unter diesem Gesichtspunkt ist eine solche herkömmliche laminierte Gummistruktur nicht für das Führungssystem geeignet, bei welchem eine hohe Steifigkeit erforderlich ist.

[0008] Die vorliegende Erfindung bezweckt dann, eine kompakte Dämpfungsstruktur zu schaffen, die in der Lage ist, ein hohes Dämpfungsverhalten zu erreichen und eine hohe Steifigkeit zu schaffen.

Mittel zur Lösung des Problems

[0009] Nachstehend wird die vorliegende Erfindung beschrieben.

[0010] Um die obigen Probleme zu lösen, konzipierten die Erfinder der betreffenden Anmeldung die Laminierungsstruktur einer Mehrzahl von dünnen Metallschichten und einer Mehrzahl von dünnen Dämpfungsschichten mit jeweils einem Young-Modul, der sich von dem der Metallschicht unterscheidet, und legten die Gesamtdicke extrem dünn fest, was in einer herkömmlichen laminierten Gummistruktur nicht konzipiert wurde.

[0011] Das heißt, um das obige Problem zu lösen, schafft die Erfindung nach Anspruch 1 eine Dämpfungsstruktur mit einer Mehrzahl von dünnen Metallschichten und einer Mehrzahl von dünnen Dämpfungsschichten mit jeweils einem Young-Modul, der sich von dem der Metallschicht unterscheidet, wobei die Metallschichten und die Dämpfungsschichten eine nach der anderen wechselweise derart laminiert sind, dass sie eine Gesamtdicke der Dämpfungsstruktur von nicht mehr als 1,0 mm schaffen.

[0012] Unter einem Gesichtspunkt, dass ein hohes Dämpfungsverhalten erreicht werden kann und auch eine hohe Steifigkeit erreicht werden kann, ist es erwünscht, dass die Dämpfungsstruktur die Gesamtdicke von nicht mehr als 0,5 mm hat, und dass die Metallschicht eine Dicke von 20 bis 40 µm hat und die Dämpfungsschicht eine Dicke von 5 bis 10 µm hat.

[0013] In einer Ausführungsform, in welcher die Dämpfungsschicht aus einer Gummi- oder Harzschicht gebildet ist und auf der Metallschicht gedruckt ist, kann die Dicke der zu laminierenden Dämpfungsschicht dünn gestaltet sein.

[0014] In einer Ausführungsform, in welcher eine Grenzfläche zwischen der Metallschicht und der Dämpfungsschicht eine gewellte Form mit kontinuierlich wechselnden Spitzen und Tälern vorsieht, kann ein Bereich der Grenzfläche erhöht werden, so dass ein weiter verbessertes Dämpfungsverhalten erreicht wird.

[0015] Ferner schafft die vorliegende Erfindung eine Bewegungsführungsvorrichtung mit einer Laufschiene und einem bewegbaren Block, der angeordnet ist, um entlang der Laufschiene verschiebbar zu sein, wobei eine Mehrzahl von dünnen Metallschichten und eine Mehrzahl von dünnen Dämpfungsschichten mit jeweils einem Young-Modul, der sich von dem der Metallschicht unterscheidet, eine nach der anderen wechselweise derart laminiert sind, dass sie eine Gesamtdicke der Dämpfungsstruktur von nicht mehr als 1,0 mm schaffen.

[0016] Noch darüber hinaus schafft die vorliegende Erfindung ein Führungssystem mit einer Basis, einem Tisch und einer Bewegungsführungsvorrichtung, die zwischen der Basis und dem Tisch angeordnet ist, so dass der Tisch in Bezug auf die Basis relativ bewegbar ist, wobei die Bewegungsführungsvorrichtung eine Laufschiene, die an der Basis montiert ist, und einen bewegbaren Block aufweist, der an dem Tisch montiert ist, um entlang der Laufschiene verschiebbar zu sein, wobei eine Mehrzahl von dünnen Metallschichten und eine Mehrzahl von dünnen Dämpfungsschichten mit jeweils einem Young-Modul, der sich von dem der Metallschicht unterscheidet, eine nach der anderen wechselweise derart laminiert sind, dass sie eine Gesamtdicke der Dämpfungsstruktur von nicht mehr als 1,0 mm schaffen.

[0017] Gemäß der vorliegenden Erfindung der oben erwähnten Gestalt kann das Dämpfungsverhalten der Dämpfungsstruktur erhöht werden. Außerdem kann auch deren Steifigkeit erhöht werden. Das heißt, ein Maß der Verformung der Dämpfungsstruktur infolge von Scherkräften kann gering gestaltet sein, und eine auszuübende Kompressionsbelastung kann groß gestaltet sein.

[0018] Darüber hinaus kann die Dämpfungsstruktur ohne Durchführung einer Gestaltungsänderung des bewegbaren Blocks durch eine zusätzliche Bearbeitung, wie Schleifen, der oberen Fläche des bewegbaren Blocks montiert werden.

[0019] Noch darüber hinaus kann, da eine Mehrzahl von Dämpfungsschichten angeordnet sind, die an der Tischseite erzeugte Wärme von einer Übertragung auf eine Bewegungsführungsvorrichtung ferngehalten werden, was eine Wärmeisolierungswirkung schafft.

Kurzbeschreibung der Zeichnungen

[0020] Fig. 1 ist eine perspektivische Ansicht, die ein Führungssystem unter Einbeziehung eines Dämpfungskissens gemäß einer Ausführungsform der vorliegenden Erfindung zeigt.

[0021] Fig. 2 ist eine teilweise Schnittansicht des Führungssystems aus Fig. 1.

[0022] Fig. 3 ist eine Schnittansicht des Dämpfungskissens.

[0023] Fig. 4 ist eine schematische Ansicht, die eine Verwindung infolge einer Scherkraft zeigt.

[0024] Fig. 5 ist eine perspektivische Ansicht, die eine Bewegungsführungsvorrichtung zeigt.

[0025] Fig. 6 ist eine Schnittansicht eines Dämpfungskissens gemäß einer anderen Ausführungsform der vorliegenden Erfindung.

Bezugszeichenliste

1 Basis
2 Tisch
3 Laufschiene
4 bewegbarer Block
6 Dämpfungskissen
8 Metallschicht
9 Dämpfungsschicht

Bevorzugte Ausführungsform der Erfindung

[0026] Fig. 1 und Fig. 2 stellen ein Führungssystem unter Einbeziehung einer Dämpfungsstruktur gemäß einer Ausführungsform der vorliegenden Erfindung dar. Das Führungssystem wird für eine Werkzeugmaschine, wie ein Bearbeitungszentrum, eine Drehmaschine, Fräsmaschine oder dergleichen, eine Teilmontagemaschine, wie einen Roboter zur Montage von Teilen an eine elektrische Leiterplatte, und eine Halbleiter- oder Flüssigkristall-Herstellungsmaschine, wie Substratzerteiler oder Drahtbonder, oder dergleichen, verwendet, und das Führungssystem wird angewendet, um eine lineare Bewegung oder krummlinige Bewegung eines Tisches **2** in Bezug auf eine Basis **1** zu tragen.

[0027] Eine sich genau erstreckende Laufschiene **3** ist an der Basis **1** angebracht. Ein bewegbarer Block **4** des Spreiztyps ist an der Laufschiene **3** montiert, um entlang der Laufschiene **3** verschiebbar zu sein. Der Tisch **2** ist an der oberen Fläche des bewegbaren Blocks **4** angebracht. In dieser Ausführungsform können, obwohl zwei Laufschienen **3**, **3** und vier bewegbare Blöcke **4**, --- angeordnet sind, die Anzahl von Laufschienen **3** und bewegbaren Blöcken **4** entsprechend den zu verwendenden Maschinen geändert oder bestimmt werden.

[0028] Eine Anzahl von Kugeln **5**, --- sind als Wälzkörper zwischen der Laufschiene **3** und dem bewegbaren Block **4** angeordnet, so dass der bewegbare Block **4** leicht gleiten kann. Diese Kugeln **5**, --- wälzen und bewegen sich zwischen einer Kugellaufrille **3a**, die sich entlang der Laufschiene **3** genau erstreckt, und einer Kugellastlaufrille **4a**, die in dem bewegbaren Block **4** derart ausgebildet ist, dass sie der Kugellaufrille **3a** gegenüberliegt. Die Details der durch diese Laufschienen **3** und die bewegbaren Blöcke **4** gebildeten Bewegungsführungsvorrichtung werden später hierin beschrieben.

[0029] Dämpfungskissen **6**, --- als eine Dämpfungsstruktur haben jeweils eine geringe Dicke und rechteckige Form entsprechend der flachen Form des bewegbaren Blocks **4**. Der Tisch **2** wird zum Beispiel in einer X-Richtung in der Zeichnung durch einen nicht gezeigten Antriebsmechanismus, wie eine Kugelumlaufspindel oder dergleichen, linear bewegt. Wenn der Tisch **2** schnell gestoppt wird, schwingt (vibriert) der Tisch **2** in der X-Richtung. In einem Falle, wo ein solches Führungssystem in eine Werkzeugmaschine einbezogen ist, kann eine Bedienperson den nächsten Bearbeitungsschritt nicht ausführen, bis eine solche Schwingung aufhört, und andererseits kann in einem Falle, wo ein solches Führungssystem in eine Teilmontagemaschine einbezogen ist, eine Bedienperson keine Teile montieren, bis die Schwingung aufhört. Das Dämpfungskissen **6** gemäß dieser Ausführungsform kann die Schwingung des Tisches in jeder Richtung in der X-Y-Ebene abfangen und dämpfen, um dadurch die Schwingung schnell zu bündeln.

[0030] Das Dämpfungskissen **6** wird zwischen dem bewegbaren Block **4** und dem Tisch **2** in der folgenden Weise fixiert. Gewindelöcher **4b**, --- sind in einer oberen Fläche des bewegbaren Blocks **4** ausgebildet, Schraubenlöcher sind in dem Tisch **2** und dem Dämpfungskissen **6** zum Einsetzen von Schrauben ausgebildet, und der Tisch **2** und das Dämpfungskissen **6** werden mit Befestigungsmitteln, wie einer Schraube, an dem bewegbaren Block **4** fixiert. Bei diesem Fixierungsvorgang wird das Schraubenbefestigungsdrehmoment derart gesteuert, dass diese drei Teile nicht integriert werden und der Tisch **2** in Bezug auf den bewegbaren Block **3** leicht verformbar ist. In einer anderen Weise können der bewegbare Block **4** und das Dämpfungskissen **6** verklebt werden, oder das Dämpfungskissen **6** und der Tisch **2** können verklebt werden.

[0031] Fig. 3 zeigt die Schnittansicht des Dämpfungskissens **6**. Das Dämpfungskissen **6** wird durch wechselweises Laminieren einer Mehrzahl von dünnen Metallschichten und einer Mehrzahl von Dämpfungsschichten mit einem Young-Modul, der sich von dem der Metallschichten unterscheidet, gebildet. Insbesondere werden die Metallschichten **8**, --- aus einer Mehrzahl von dünnen flachplattenförmigen rostfreien oder Eisen-Metallschichten gebildet, und die Dämpfungsschichten **9** werden aus einer Mehrzahl von dünnen flachplattenförmigen Gummi- oder Leimschichten derart gebildet, dass diese Schichten **8** und **9** eine nach der anderen wechselweise laminiert werden. Das Dämpfungskissen **6** in dieser Ausführungsform wird aus einer Mehrzahl von laminierten Einheiten U gebildet, die jeweils aus der Metallschicht **8** bestehen, auf welche die aus Gummi hergestellte Dämpfungsschicht **9** gedruckt wird. Die Einheiten U, auf welche die Dämpfungsschichten **9** gedruckt werden, verbinden sich nicht miteinander. Die Dämpfungsschicht **9** wird in einer Weise gebildet, dass Gummi im flüssigen Zustand mit einer Dämpfungswirkung auf die gesamte Fläche der Metallschicht **8** siebgedruckt wird und der Gummi im flüssigen Zustand danach zum Beispiel durch einen Erwärmungsvorgang gehärtet wird. In den anderen Weisen kann ein Verfahren, bei welchem eine Gummifolie, die auf einer Metallplatte liegt, erwärmt und gepresst wird, oder ein Verfahren angewendet werden, bei welchem eine Gummischicht auf einer Metallplatte mittels eines Spritzgießvorgangs gebildet wird.

[0032] Ferner, um eine große Dämpfungskraft zu erreichen, ist es erwünscht, die Einheiten U nicht miteinander zu verbinden, aber es kann möglich sein, die Einheiten U unter Berücksichtigung ihrer leichten Handhabung zu verkleben. Die äußerste Schicht des Dämpfungskissens **6** kann mit der Metallschicht **8** oder der Dämpfungsschicht **9** gebildet werden. Andererseits kann die außen positionierte Metallschicht **8** verstemmt werden, um ein integriertes Dämpfungskissen zu schaffen.

[0033] Das charakteristische Merkmal des Dämpfungskissens **6** der vorliegenden Ausführungsform liegt in der Bildung der laminierten Schichtstrukturen der dünnen Metallschichten **8** und der Dämpfungsschichten **9** mittels einer Grenzfläche **10**, die zwischen jeweils benachbarten Schichten **8** und **9** angeordnet ist. Einer der Gründe, weshalb die Anordnung einer Mehrzahl von Grenzflächen **10** dazu dient, eine große Dämpfungskraft zu schaffen, ist wie folgt. Wenn eine Scherkraft auf das Dämpfungskissen **6** ausgeübt wird, wirkt eine Kraft, um eine Verschiebung an der Grenzfläche **10** zwischen der Metallschicht **8** und der Dämpfungsschicht **9** zu bewirken, und entsprechend einer solchen Verschiebung wird eine Reibungskraft an der Grenzfläche **10** verursacht, welche eine Schwingungsenergie in eine Wärmeenergie umwandelt, wodurch die Dämpfungskraft erzeugt wird. Daher bewirkt die Anordnung einer Mehrzahl solcher Grenzflächen **10** eine große Reibungskraft und erzeugt somit eine große Dämpfungskraft.

[0034] Bei einer speziellen Struktur hat die Metallschicht **8** eine Dicke von 20 bis 80 µm, und die Dämpfungsschicht **9** hat eine Dicke von 5 bis 10 µm. Die Gesamtdicke des Dämpfungskissens **6** wird auf weniger als 1 mm, und etwa 0,5 mm in dieser Ausführungsform festgelegt. In einem Falle der Metallschicht **8** und der Dämpfungsschicht **9** mit Dicken von mehr als denen der obigen, wird die Anzahl von zu laminierenden Schichten reduziert, und daher wird die Dämpfungskraft reduziert. Andererseits wird in einem Falle der Metallschicht **8** und der Dämpfungsschicht **9** mit Dicken von weniger als denen der obigen eine Kompressionsbelastung in der zu belastenden Dickenrichtung reduziert.

[0035] Der Grund, weshalb die Gesamtdicke des Dämpfungskissens weniger als (nicht mehr als) 1 mm, und etwa 0,5 mm in dieser Ausführungsform gestaltet ist, wird nachfolgend beschrieben.

[0036] Wenn der in Fig. 1 gezeigte Tisch **2** schnell gestoppt wird, wird die Scherkraft P auf das Dämpfungskissen **6** ausgeübt, wie in Fig. 4 gezeigt ist. Wenn die Scherkraft P ausgeübt wird, wird die obere Fläche um einen Betrag von λ in Bezug auf die untere Fläche verschoben. Dieses λ ist ein Betrag der Verschiebung, die durch die Scherkraft P verursacht wird. Angenommen, dass das Dämpfungskissen um einen Betrag von λ in Bezug auf die Dicke t verschoben wird, wird eine Scherung φ als $\varphi = \lambda/t$ ausgedrückt. Bei der Festigkeit von Materialien ist in dem Falle, dass die Scherkraft P konstant ist, die Scherung φ ebenfalls konstant, so dass, wenn die Dicke t groß ist, die Verschiebung λ ebenfalls groß ist. Dementsprechend kann durch extrem dünne Gestaltung der Gesamtdicke des Dämpfungskissens **6**, wie etwa 0,5 mm, die Verschiebung infolge der Scherkraft möglichst klein gestaltet werden. Andererseits wird für einen herkömmlichen Baulaminierungsgummi mit einer Dicke von etwa 20 mm die Verschiebung λ zu groß, und daher ist dieser für ein Führungssystem, bei welchem hohe Steifigkeit erforderlich ist, nicht geeignet.

[0037] Ein anderer Grund, weshalb die Dicke des Dämpfungskissens auf etwa 0,5 mm in dieser Ausführungsform festgelegt wird, liegt darin, dass das Dämpfungskissen **6** durch Ausführen einer zusätzlichen Bearbeitung, zum Beispiel Schleifen der oberen Fläche des bewegbaren Blocks **4**, ohne Änderung der Gestaltung des bestehenden bewegbaren Blocks **4** in den bewegbaren Block **4** einbezogen werden kann. Da es nicht notwendig ist, die Gestaltung des bestehenden bewegbaren Blocks **4** zu verändern, kann das Dämpfungskissen **6** nach der Montage in eine bestehende Werkzeugmaschine oder Teilmontagemaschine einbezogen werden.

[0038] Darüber hinaus wird, da das Dämpfungskissen **6** mit einer Mehrzahl von Dämpfungsschichten **9**, --- versehen ist, die an der Tischseite erzeugte Wärme von der Übertragung auf eine Bewegungsführungsvorrichtung ferngehalten, wodurch eine Wärmeisolierungswirkung erreicht wird.

[0039] Fig. 5 zeigt die Details der Bewegungsführungsvorrichtung. Diese Bewegungsführungsvorrichtung weist eine Laufschiene **3**, die sich als ein Spurteil linear erstreckt, und einen bewegbaren Block **4** auf, der an der Laufschiene **3** relativ zu dieser verschiebbar montiert ist. Eine Anzahl von Kugeln **5**, --- als Wälzkörper sind zwischen der Laufschiene **3** und dem bewegbaren Block **4** angeordnet.

[0040] Die Laufschiene **3** hat beiderseits seitliche Flächen, an welchen zwei Reihen von Kugellaufrillen **3a**, **3a** derart ausgebildet sind, dass sie sich parallel zueinander in der Längsrichtung der Laufschiene **3** erstrecken.

[0041] Der bewegbare Block **4** weist einen mittigen flachen Abschnitt **11**, welcher der oberen Fläche der Laufschiene **3** gegenüberliegt, und Seitenwandabschnitte **12** auf, die sich an beiderseits seitlichen Endabschnitten des mittigen Abschnitts **11** derart nach unten erstrecken, dass sie den Seitenflächen der Laufschiene **3** gegenüberliegen. Der bewegbare Block **4** ist auch mit einem Paar Endplatten **13**, **13** als Seitendeckel an beiden Längsenden (Bewegungsrichtungsende) des bewegbaren Blocks **4** versehen. Die Seitenwandabschnitte **12** des bewegbaren Blocks **4** sind mit zwei Reihen von Kugellastlaufrillen **4a**, **4a** versehen, die jeweils den Kugellaufrillen **3a**, **3a** der Laufschiene **3** gegenüberliegen. Zwei Kugellastlaufrillen **4a**, **4a** sind vertikal an jedem Seitenwandabschnitt **12** des bewegbaren Blocks **4** ausgebildet, und somit sind vier Kugellastlaufrillen **4a**, **4a** an den beiden Seitenwandabschnitten **12** parallel zueinander ausgebildet.

[0042] Der bewegbare Block **4** ist ferner an seinen Seitenwandabschnitten **12** mit zwei vertikalen Kugelrücklaufpassagen **14**, **14**, die parallel zueinander in einem vorbestimmten Abstand an Abschnitten von den beiden vertikalen Kugellastlaufrillen **4a** entfernt angeordnet sind, und mit U-förmigen Kugellastlauf-Richtungswechselpassagen für den Umlauf der Kugeln **5**, --- durch Verbinden des Endabschnitts der Kugellastlaufrille **4a** und der Kugelrücklaufpassage **14** versehen. Wie oben erwähnt, wird eine Kugelumlaufpassage in Kreislaufform durch die Kugellastlaufrille **4a**, die paarweisen Richtungswechselpassagen und die Kugelrücklaufpassage **14** gebildet.

[0043] Eine Anzahl von Kugeln **5**, --- sind in der Kugelumlaufpassage untergebracht und angeordnet. Die Kugeln **5**, --- können in Reihe mittels eines Kugelhalters oder Rückhalters gekuppelt sein.

[0044] Der Seitendeckel (Endplatte) **13** hat eine Querschnittsform entsprechend dem bewegbaren Block **4**. Jeder der Seitendeckel **13** ist mit einer Außenumfangsseite der Richtungswechselpassage versehen. Der Seitendeckel **13** ist auch mit einer Schmiermittelzuführpassage zum Zuführen eines Schmiermittels zu der Kugellastlaufrille des bewegbaren Blockkörpers versehen.

[0045] Wenn der bewegbare Block **4** in Bezug auf die Laufschiene **3** bewegt wird, wälzen und bewegen sich die Kugeln **5**, --- unter dem Lastzustand zwischen der Kugellaufrille **3a** der Laufschiene **3** und der Kugellaufrille **4a** des bewegbaren Blocks **4**. Die Kugeln **5**, ---, die zu dem einen Ende der Kugellastlaufrille **4a** des bewegbaren Blocks **4** bewegt werden, passieren die eine Richtungswechselpassage an der einen Seite, die Kugelrücklaufpassage **14** und die andere Richtungswechselpassage an der anderen Seite in dieser Reihenfolge, und wälzen danach wieder in der Kugellastlaufrille **4a** ab. Wie oben erwähnt, wird zu dem Zeitpunkt, wenn sich die Kugeln **5**, --- von dem nicht belasteten Bereich zu dem Lastbereich bewegen, eine leichte Schwingung oder Vibration erzeugt. Jedoch kann gemäß dem Dämpfungskissen **6** der vorliegenden Ausführungsform sogar eine solche Schwingung gedämpft werden, was somit wirksam ist.

[0046] Fig. 6 zeigt die Schnittansicht eines anderen Dämpfungskissens **21**. Dieses Dämpfungskissen **21** besteht auch aus einer Laminierungsstruktur einer Mehrzahl von dünnen Metallschichten **22** und einer Mehrzahl von Dämpfungsschichten **23** mit jeweils einem Young-Modul, der sich von dem der Metallschicht **22** unterscheidet, wobei die Metallschichten **22** und die Dämpfungsschichten **23** wechselweise laminiert sind. Das Dämpfungskissen **21** dieser Ausführungsform wird durch Pressen der Metallschichten **22** und dergleichen gebildet, um eine gewellte (Welle) Form zu schaffen. Die Dämpfungsschichten **23**, die jeweils aus einer Gummischicht gebildet sind, werden jeweils in Form einer Wellung auf die gewellten Metallschichten **22** gedruckt. Das Dämpfungskissen **21** wird durch Laminieren einer Mehrzahl von Platteneinheiten U gebildet, die jeweils aus der Metallschicht **22** bestehen, auf welche die Dämpfungsschicht **23** gedruckt wird, und die Einheiten U, in welchen die Dämpfungsschichten **23** gedruckt sind, werden nicht miteinander laminiert. Die Metallschicht ist mit einer Dicke von 20 bis 40 μm bestimmt, die Dämpfungsschicht ist mit einer Dicke von 5 bis 10 μm bestimmt, und die Gesamtdicke des Dämpfungskissens ist mit weniger als 1,0 mm, und etwa 0,5 mm in dieser Ausführungsform bestimmt.

[0047] Das charakteristische Merkmal dieses Dämpfungskissens **21** liegt darin, dass die Grenzfläche **24** zwischen der Metallschicht **22** und der Dämpfungsschicht **23** derart ausgebildet ist, dass sie eine gewellte Form schafft, welche abwechselnd Spitzen und Täler hat. Die gewellte Form der Grenzfläche **24** erhöht einen Bereich der Grenzfläche **24** mit einem konstanten Volumen, woraus sich die Vergrößerung eines Bereichs zum Umwandeln der Schwingungsenergie in die Wärmeenergie ergibt, so dass eine größere Dämpfungskraft erreicht wird.

[0048] Die Dämpfungsstruktur der vorliegenden Erfindung ist nicht auf die beschriebene Ausführungsform beschränkt, und viele Änderungen und Modifikationen können vorgenommen werden, ohne von dem Kern der vorliegenden Erfindung abzuweichen. Zum Beispiel kann die Dämpfungsstruktur der vorliegenden Erfindung an verschiedenen Abschnitten von Maschinen angeordnet sein, die eine Dämpfung der Schwingung oder Vibration erfordern, ohne Beschränkung auf eine Position zwischen dem Tisch und der Bewegungsführungsvorrichtung in einem Führungssystem wie bei der vorliegenden Erfindung. Darüber hinaus kann die Dämpfungsstruktur der vorliegenden Erfindung auch in eine Bewegungsführungsvorrichtung, wie eine Kugelkeilwelle, eine Kugelumlaufspindel oder dergleichen, einbezogen sein, ohne Beschränkung auf eine Bewegungsführungsvorrichtung, wie eine Linearbewegungsvorrichtung.

[0049] Darüber hinaus wird angemerkt, dass die verschiedenen Änderungen und Modifikationen der Ausführungsformen der vorliegenden Erfindung, die oben erwähnt sind, für die Ausführung der Erfindung verwendbar sind. Daher sind die Patentansprüche der vorliegenden Erfindung zum Definieren von Bereichen der Erfindung, und Strukturen und äquivalente Gegenstände, die in den Ansprüchen enthalten sind, sollten darin einbezogen sein.

[0050] Die gesamte Offenbarung der jeweiligen japanischen Patentanmeldung Nr. 2003-155351, eingereicht am 30. Mai 2003, und 2004-148908, eingereicht am 19. Mai 2004, einschließlich der Beschreibung, Ansprüche, Zeichnungen und Zusammenfassung, ist hierin durch Bezugnahme in deren Gesamtheit einbezogen.

ZUSAMMENFASSUNG

[0051] Eine Mehrzahl von dünnen Metallschichten **8** und eine Mehrzahl von dünnen Dämpfungsschichten **9** sind eine nach der anderen wechselweise laminiert. Die Gesamtdicke der laminierten Dämpfungsstruktur ist auf nicht mehr als 1,0 mm festgelegt. Gemäß dieser Struktur wird, da eine Mehrzahl von Grenzflächen zwischen den Metallschichten **8** und den Dämpfungsschichten existieren, wird Schwingungsenergie leicht in Reibungsenergie umgewandelt, wodurch eine große Dämpfungskraft geschaffen wird. Außerdem kann, da die Gesamtdicke auf nicht mehr als 1,0 mm festgelegt ist, das Verformungsmaß der Dämpfungsstruktur **6** infolge der Scherkraft gering gehalten werden, so dass die Steifigkeit der Dämpfungsstruktur **6** erhöht werden kann.

Patentansprüche

1. Dämpfungsstruktur mit einer Mehrzahl von dünnen Metallschichten und einer Mehrzahl von dünnen Dämpfungsschichten mit jeweils einem Young-Modul, der sich von dem der Metallschicht unterscheidet, wobei die Metallschicht und die Dämpfungsschicht eine nach der anderen wechselweise derart laminiert sind, dass sie eine Gesamtdicke der Dämpfungsstruktur von nicht mehr als 1,0 mm schaffen.

2. Dämpfungsstruktur nach Anspruch 1, wobei die Dämpfungsstruktur die Gesamtdicke von nicht mehr als 0,5 mm hat.

3. Dämpfungsstruktur nach Anspruch 1 oder 2, wobei die Metallschicht eine Dicke von 20 bis 40 µm hat und die Dämpfungsschicht eine Dicke von 5 bis 10 µm hat.

4. Dämpfungsstruktur nach Anspruch 1, wobei die Dämpfungsschicht aus einer Gummi- oder Harzschicht gebildet ist und auf der Metallschicht gedruckt ist.

5. Dämpfungsstruktur nach einem der Ansprüche 1 bis 4, wobei eine Grenzfläche zwischen der Metallschicht und der Dämpfungsschicht existiert, um eine gewellte Form mit kontinuierlich wechselnden Spitzen und Tälern zu schaffen.

6. Bewegungsführungsvorrichtung mit einer Laufschiene und einem bewegbaren Block, der angeordnet ist, um entlang der Laufschiene verschiebbar zu sein, wobei eine Mehrzahl von dünnen Metallschichten und eine Mehrzahl von dünnen Dämpfungsschichten mit jeweils einem Young-Modul, der sich von dem der Metallschicht unterscheidet, eine nach der anderen wechselweise derart laminiert sind, dass sie eine Gesamtdicke der Dämpfungsstruktur von nicht mehr als 1,0 mm schaffen.

7. Führungssystem mit einer Basis, einem Tisch und einer Bewegungsführungsvorrichtung, die zwischen der Basis und dem Tisch angeordnet ist, so dass der Tisch in Bezug auf die Basis relativ bewegbar ist, wobei die Bewegungsführungsvorrichtung eine Laufschiene, die an der Basis montiert ist, und einen bewegbaren Block aufweist, der an dem Tisch montiert ist, um entlang der Laufschiene verschiebbar zu sein, wobei eine Mehrzahl von dünnen Metallschichten und eine Mehrzahl von dünnen Dämpfungsschichten mit jeweils einem Young-Modul, der sich von dem der Metallschicht unterscheidet, eine nach der anderen wechselweise derart laminiert sind, dass sie eine Gesamtdicke der Dämpfungsstruktur von nicht mehr als 1,0 mm schaffen.

Es folgen 5 Blatt Zeichnungen

Anhängende Zeichnungen

FIG. 1

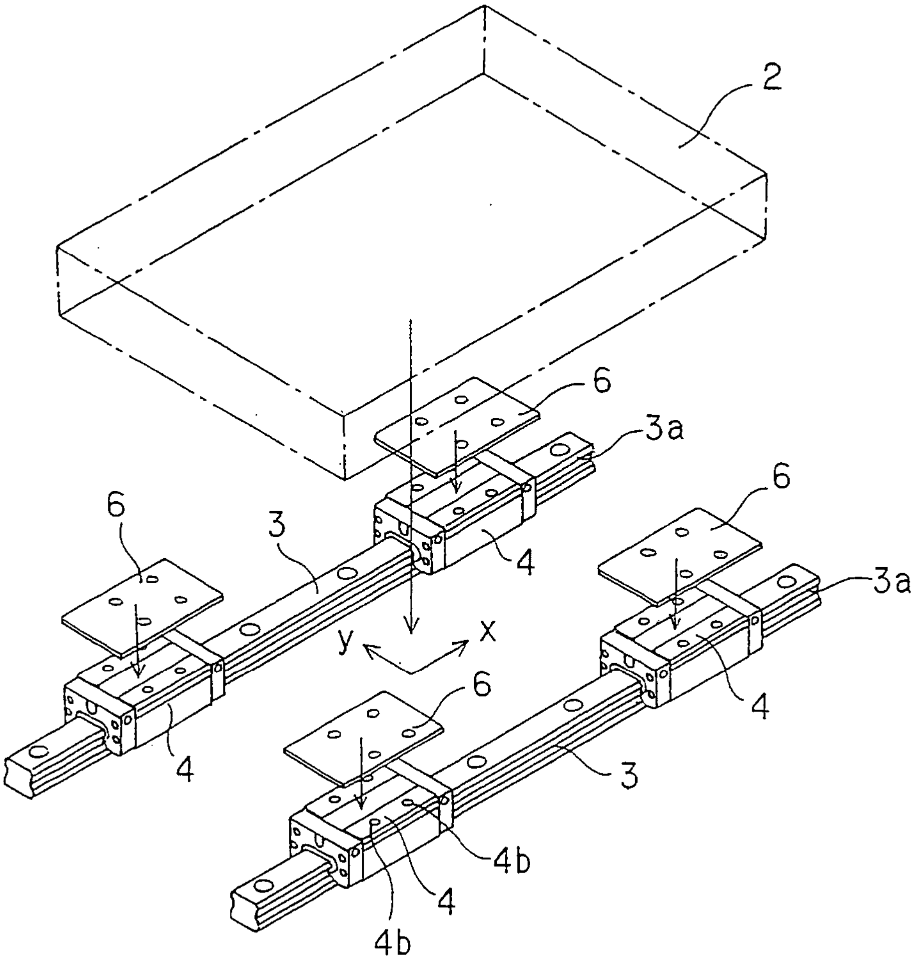


FIG. 2

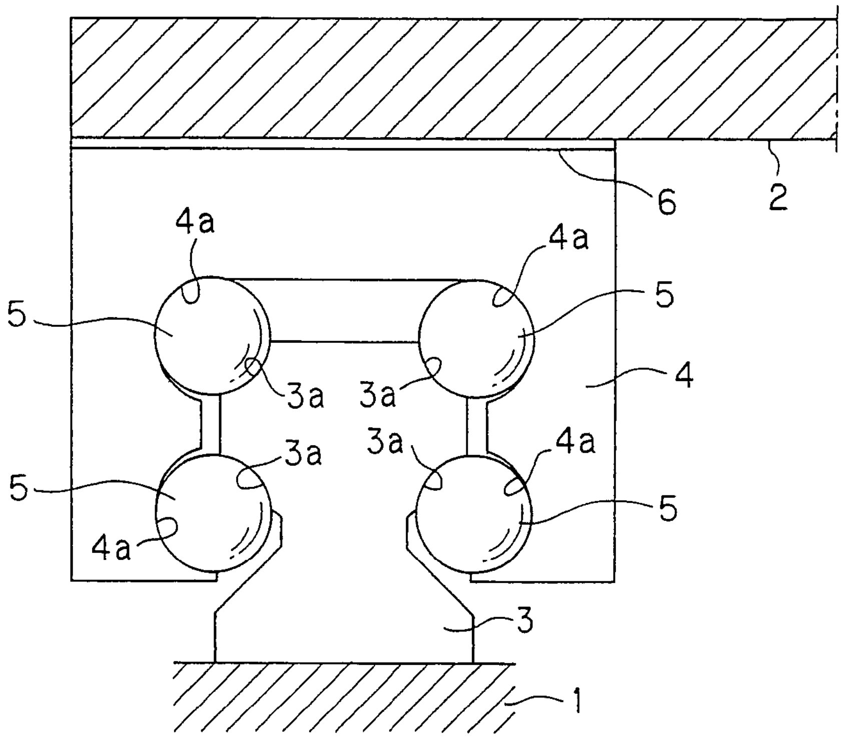


FIG. 3

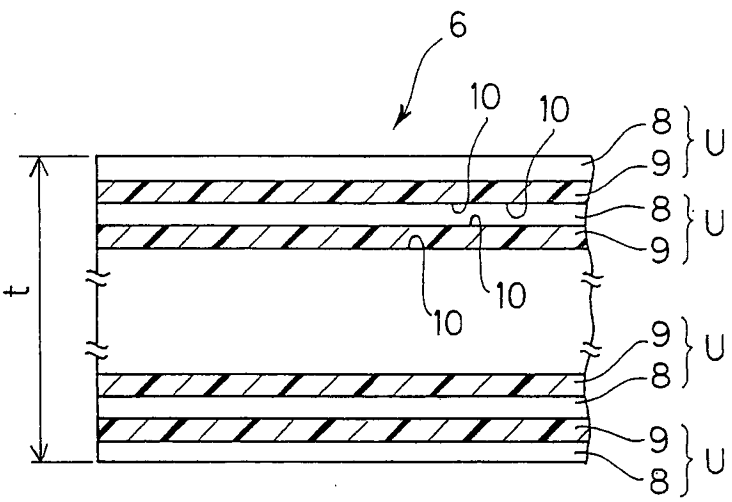


FIG. 4

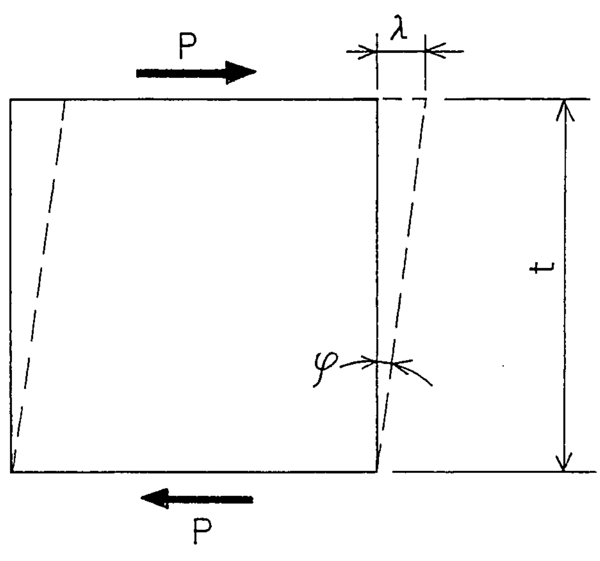


FIG. 5

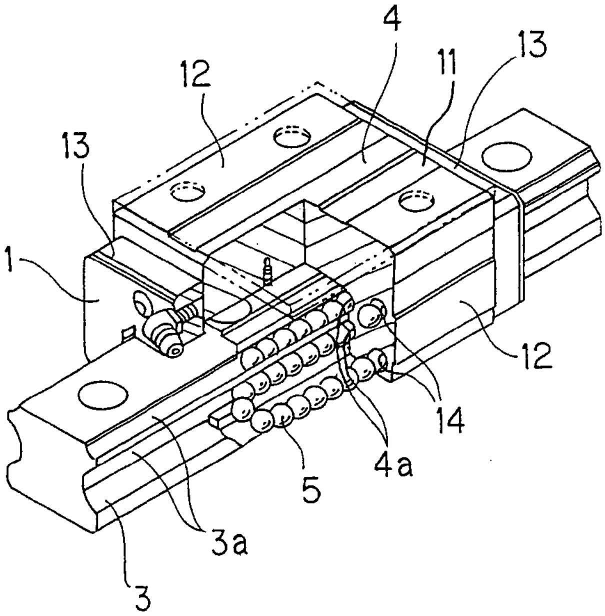
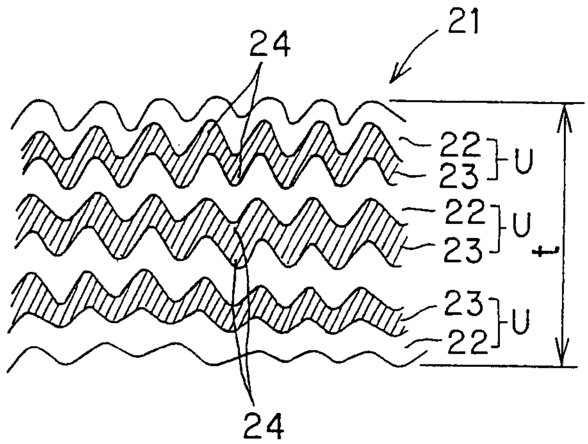


FIG. 6



(19) **Bundesrepublik Deutschland**
Deutsches Patent- und Markenamt

(10) **DE 603 01 109 T2** 2006.03.30

(12) # Übersetzung der europäischen Patentschrift

(97) **EP 1 403 541 B1**
(21) Deutsches Aktenzeichen: **603 01 109.8**
(96) Europäisches Aktenzeichen: **03 022 208.7**
(96) Europäischer Anmeldetag: **30.09.2003**
(97) Erstveröffentlichung durch das EPA: **31.03.2004**
(97) Veröffentlichungstag der Patenterteilung beim EPA: **27.07.2005**
(47) Veröffentlichungstag im Patentblatt: **30.03.2006**

(51) Int Cl.[8]: ***F16C 29/06*** (2006.01)
F16C 33/50 (2006.01)
F16C 33/46 (2006.01)

(30) Unionspriorität:
2002285422 30.09.2002 JP

(84) Benannte Vertragsstaaten:
CH, DE, LI

(73) Patentinhaber:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Viering, Jentschura & Partner, 80538 München

(72) Erfinder:
Mochizuki, Hiroaki, Nakakoma-gun, Yamanashi-ken 409-3801, JP; Fujii, Yuuki, Nakakoma-gun, Yamanashi-ken 409-3801, JP; Horie, Takuya, Nakakoma-gun, Yamanashi-ken 409-3801, JP

(54) Bezeichnung: **Linearwälzlager mit in einem flexibelen Käfig festgehaltenen Rollen**

Beschreibung

(Gebiet der Erfindung)

[0001] Die vorliegende Erfindung betrifft eine Bewegungsführungsvorrichtung zum Führen einer linearen Bewegung oder einer bogenförmigen Bewegung eines zu führenden Gegenstandes, und insbesondere eine Bewegungsführungsvorrichtung des Wälztyps, bei welcher Rollen zum Führen einer Wälzbewegung zwischen einem Führungselement und einem bewegbaren Element relativ zu dem Führungselement bewegbar angeordnet sind.

(Stand der Technik)

[0002] Im Allgemeinen ist eine Bewegungsführungsvorrichtung mit einer Führungsschiene, einem bewegbaren Block, der entlang der Führungsschiene bewegbar angeordnet ist, und einer Mehrzahl von Rollen versehen, die zwischen der Führungsschiene und dem bewegbaren Block angeordnet sind. Fig. 4 zeigt eine herkömmliche Bewegungsführungsvorrichtung, die Rollen benötigt, um eine Bewegung eines bewegbaren Elements zu veranlassen. Wenn sich der bewegbare Block **21** relativ zu einer Führungsschiene **22** bewegt, werden Rollen **23**, die sich in einem Lastbereich zwischen Rollenwälzflächen **21a** und **22a** befinden, gezwungen, sich in einer Wälzbewegung derart zu bewegen, dass eine Relativbewegung des bewegbaren Blocks **21** ermöglicht wird.

[0003] Eine Kugel, welche eine Art des Wälzelements ist, ist üblicherweise zu einem Sphärenelement geformt, das eine unendliche Anzahl von Drehachsen aufweist und in der Lage ist, sich in allen Richtungen ohne irgendwelche Einschränkungen zu drehen. Im Gegensatz dazu ist jede der Rollen **23** zu einem zylindrischen Körper geformt, mit dem Ergebnis, dass jede Rolle **23** daran gebunden ist, nur eine Drehachse zu haben, wenn jede Rolle **23** eine Wälzbewegung einnimmt. In anderen Worten ist die Bewegungsrichtung jeder Rolle **23** auf nur eine Richtung beschränkt. Um zu ermöglichen, dass die Rollen **23** Wälzbewegungen ohne Schlupf ausführen, sollte Orthogonalität zwischen den Drehachsen der Rollen **23** und einer Fortbewegungsrichtung der Rollen **23** gehalten werden.

[0004] Bei der herkömmlichen Bewegungsführungsvorrichtung, welche die Rollen **23** anwendet, gibt es, wenn Parallelität zwischen der Rollenwälzfläche **21a** des bewegbaren Blocks **21** und der Rollenwälzfläche **22a** der Führungsschiene **22** verloren geht oder eine versetzte Belastung auf den bewegbaren Block **21** ausgeübt wird, einige Fälle, wo auch die Orthogonalität zwischen den Drehachsen der Rollen **23** und der Fortbewegungsrichtung der Rollen **23** verloren geht. Die Erscheinung, dass die Rollen **23** gegen deren normalen Drehachsen schräggestellt sind, wird „Schräglauf" genannt.

[0005] Um die Schräglauferscheinung zu verhindern, wendet die herkömmliche Bewegungsführungsvorrichtung eine Stufe **24** an, die an dem einen Rand der Rollenwälzfläche **21a** des bewegbaren Blocks **21** ausgebildet ist. Die Stufe **24** ist derart gestaltet, dass sie einen Verbindungsvorsprung **24a** aufweist, mit welchem die eine Endfläche jeder Rolle **23** in Kontakt gelangen kann, wobei die eine Endfläche orthogonal zu deren Drehachsenrichtung ist. Das Vorhandensein des Verbindungsvorsprungs **24a** verhindert, dass die Rollen **23** schräggestellt werden können (bezogen auf die japanische offengelegte (KOKAI) Patentveröffentlichung Nr. 2002-54633). Dieser Verbindungsvorsprung **24a** kann, wie in Fig. 4 dargestellt ist, an nur einerseitigen Endfläche der Rollenwälzfläche **21a** in deren Achslinienrichtung ausgebildet sein oder kann an deren beiderseitigen Endflächen ausgebildet sein. Alternativ ist die Stufe an nur einer Seite der Rollenwälzfläche ausgebildet, und eine Eisenplatte ist an der anderen Seite der Rollenwälzfläche derart angeordnet, dass sie jeder Rolle derart zugewandt ist und diese andrückt, dass ein Spalt zwischen den Rollen und der Rollenwälzfläche eingestellt wird.

[0006] Jedoch wird, wenn die Rollen schräggestellt sind, eine den Verbindungsvorsprung andrückende Kraft infolge der Schrägstellung der Rollen extrem größer. Der herkömmliche Verbindungsvorsprung ist daher aus Metall hergestellt, dessen Festigkeit größer ist (zum Beispiel ein Metall aus demselben Material wie jenes, das zum Formen der Rollenwälzfläche des bewegbaren Blocks verwendet wird). Es war lange allgemeines Wissen, die Schrägläufe der Rollen durch einen Kontakt zwischen den Metallelementen zu verhindern.

[0007] Jedoch bewirkt der Kontakt zwischen den Metallelementen einen höheren Reibungsfaktor, wodurch sich der Gleitwiderstand erhöht, der auftritt, wenn der bewegbare Block entlang der Führungsschiene gleitet. Daher kann es schwierig sein, sanfte und stabile Bewegungen des bewegbaren Blocks zu erreichen.

[0008] Das Dokument EP 0 838 602 A offenbart eine lineare Rollenführungsvorrichtung mit einer Führungsschiene **202**, einem bewegbaren Block **204**, der an einer oberen Fläche der Führungsschiene **202** mittels vier Reihen von Rollen **203** bewegbar montiert ist, und einem Umlaufkanal für die Rollen **203**, der von dem Lastbereich zwischen den Rollenwälzflächen **206**, **207**, **205**, **208** des metallischen Blockkörpers **2040** des bewegbares Blocks **204** und entsprechend der Führungsschiene **202** durch den Richtungswechselkanal **210** und den Rollenrücklaufkanal **209** gebildet wird. Der Blockkörper **2040** ist mit Rücklaufkanälen **209** zum Umlaufen und Führen der Rollen **203** versehen. Der Rollenrücklaufkanal **209** erstreckt sich linear parallel zu den jeweiligen Rollenwälzflächen **205**, **206**, die an dem Blockkörper **2040** ausgebildet sind. Ferner offenbart das Dokument Rollen **203**, welche durch eine Rollenkette **218** miteinander verbunden sind, welche ein aus Harz geformtes Produkt ist und Abstandsstücke **218a** aufweist, welche zwischen den benachbarten Rollen **203** angeordnet sind und mit einem haltenden vertieften Abschnitt **218c** an den beiden Seitenflächen versehen sind, die eine der Fläche der Rollen **203** entsprechenden Form haben. Die Lastrollenendflächenführungswände **213** zum Führen beider Endflächen der Rolle **203** sind mit Führungsnuten **213a** versehen, mit welchen die Führungsvorsprungsabschnitte **2181** der Rollenkette **218** in Eingriff stehen. Um die Lastrollenendflächenführungswand **213** zu bilden, weist der Blockkörper **2040** eine erste bis dritte Flächenführungswand auf, die Elemente **2141–2143** bildet, die aus Harz bestehen.

[0009] Das Dokument US 6 287 005 A offenbart eine Rollenführungsvorrichtung **1** mit einer länglichen Laufschiene **2**, die eine Mehrzahl von daran ausgebildeten Rollenwälzflächen **5** aufweist, einem bewegbaren Körper **3**, der eine Mehrzahl von daran in Gegenüberstellung mit den entsprechenden Rollenwälzflächen **5** der Laufschiene **2** ausgebildeten Rollenwälzflächen **6** aufweist, und einer Vielzahl von Rollen **4**, die zwischen den entsprechenden Rollenwälzflächen **5**, **6** der Schiene **2** und dem bewegbaren Körper **3** angeordnet sind. Die Rollen **4** sind zu einer Mehrzahl von Zügen von Rollen geformt, wobei jeder Zug von Rollen mittels eines Rollenverbinders **20** in Position gehalten wird. Jeder der Rollenverbinder **20** weist einen gurtförmigen Körper oder Teil **26** mit einer Vielzahl von Aufnahmelöchern **24** zum Halten der Rollen **4**, die entlang dessen Länge in einem vorbestimmten Abstand mit einem zwischen benachbarten Löchern angeordneten Abstandsstück **25** ausgebildet sind, und ein Paar stirnflächige Halteplatten auf, die an den quer einander gegenüberliegenden Seitenrändern jedes Aufnahmeloches **24** in dem Gurtelement **2** vorgesehen sind. Die stirnflächigen Halteplatten **27** sind in deren Mitte mit Eingriffsvorsprüngen **28** versehen, welche in passendem Eingriff mit den Mittellöchern **4a** sind, die an den gegenüberliegenden Stirnflächen jeder Rolle **4** zur drehbaren Gleitbewegung ausgebildet sind. Die stirnflächigen Halteplatten **27** jedes Rollenverbinders **20** werden von einer Innenwand einer entsprechenden Rollenlaufnut **6** geführt. Der bewegbare Körper **3** weist ein Blockelement **10** mit einem passenden Blockkörper **7** und einem Paar Schenkel **8**, **8**, die sich von den quer einander gegenüberliegenden Enden des passenden Blockkörpers **7** nach unten erstrecken, und ein Paar Seitenabdeckungen **11**, **11** auf, die an den Axial- oder Längsenden des Blockelements **10** montiert sind. Der passende Blockkörper **7** und die gegenüberliegenden Schenkel **8**, **8** sind jeweils mit Rollenrücklaufkanälen **12** versehen, die sich parallel zu den Rollenwälzflächen **6** erstrecken, die an deren Innenfläche ausgebildet sind.

[0010] Die vorliegende Erfindung wurde in Anbetracht der obigen Dinge konzipiert, und ein Ziel der vorliegenden Erfindung ist es, in einer einfachen und kostengünstigen Weise eine Bewegungsführungsvorrichtung zu schaffen, die nicht nur zum Verhindern der Schrägläufe der Rollen geeignet ist, sondern auch zum Reduzieren des Gleitwiderstandes, der auftritt, wenn das bewegbare Element entlang des Führungselements gleitet.

Zusammenfassung der Erfindung

[0011] Um das obige Ziel zu erreichen, schafft die vorliegende Erfindung eine Bewegungsführungsvorrichtung, aufweisend ein Führungselement, das daran eine Rollenwälzfläche aufweist; ein bewegbares Element, das einen Rollenumlaufkanal mit einer Lastrollenwälzfläche aufweist, die sich gegenüber der Rollenwälzfläche befindet und an dem Führungselement relativ zu dem Führungselement bewegbar angeordnet ist; eine Mehrzahl von Rollen, die jeweils aus Metall hergestellt und in dem Rollenumlaufkanal mit einer Drehachse jeder der Rollen parallel zueinander angeordnet sind, um dadurch in Antwort auf eine Relativbewegung des bewegbaren Elements zu dem Führungselement zu zirkulieren; und einen Rollenhalter, um die Mehrzahl der Rollen drehbar und gleitend zu halten. Das bewegbare Element weist Verbindungsvorsprünge auf, die daran ausgebildet und nur aus Harz hergestellt sind, um dadurch den Verbindungsvorsprüngen zu ermöglichen, mit beiden Achslinienrichtungs-Endflächen jeder der Rollen in Kontakt zu gelangen, die entlang der Lastrollenwälzfläche rollen, wobei die Verbindungsvorsprünge nur an einer Außenseite relativ zu der Drehachse jeder Rolle angeordnet sind, die entlang der Lastrollenwälzfläche rollt.

[0012] Daher werden bei der vorliegenden Erfindung, selbst wenn die Rollen schräggestellt sind, der Verbindungsvorsprung, der gestaltet ist, um die Schrägläufe zu verhindern, und die Endfläche der Rollen durch Kollisionen zwischen dem Harz- und Metallwerkstoffen in Kontakt miteinander gebracht. Dementsprechend verringert sich ein Reibungsfaktor zwischen dem Verbindungsvorsprung und der Endfläche, wodurch der Gleitwiderstand sinkt, der verursacht wird, wenn das bewegbare Element entlang des Führungselements gleitet. Dadurch kann sich das bewegbare Element in einer sanften und stabilen Weise bewegen. Außerdem machen es die Verbindungen der Rollen mit dem Rollenhalter möglich, den Widerstand gegen das Auftreten von Schrägläufen zu verstärken. Somit sind die aus Harz hergestellten Verbindungsvorsprünge in der Lage, zu verhindern, dass die Rollen schräggestellt werden.

[0013] Vorzugsweise ist der Rollenhalter platziert, um zwischen zwei der Rollen einzugreifen, und ist mit einer Mehrzahl von Abstandselementen mit zwei vertieften Flächen an deren beiden Seiten, wobei jede der vertieften Flächen in einer Form mit einer Außenumfangsfläche der neben der jeweiligen Rolle angeordneten Rolle übereinstimmt, und einem Verbindungselement versehen, das platziert ist, um sich von einer Drehachsrichtungs-Endfläche jeder der Rollen nach außen zu erstrecken und die Abstandselemente miteinander zu verbinden.

[0014] Noch bevorzugt ist der Verbindungsvorsprung an einem Stützelement ausgebildet, um durch Herstellen einer Verbindung mit dem Verbindungselement des Rollenhalters zu verhindern, dass die Rollen von der Lastrollenwälzfläche weg gelangen, wenn das bewegbare Element von dem Führungselement entfernt wird.

[0015] Daher ist der Rollenhalter in der Lage, die beiden Funktionen des Verhinderns des Weggelangens der Rollen, wenn das bewegbare Element von dem Führungselement entfernt wird, und des Verhinderns des Schräglaufes der Rollen zu erfüllen.

Kurze Beschreibung der Zeichnungen

[0016] Andere Ziele und Aspekte der vorliegenden Erfindung werden aus der folgenden Beschreibung und den Ausführungsformen mit Bezug auf die begleitenden Zeichnungen deutlich, in welchen:

[0017] Fig. 1 ist eine demontierte perspektivische Ansicht, die eine lineare Bewegungsführungsvorrichtung gemäß einer Ausführungsform der vorliegenden Erfindung erläutert;

[0018] Fig. 2 ist eine perspektivische Ansicht, die Rollen zeigt, die von einem Rollenhalter gehalten werden;

[0019] Fig. 3A ist ein detaillierter teilweiser Schnitt, der eine Rollenstützstruktur gemäß der Ausführungsform zeigt, bei welcher eine Rolle zwischen einer Führungsschiene und einem bewegbaren Block rollt;

[0020] Fig. 3B ist ein detaillierter teilweiser Schnitt, der eine Rollenstützstruktur gemäß einem Vergleichsbeispiel zeigt, bei welcher eine Rolle zwischen einer Führungsschiene und einem bewegbaren Block rollt; und

[0021] Fig. 4 zeigt die Vorderansicht einer herkömmlichen Bewegungsführungsvorrichtung.

Ausführliche Beschreibung der bevorzugten Ausführungsform

[0022] Eine bevorzugte Ausführungsform der vorliegenden Erfindung wird nun zusammen mit den begleitenden Zeichnungen beschrieben.

[0023] Mit Bezug auf Fig. 1 bis Fig. 3A und Fig. 3B wird nun eine lineare Bewegungsführungsvorrichtung gemäß einer Ausführungsform der vorliegenden Erfindung beschrieben.

[0024] Eine lineare Bewegungsführungsvorrichtung ist mit einer linearen länglichen Führungsschiene **1**, die als ein Führungselement dient, und einem bewegbaren Block **2** versehen, welcher als ein bewegbares Element dient und mit der Führungsschiene **1** derart montiert ist, dass er entlang der Führungsschiene **1** relativ verschiebbar ist. Zwischen der Führungsschiene **1** und dem bewegbaren Block sind eine große Anzahl von Rollen **3** vorgesehen, welche als eine Mehrzahl von Wälzelementen dienen. Die Rollen **3** sind aus Metall hergestellt und derart ausgebildet, dass sie rollen.

[0025] Um genau zu sein, wird die Führungsschiene **1** mit einem annähernd rechteckigen Querschnitt orthogonal zu deren Längsrichtung produziert. An jeder der beiden seitlichen Seiten der Führungsschiene **1** ist eine Nut **1a**, die aus Wandflächen **1b** und **1b** und einer Bodenfläche **1c** gebildet ist, entlang der Längsrichtung ausgebildet.

[0026] In jeder Nut **1a** sind die beiden Wandflächen **1b** und **1b** in rechten Winkeln gekreuzt. Jede der oberen Wandfläche **1b** und der unteren Wandfläche **1b** bilden eine Rollenwälzfläche, die als ein Wälzkörperrollabschnitt dient, entlang welcher die Rollen **3** abrollen. Das heißt, an der rechten und linken Seite der Führungsschiene **1** sind insgesamt vier Rollenwälzflächen **1b** ausgebildet, d.h. obere und untere Wälzflächen (zwei Wälzflächen) an jeder Seite. Diese Rollenwälzflächen sind parallel zueinander ausgebildet, um sich entlang der Führungsschiene **1** zu erstrecken.

[0027] Der bewegbare Block **2** ist mit einem Mittelabschnitt **2a**, der einer oberen Fläche der Führungsschiene **1** zugewandt ist, und Seitenwandabschnitten **2b** und **2b** versehen, die sich jeweils von beiden Seitenenden des Mittelabschnitts **2a** nach unten erstrecken und den beiden seitlichen Seitenflächen der Führungsschiene **1** zugewandt sind.

[0028] Der Mittelabschnitt **2a** weist einen Hauptblock **4** aus Stahl, eine Umlaufkanalbildungsstruktur aus Harz, die in den Hauptblock **4** eingebaut ist, und ein Paar Seitendeckel **5** und **5** auf, die an beiden Seitenflächen des Hauptblocks **4** angeordnet sind, in welchem die Umlaufkanalbildungsstruktur aus Harz eingebaut ist, wobei die beiden Seitenflächen entlang einer Bewegungsrichtung des Hauptblocks **4** verlaufen.

[0029] An Seitenwandabschnitten **4b** und **4b** des Hauptblocks **4** sind Vorsprünge **4c** und **4c** ausgebildet, wobei die Form jedes Vorsprungs **4c** mit der Form jeder Nut **1a** übereinstimmt, die an jeder Seitenfläche der Führungsschiene **1** ausgebildet ist. An jedem der Vorsprünge **4c** und **4c** sind zwei Lastrollenwälzflächen **4d** und **4d** ausgebildet, die als Lastwälzkörperrollabschnitte dienen, wobei jede Lastrollenwälzfläche **4d** jeder Rollenwälzfläche **1b** zugewandt ist. In anderen Worten sind die Lastrollenwälzflächen **4d** aus insgesamt vier Wälzflächen aufgebaut, d.h. zwei Wälzflächen (obere und untere Wälzflächen) an jeder der beiden rechten und linken Seitenwandabschnitte **4b** und **4b** des Hauptblocks **4**. Diese Lastrollenwälzflächen **4d** erstrecken sich parallel zueinander in der Bewegungsrichtung, entlang welcher der bewegbare Block **2** bewegt wird.

[0030] In den Seitenwandabschnitten **2b** und **2b** des bewegbaren Blocks **2** sind obere und untere Rollenausweichkanäle **7** und **7**, welche insgesamt zwei an jeder Seite sind, und ein U-förmiger Wälzrichtungswechselkanal ausgebildet. In jedem Seitenwandabschnitt **2b** sind die Rollenausweichkanäle **7** und **7** parallel. zueinander ausgebildet und im vorbestimmten Abstand von den oberen bzw. unteren beiden Lastrollenwälzflächen **4d** und **4d a**ngeordnet.

[0031] Der Wälzrichtungswechselkanal ist ausgebildet, um jede der Lastrollenwälzflächen **4d** und **4d** und beide Enden jeder der Rollenausweichkanäle **7** und **7** miteinander zu verbinden, damit die Rollen **3** durch diese hindurch umlaufen. Diese Lastrollenwälzfläche **4d**, der Wälzrichtungswechselkanal und der Rollenausweichkanals **7** bilden einen Rollenumlaufkanal.

[0032] Von diesen Bauteilen werden die Rollenausweichkanäle **7** von insgesamt vier, d.h. zwei Rollenausweichkanälen **7** und **7** in vorbestimmten oberen und unteren Positionen in jedem der rechten und linken Seitenwandabschnitte **2b** und **2b** des bewegbaren Blocks **2** gebildet. An jeder Seite des bewegbaren Blocks **2** verbindet der Wälzrichtungswechselkanal sowohl die obere Lastrollenwälzfläche **4d** und den unteren Rollenausweichkanal **7** als auch die untere Lastrollenwälzfläche **4d** und den oberen Rollenausweichkanal **7**, so dass die beiden verbundenen Kanäle eine Überquerung miteinander bilden.

[0033] Die Rollenumlaufkanäle werden von insgesamt vier, d.h. zwei in bzw. an jedem der seitlichen Seitenwandabschnitte **2b** und **2b** gebildet. Es werden zwei Rollenumlaufkanäle produziert. Jeder Rollenumlaufkanal ist ausgebildet, um in derselben Ebene zu liegen, mit dem Ergebnis, dass die Rollen **3** zweidimensional entlang jedes Rollenumlaufkanals zirkulieren können. An jeder Seite des bewegbaren Blocks **2** kreuzen die beiden Ebenen, in welchen die beiden Rollenumlaufkanäle jeweils angeordnet sind, in rechten Winkeln miteinander, und der eine Rollenumlaufkanal ist in einer Innenposition in Bezug auf den übrigen Rollenumlaufkanal angeordnet.

[0034] Die mehreren Rollen **3** sind in jedem Rollenumlaufkanal angeordnet, wobei die Drehachsen der Rollen **3** parallel zueinander sind. Die Rollen **3** sind durch einen Rollenhalter **10** derart miteinander verbunden, dass eine Kette von Rollen **3** erzeugt wird. Die Rollen **3** werden durch den Rollenhalter **10** drehbar und gleitend gehalten und sind in der Lage, entlang jedes vorgegebenen Rollenumlaufkanals zu zirkulieren. Fig. 2 zeigt die Rollen **3**, die von dem Rollenhalter **10** gehalten werden.

[0035] Zwischen den Rollen **3** und **3** gibt es ein Abstandselement **10b**. Daher sind eine Mehrzahl von Abstandselementen **10b** in jedem Zug der Rollen **3** angeordnet. An jeder Seite jedes Abstandselements **10b** ist eine Vertiefung ausgebildet, deren Krümmung mit einer Außenkrümmung jeder benachbarten Rolle **3** übereinstimmt. Die Abstandselemente **10b** sind durch ein Paar Verbindungselemente **10d** und **10d** miteinander gekuppelt, die derart angeordnet sind, dass sie sich von jeder Endfläche in den Drehachsrichtungen der Rollen **3** erstrecken.

[0036] Wie in Fig. 1 gezeigt ist, ist die Umlaufkanalbildungsstruktur aus Harz mit Stützelementen **11** und **11**, Ausweichkanalbildungselementen **14** und Richtungswechselkanalbildungselementen **8** versehen.

[0037] Unter diesen Bauteilen sind die Stützelemente **11** und **11**, welche sich entlang der Seitenränder der beiden Lastrollenwälzflächen **4d** und **4d** erstrecken, angeordnet, um zu verhindern, dass die Rollen **3** von den Lastrollenwälzflächen **4d** und **4d** weg gelangen, wenn der bewegbare Block **2** von der Führungsschiene **1** entfernt wird. Die Ausweichkanalbildungselemente **14** sind platziert, um einen Rollenausweichkanal für die Rollen **3** zu bilden, während die Richtungswechselkanalbildungselemente **8** angeordnet sind, um einen Richtungswechselkanal für die Rollen **3** zu bilden.

[0038] Die Stützelemente **11** und **11**, Ausweichkanalbildungselemente **14** und Richtungswechselkanalbildungselemente **8** werden jeweils als unterschiedliche Elemente gebildet, die von dem Hauptblock **4** getrennt sind, und werden aus Harz hergestellt, und werden dann in den Hauptblock **4** eingebaut.

[0039] Jedes der Stützelemente **11** aus Harz weist erste, zweite und dritte Stützelemente **11a**, **11b** und **11c** auf, die jeweils zu einem dünnen und lang bemessenen Element aus einem Harzwerkstoff geformt sind, und wird durch Bilden der ersten bis dritten Elemente **11a** bis **11c** zu einer Einheit konstruiert. Das erste Stützelement **11a** ist unter den unteren Rollen **3** angeordnet, das zweite Stützelement **11b** ist zwischen den unteren Rollen **3** und den oberen Rollen **3** angeordnet, und das dritte Stützelement **11c** ist über den oberen Rollen **3** angeordnet. Jedes der Stützteile **11** und **11** ist zwischen dem Paar Seitendeckeln **5** und **5** oder den paarweisen Richtungswechselkanalbildungselementen **8** und **8** gesteckt, so dass jedes Stützteil **11** mit beiden Enden an dem bewegbaren Block **2** abgestützt und befestigt ist.

[0040] In Fällen, wo der bewegbare Block **2** von der Führungsschiene **1** entfernt wird, ist jedes Stützteil **11** in der Lage, sich mit dem Verbindungselement **10d** des Rollenhalters **10** zu verbinden, um zu verhindern, dass die Rolle von den Lastrollenwälzflächen **4d** weg gelangt. Wie später detailliert wird, weisen die ersten, zweiten und dritten Stützelemente **11a**, **11b** und **11c** Verbindungsabschnitte **16** und **16** auf, die in der Lage sind, mit Endflächen jeder der Rollen **3** in deren Achslinienrichtung (bezogen auf **Fig.** 3) in Kontakt zu gelangen.

[0041] Die Ausweichkanalbildungselemente **14** bestehen aus einem Paar Rohrhälften **14a** und **14b**, die durch Trennen eines Rohrmaterials in zwei Elemente in einer Richtung orthogonal zu einer Achslinienrichtung des Rohres hergestellt werden. Jede der Rohrhälften **14a** und **14b** ist mit einer Nut, deren Form mit der jeder Rolle **3** übereinstimmt, und verläuft entlang deren Längsrichtung, und einer Führungsnut versehen, um das Verbindungselement **10d** des Rollenhalter **10** zu führen.

[0042] Die Richtungswechselkanalbildungselemente **8** weisen die U-förmigen Richtungswechselkanäle auf, welche in den Elementen **8** ausgebildet sind, um in einer Überquerung einander zu kreuzen. In diesem Richtungswechselkanal ist die Führungsnut ausgebildet, um das Verbindungsteil **10d** des Rollenhalters **10** zu führen.

[0043] Jeder Seitendeckel **5**, welcher einen Querschnitt hat, der mit dem des Hauptblocks **4** übereinstimmt, weist einen Mittelabschnitt **5a** und Seitenwandabschnitte **5b** und **5b** auf. In jedem der Seitenwandabschnitte **5b** und **5b** ist ein Außenführungsabschnitt des außenseitigen Rollenumlaufkanals ausgebildet. In jedem der Seitenwandabschnitte **5b** und **5b** sind die Richtungswechselkanalbildungselemente **8** und **8** eingebaut. Die Seitendeckel **5** und **5** sind an beiden Bewegungsrichtungsseiten des Hauptblocks **4** befestigt. Schrauben sind in Schraubeneinsetzlöcher eingesetzt, die in den Seitendeckeln **5** und **5** ausgebildet sind, und die Schrauben sind in Schraubenlöcher eingesetzt, die in den Endflächen des Hauptblocks **4** ausgebildet sind, so dass die Seitendeckel **5** und **5** an dem Hauptblock **4** befestigt und fixiert werden können.

[0044] An einer Innenseite jedes der Seitendeckel **5** und **5** sind Schmiermittelzuführplatten **12** und **12** platziert, um den Lastrollenwälzflächen des Hauptblocks **4** Schmiermittel zuzuführen.

[0045] An einer Außenseite jedes der Seitendeckel **5** und **5** (d.h. entsprechend beiden Bewegungsrichtungsseitenflächen des bewegbaren Blocks) sind jeweils Endplatten **13** und **13** befestigt. Jede der Endplatten **13** und **13** stimmt in ihren Querschnitten mit dem Hauptblock **4** überein und weist einen Mittelabschnitt **13a** und Seitenwandabschnitte **13b** und **13b** auf. Die Endplatten **13** und **13** sind an den jeweiligen Seitendeckeln **5** und **5** mittels Schrauben fixiert. Ein Dichtungsabschnitt **13c** ist entlang eines Innenumfangsrandes jeder Endplatte **13** ausgebildet, wobei der Innenumfangsrand der Führungsschiene **1** gegenüberliegt.

[0046] Fig. 3A zeigt im Detail einen Schnitt, bei welchem die eine obere Rolle **3** zwischen der Führungsschiene **1** und dem bewegbaren Block **2** rollt, welches die vorliegende Ausführungsform betrifft. Im Gegensatz dazu zeigt Fig. 3B ein Vergleichsbeispiel zu der vorliegenden Ausführungsform.

[0047] An den Stützelementen **11b** und **11c** sind jeweils Verbindungsvorsprünge **16** und **16** ausgebildet. Jeder der Verbindungsvorsprünge **16** und **16** ist in der Lage, jeweils eine der beiden Achslinienrichtungs-Endflächen **3a** und **3a** jeder Rolle **3** zu kontaktieren, die an der Lastrollenwälzfläche **4d** rollt. Die Verbindungsvorsprünge **16** und **16** sind weiter als die Kreisbahn der Drehachse **3b** jeder Rolle **3**, die entlang der Lastrollenwälzfläche **4d** rollt, nach außen hin angeordnet und um denselben Abstand von der Lastrollenwälzfläche **4d** getrennt. Ein Abstand L + ΔL zwischen den Verbindungsvorsprüngen **16** und **16** ist derart bestimmt, dass der Abstand L + ΔL etwas größer als eine Länge L jeder Rolle **3** in deren Drehachsrichtung ist, um ein Spiel ΔL in der Drehachsrichtung zu erreichen. Der Kontakt der Endflächen **3a** und **3a** jeder Rolle **3** zu den Verbindungsvorsprüngen **16** und **16** verhindert, dass die Drehachse **3b** jeder Rolle **3** aus den rechten Winkeln (d.h. in eine Schräglage zu einer orthogonalen Richtung) zu der Bewegungsrichtung der Rollen **3** während der Wälzbewegung der Rollen **3** verschoben wird.

[0048] Bei der vorliegenden Ausführungsform sind die Verbindungsvorsprünge **16** und **16** nur aus einem Harz hergestellt; kein Metallbestandteil ist in den Werkstoffen der Vorsprünge **16** enthalten. Daher wird der Kontakt zwischen den Endflächen **3a** jeder Rolle **3** und den Verbindungsvorsprüngen **16** zur Verhinderung der Schrägläufe der Rollen **3** zwischen Harz- und Metallwerkstoffen durchgeführt. Wenn die Rollen in einer Wälzbewegung sind, verringert sich ein Reibungsfaktor zwischen den Endflächen **3a** und den Verbindungsabschnitten **16**. Somit kann auch der

Gleitwiderstand gesenkt werden, der verursacht wird, wenn sich der bewegbare Block **2** gleitend entlang der Führungsschiene **1** bewegt, so dass eine stabile Bewegung des bewegbaren Blocks **2** geschaffen wird.

[0049] Außerdem, da der Rollenhalter **10** die Rollen **3** in Reihe in einer vorbestimmten Lage formiert, ist es möglich, zu vermeiden, dass die Rollen **3** schräggestellt werden. Selbst wenn die Rollen **3** schräggestellt werden, ist eine federnde Rückstellkraft, die von dem Paar Verbindungselementen **10d** und **10d** bereitgestellt wird, in der Lage, diese von den Schrägläufen zu befreien, in dessen Folge die Rollen **3** in der Lage sind, deren Drehachse wieder in rechten Winkeln zu halten. Eine kombinierte Verwendung der Verbindungsvorsprünge **16** und **16** aus Harz und des Rollenhalters **10** verhindert zuverlässig, dass die Rollen **3** schräggestellt werden.

[0050] Fig. 3B veranschaulicht eine andere Struktur, bei welcher eine Stufe **17** an der Lastrollenwälzfläche **4d** ausgebildet ist, um eine metallische Kontaktfläche **17a** zu erzeugen, und diese Kontaktfläche **17a** ist positioniert, um mit der einen Endfläche **3a** jeder Rolle **3** in Kontakt zu gelangen. Diese Struktur ist ebenso in der Lage, die Schrägläufe der Rollen **3** zu verhindern.

[0051] Jedoch in diesem Falle, da die Schräglaufverhinderungskontaktfläche **17a** aus Metall hergestellt ist, wäre es nötig, dass die Fläche **17a** einer höhergenauen Schleifbearbeitung unterzogen wird und eine Ausweichnut **18** an dem Eckpunkt der Stufe **17** gebildet wird.

[0052] Wie oben beschrieben, verwendet die vorliegende Ausführungsform die Verbindungsvorsprünge **16** aus Harz, so dass es nicht erforderlich ist, verschiedene Arten der Bearbeitung, wie Schleifen, an den Verbindungsvorsprüngen **16** anzuwenden. Es ist daher möglich, die Bewegungsführungsvorrichtung in einer kostengünstigen Weise herzustellen.

[0053] Bei der vorliegenden Ausführungsform gibt es einen zusätzlichen Vorteil bei der Vermeidung von einseitigem Kontakt der Rollen **3**. Wenn die paarweisen Verbindungsvorsprünge **16** und **16** mit jeder Rolle **3** zwischen diesen in unterschiedlichen Abständen von der Rollenwälzfläche **4d** angeordnet sind, besteht eine Gefahr, dass die Rollen **3** mit dem Verbindungsvorsprung **16** an der einen Seite (d.h. einseitiger Kontakt) in Kontakt gebracht werden, wenn die Rollen **3** schräggestellt sind. Im Gegensatz dazu ist die Vorrichtung gemäß der vorliegenden Ausführungsform derart strukturiert, dass sie die paarweisen Verbindungsvorsprünge **16** und **16** in denselben Höhenpositionen angeordnet hat, so dass ein solcher einseitiger Kontakt verhindert wird.

[0054] Wie oben beschrieben, werden bei der vorliegenden Ausführungsform, selbst wenn die Rollen schräggestellt sind, die Verbindungsvorsprünge und die Endflächen der Rollen durch Kollisionen zwischen den Harz- und Metallwerkstoffen in Kontakt miteinander gebracht. Dementsprechend verringert sich ein Reibungsfaktor zwischen den Verbindungsvorsprüngen und den Endflächen, so dass der Gleitwiderstand sinkt, der verursacht wird, wenn das bewegbare Element entlang der Führungsschiene gleitet, wodurch sich das bewegbare Element in einer sanften und stabilen Weise bewegen kann. Außerdem machen es die Verbindungen der Rollen mit dem Rollenhalter möglich, den Widerstand gegen das Auftreten von Schrägläufen zu verstärken. Somit sind die Verbindungsvorsprünge aus Harz in der Lage, zu verhindern, dass die Rollen schräggestellt werden.

[0055] Die vorliegende Ausführungsform ist besonders in Fällen wirksam, wo der Durchmesser jeder Rolle so klein ist, dass eine mit den Endflächen der Rolle kontaktierende Kontaktfläche nicht sichergestellt werden kann. Obwohl die oben genannte Ausführungsform mit der Bewegungsführungsvorrichtung beschrieben wurde, die auf eine lineare Bewegungsführung gerichtet ist, ist die Bewegung nicht auf eine solche lineare Bewegung beschränkt. Die vorliegende Erfindung kann auch für eine Bewegungsführungsvorrichtung zur Führung einer bogenförmigen Bewegung angewendet werden. Ferner können die Stützelemente, Ausweichkanalbildungselemente und Richtungswechselkanalbildungselemente als eine Einheit mit dem Hauptblock durch die Verwendung von Umspritzen gebildet werden, was erfordert, dass der Hauptblock einzulegen ist.

[0056] Der Vollständigkeit halber sollte erwähnt werden, dass die Ausführungsform und Modifikationen, soweit erläutert, keine definitiven Aufzählungen von möglichen Ausführungsformen der vorliegenden Erfindung sind. Der Fachmann wird verstehen, dass es möglich ist, die verschiedenen konstruktiven Details zu kombinieren oder diese durch Maßnahmen zu ergänzen oder zu modifizieren, die aus dem Stand der Technik bekannt sind, ohne von dem grundlegenden Erfindungsgedanken abzuweichen, wie in den Ansprüchen definiert ist.

Patentansprüche

1. Eine Bewegungsführungsvorrichtung, aufweisend:
ein Führungselement (**1**), das eine Rollenwälzfläche (**1b**) darauf aufweist;
ein bewegbares Element (**2**), das einen Rollenumlaufkanal mit einer Lastrollenwälzfläche (**4d**) aufweist, die sich gegenüber der Rollenwälzfläche (**1b**) befindet und an dem Führungselement (**1**) relativ zu dem Führungselement (**1**) bewegbar angeordnet ist;

eine Mehrzahl von Rollen (**3**), die jeweils aus Metall hergestellt und in dem Rollenumlaufkanal mit einer Drehachse jeder der Rollen (**3**) parallel zueinander sind, um dadurch in Antwort auf eine Relativbewegung des bewegbaren Elements (**2**) zu dem Führungselement (**1**) zu zirkulieren; und
einen Rollenhalter (**10**), um die Mehrzahl der Rollen (**3**) drehbar und gleitend zu halten;
wobei das bewegbare Element (**2**) Verbindungsvorsprünge (**16**) aufweist, die daran ausgebildet und nur aus Harz hergestellt sind, um dadurch den Verbindungsvorsprüngen (**16**) zu erlauben, mit beiden Achslinienrichtungs-Endflächen jeder der Rollen (**3**) in Kontakt zu gelangen, die entlang der Lastrollenwälzfläche (**4d**) rollen, wobei die Verbindungsvorsprünge (**16**) nur an einer Außenseite relativ zu der Drehachse jeder Rolle (**3**) angeordnet sind, die entlang der Lastrollenwälzfläche (**4d**) rollt.

2. Die Bewegungsführungsvorrichtung nach Anspruch 1, wobei der Rollenhalter (**10**) platziert ist, um zwischen zwei der Rollen (**3**) einzugreifen, und mit einer Mehrzahl von Abstandselementen (**10b**) mit zwei vertieften Flächen an deren beiden Seiten, wobei jede der vertieften Flächen in einer Form mit einer Außenumfangsfläche der neben der jeweiligen Rolle angeordneten Rolle (**3**) übereinstimmt, und einem Verbindungselement (**10d**) versehen ist, das platziert ist, um sich von einer Drehachsrichtungs-Endfläche jeder der Rollen (**3**) nach außen zu erstrecken und die Abstandselemente (**10d**) miteinander zu verbinden.

3. Die Bewegungsführungsvorrichtung nach Anspruch 1 oder 2, wobei der Verbindungsvorsprung (**16**) an einem Stützelement (**11**) ausgebildet ist, um durch Herstellen einer Verbindung mit dem Verbindungselement (**10d**) des Rollenhalters (**10**) zu verhindern, dass die Rollen (**3**) von der Lastrollenwälzfläche (**4d**) weg gelangen, wenn das bewegbare Element (**2**) von dem Führungselement (**1**) entfernt wird.

Es folgen 4 Blatt Zeichnungen

Anhängende Zeichnungen

FIG. 1

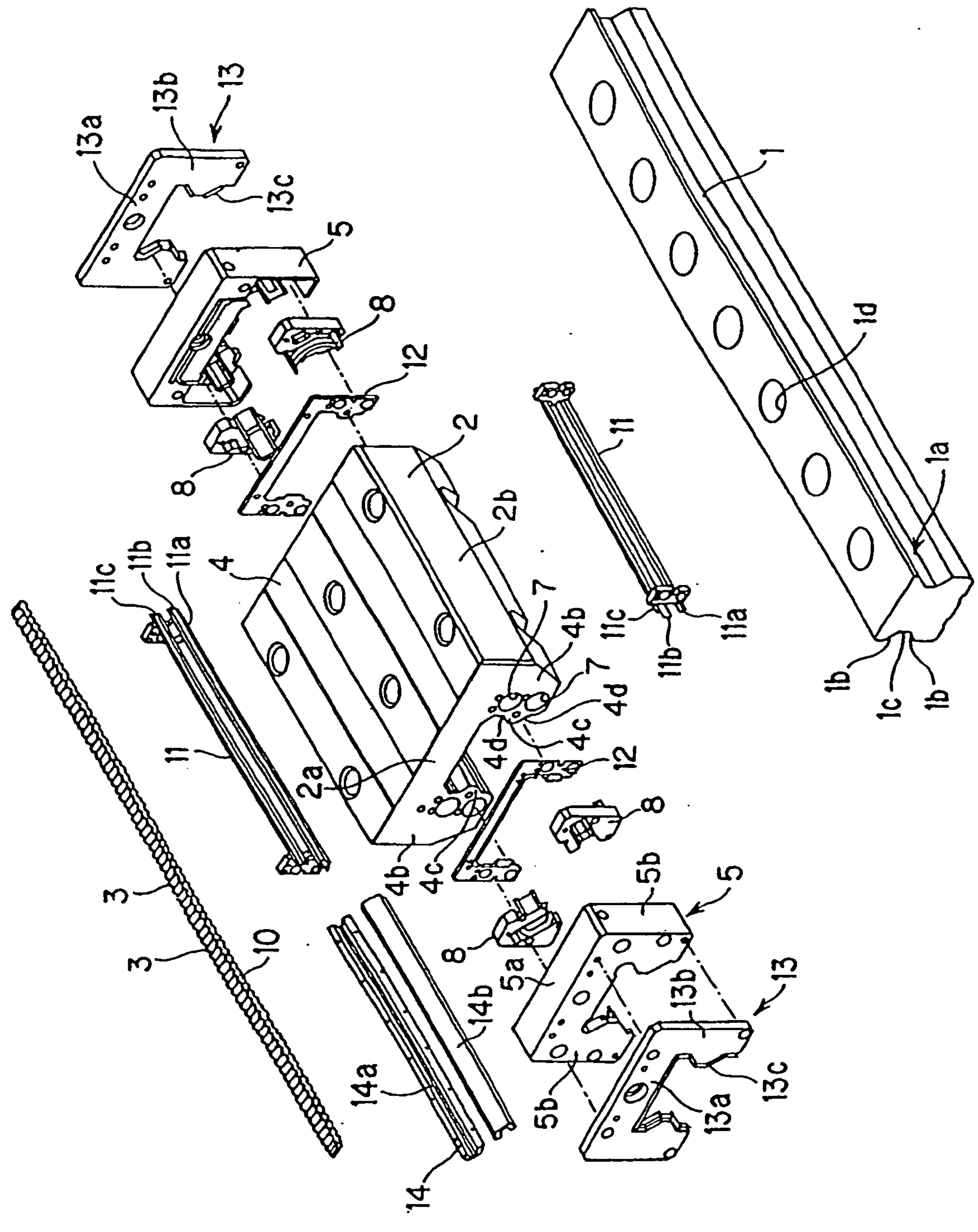


FIG. 2

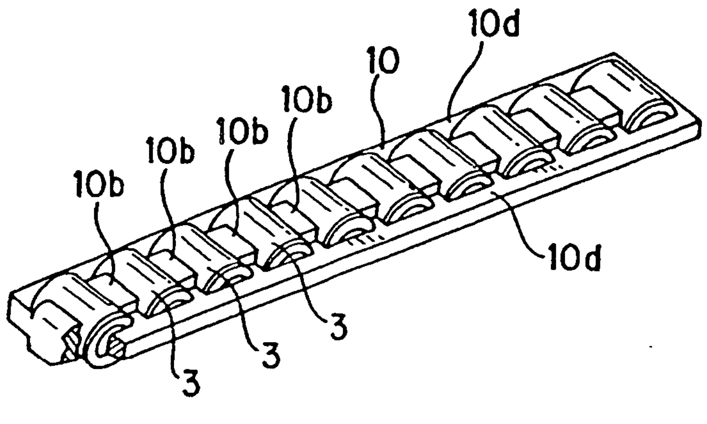


FIG. 3B

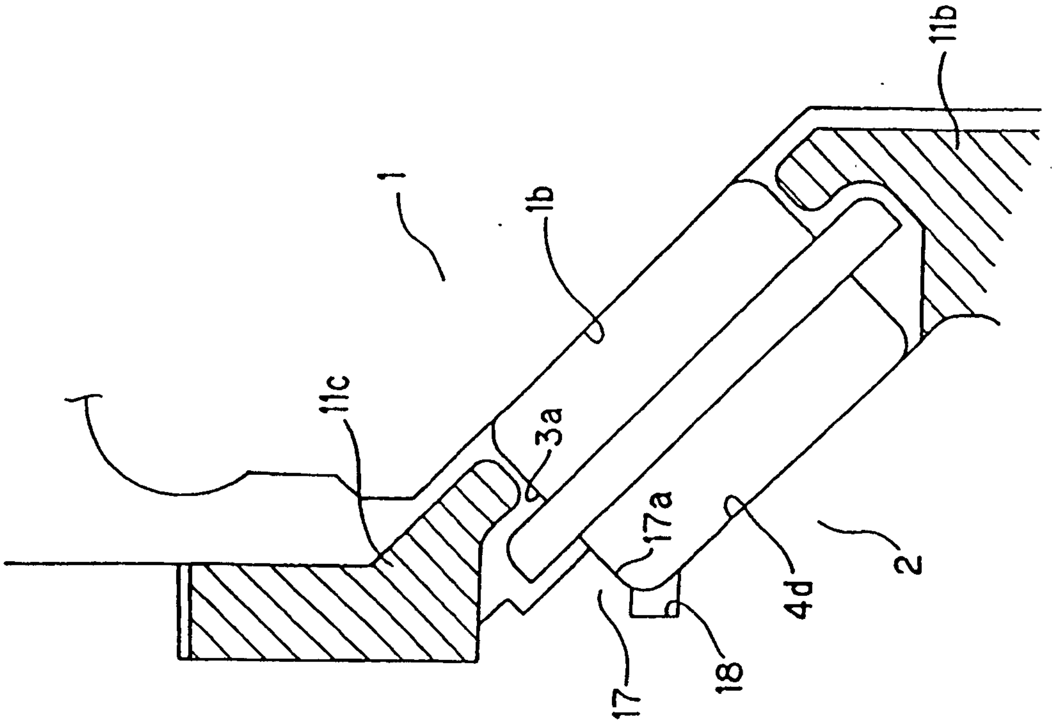

1
1b
11b
11c
3a
17a
4d
2
17
18

FIG. 3A

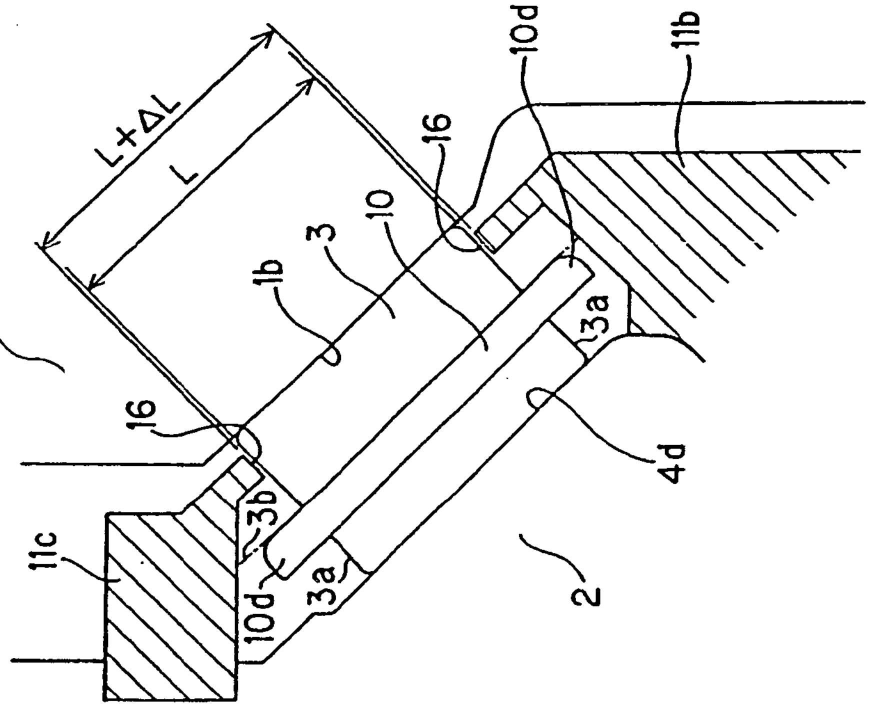
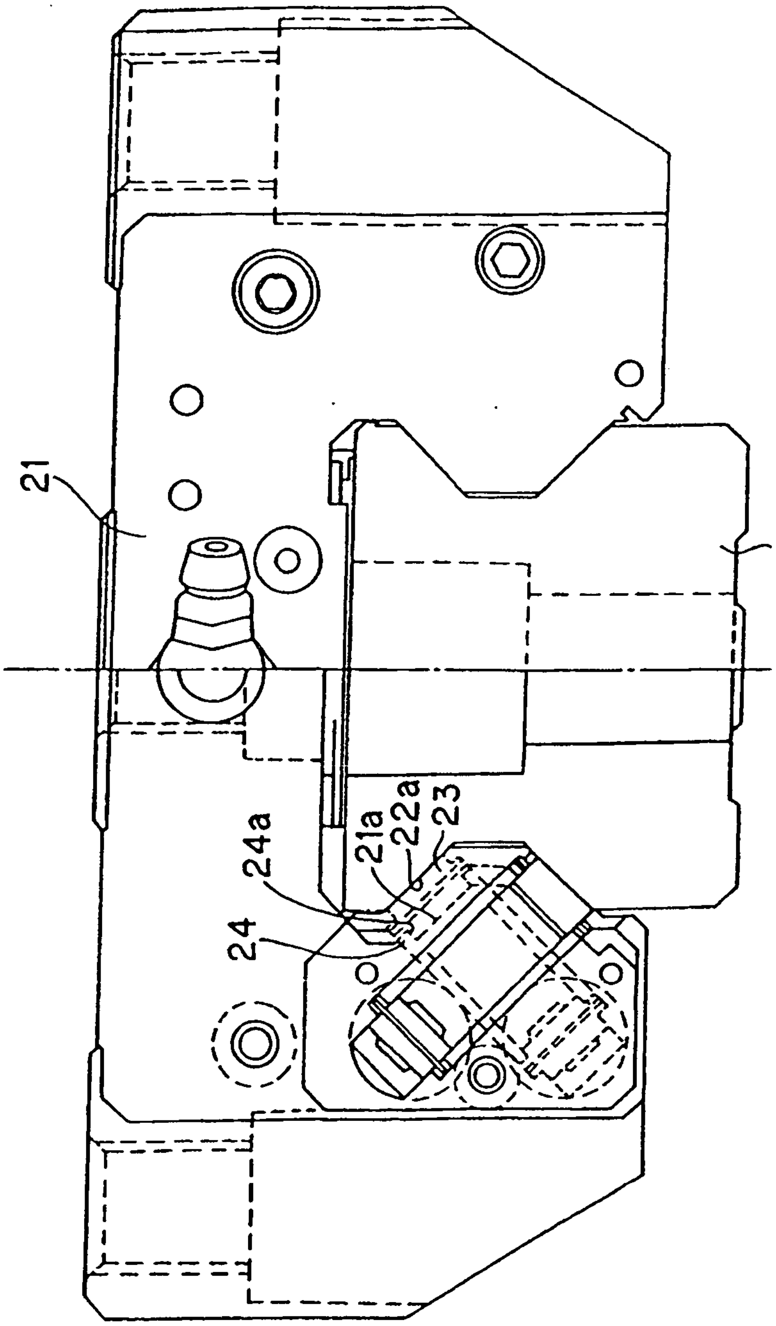

L+ΔL
L
1
16
1b
3
10
10d
11b
3a
4d
2
11c
3b
10d
3a

FIG. 4



(19)
Bundesrepublik Deutschland
Deutsches Patent- und Markenamt

(10) **DE 600 24 741 T2** 2006.07.06

(12)
Übersetzung der europäischen Patentschrift

(97) **EP 1 083 347 B1**
(21) Deutsches Aktenzeichen: **600 24 741.4**
(96) Europäisches Aktenzeichen: **00 307 728.6**
(96) Europäischer Anmeldetag: **07.09.2000**
(97) Erstveröffentlichung durch das EPA: **14.03.2001**
(97) Veröffentlichungstag der Patenterteilung beim EPA: **14.12.2005**
(47) Veröffentlichungstag im Patentblatt: **06.07.2006**

(51) Int Cl.[8]: ***F16C 29/06*** (2006.01)

(30) Unionspriorität:
25257299 07.09.1999 JP

(84) Benannte Vertragsstaaten:
DE, FR, GB, IT

(73) Patentinhaber:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Grünecker, Kinkeldey, Stockmair & Schwanhäusser, 80538 München

(72) Erfinder:
Michioka, Hidekazu, Tokyo, JP; Matsumoto, Yasuhiro, Tokyo, JP; Nakabayashi, Hiroshi, Nakakoma-gun, Yamanashi-ken, JP; Iida, Katsuya, Nakakoma-gun, Yamanashi-ken, JP; Yatsushiro, Daisuke, Nakakoma-gun, Yamanashi-ken, JP

(54) Bezeichnung: **Herstellungsverfahren von einer Wälzkörperkette**

Beschreibung

[0001] Die vorliegende Erfindung betrifft ein Verfahren zum Herstellen einer Wälzkörperkette, bei der eine Anzahl von Wälzkörpern in einer Reihe mit vorgeschriebenen Abständen ausgerichtet ist und wälzbar gehalten wird, und die verwendet wird, indem sie zum Beispiel in eine Geradführung zur endlosen Gleitbewegung eingebaut wird. Spezieller betrifft die Erfindung eine verbesserte Wälzkörperkette, deren Zug- und Biegefestigkeit erhöht ist.

[0002] Normalerweise ist die bekannte Geradführung, um einen beweglichen Körper wie einen Tisch längs des feststehenden Teils wie zum Beispiel ein Bett zu führen, von der Art, die einen Rollweg mit einer Kugellaufrille, ein Gleitstück mit einer der Kugellaufrille gegenüber liegenden belasteten Laufrille und einem lastfreien Rollweg, in dem die Kugel von einem Ende zum anderen Ende der belasteten Laufrille in Umlauf gebracht wird und sich längs des Rollweges bewegt, sowie eine Anzahl von Kugeln umfasst, die zwischen dem Gleitstück und dem Rollweg unter Belastungsbedingungen rollen und längs der endlosen Laufrille, die aus einer belasteten Laufrille und einem lastfreien Rollweg des Gleitstücks besteht, umlaufen.

[0003] In der normalen Geradführung neigen die benachbarten Kugeln in dieser Anordnung bei ihrem Umlauf längs der endlosen Laufrille, wenn sich das Gleitstück längs des Rollwegs bewegt, dazu, miteinander zu kollidieren oder gegeneinander zu reiben, da die endlose Laufrille des Gleitstücks mit Kugeln gefüllt ist, was zu einem früheren Verschleiß von Kugeln und einer kürzeren Betriebslebensdauer der Vorrichtung führt.

[0004] Um das oben beschriebene Problem zu lösen, wurde deshalb eine Geradführung vorgeschlagen, die eine Wälzkörperkette mit einer Vielzahl von Kugeln enthält, die in einer Reihe in der endlosen Laufrille ausgerichtet sind (siehe Japanische Offenlegungsschrift Nr. 5-52217 oder EP-A-890 754). Wie in den vorliegenden Fig. 17 und Fig. 18, die den Fig. 16 und Fig. 17 von EP-A-890 754 entsprechen, gezeigt ist, umfasst die Wälzkörperkette **100** die Kugelhalteelemente **102**, die zwischen den jeweiligen benachbarten Kugeln **101** eingelegt sind, und ist derart aufgebaut, dass die Kugeln aufeinander folgend verbunden sind, indem die jeweiligen Kugelhalteelemente **102** mit einem Paar von Lochkranzelementen **103**, die in Richtung der Ausrichtung der Kugeln **101** angeordnet sind, verbunden werden, und wird durch Spritzgießen eines elastischen Kunstharzes hergestellt, wobei die Kugeln **101** in einer Form als Kernstücke angeordnet sind.

[0005] Bei der in dieser Weise angeordneten normalen Wälzkörperkette **100**, die in die endlose Laufrille **105** eingebaut ist und längs der endlosen Laufrille gemäß der vorliegenden Fig. 19, die der Fig. 18 von EP-A-890 754 entspricht, umläuft, wird verhindert, dass Reibung oder Zusammenstoß zwischen Kugeln auftritt, und Reibungsverschleiß der Kugeln **101** soweit wie möglich vermieden werden kann, da die Kugelhalteelemente **102** zwischen den jeweiligen benachbarten Kugeln **101** eingelegt sind.

[0006] Da beim herkömmlichen Verfahren eine längliche Wälzkörperkette der Länge, die einer Kreisbahn der endlosen Laufrille entspricht, durch Spritzgießen hergestellt wird, gab es dadurch ein Problem, dass eine Anzahl von Zugängen vorgesehen werden muss, um geschmolzenes Kunstharz in einen Hohlraum in der Form einzuspritzen, damit sich das Lochkranzelement **103** zum Verbinden der jeweiligen Kugelhalteelemente **102** zu einer gleichmäßigen Dicke formen lässt, wodurch die Form komplex wird und sich die Kosten erhöhen.

[0007] Es gab ein anderes Problem darin, dass es in Anbetracht der weiteren Verkleinerung der Geradführung erforderlich ist, das dünnere Lochkranzelement für die Wälzkörperkette in die endlose Laufrille einzubauen und eine Abnahme der Zug- und Biegefestigkeit des Lochkranzelements, die mit dessen Verdünnen verbunden ist, einen Bruch der Wälzkörperkette in der endlosen Laufrille verursachen kann, wodurch die Fähigkeit der Wälzkörperkette, die Kugeln festzuhalten, nachteilig beeinflusst wird.

[0008] Es gab noch ein weiteres Problem darin, dass das von dem Zugang aus eingespritzte geschmolzene Kunstharz nicht den tiefsten Teil des Hohlraums in der Form erreichen kann, wenn das weitere Verdünnen des Lochkranzelements in Erwägung gezogen wird, was zu einer Anzahl von schadhaften Formteilen führt und somit Fertigungen reduziert.

[0009] Die vorliegende Erfindung ist auf die oben beschriebenen Probleme gerichtet und folglich ist es eine Aufgabe zumindest von bevorzugten Ausführungen, ein Verfahren zum Herstellen einer Wälzkörperkette bereitzustellen, durch welches eine weiter verkleinerte Wälzkörperkette mit geringen Kosten leicht hergestellt werden kann und durch das auch nach dem Verkleinern eine Wälzkörperkette mit ausgezeichneter Zugfestigkeit und Biegefestigkeit hergestellt werden kann.

[0010] EP-A-0 890 754 offenbart eine Wälzkörperkette mit einer Anzahl von Wälzelementen, wobei die Kette in einer Ausführung aus einem mit Durchgangslöchern ausgebildeten, streifenförmigen Feinblech aus rostfreiem Stahl gebildet ist, auf das Abstandsstücke aufgepolstert sind, die aus Kunstharz durch Spritzgießen mit den als Kernstücke verwendeten Kugelmatrizen oder den als Kernstücke verwendeten Wälzelementen gebildet sind.

[0011] Aus der Sicht von einer Ausführung stellt die vorliegende Erfindung ein Verfahren zum Herstellen einer Wälzkörperkette zur Verfügung, die eine Anzahl von Wälzelementen aufweist, die darin in vorgeschriebenen Abständen ausgerichtet sind und wälzbar gehalten werden, wobei das Verfahren umfasst:
Bilden eines flachen, bandförmigen Lochkranzelements;
Bilden von Käfiglöchern, um die Wälzelemente in einer Reihe auf dem Lochkranzelement lose aufzunehmen; und
Bilden von Abstandsbereichen durch Spritzgießen, um die Wälzelemente zwischen den benachbarten Käfiglöchern zu halten;
dadurch gekennzeichnet, dass das flache, bandförmige Lochkranzelement gebildet wird, indem ein längliches, flaches, bandförmiges Element aus einem Spritzwerkzeug durch Strangpressen eines Kunstharzes extrudiert wird, während ein verstärkendes Material eingebaut wird, und das flache, bandförmige Element zu einer vorgeschriebenen Länge geschnitten wird;
und dadurch, dass die Abstandsbereiche durch Ausrichten der Wälzelemente in den Käfiglöchern gebildet und die Abstandsbereiche mit den als Kernstücke verwendeten Wälzelementen spritzgegossen werden, so dass die Wälzelemente in den Käfiglöchern eingeschlossen sind.

[0012] So umfasst das Verfahren nach der ersten Ausführung einen ersten Schritt zum Bilden eines flachen, bandförmigen Lochkranzelements mit einem Kunstharz durch Strangpressen und Schneiden auf eine erforderliche Länge, einen zweiten Schritt zum Bilden von in einer Reihe ausgerichteten Käfiglöchern auf dem Lochkranzelement, um Wälzelemente lose aufzunehmen, und einen dritten Schritt zum Anordnen der Wälzelemente in den jeweiligen Käfiglöchern, Bilden von Abstandsbereichen zwischen den jeweiligen benachbarten Käfiglöchern, um die Wälzelemente darin festzuhalten, durch Spritzgießen mit diesen als Kernstücke verwendeten Wälzelementen und Einschließen der Wälzelemente in den Käfiglöchern. Da die Abstandsbereiche gebildet werden, nachdem das flache, bandförmige Lochkranzelement in dem ersten Schritt geformt ist und die Wälzelemente dann in den auf dem Lochkranzelement ausgebildeten Käfiglöchern eingeschlossen werden, kann das Lochkranzelement anschließend durch Strangpressen, nicht durch Spritzgießen, eines Kunstharzes in einem langen Streifen gebildet werden. Deshalb kann ein Lochkranzelement gleichmäßiger Dicke auch dann formfest gebildet werden, wenn die Dicke des Lochkranzelements in Verbindung mit einer Verkleinerung der Wälzkörperkette verringert ist.

[0013] Da das Lochkranzelement und die Abstandsbereiche getrennt geformt werden, kann das Lochkranzelement außerdem aus einem Kunstharzmaterial gebildet werden, das vollkommen anders als ein für die Abstandsbereiche verwendeter Formwerkstoff ist. Daher kann dadurch, dass das Lochkranzelement mit einem Kunstharz gebildet wird, dessen Zug- oder Biegefestigkeit durch Hinzufügen zum Beispiel von Kohlenstofffüller verbessert worden ist, eine Wälzkörperkette hoher Zugfestigkeit auch dann hergestellt werden, wenn die Dicke des Lochkranzteils reduziert ist. Andererseits kann, da die Abstandsbereiche in Gleitberührung mit den Wälzelementen gehalten werden sollen, das Material für die Abstandsbereiche so ausgewählt werden, dass es einen geringen Reibungskoeffizient wie zum Beispiel Ölharz aufweist, wodurch eine ruhige Drehung der Wälzelemente gewährleistet wird.

[0014] Der Einbau eines verstärkenden Materials wie zum Beispiel eine Kohlefaser oder eine Glasfaser in der Länge des Lochkranzelements, wenn dieses durch Strangpressen geformt wird, lässt dadurch eine Erhöhung der Zugfestigkeit des Lochkranzelements auch dann zu, wenn die Zug- oder Biegefestigkeit des das Lochkranzelement bildenden Kunstharzes gering ist.

[0015] Wie soweit beschrieben, kann nach dem Verfahren zum Herstellen der Wälzkörperkette nach der vorliegenden Erfindung das Band aufeinander folgend in einem langen Streifen durch Strangpressen, jedoch nicht durch Spritzgießen, gebildet werden, da die Abstandsbereiche zum Festhalten des Wälzelements innerhalb des Lochkranzelements durch Spritzgießen geformt werden, nachdem das Lochkranzelement zum Ausrichten der Wälzelemente geformt ist, wodurch ein Lochkranzelement gleichmäßiger Dicke bei niedrigen Kosten leicht gebildet werden kann, auch wenn die Dicke des Lochkranzelements in Verbindung mit einer Verkleinerung der Wälzkörperkette verringert wird.

[0016] Aus der Sicht einer anderen Ausführung stellt die vorliegende Erfindung ein Verfahren zum Herstellen einer Wälzkörperkette mit einer Anzahl von Wälzelementen bereit, die darin in vorgeschriebenen Abständen ausgerichtet sind und wälzbar gehalten werden, wobei das Verfahren umfasst:
Bilden eines flachen, bandförmigen Lochkranzelements;
Bilden von Käfiglöchern, um die Wälzelemente lose in einer Reihe auf dem Lochkranzelement aufzunehmen; und
Ausrichten von Wälzelementmodellen in den Käfiglöchern, wobei die Wälzelementlöcher im Durchmesser etwas größer sind als die Wälzelemente, und Bilden von Abstandsbereichen zum Halten der Wälzelemente zwischen den benachbarten Käfiglöchern durch Spritzgießen mit den als Kernstücke verwendeten Wälzelementmodellen und Ersetzen der Wälzelementmodelle durch die Wälzelemente, nachdem die Abstandsbereiche durch Spritzgießen geformt sind;

dadurch gekennzeichnet, dass das flache, bandförmige Lochkranzelement durch Strangpressen eines länglichen, flachen, bandförmigen Elements aus einem Spritzwerkzeug durch Strangpressen eines Kunstharzes geformt wird, während ein verstärkendes Material eingebaut wird, und Schneiden des flachen, bandförmigen Elements auf eine vorgeschriebene Länge.

[0017] Der dritte Schritt kann als das Ausrichten von Wälzelement-Kerneinrichtungen in den Käfiglöchern und das Bilden von Abstandsbereichen gesehen werden, um die Wälzelemente zwischen den benachbarten Käfiglöchern durch Spritzgießen mit den als Kernstücke verwendeten Wälzelement-Kerneinrichtungen zu halten. In der Erfindung aus Sicht der ersten Ausführung umfassen die Wälzelement-Kerneinrichtungen die Wälzelemente und werden innerhalb der Käfiglöcher durch das spritzgegossene Teil festgehalten. In der Erfindung aus Sicht der zweiten Ausführung sind die Wälzelement-Kerneinrichtungen Wälzelementmodelle, die einen etwas größeren Durchmesser als die Wälzelemente aufweisen, und werden durch die Wälzelemente ersetzt, nachdem die Abstandsbereiche gebildet sind.

[0018] Es werden jetzt mit Bezug auf die begleitenden Zeichnungen Ausführungen nach der Erfindung nur beispielhaft beschrieben, wobei

[0019] Fig. 1 ist eine Draufsicht, die eine erste Ausführung einer Wälzkörperkette darstellt, die nach einem Verfahren gemäß der vorliegenden Erfindung hergestellt wurde;

[0020] Fig. 2 ist eine die Wälzkörperkette von Fig. 1 darstellende Ansicht im Querschnitt, der längs der Linie II-II geführt ist;

[0021] Fig. 3 ist eine die Wälzkörperkette nach der ersten Ausführung darstellende Vorderansicht;

[0022] Fig. 4 ist eine perspektivische Darstellung, die das Lochkranzelement nach der ersten Ausführung darstellt, das in dem ersten Schritt eines Verfahrens gemäß der vorliegenden Erfindung gebildet ist;

[0023] Fig. 5 ist eine perspektivische Ansicht, die zeigt, wie die Kugelkäfiglöcher auf dem Streifen nach der ersten Ausführung ausgebildet sind und wie die Kugeln in den Kugelkäfiglöchern ausgerichtet sind;

[0024] Fig. 6 ist eine perspektivische Ansicht, die den Zustand zeigt, wie die Abstandsbereiche durch Spritzgießen auf dem Lochkranzelement nach der ersten Ausführung, das darin ausgerichtete Kugeln aufweist, gebildet sind;

[0025] Fig. 7 ist eine Draufsicht, die eine zweite Ausführung der Wälzkörperkette darstellt, die nach einem Verfahren entsprechend der vorliegenden Erfindung hergestellt ist;

[0026] Fig. 8 ist eine Ansicht der Wälzkörperkette von Fig. 7 im längs der Linie VIII-VIII geführten Schnitt;

[0027] Fig. 9 ist eine Ansicht der Wälzkörperkette von Fig. 8 im längs der Linie IX-IX geführten Schnitt;

[0028] Fig. 10 ist eine perspektivische Ansicht der zweiten Ausführung, die in dem ersten Schritt des Verfahrens nach der vorliegenden Erfindung gebildet ist;

[0029] Fig. 11 ist eine Zeichnung, die einen Schritt zum Bilden des Lochkranzelements nach der zweiten Ausführung veranschaulicht, das darin verstärkendes Material aufweist, das durch Strangpressen eines Kunstharzes eingebaut wird;

[0030] Fig. 12 ist eine Zeichnung, die einen Schritt zum Bilden des Lochkranzelements nach der zweiten Ausführung durch Strangpressen mit zwei Arten von Kunstharz, deren physikalische Eigenschaften sich voneinander unterscheiden, veranschaulicht;

[0031] Fig. 13 ist eine perspektivische Ansicht, die zeigt, wie die Kugelkäfiglöcher auf dem Streifen der zweiten Ausführung ausgebildet sind und wie die Kugeln in den Kugelkäfiglöchern ausgerichtet sind;

[0032] Fig. 14 ist eine perspektivische Ansicht, die den Zustand zeigt, wie die Abstandsbereiche durch Spritzgießen auf dem Lochkranzelement nach der zweiten Ausführung mit darin ausgerichteten Kugeln gebildet sind;

[0033] Fig. 15 ist eine perspektivische Ansicht, die zeigt, wie die Walzenkäfiglöcher auf dem Streifen ausgebildet sind und wie die Walzen in den Walzenkäfiglöchern ausgerichtet sind;

[0034] Fig. 16 ist eine perspektivische Ansicht, die den Zustand zeigt, wie die Abstandsbereiche durch Spritzgießen auf dem Lochkranzelement mit darin ausgerichteten Walzen gebildet sind;

[0035] Fig. 17 ist eine Draufsicht, die die herkömmliche Wälzkörperkette darstellt;

[0036] Fig. 18 ist eine Vorderansicht, die die herkömmliche Wälzkörperkette darstellt; und

[0037] Fig. 19 ist eine Querschnittsansicht, die den Zustand zeigt, bei dem die Wälzkörperkette in den endlosen Laufring der Geradführung eingebaut ist.

[0038] Mit Bezug jetzt auf die Zeichnungen werden bevorzugte Ausführungen der vorliegenden Erfindung beschrieben.

[0039] Fig. 1 bis Fig. 3 zeigen eine erste Ausführung einer nach einem Verfahren der vorliegenden Erfindung hergestellten Wälzkörperkette. Die Wälzkörperkette **1** umfasst ein aus einem Kunstharz gebildetes Kettenband **2** und Kugeln **3** als Wälzkörper, die in einer Reihe in vorgeschriebenen Abständen ausgerichtet sind, wobei diese Kugeln **3** in dem Zustand, wo sie in dem Kettenband **2** festgehalten werden, wälzbar sind.

[0040] Das Kettenband **2** umfasst ein Lochkranzelement **21**, das in der flachen Bandform ausgebildet ist und Käfiglöcher **20** aufweist, um Kugeln **3** in vorgeschriebenen Abständen festzuhalten, und Abstandsbereiche **22**, die von beiden Flächen des Lochkranzelements **21** zwischen den entsprechenden benachbarten Käfiglöchern **20** hervorstehen, wobei die Kugeln **3** innerhalb der Käfiglöcher **20** des Lochkranzelements **21** durch die jeweiligen Abstandsbereiche **22** wälzbar eingeschlossen sind.

[0041] Das Verfahren zum Herstellen der Wälzkörperkette **1** wird jetzt schrittweise beschrieben.

[0042] Fig. 4 zeigt ein Lochkranzelement **21**, das in dem ersten Schritt gemäß der vorliegenden Erfindung gebildet wurde. Das Lochkranzelement **21** wird durch Spritzgießen eines Kunstharzes hergestellt. Das aus dem Spritzwerkzeug fortlaufend extrudierte Lochkranzelement **21** wird in einem Wassertank abgekühlt und anschließend durch eine Spule aufgewickelt. Im folgenden Schritt wird das auf die Spule aufgewickelte Lochkranzelement **21** auf eine vorgeschriebene Länge geschnitten und verwendet.

[0043] Weil das Lochkranzelement **21**, bevor daran die Abstandsbereiche **22** angebaut werden, über seine Länge einen gleichmäßigen Querschnitt aufweist, kann durch Strangpressen ein Lochkranzelement **21** von gleichmäßiger Dicke bei geringen Kosten leicht gebildet werden, auch wenn das Lochkranzelement **21** dünn ist.

[0044] Das auf diese Weise gebildete Lochkranzelement **21** wird auf eine Länge geschnitten, die einer Kreisbahn des endlosen Laufrings der Geradführung entspricht, und dann mit Käfiglöchern **20** ausgebildet, um die Kugeln **3** längs ihrer Länge in vorgeschriebenen Abständen festzuhalten. Jedes Käfigloch **20** ist derart geformt, dass dessen Innendurchmesser etwas größer ist als der Durchmesser der Kugel **3**, so dass die Kugel **3** ohne Reibung eingelegt und herausgenommen werden kann. Das Spritzgießen der Abstandsbereiche **22** wird mit den innerhalb dieser Käfiglöcher **20** ausgerichteten Kugeln **3** durchgeführt.

[0045] Das Spritzgießen wird in dem Zustand durchgeführt, wo das zu einer vorgeschriebenen Länge geschnittene Lochkranzelement **21** bei einer vorgeschriebenen Position in die Form gesetzt wird und die Kugeln **3** in den jeweiligen, auf dem Lochkranzelement **21** ausgebildeten Käfiglöchern **20** angeordnet werden, wobei dieses Lochkranzelement **21** und die Kugeln **3** als Kernstücke verwendet werden. Die Abstandsbereiche **22** sind zwischen den jeweiligen benachbarten Käfiglöchern **20** auf dem Lochkranzelement **21** aufgebaut, damit sie einen Teil der Flächen der Kugeln **3** bedecken, wobei die teilweise bedeckten Kugeln **3** innerhalb der Käfiglöcher **20** des Lochkranzelements **21** eingeschlossen sind. Dementsprechend ist gemäß Fig. 6 ein Kettenband **2** fertig, das auf dem Lochkranzelement **21** in vorgeschriebenen Abständen ausgerichtete und festgehaltene Kugeln **3** aufweist. Beim Spritzgießen der Abstandsbereiche **22** wird wie im Fall der Formung des Lochkranzelements **21** ein Kunstharz wie zum Beispiel Polyamid-Elastomer oder Polyester-Elastomer verwendet. Durch Bildung der Abstandsbereiche **22** durch Spritzgießen unter Verwendung des gleichen Kunstharzes wie das Lochkranzelement **21**, werden die Abstandsbereiche **22** an das Lochkranzelement **21** geschweißt, wenn es geformt ist, und als Folge werden das Abstandsteil **22** und das Lochkranzelement **21** fest eingebaut.

[0046] Wenn die Abstandsbereiche **22** durch Spritzgießen mit den Kugeln **3** als Kernstücke gebildet sind, kommen die Abstandsbereiche **22** mit den Flächen der Kugeln **3** in engen Kontakt, wodurch verhindert wird, dass die Kugel ruhig läuft. Deshalb wird bei Beendigung dieses Spritzgießens das Lochkranzelement **21** einen bestimmten Zeitraum lang in Öl eingetaucht. Da das aus einem Kunstharz gebildete Kettenband **2** Öl aufnimmt und somit anschwillt, werden zwischen den Abstandsbereichen **22** und den Kugeln **3** kleine Spalte gebildet, nachdem ein vorgeschriebener Zeitraum verstrichen ist, wodurch ungehindertes Rollen der Kugeln **3** ermöglicht wird, ohne dass sie aus den Käfiglöchern **20** herausfallen. Die Wälzkörperkette **1** ist damit fertig.

[0047] Andererseits ist es auch möglich, die Abstandsbereiche **22** zu formen, indem Kugelmodelle (Wälzkörpermodell), die im Durchmesser etwas größer sind als die Kugeln **3**, in den Käfiglöchern **20** des Lochkranzelements **21** ausgerichtet werden und mit den Kugelmodellen und dem Lochkranzelement **21**, die als Kernstücke verwendet werden, zu formen. Wenn die Kugeln **3** als Kernstücke verwendet werden, ist der Schritt zum Bilden von Spalten zwischen den jeweiligen Kugeln **3** und Abstandsbereichen **22** nach Beendigung der Formung der Abstandsbereiche **22** wie oben beschrieben erforderlich. Andererseits werden die Abstandsbereiche **22** in dem Fall, wo die Kugelmodelle als Kernstücke verwendet werden, entsprechend kleiner, weil die Kugelmodelle etwas größer sind als die Kugeln **3**. Deshalb können die Kugeln **3** dadurch, dass die Kugelmodelle aus dem Kettenband **2** gedrückt und anschließend stattdessen Kugeln **3** eingesetzt werden, wenn die Formung der Abstandsbereiche **22** beendet ist, in den Käfiglöchern **20** ungehindert rollen, ohne den Zeit raubenden Schritt, das Kettenband **2** einen vorgeschriebenen Zeitraum lang in Öl zu tauchen.

[0048] Nach dem Verfahren zum Herstellen der wie oben beschriebenen Wälzelementkette **1** ist die Bildung einer länglichen Wälzelementkette in einer Form durch Spritzgießen wie auf die herkömmliche Art und Weise nicht mehr notwendig, und die ein dünnes Lochkranzelement **21** umfassende Wälzelementkette **1** kann einfach mit geringen Kosten und dauerhaft hergestellt werden.

[0049] Nach dem Verfahren zum Herstellen der soweit beschriebenen Wälzkörperkette **1** wird für das Lochkranzelement **21** das gleiche Material wie für das Abstandsteil **22** verwendet und ein verstärkendes Material (nicht dargestellt) innerhalb des Lochkranzelements **21** eingebaut, um die Zugfestigkeit und die Biegefestigkeit des Lochkranzelements **21** zu erhöhen. Es ist jedoch außerdem möglich, die Zugfestigkeit und die Biegefestigkeit des Lochkranzelements **21** zu erhöhen, indem Kohlenstofffüller oder dergleichen zu dem Material für das Lochkranzelement **21** selbst zugegeben werden, um eine Verschlechterung der Zugfestigkeit und der Biegefestigkeit des Lochkranzelements **21** verbunden mit der Verringerung seiner Dicke zu kompensieren.

[0050] Fig. 7 bis Fig. 9 stellen eine zweite Ausführung einer Wälzkörperkette dar, die nach dem Verfahren der vorliegenden Erfindung hergestellt wurde.

[0051] Die Wälzkörperkette **1A** besitzt fast den gleichen Aufbau wie die Wälzkörperkette **1** nach der ersten Ausführung. Jedoch enthält das Lochkranzelement **21** wie es in Querschnitten von Fig. 8 und Fig. 9 dargestellt ist, ein verstärkendes Material wie zum Beispiel eine Glasfaser, eine Kohlefaser oder eine keramische Faser, die in beiden Kantenbereichen entlang ihrer Länge eingebaut sind. Deshalb wird, wenn die Zugkraft entlang der Länge des Kettenbandes **2** aufgebracht wird, das verstärkende Material **23** durch die Zugkraft belastet, wodurch der Bruch des Kettenbandes **2** wirksamer als in der ersten Ausführung verhindert werden kann. Mit den gleichen Bezugszahlen werden Komponenten, die der ersten Ausführung gleich sind, bezeichnet und eine ausführliche Beschreibung wird weggelassen.

[0052] Das Verfahren zum Herstellen der Wälzelementkette **1A** wird jetzt schrittweise beschrieben.

[0053] Fig. 10 zeigt ein in dem ersten Schritt nach der vorliegenden Erfindung gebildetes Lochkranzelement **21**. Das Lochkranzelement **21** ist durch Strangpressen eines Kunstharzes hergestellt, und ein oben beschriebenes verstärkendes Material **23** wird während des Strangpressens darin eingebaut.

[0054] Fig. 11 ist eine schematische Darstellung, die den Schritt der Ausführung von Strangpressen des Lochkranzelementes **21** zeigt, während ein verstärkendes Material eingebaut wird. Das verstärkende Material **23** ist auf einer Spule **4** mit großem Durchmesser aufgewickelt. Das von der Spule **4** abgewickelte verstärkende Material **23** wird durch die Vorwärmeinrichtung **5** vorgewärmt, anschließend durch den Ziehdorn **7** der Kreuzkopfmatrize **6** hindurch gelassen und aus dem Spritzwerkzeug **8** herausgezogen. Geschmolzenes Kunstharz wie zum Beispiel Polyamid-Elastomer oder Polyester-Elastomer wird in die Kreuzkopfmatrize **6** durch eine nicht gezeigte Schnecke gedrückt und um das verstärkende Material **23** herum aufgebaut, wenn es aus dem Spritzwerkzeug **8** extrudiert wird, wodurch ein längliches Lochkranzelement **21** aufeinanderfolgend aus der Kreuzkopfmatrize **6** extrudiert wird. Das extrudierte Lochkranzelement **21** wird in dem Wassertank **9** abgekühlt und anschließend durch die Spule **10** aufgewickelt, wobei es zu einer vorgeschriebenen Länge geschnitten und in einem anschließenden Schritt verwendet wird.

[0055] Das verstärkende Material **23** braucht nicht zwangsläufig selbst eine Glasfaser zu sein, sondern kann eine Kunstfaser sein, deren Zugfestigkeit oder Biegefestigkeit durch das Hinzugeben von Kohlenstofffüller oder dergleichen verbessert worden ist. In diesem Fall kann doppelschichtiges Strangpressen eingesetzt werden, um das Lochkranzelement **21** der in Fig. 10 gezeigten Form zu bilden. Gemäß Fig. 12 werden zwei Extruder **11**, **12** bei diesem doppelschichtigen Extrudieren verwendet. Nach dem Erstarren eines Kunstharzes zum Bilden eines verstärkenden Materials im Trichter **13** der Schneckenpresse **11** und eines Kunstharzes zum Überziehen des verstärkendes Material im Trichter **14** der anderen Schneckenpresse **12** werden diese Kunstharze aus der gemeinsamen Düse **15** extrudiert. Anschließend wird, wie in Fig. 11, das extrudierte Lochkranzelement **21** in dem Wassertank abgekühlt und durch die Spule gewickelt, und es kann ein längliches Lochkranzelement **21** einschließlich eines Kunstharzes von hoher Zugfestigkeit und Biegefestigkeit als ein verstärkendes Material **23**, das mit einer anderen Art von Kunstharz überzogen ist, erzielt werden.

[0056] Auf diese Weise besitzt das Lochkranzelement **21**, auch wenn ein verstärkendes Material **23** innerhalb des Lochkranzelements **21** eingebaut ist, einen gleichmäßigen Querschnitt entlang seiner Länge, bevor das Abstandsteil **22** darauf aufgebaut ist, wobei das Lochkranzelement **21** gleichmäßiger Dicke mit geringen Kosten wie im Fall der ersten Ausführung einfach gebildet werden kann.

[0057] Anschließend wird das Formen des Abstandsteils **22** in der gleichen Art und Weise wie bei der Wälzkörperkette **1** nach der ersten Ausführung durchgeführt.

[0058] Mit anderen Worten, das Lochkranzelement **21**, das in die einer Kreisbahn des Laufrings der endlosen Geradführung entsprechende Länge geschnitten ist, wird mit Käfiglöchern **20** ausgebildet, um die Kugeln **3** entlang ihrer Länge in vorgeschriebenen Abständen gemäß Fig. 13 festzuhalten, wobei Spritzgießen der Abstandsbereiche **22** mit den in diesen Käfiglöchern **20** ausgerichteten Kugeln **3** durchgeführt wird. Das Kettenband **2** wird, nachdem das Formen des Abstandsteils **22** beendet ist, einen bestimmten Zeitraum lang in Öl eingetaucht, wodurch Spalte zwischen den Abstandsbereichen **22** und den Kugeln **3** gebildet werden, die das Rollen der Kugeln **3** ermöglichen. Im Ergebnis ist, wie in Fig. 14 gezeigt wird, die Wälzkörperkette **1A** nach der zweiten Ausführung mit einem darin eingebauten verstärkenden Material **23** fertig.

[0059] In den Ausführungen werden, wie es soweit beschrieben ist, Kugeln als in dem Lochkranzelement auszurichtende Wälzelemente verwendet. Jedoch kann diese Erfindung auf den Fall angewandt werden, wo als Wälzelemente Walzen eingesetzt werden. Spezieller wird gemäß Fig. 15, nachdem Käfiglöcher **31** für Walzen **30** auf dem Lochkranzelement **21** entlang seiner Länge in vorgeschriebenen Abständen geformt sind, gemäß Fig. 16 mit den in diesen Käfiglöchern **31** ausgerichteten Walzen **30** Spritzgießen durchgeführt. Folglich sind die Walzen **30** innerhalb der Käfiglöcher **31** des Lochkranzelements **21** eingeschlossen und, wie es in dem Fall ist, wo die Kugeln **3** als Wälzelemente eingesetzt sind, kann das Kettenband **2** mit den in dem Lochkranzelement **21** in vorgeschriebenen Abständen ausgerichteten und festgehaltenen Walzen **30** fertig gestellt werden.

Patentansprüche

1. Verfahren zum Herstellen einer Wälzkörperkette (**1**; **1A**) mit einer Anzahl von Wälzkörpern (**3**; **30**), die darin in vorgeschriebenen Abständen ausgerichtet sind und wälzbar gehalten werden, wobei das Verfahren umfasst
Bilden eines flachen, bandförmigen Lochkranzelements (**21**);
Bilden von Käfiglöchern (**20**; **31**), um die Wälzelemente (**3**; **30**) in einer Reihe auf dem Lochkranzelement (**21**) locker aufzunehmen; und
Bilden von Abstandsbereichen (**22**, **32**) zum Festhalten der Wälzelemente (**3**; **30**) zwischen den benachbarten Käfiglöchern (**20**; **31**) durch Spritzgießen;
dadurch gekennzeichnet, dass das flache, bandförmige Lochkranzelement (**21**) durch Strangpressen eines länglichen, flachen, bandförmigen Elements aus einem Spritzwerkzeug gebildet wird, indem ein Kunstharz extrudiert wird, während ein verstärkendes Material (**23**) eingebaut wird; und Schneiden des flachen, bandförmigen Elements auf eine vorgeschriebene Länge,
und dadurch, dass die Abstandsbereiche (**22**; **32**) durch Ausrichten der Wälzelemente (**3**; **30**) in den Käfiglöchern (**20**; **31**) und Spritzgießen der Abstandsbereiche (**22**; **32**) mit den als Kernstücke verwendeten Wälzelementen (**3**; **30**) gebildet sind, so dass die Wälzelemente (**3**; **30**) in den Käfiglöcher (**20**; **31**) aufgenommen werden.

2. Verfahren zum Herstellen einer Wälzkörperkette (**1**; **1A**) nach Anspruch 1, dadurch gekennzeichnet, dass das Lochkranzelement (**21**) aus einem Kunstharz geformt ist, das eine ausgezeichnete Zugfestigkeit oder Biegefestigkeit gegenüber einem Kunstharz, das zum Formen der Abstandsbereiche (**22**; **32**) durch Spritzgießen verwendet wird, aufweist.

3. Verfahren zum Herstellen einer Wälzkörperkette (**1**; **1A**) mit einer Anzahl von Wälzelementen (**3**; **30**), die darin in vorgeschriebenen Abständen ausgerichtet sind und wälzbar gehalten werden, wobei das Verfahren umfasst
Formen eines flachen, bandförmigen Lochkranzelements (**21**);
Formen von Käfiglöchern (**20**; **31**), um die Wälzelemente (**3**; **30**) in einer Reihe auf dem Lochkranzelement (**21**) locker aufzunehmen; und
Ausrichten von Wälzelementmustern in den Käfiglöchern (**20**; **31**), wobei die Wälzelementmuster im Durchmesser etwas größer als die Wälzelemente (**3**; **30**) sind; und
Bilden von Abstandsbereichen (**22**; **32**) zum Festhalten der Wälzelemente (**3**; **30**) zwischen den benachbarten Käfiglöchern (**20**; **31**) durch Spritzgießen mit den als Kernstücke verwendeten Wälzelementmustern, und
Ersetzen der Wälzelementmuster durch die Wälzelemente (**3**; **30**), nachdem die Abstandsbereiche (**22**; **32**) durch Spritzgießen geformt sind;
dadurch gekennzeichnet, dass das flache, bandförmige Lochkranzelement (**21**) durch Extrudieren eines länglichen, flachen, bandförmigen Elements aus einem Spritzwerkzeug durch Strangpressen eines Kunstharzes gebildet wird, während ein Verstärkungsmaterial (**23**) eingebaut wird; und Schneiden des flachen, bandförmigen Elements auf eine vorgeschriebene Länge.

Es folgen 13 Blatt Zeichnungen

Anhängende Zeichnungen

Fig. 1

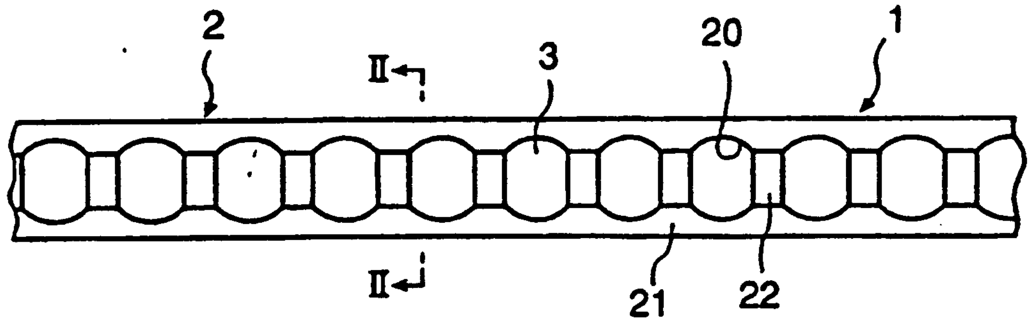


Fig. 2

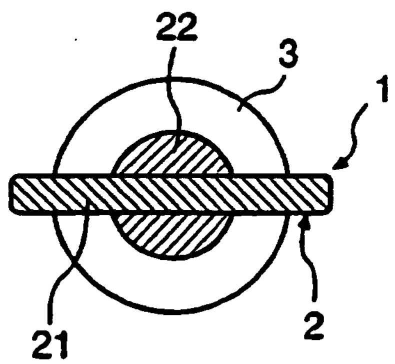


Fig. 3

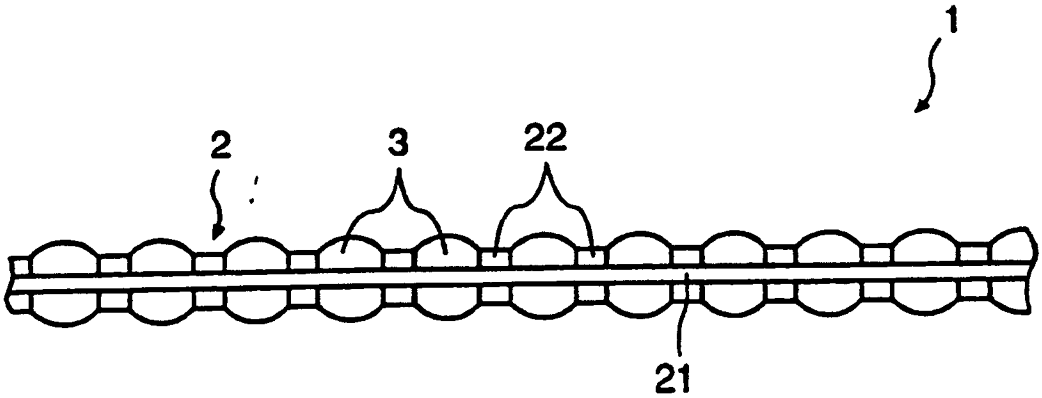


Fig. 4

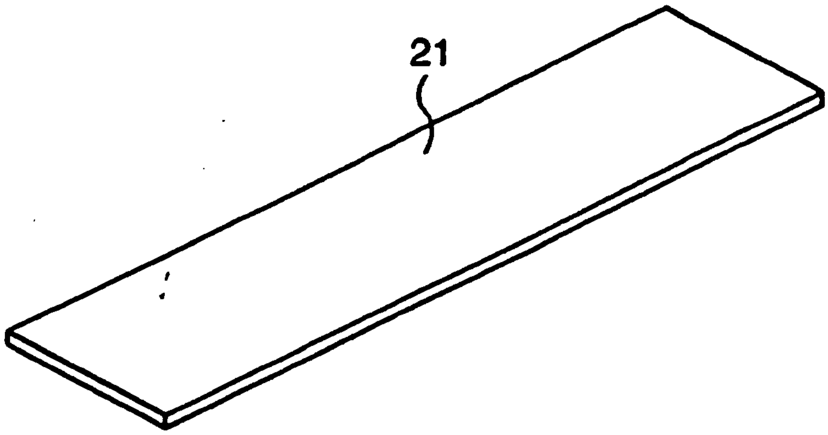


Fig. 5

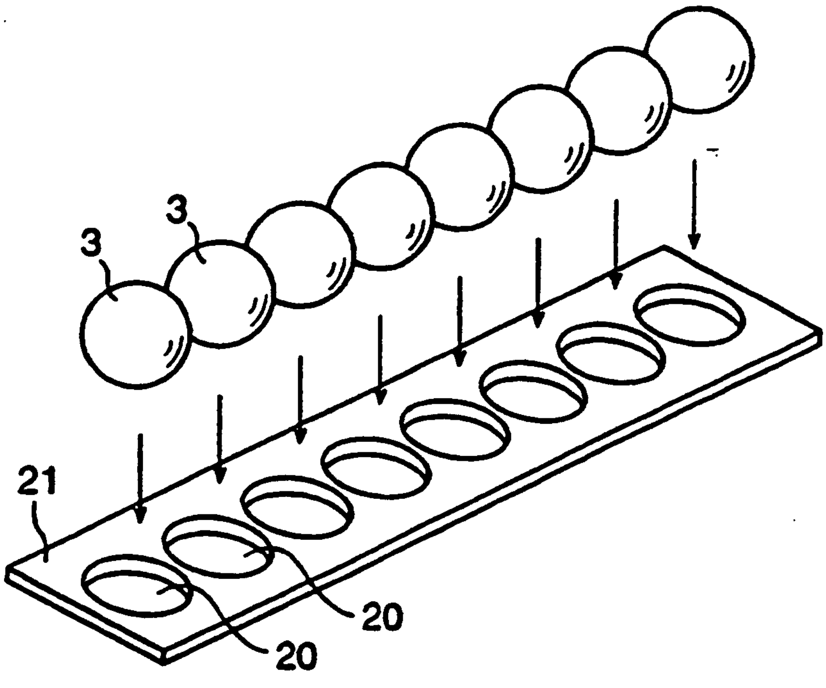


Fig. 6

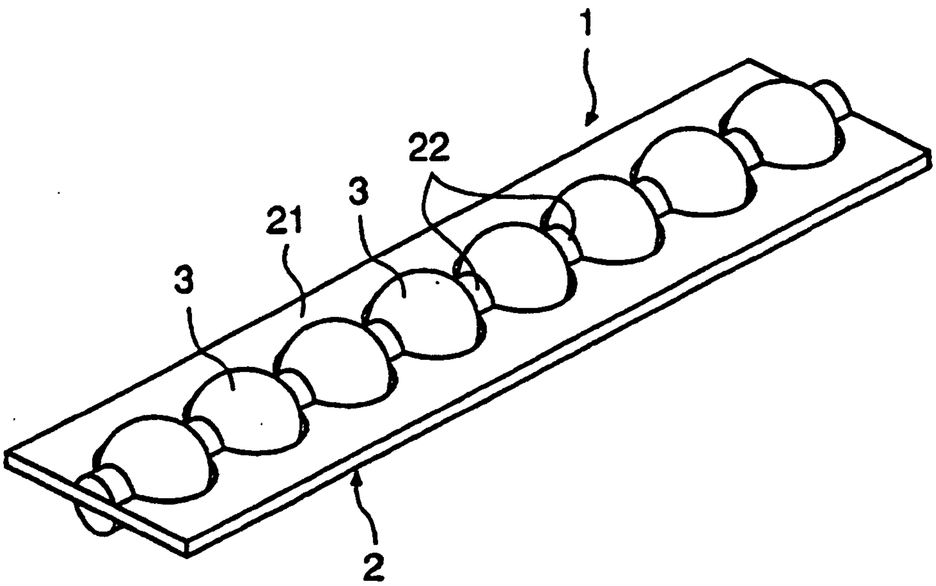


Fig. 7

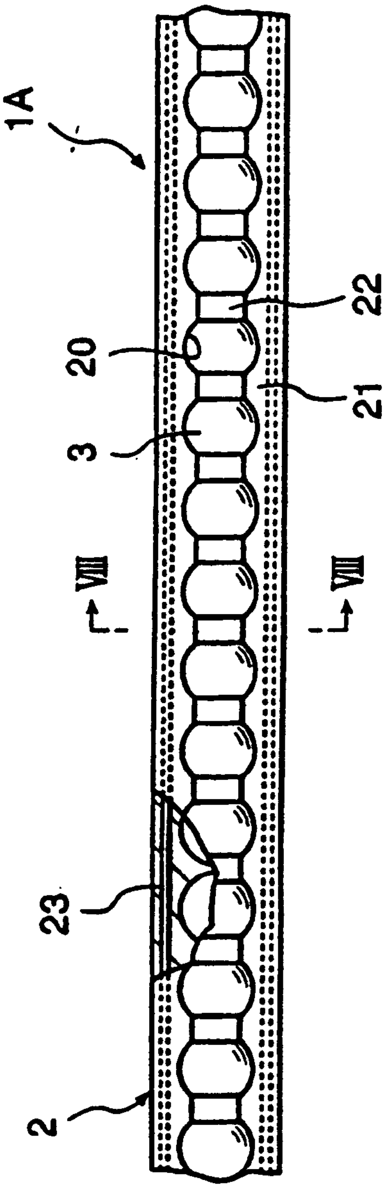


Fig. 8

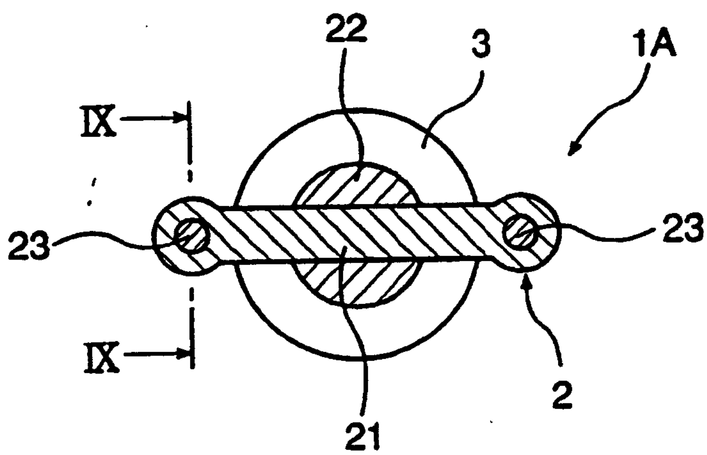


Fig. 9

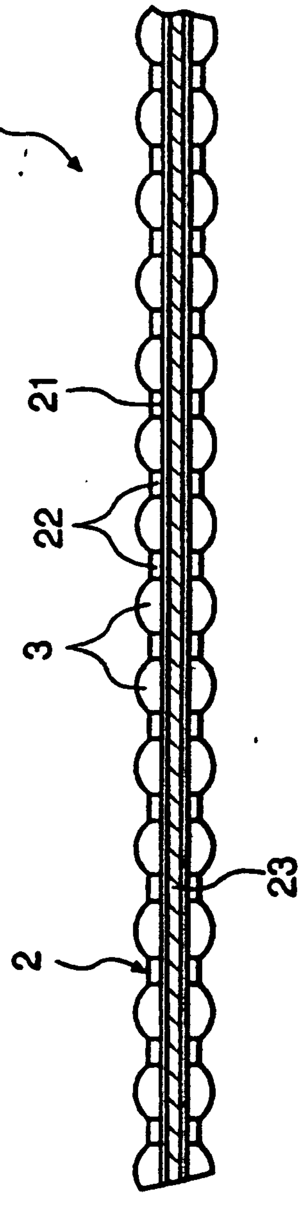


Fig. 10

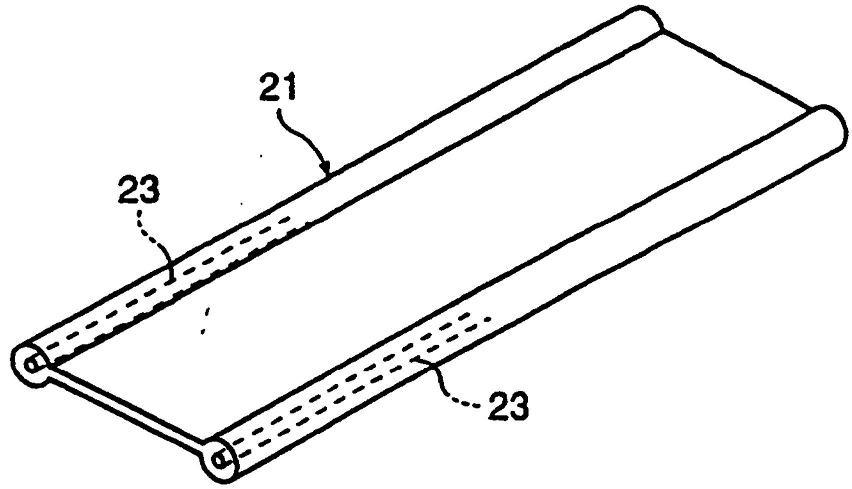


Fig. 11

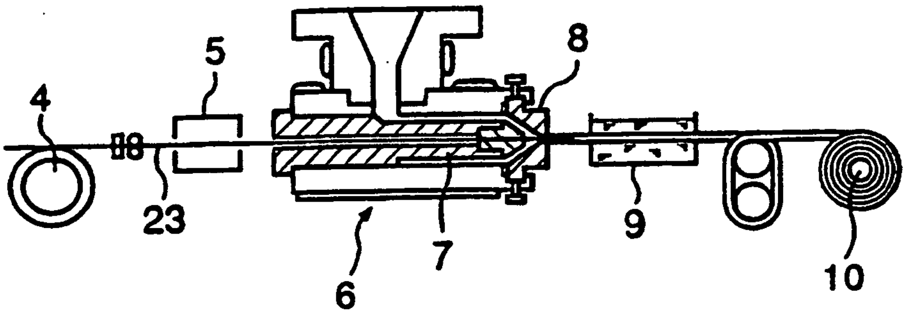


Fig. 12

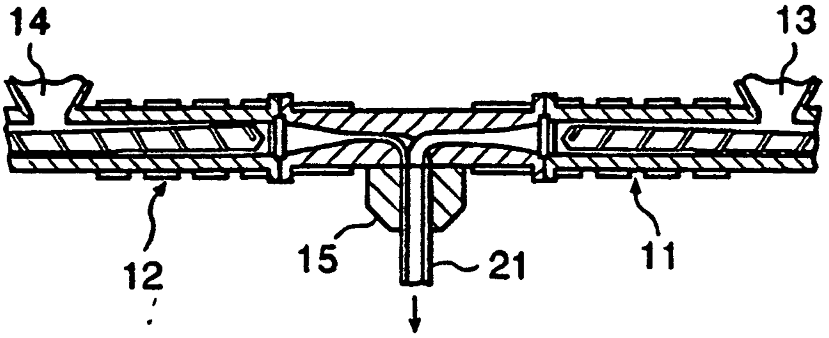
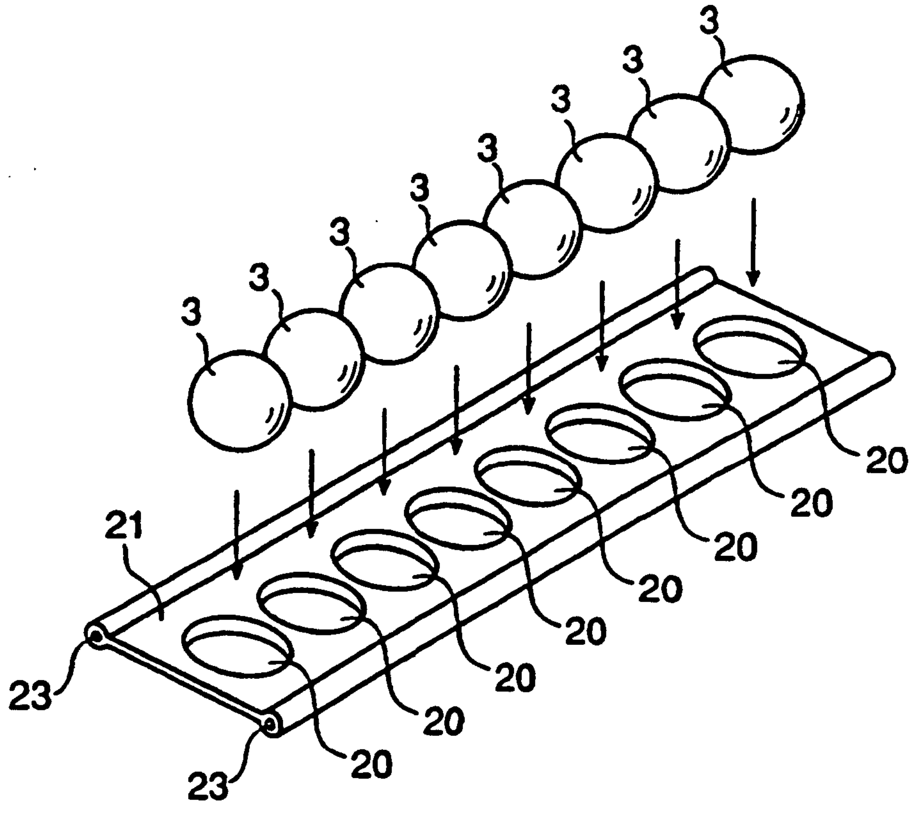


Fig. 13



F i g. 14

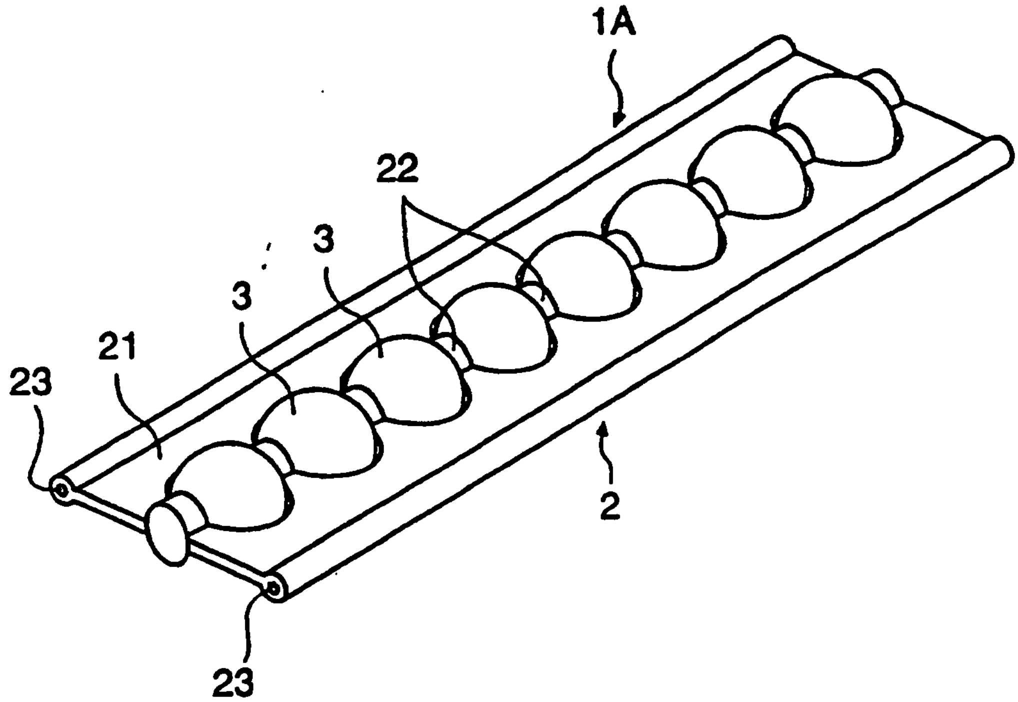


Fig. 15

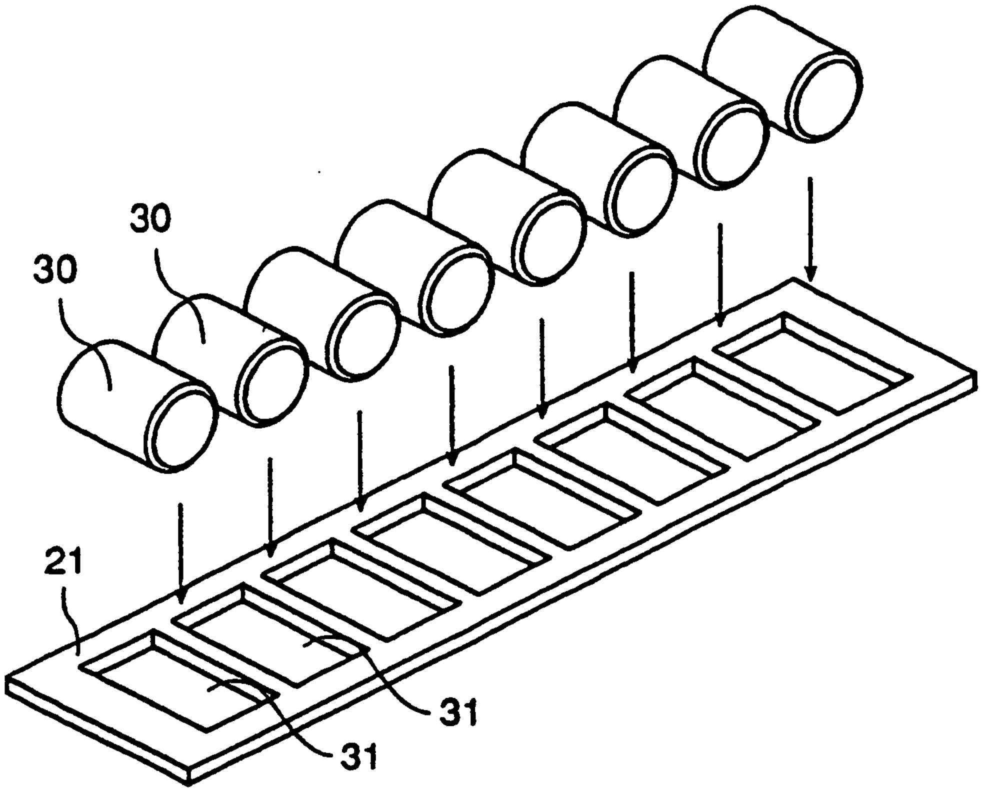


Fig. 16

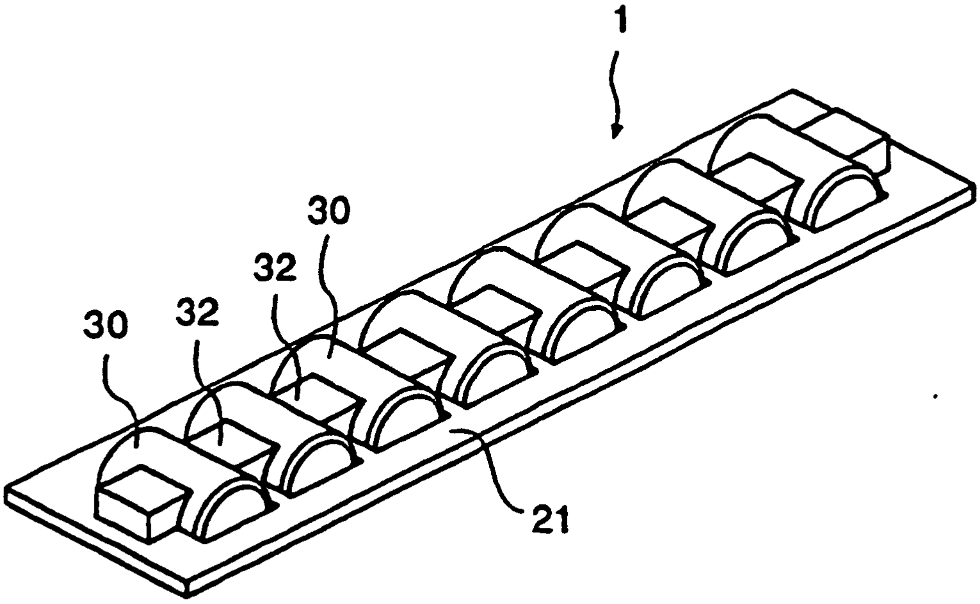


Fig. 17

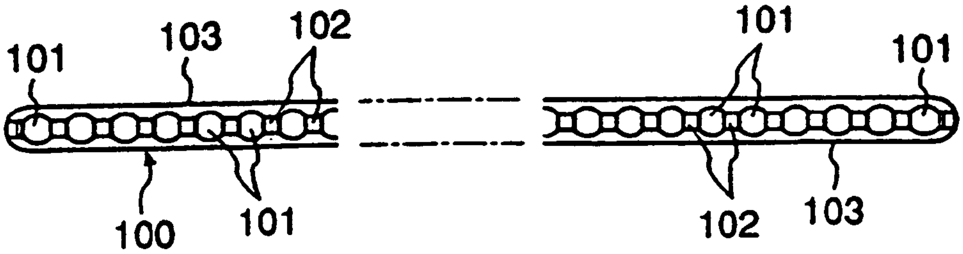

101
103
102
101
101
100
101
102
103

Fig. 18

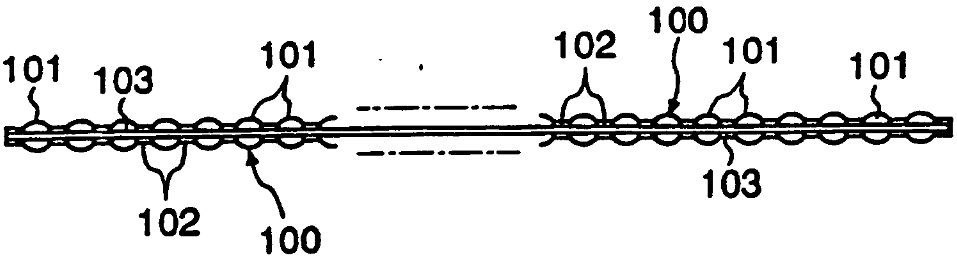
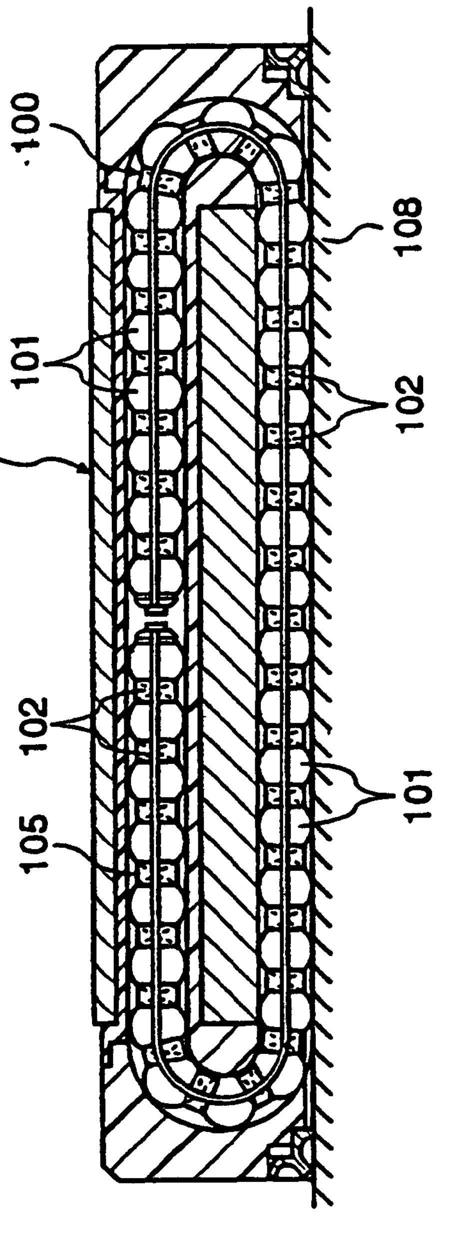

101
103
101
102
100
102
100
101
101
103

Fig. 19



(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 100 05 765 A 1**

(51) Int. Cl.[7]:
F 16 C 29/08
F 16 H 25/24

(21) Aktenzeichen: 100 05 765.9
(22) Anmeldetag: 10. 2. 2000
(43) Offenlegungstag: 17. 8. 2000

DE 100 05 765 A 1

(30) Unionspriorität:
11-033176 10. 02. 1999 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

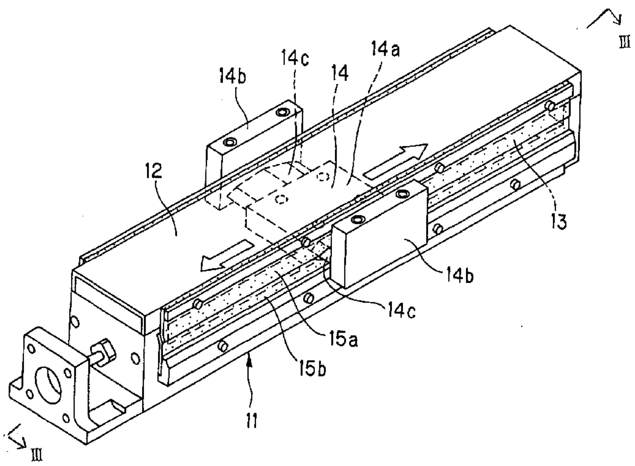
(74) Vertreter:
Viering, Jentschura & Partner, 80538 München

(72) Erfinder:
Kawaguchi, Takahiro, Tokio/Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Führungsvorrichtung mit einer staubdichten Struktur

(57) Die Erfindung betrifft eine Führungsvorrichtung mit einer staubdichten Struktur, umfassend eine lineare Führungsvorrichtung (11), eine Außenabdeckung (12, 50), die an der linearen Führungsvorrichtung befestigt ist, um die Führungsvorrichtung zu schützen, und die mit einer Öffnung (13) versehen ist, wobei die lineare Führungsvorrichtung ein bewegliches Glied (14, 40) mit einem nach außen durch die von der Außenabdeckung gebildete Öffnung hervorragenden Teil umfasst, und das bewegliche Glied entlang der Öffnung (13) bewegt werden kann; und eine Abdichtstruktur mit einer Mehrzahl Dichtungsglieder (15a, 15b; 51a, 51b), von denen jedes die Form eines Streifens hat und flexibel ist. Die Dichtungsglieder sind an Randabschnitten der Öffnung (13) der Außenabdeckung (12, 50) angeordnet, um sich so gegenseitig zu überlappen, wodurch ein im Wesentlichen abgedichteter Zustand innerhalb der linearen Führungsvorrichtung erhalten wird. Die Dichtungsglieder werden durch eine an dem beweglichen Glied ausgebildete Führungsstruktur getrennt und auf die Seite gedrückt, wenn das bewegliche Glied bewegt wird, wobei der abgedichtete Zustand innerhalb der linearen Führungsvorrichtung im Wesentlichen erhalten bleibt.



DE 100 05 765 A 1

Beschreibung

Die vorliegende Erfindung betrifft eine Führungsvorrichtung mit einer staubdichten Struktur (nachfolgend auch als "staubdichte Führungsvorrichtung" bezeichnet) zum Führen einer beweglichen Plattform oder dergleichen und insbesondere eine staubdichte Führungsvorrichtung, die mit einer äußeren (Panzer-) Abdeckung versehen ist.

Fig. 10 zeigt ein Beispiel einer herkömmlich bekannten staubdichten Führungsvorrichtung unter Verwendung einer Kugelgewindespindel. Die in **Fig.** 10 gezeigte staubdichte Führungsvorrichtung umfasst eine ausschließlich drehbar gelagerte Gewindewelle **1**, ein auf die Gewindewelle **1** geschraubtes Schraubenmutternglied **2** und eine die Gewindewelle **1** und das Mutternglied **2** schützende Außenabdekkung **3**. Die Außenabdeckung **3** ist mit einer oberen Öffnung **4** ausgebildet, die sich gemäß der Darstellung parallel zur Gewindewelle **1** erstreckt. Das Mutternglied **2** ist mit einem beweglichen Glied **5** einteilig ausgebildet, das an ein zu führendes Glied befestigt ist, so dass das bewegliche Glied **5** gemäß der Drehung der Gewindewelle **1** entlang der Öffnung geradlinig bewegt wird. Die Öffnung **4** der Außenabdeckung **3** ist durch ein Dichtungsglied **6** aus Gummi verdeckt und das Dichtungsglied **6** ist mit einem linearen Schnitt (Schnittlinie) **6**a entlang der Gewindewelle **1** ausgebildet. Das bewegliche Glied **5** biegt das Dichtungsglied **6** zwangsweise entlang der Schnittlinie **6**a nach außen, um durch eine Öffnung O nach außen vorzuragen, die durch die erzwungene Biegung des Dichtungsgliedes **6** gebildet wird. Das bewegliche Glied **5** führt entlang der Schnittlinie **6**a eine lineare richtungswechselnde Bewegung aus, wobei beide Seiten der Schnittlinie **6**a des Dichtungsgliedes **6** aufgeweitet werden. Gemäß dieser Struktur kann der durch die Kugelgewindespindel erzeugte Staub oder dergleichen durch Abdecken der Gewindewelle **1** und des Muttergliedes **2** durch die Außenabdeckung **3** und das Dichtungsglied **6** nicht nach außen gelangen.

In der in **Fig.** 10 gezeigten Struktur der staubdichten Führungsvorrichtung, in der der lineare Schnitt **6**a an dem Dichtungsglied **6**a ausgebildet ist, tritt jedoch ein Spalt mit einer geringen Breite zwischen den Abschnitten **6**b und **6**c des Dichtungsgliedes **6** auf, die einander entlang der Schnittlinie 6a zugewandt sind, und die Breite dieses Spaltes wird graduell größer, wenn das bewegliche Glied **5** wiederholt hin und herbewegt wird, was zu dem Problem führt, dass Staub oder dergleichen durch einen derart aufgeweiteten Spalt von der Außenabdeckung **3** nach außen gelangt. Demzufolge ist es gemäß der Struktur herkömmlicher staubdichter Führungsvorrichtungen wie der in **Fig.** 10 gezeigten schwierig, eine gute Staubabdichtung zu erhalten.

Aufgabe der vorliegenden Erfindung ist es, die zum Stand der Technik oben genannten Mängel oder Nachteile im Wesentlichen zu eleminieren und eine Führungsvorrichtung mit einer staubdichten Struktur vorzusehen, mit der eine hohe Staubabdichtung realisiert werden kann.

Diese Aufgabe wird gemäß der vorliegenden Erfindung gelöst, indem eine Führungsvorrichtung mit einer staubdichten Struktur vorgesehen ist, umfassend:
eine lineare Führungsvorrichtung;
eine an der linearen Führungsvorrichtung befestigte Außenabdeckung, um die lineare Führungsvorrichtung zu schützen, die mit einer Öffnung versehen ist, wobei die lineare Führungsvorrichtung ein bewegliches Glied mit einem durch die an der Außenabdeckung gebildete Öffnung nach außen hervorragenden Teil enthält und das bewegliche Glied entlang der Öffnung bewegt werden kann; und
eine Abdichtstruktur mit einer Mehrzahl Dichtungsglieder, von denen jedes die Form eines Riemenstreifens besitzt und flexibel ist, wobei die Dichtungsglieder an Randabschnitten der Öffnung der Außenabdeckung angeordnet sind, um sich so gegenseitig zu überlappen, wodurch im Wesentlichen ein abgedichteter Zustand innerhalb der linearen Führungsvorrichtung erhalten wird.

In bevorzugten Ausführungen der Erfindung besitzt das bewegliche Glied eine Führungsstruktur, die mit einem scharfkantigen Endabschnitt versehen ist, um die überlappten Dichtungsglieder gemäß einer Vorwärtsbewegung des beweglichen Gliedes zu trennen und seitwärts zu drücken, wobei die Führungsstruktur mit einem Seitenteil versehen ist, das in einer zur Bewegungsrichtung des beweglichen Gliedes entgegengesetzten Richtung graduell nach außen verbreitert ist.

Die Führungsstruktur ist vorteilhafterweise mit dem beweglichen Glied einteilig oder als ein von dem beweglichen Glied unabhängiges Glied ausgebildet.

Das bewegliche Glied ist vorteilhafterweise mit einem Verschlußglied zum Schließen der Öffnung der Dichtungsglieder versehen.

Eine Gleitfläche ist vorteilhafterweise zwischen der Führungsstruktur und der Abdichtstruktur mit einem sich in deren Längsrichtung kontinuierlich erstreckenden Vorsprung ausgebildet.

Neben der oben genannten Aufgabe werden durch die Strukturen der vorliegenden Erfindung folgende vorteilhafte Resultate oder Funktionen erzielt.

Da die Dichtungsglieder sich überlappende Endabschnitte besitzen, entsteht zwischen den jeweiligen Dichtungsgliedern kein Spalt, wodurch der Innenraum der Außenabdeckung, d. h. die lineare Führungsvorrichtung, vollständig verschlossen bleibt. Das bewegliche Glied wird bewegt, wodurch die Dichtungsglieder zwangsweise zur Seite gedrückt und geöffnet werden, und die Dichtungsglieder kehren dann aufgrund ihres eigenen flexiblen oder elastischen Vermögens in ihre ursprünglichen Formen zurück. Das bedeutet, dass die Dichtungsglieder gemäß der Struktur der erfindungsgemäßen Führungsvorrichtung nur an den Abschnitten geöffnet sind, die das bewegliche Glied passiert, und andere Abschnitte der Dichtungsglieder während der Vorwärtsbewegung des beweglichen Gliedes vollständig geschlossen sind, wodurch die Führungsvorrichtung mit einer hohen staubabdichtenden Struktur realisiert ist.

Desweiteren werden die Dichtungsglieder gemäß der bevorzugten Ausführungen während der Umkehrbewegung des beweglichen Gliedes sanft durch die Führungsstruktur deformiert und nach dem Passieren des beweglichen Gliedes werden die Dichtungsglieder in den ursprünglichen Schließzustand zurückgeführt, wodurch eine Spaltbildung zwischen der Führungsstruktur und den Dichtungsgliedern sicher verhindert wird.

Durch eine getrennte, d. h. unabhängige Bildung der Führungsstruktur kann eine relativ komplizierte Führungsstruktur leicht hergestellt werden, was zu einer einfachen Herstellung des beweglichen Gliedes selbst führt.

Wenn das bewegliche Glied die wiederholten Umkehrbewegungen ausführt, kann es passieren, dass die Dichtungsglieder die gebogenen Formen beibehalten und nicht vollständig in ihre ursprünglichen Formen zurückkehren. Gemäß der vorliegenden Erfindung werden derartig gebogene Abschnitte der Dichtungsglieder durch ein Verschlußglied, wie beispielsweise stabförmige Stifte, zwangsweise nach innen gedrückt, wodurch die Dichtungsglieder nach dem Passieren des beweglichen Gliedes sicherer geschlossen werden können.

Darüber hinaus kann die Anordnung der kontinuierlichen Vorsprünge der Gleitfläche den Reibungswiderstand zwischen der Führungsstruktur und der Abdichtstruktur reduzieren, wodurch die Linearbewegung des beweglichen Gliedes leicht ausgeführt wird.

Gemäß eines weiteren Aspekts der vorliegenden Erfindung ist eine Führungsvorrichtung mit einer staubdichten Struktur vorgesehen, umfassend:

eine lineare Führungsvorrichtung mit einem im Wesentlichen D-förmigen Querschnitt mit einer Öffnung;

eine Außenabdeckung, die an der linearen Führungsvorrichtung befestigt ist, um die Öffnung der D-förmigen Führungsvorrichtung zu überdecken, und die mit einer Öffnung versehen ist, wobei die lineare Führungsvorrichtung ein bewegliches Glied und ein lineares Glied umfasst, entlang dem das bewegliche Glied hin und herbewegt wird, wobei das bewegliche Glied einen nach außen durch eine zwischen der Außenabdeckung und der linearen Führungsvorrichtung gebildete Öffnung hervorragenden Teil umfasst, um entlang der zwischen der Außenabdeckung und der linearen Führungsvorrichtung gebildeten Öffnung bewegt werden zu können; und

eine Abdichtstruktur mit einer Mehrzahl Dichtungsglieder, von denen jedes die Form eines Streifens hat und flexibel ist, wobei die Dichtungsglieder an Randabschnitten der zwischen der Außenabdeckung und der linearen Führungsvorrichtung gebildeten Öffnung angeordnet sind, um sich gegenseitig zu überlappen, und die Öffnung zwischen der Außenabdeckung und der linearen Führungsvorrichtung abzudecken und im Wesentlichen einen abgedichteten Zustand innerhalb der linearen Führungsvorrichtung zu erhalten.

In bevorzugten Ausführungen der Erfindung umfasst das bewegliche Glied einen beweglichen Körper, Seitenteile, die als Vorsprünge auf beiden Seiten des beweglichen Gliedes vorgesehen sind, und Kupplungsteile, durch die der bewegliche Körper und die Seitenteile miteinander verbunden sind, wobei die Kupplungsteile in einem Niveau entsprechend der sich überlappenden Abschnitte der Dichtungsglieder angeordnet sind.

Die Kupplungsteile besitzen in der Bewegungsrichtung des beweglichen Gliedes scharfkantige Endabschnitte.

Die Kupplungsteile können an deren beiden Endabschnitten entlang der Bewegungsrichtung des beweglichen Gliedes mit Führungsteilen ausgebildet sein, wobei die Führungsteile jeweils einen scharfkantigen Endabschnitt in der Bewegungsrichtung des beweglichen Gliedes besitzen, um die sich überlappenden Dichtungsglieder gemäß einer Vorwärtsbewegung des beweglichen Gliedes zu trennen und seitwärts zu drücken, wobei das Führungsteil mit einem Seitenteil versehen ist, das in einer zur Vorwärtsrichtung des beweglichen Gliedes entgegengesetzten Richtung graduell nach außen verbreitert ist. Die Führungsteile können mit dem Kupplungsteil des beweglichen Gliedes einteilig oder von den Kupplungsteilen des beweglichen Gliedes unabhängig ausgebildet sein.

Das bewegliche Glied ist mit einem Verschlußglied versehen, das zwei Paare von stabförmigen Stiften umfasst, die an den Seitenteilen des beweglichen Gliedes befestigt sind, um in einer sich gegenüberstehenden Weise auf beiden Seiten des beweglichen Gliedes in seiner Bewegungsrichtung nach innen vorstehen, wobei die Stifte stirnseitige Enden haben, die sich im Wesentlichen an die sich überlappenden Abschnitte der Dichtungsglieder erstrecken.

Die Dichtungsglieder sind aus Gummi oder flexiblem synthetischen Harzmaterial hergestellt.

Die Dichtungsglieder sind an Seitenteilen der Außenabdeckung mittels eines Haftmittels angeordnet und jedes dieser Dichtungsglieder läuft an ein Vorderende spitz zu. Die Außenabdeckung kann mit Schwalbenschwanznuten ausgebildet sein und die Dichtungsglieder haben verbreiterte Endabschnitte, die in die Schwalbenschwanznuten der Außenabdeckung passen.

Gemäß dieses Ausführungsteils der vorliegenden Erfindung werden im Wesentlichen die gleichen Funktionen und Resultate erzielt, wie sie oben mit Bezug auf die erste Ausführung der vorliegenden Erfindung erwähnt wurden.

Der Gegenstand und weitere kennzeichnende Merkmale der vorliegenden Erfindung werden durch die folgende Beschreibung mit Bezug auf die beigefügte Zeichnung dargestellt.

In der beigefügten Zeichnung zeigt:

Fig. 1 eine perspektivische Ansicht einer erfindungsgemäßen Führungsvorrichtung mit staubdichter Struktur;

Fig. 2 eine perspektivische Explosionsansicht der Führungsvorrichtung von **Fig.** 1;

Fig. 3 einen Längsschnitt entlang der Schnittlinie III-III aus **Fig.** 1;

Fig. 4 einen Querschnitt entlang der Linie IV-IV aus **Fig.** 3;

Fig. 5 eine perspektivische Ansicht eines anderen Beispiels eines beweglichen Gliedes der Führungsvorrichtung;

Fig. 6 ein Führungsteil einschließlich der **Fig.** 6A, die eine perspektivische Ansicht des Führungsteils ist, und **Fig.** 6B, die dessen Draufsicht zeigt, und **Fig.** 6C mit dessen Seitenansicht;

Fig. 7 eine perspektivische Ansicht, die einen Zustand zeigt, in dem das Führungsteil ein Dichtungsglied der Führungsvorrichtung trennt und seitwärts drückt;

Fig. 8 einen Querschnitt eines anderen Beispiels einer Außenabdeckung der Führungsvorrichtung;

Fig. 9 einen Querschnitt eines weiteren Beispiels der Außenabdeckung der Führungsvorrichtung; und

Fig. 10 eine perspektivische Ansicht einer herkömmlichen staubdichten Führungsvorrichtung.

Mit Bezug auf die **Fig.** 1 und 2, die eine Führungsvorrichtung mit staubdichter Struktur gemäß der vorliegenden Erfindung zeigen (nachfolgend auch als "staubdichte Führungsvorrichtung oder lediglich als "Führungsvorrichtung", bezeichnet), umfasst die staubdichte Führungsvorrichtung zunächst eine lineare Führungsvorrichtung **11**, die ein Objekt wie beispielsweise eine Plattform auf einem befestigten Teil, wie beispielsweise einem Bett oder einem Sattel, führt, und eine äußere (Panzer-) Abdeckung **12**, die an einem oberen Abschnitt der linearen Führungsvorrichtung **11** befestigt ist.

Ein Öffnungspaar **13** ist zwischen den Seitenflächen der Außenabdeckung **12** und den Seitenflächen der linearen Führungsvorrichtung **11** ausgebildet. Das an dem Objekt befestigte bewegliche Glied **14** besitzt Teile, die durch diese Öffnungen **13** nach außen hervorragen, und während dieses Zustands bewegt sich das bewegliche Glied **14** entlang der Öffnungen **13** linear in der Längsrichtung der Führungsvorrichtung **11**. Die Öffnungen **13** werden durch ein Paar Dichtungsglieder **15**a und **15**b verschlossen oder abgedeckt, welche an oberen und unteren Randabschnitten der Öffnungen **13** befestigt sind.

Wie das in **Fig.** 2 gezeigt ist, umfasst die lineare Führungsvorrichtung **11** eine auf dem befestigten Teil angeordnete Führungsschiene **21**, ein Schlittenglied **22** in der Form eines Blocks, der entlang der Führungsschiene **21** linear geführt wird, das auf einer oberen Fläche des Schlittengliedes **22** befestigte bewegliche Glied **14**, und eine Kugelgewindespindel **23** als ein Zugspindelglied zum Antreiben des Schlittengliedes **22**.

Die Führungsschiene **21** besitzt gemäß der Darstellung einen zförmigen Abschnitt mit einer oberen Öffnung. Das heißt, dass sich die Führungsschiene **21** aus einem flachen Bodenteil und einem Paar gegenüberliegender Vorsprünge **24**a und **24**b zusammensetzt, die sich einander parallel an beiden längsseitigen Randabschnitten des flachen Bodenteiles erstrecken, um so den D-förmigen Abschnitt zu bilden. Der Bodenabschnitt ist zur Befestigung mit Schraubenlöchern versehen. Die innenseitige Oberfläche der jeweiligen Vorsprünge **24**a und **24**b ist mit vertieften Nuten **25** und einer jeweils großen Breite über die Längsrichtungen der Vorsprünge ausgebildet. An den Ober- und Unterabschnitten der Eckteile der vertieften Nuten **25** sind jeweils zwei Kugelrollnuten ausgebildet. So sind insgesamt vier Kugelrollnuten vorgesehen. Beide längsseitigen Endabschnitte der n-förmigen Führungsschiene sind jeweils durch Gehäuse **26**a und **26**b geschlossen, deren Höhe jeweils die Höhe der Vorsprünge **24**a und **24**b übersteigt, und deren Breite im Wesentlichen der der Führungsschiene **21** selbst entspricht.

Das Schlittenglied **22** ist aus einem Blockkörper **22**a und Endplatten **22**b zusammengesetzt, die an beiden längsseitigen Endabschnitten des Blockkörpers **22**a befestigt sind. Das Schlittenglied **22** ist in dem vertieften oberen Abschnitt der D-förmigen Führungsschiene eingepaßt und unterstützt, um durch als Rollglieder fungierende Kugeln **27** zwischen beiden Vorsprüngen **24**a und **24**b gleiten zu können.

Der Blockkörper **22**a des Schlittengliedes **22** besitzt beide Seitenflächen, an denen vier belastbare Kugelrollnuten ausgebildet sind, um den an der Führungsschiene **21** ausgebildeten Kugelrollnuten zu entsprechen, und eine Anzahl Kugeln **27** ist zwischen sich gegenüberliegenden Kugelrollnuten der Führungsschiene **21** und den an dem Blockkörper **22**a vorgesehenen belastbaren Kugelrollnuten jeweils rollbar angeordnet.

Der Blockkörper **22**a ist in seinem Zentralabschnitt mit einem Kugelgewindeloch **28** ausgebildet, das sich hierdurch in der Längsrichtung erstreckt, und eine Kugelgewindewelle **23** ist mit diesem Gewindeloch **28** verschraubt. Das Kugelgewindeloch **28** ist mit einer spiralförmig belastbaren Kugelrollnut ausgebildet, um einer spiralförmigen Kugelrollnut zu entsprechen, die in dem Außenumfangsbereich der Kugelgewindewelle **23** ausgebildet ist, und eine Anzahl Kugeln **29** ist zwischen der spiralförmigen belastbaren Kugelrollnut der Kugelgewindewelle **23** und der spiralförmigen Kugelrollnut des Kugelgewindeloches **28** rollbar angeordnet.

An der oberen Oberfläche des Blockkörpers **22**a sind Schraubenlöcher ausgebildet, um das bewegliche Glied **14** mittels Schrauben oder dergleichen zu befestigen.

Zwei Reihen Kugelsenklöcher sind auf jeder Seite des Kugelgewindeloches **28** ausgebildet, d. h. insgesamt vier Löcher, entsprechend den jeweiligen belasteten Kugelrollnuten des Blockkörpers **22**a, um die Kugeln in dem Lastbereich aufzunehmen. Das den Zentralabschnitt des Blockkörpers **22**a durchdringende Kugelgewindeloch **28** ist in seinem circa halben Längenbereich in der Längsrichtung mit einer Gewindenut ausgebildet, und ein Rückweg ist durch einen Rückführtunnel gebildet.

Jede der Endplatten **22**b ist ein Glied mit einer im Wesentlichen rechteckigen Form, ähnlich der der Endstirnseite des Blockkörpers **22**a, und ein Einsatzloch zum Einsetzen der Kugelgewindewelle **23** ist in seinem Zentralabschnitt ausgebildet, und Schraubenlöcher sind beidseitig auf beiden Seiten des Einsatzloches ausgebildet. Die Endplatten **22**b sind an dem Blockkörper **22**a mittels Schrauben befestigt, die in diese Schraubenlöcher eingesetzt sind. An den Endplatten **22**b sind vier Rückführgänge ausgebildet, um die Kugeln **27** in dem Lastbereich zwischen dem Blockkörper **22**a und der Führungsschiene **21** aufzunehmen und dann die Kugeln **27** wieder in den Lastbereich zurückzuführen.

Die Gewindewelle **23** ist an ihren beiden Endabschnitten durch Gehäuse **26**a, **26**b so unterstützt, dass sie sich nur drehen kann, und sie ist an ihrer Außenumfangsfläche mit einer spiralförmigen Kugelrollnut ausgebildet, entlang der die Kugeln **29** rollen. Wie das in **Fig.** 3 gezeigt ist, ist eine Kupplung **30** an einem Ende der Gewindewelle **23** befestigt, und die Kupplung **30** ist funktional an eine Abtriebswelle eines Motors angeschlossen, die an einem Zwischenflansch **31** befestigt ist, der sich von dem Gehäuse **26**a (oder **26**b) erstreckt.

Mit Bezug auf **Fig.** 2 ist das bewegliche Glied **14** mit einem beweglichen Körper **14**a und einem Paar Vorsprünge (Seitenteile) **14**b versehen, die an den Seitenabschnitten des beweglichen Körpers **14**a durch Kupplungsteile **14**c angeschlossen sind. Der bewegliche Körper **14**a ist mit Schraubeneinsatzlöchern versehen, um das bewegliche Glied **14** an dem Schlittenglied **22** mittels Schrauben zu befestigen. In einem dargestellten, d. h. eingebauten Zustand des beweglichen Gliedes **14**, sind Schraubenlöcher an der oberen Oberfläche der Seitenteile **14**b ausgebildet, und ein zu führendes Glied oder eine zu führende Einheit ist an den Seitenteilen **14**b des beweglichen Gliedes **14** durch Einsetzen von Schrauben oder dergleichen in diese Schraubenlöcher befestigt. Wie das in **Fig.** 3 gezeigt ist, besitzt das Kupplungsteil **14**c in einer Schnittebene, die die an dem beweglichen Glied **14** ausgebildeten Dichtungsglieder **15**a enthält, eine im Wesentlichen beidseitige symmetrische Stromlinienform. Das heißt, dass die beiden beidseitigen Enden des Kupplungsteiles **14**c jeweils eine scharfkantige hervorragende Form besitzen, und die den scharfkantigen Vorsprung bildenden gegenüberliegenden Seiten sind einmal im Zwischenabschnitt in Richtung des Zentralabschnittes des Kupplungsstückes **14**c gekrümmt, um dessen Kurvenneigung zu glätten.

Die Außenabdeckung **12** ist gemäß **Fig.** 2 aus einem im Wesentlichen langförmigen, rechteckigen, dünnen Plattenglied und durch Biegen seiner längsseitigen Seitenränder gebildet, und ein Paar Abstandshalter **32** ist an seiner unteren Oberfläche an den längsseitigen Enden befestigt. Die Außenabdeckung **12** ist an der linearen Führungsvorrichtung **11** durch Befestigen der Abstandshalter an den Gehäusen **26**a, **26**b der Führungsvorrichtung **11** befestigt. In der Form, in der die Außenabdeckung **12** an der linearen Führungsvorrichtung **11** befestigt ist, ist eine Stufe (stufiger Abschnitt) zwischen dem Gehäuse **26**b und den hervorragenden Seitenabschnitten **24**a, **24**b der Führungsschiene **21** gebildet, wodurch ein Öffnungspaar **13** in einer jeweils rechteckigen Form zwischen den Seitenflächen der Außenabdeckung **12** und den hervorragenden Seitenteilen **24**a, **24**b gebildet ist, wie das in **Fig.** 1 gezeigt ist. Die Kupplungsstücke **14**c des beweglichen Gliedes **14** erstrecken sich durch diese Öffnungen **13** nach außen, womit die Seitenteile (Vorsprünge) **14**b, **14**b, an die ein zu führendes Glied oder eine zu führende Einheit befestigt ist, des beweglichen Gliedes **14** nach außen freigesetzt werden.

Das streifenförmige obere Dichtungsglied **15**a ist an der Seitenfläche der Außenabdeckung **12**, d. h. an dem oberen Abschnitt des die Öffnung **13** bildenden Randes befestigt, wodurch es sich über die gesamte Längsseite der Öffnung **13** erstreckt. Das obere Dichtungsglied **15**a ist aus einem Gummi oder einem synthetischen Harz in einer langen, rechteckigen Form gebildet und an der Seitenfläche der Außenabdeckung **12** durch eine Pressdichtung **32** unter Verwendung einer Schraube oder dergleichen befestigt. Das untere Dichtungsglied ist in der Form eines Streifens/Riemens am unteren Abschnitt des die Öffnung **13** bildenden Randes befestigt, wodurch es sich über die gesamte Längsseite der Öffnung **13** erstreckt. Das untere Dichtungsglied ist ebenso durch eine Pressdichtung **33** befestigt.

Gemäß **Fig.** 4 überlappen sich die unteren Endabschnitte der oberen Dichtungsglieder **15**a und die oberen Endabschnitte der unteren Dichtungsglieder **15**b gegenseitig, wobei das obere Dichtungsglied **15**a außen angeordnet ist, wie das mit den gestrichelten Linien gezeigt ist, um so die Öffnungen **13** vollständig abzudecken. Da die Kupplungsteile **14**c des beweglichen Gliedes **14** durch die Öffnungen **13** nach außen hervorragen, sind diese oberen und unteren Dichtungsglieder **15**a und **15**b in den Formen entlang der oberen und unteren Oberflächen **14**c gebogen, wenn die Kupplungsstücke **14**c, d. h. das bewegliche Glied **14**, bewegt wird.

Mit der linearen Führungsvorrichtung **11** der oben erwähnten Struktur wird die mit der Drehwelle des Motors durch ein Anschlußstück verbundene Kugelgewindewelle **23** gedreht, wenn der Motor angetrieben wird, wobei dessen Drehbewegung auf das Schlittenglied **22** mittels der Kugelgewindespindel auf das Schlittenglied **22** übertragen wird und dieses daher entlang der Führungsschiene **21** linear bewegt wird.

Wie das in **Fig.** 1 gezeigt ist, wird das an dem Schlittenglied **22** befestigte bewegliche Glied **14** gemäß dieser Bewegung ebenso linear bewegt, und die Kupplungsstücke **14c** werden dadurch entlang den Längsrichtungen der Öffnungen **13** linear bewegt. Da die Öffnungen **13** durch die oberen und unteren sich gegenseitig überlappenden Dichtungsglieder **15**a und **15**b während dieser Bewegung abgedeckt sind, sind die innenseitigen Abschnitte der Außenabdeckung **12** und die lineare Führungsvorrichtung **11** selbst während der Linearbewegung des beweglichen Gliedes **14** im Wesentlichen vollständig abgedichtet. Die Kupplungsteile **14**c des beweglichen Gliedes **14** öffnen zwangsweise die oberen und unteren Dichtungsglieder **15**a und **15**b und drücken die Dichtungsglieder durch die Bewegung zur Seite. Nach dem Passieren der Kupplungsteile **14**c kehren die oberen und unteren Dichtungsglieder **15**a und **15**b aufgrund ihrer eigenen Elastizität oder Flexibilität in ihre ursprüngliche Form zurück, um somit wiederum die inneren Abschnitte der Außenabdeckung **12** und der linearen Führungsvorrichtung **11** abzudichten. Das bedeutet, dass die oberen und unteren Dichtungsglieder **15**a und **15**b nur in Abschnitten geöffnet sind, die das bewegliche Glied **14** während seiner Hin und Herbewegung durchfährt.

Fig. 5 ist eine perspektivische Ansicht, die ein anderes Beispiel des beweglichen Gliedes als bewegliches Glied **40** zeigt. Das bewegliche Glied **40** ist mit einem beweglichen Körper **40**a und einem Paar an Vorsprüngen (Seitenteilen) **40**b versehen, die an beiden Seitenteilen des beweglichen Gliedes **40** befestigt sind. Der bewegliche Körper **40**a besitzt breiter reduzierte Abschnitte, die als Kupplungsteile **40**c ausgebildet sind, durch welche die Seitenteile **40**b befestigt sind. Die Kupplungsteile **40**c haben jeweils eine in der Länge der Bewegungsrichtung des beweglichen Gliedes reduzierte Abmessung, und Führungsteile **41**a und **41**b sind an den breiten, reduzierten Abschnitten an deren beiden Enden in der Bewegungsrichtung des beweglichen Gliedes befestigt und haben scharfkantige Endformen, die zum Zur-seitedrücken der Dichtungsglieder geeignet sind, wie das nachfolgend im Detail erläutert wird. Das bedeutet, dass die Führungsteile **41**a und **41**b an vier Eckabschnitten vorgesehen sind, die durch den beweglichen Körper **40**a und die Kupplungsteile **40**c gebildet sind.

Die **Fig.** 6A bis 6C zeigen ein derartiges Führungsteil in vergrößertem Maßstab.

Gemäß **Fig.** 6B besitzt das Führungsteil **41**a einen Abschnitt, der in einer zur Bewegungsrichtung (Richtung **1**) entgegengesetzten Richtung nach außen graduell verbreitert ist, und gemäß **Fig.** 6C besitzt die Seitenfläche des Führungsteiles **41** eine sich in Richtung **1** zugespitzte Form. Darüber hinaus hat die Querschnittsform des Führungsteiles einen Vorsprung in Richtung **2** senkrecht auf die Bewegungsrichtung **1**, um eine im Wesentlichen fünfeckige Form zu schaffen, wie das durch die Schraffur in **Fig.** 6A gezeigt ist. Darüber hinaus besitzt das Führungsteil **41**b im Wesentlichen dieselbe Form wie das Führungsteil **41**a und ist an einem Eckabschnitt des beweglichen Gliedes **40** auf dessen Rückseite befestigt, um in die entgegengesetzte Richtung zum Führungsteil **41**a zu zeigen. Darüber hinaus ist zu beachten, dass sobald das bewegliche Glied **40** eine rückwärtige Bewegung ausführt, die Bewegungsrichtung des Führungsteiles **41**b zur Bewegungsrichtung des Führungsteils **41**a entgegengesetzt ist.

Mit Bezug auf **Fig.** 5 sind Paare stabförmiger Verschlußstifte **42**a und **42**b an beiden längsseitigen Endabschnitten eines jeden Seitenteiles (Vorsprünge) **40**b des beweglichen Gliedes **40** befestigt. Diese Verschlußstifte **42**a und **42**b sind an Abschnitten auf beiden Seiten der stirnseitigen Enden der Führungsteile **41**a und **41**b in einem hohen Niveau entsprechend der Stelle eines zentralen Schlitzabschnittes **42** angeordnet, der auf der Seitenfläche des Führungsteiles **41**a (**41**b) gebildet ist, um sich innenseitig horizontal an Positionen nahe der Stelle der Dichtungsglieder **15**a und **15**b zu erstrecken. Darüber hinaus sind die an den Seitenteilen **40**b und **40**b befestigten Verschlußstifte **42**a und **42**b symmetrisch zueinander angeordnet.

Fig. 7 zeigt eine Ausführung, in der die oberen und unteren Dichtungsglieder **15**a und **15**b durch das Führungsteil **41**a, gemäß der Vorwärtsbewegung des beweglichen Gliedes **40** getrennt und zur Seite gedrückt sind. Das heißt, dass sich unter Annahme einer Bewegung des beweglichen Gliedes **40** in Richtung A in **Fig.** 7 die oberen und unteren Dichtungsglieder **15**a und **15**b, die die Öffnungen O an beiden Seiten der linearen Führungsvorrichtung **11** schließen, gemäß der Vorwärtsbewegung der Führungsteile **41**a in die Richtung **1** seitwärts gedrückt werden und sich allmählich öffnen. In dieser Vorwärtsbewegung werden die oberen und unteren Dichtungsglieder **15**a und **15**b sanft deformiert und geöffnet, da die Führungsteile **41**a die scharfkantigen stirnseitigen Enden in der Bewegungsrichtung und die nach außen aufgeweiteten Seitenteile in der zur Bewegungsrichtung entgegengesetzten Richtung haben. Aus diesem Grund kann die Abdichtung zwischen den Dichtungsgliedern **15**a und **15**b und den Führungsteilen **41**a sorgfältig realisiert werden und die Bildung eines dazwischenliegenden Spalts kann sicher verhindert werden. Die deformierten Dichtungsglieder **15**a und **15**b werden letztendlich in einem Winkel von 90° an den oberen und unteren Oberflächen der Kupplungsteile **40**c gebogen.

Ausgehend von einer Bewegung des beweglichen Gliedes **40** in der Richtung B, werden gemäß **Fig.** 7 nachfolgend die geöffneten Dichtungsglieder **15**a und **15**b während der Vorwärtsbewegung des beweglichen Gliedes **40** allmählich deformiert und dann in ihre ursprüngliche geschlossenen Positionen aufgrund ihres eigenen elastischen Vermögens gemäß deren Rückwärtsbewegung zurückgeführt, wobei die Abdichtung gut realisiert wird und die Bildung eines dazwischenliegenden Spaltes sicher vermieden werden kann.

Darüber hinaus ist es einfach zu erkennen, dass die Dichtungsglieder **15**a und **15**b an dem gegenüberliegenden Seitenteil des beweglichen Gliedes **40** durch die Führungsteile **41**b verschlossen werden, wenn das bewegliche Glied **40** in der Richtung A bewegt wird, und im Gegensatz dazu die Dichtungsglieder **15**a und **15**b an dieser Seite durch die Führungsteile **41**b geöffnet werden, wenn das bewegliche Glied **40** in der Richtung B bewegt wird.

Darüber hinaus kann es besser sein, auf den Gleitflächen kontinuierliche Vorsprünge zwischen den Dichtungsgliedern **15**a und **15**b und den Führungsteilen **41**a und **41**b in deren Längsrichtung zu auszubilden. Die Ausbildung derartiger Vorsprünge reduziert Kontaktflächen, d. h. Reibungsflächen der Führungsteile **15**a und **15**b und der Führungsteile **41**a und **41**b, wodurch der während der Linearbewegung des beweglichen Gliedes **40** entstehende Reibungswiderstand reduziert wird.

Währenddessen kann in einem Fall, wo das bewegliche Glied **40** wiederholt die Umkehrbewegung ausführt, auftreten, dass die Dichtungsglieder **15**a und **15**b nicht vollständig in ihre ursprünglichen Formen (Positionen) zurückkehren und ihre gebogenen Zustände beibehalten, und daher die Öffnungen O nicht vollständig schließen. Selbst in einem derartigen Fall, werden gemäß der beschriebenen Ausführung der vorliegenden Erfindung die gebogenen Abschnitte der Dichtungsglieder **15**a und **15**b zwangsweise durch die Verschlußstifte **42**a und **42**b nach innen gebogen, wenn diese Stifte die Öffnungen O durchfahren, da die Verschlußstifte **42**a und **42**b an beiden Seiten der Führungsteile **41**a und **41**b angeordnet sind. Demgemäß werden selbst dann, wenn die Öffnungen O nicht vollständig geschlossen sind, die Dichtungsglieder **15**a und **15**b zwangsweise in ihre ursprünglichen Positionen zurückgeführt, wodurch die Öffnungen O vollständig verschlossen werden.

Fig. 8 zeigt ein anderes Beispiel der Außenabdeckung, wobei in diesem Beispiel an der Außenabdeckung **50** Dichtungsglieder **51**a an die unteren Endabschnitte der Seitenflächen der Außenabdeckung **50** angefügt sind. Jedes Dichtungsglied **51**a ist im Querschnitt zu einem Vorderende abgeschrägt, um dadurch leicht gebogen werden zu können und den Reibungswiderstand während der Linearbewegung des beweglichen Gliedes **14** zu reduzieren. Ein geeignetes Haftmittel oder Material ist gemäß dem die Dichtungsglieder **51**a und die Außenabdeckung **50** bildenden Materials frei wählbar. Gemäß dieses Beispiels kann die Anzahl der Glieder oder Elemente, wie beispielsweise Befestigungsglieder reduziert werden, da die Außenabdeckung **50** und die Dichtungsglieder **51**a einteilig ausgebildet sind, und daher kann das Gesamtgewicht der Außenabdeckung **50** und der Dichtungsglieder **51**a ebenso reduziert sein. Darüber hinaus werden diese Glieder mittels eines Haftmittels ohne Verwendung einer mechanischen Vorrichtung, wie beispielsweise Schrauben, zusammengefügt, wobei verhindert wird, dass die Dichtungsglieder **51**a an der Außenabdekkung **50** beispielsweise in geneigtem Zustand befestigt sind.

Fig. 9 zeigt ein anderes Beispiel der Außenabdeckung, und in diesem Beispiel ist die Außenabdeckung **50** mit Schwalbenschwanznuten **62** an beiden längsseitigen Endabschnitten ausgebildet und Dichtungsglieder **61**a sind mit verbreiterten oder vorstehenden Abschnitten **63** an ihren Oberteilen ausgebildet, deren Form zum Einpassen in die jeweilige Schwalbenschwanznut **62** bestimmt ist. Daher sind die Dichtungsglieder **61**a und die Außenabdeckung **60** einteilig durch jeweiliges Eingreifen der verbreiterten Abschnitte **63** mit den Schwalbenschwanznuten **62** ausgebildet. Darüber hinaus sind die anderen Dichtungsglieder **61**b ebenso an ihren unteren Endabschnitten mit verbreiterten oder vorstehenden Abschnitten **64** ausgebildet, die in die Dichtungsgliedaufnehmer **65** in der Form von Schwalbenschwanznuten eingreifen, die an den Seitenflächen der linearen Führungsvorrichtung **11** ausgebildet sind.

Gemäß dieses Beispiels, können verschlechterte Dichtungsglieder leicht mit neuen ausgetauscht werden, da, wie das oben erwähnt wurde, die Dichtungsglieder an der Außenabdeckung und der Führungsvorrichtung unter Verwendung verbreiterter Abschnitte befestigt sind, die in die Schwalbenschwanznuten eingreifen.

Es wird betont, dass die vorliegende Erfindung nicht auf die beschriebenen Ausführungen begrenzt ist und Modifikationen möglich sind, ohne sich vom Umfang der beigefügten Ansprüche zu entfernen.

Patentansprüche

1. Führungsvorrichtung mit einer staubdichten Struktur, umfassend:
eine lineare Führungsvorrichtung (**11**);
eine Außenabdeckung (**12**, **50**), die an der linearen Führungsvorrichtung befestigt ist, um die lineare Führungsvorrichtung zu schützen, und die mit einer Öffnung (**13**) versehen ist, wobei die lineare Führungsvorrichtung ein bewegliches Glied (**14**, **40**) mit einem nach außen durch die an der Außenabdeckung (**12**, **50**) gebildete Öffnung (**13**) hervorragenden Teil umfasst, wobei das bewegliche Glied (**14**, **40**) entlang der an der Außenabdeckung gebildeten Öffnung bewegt werden kann; und
eine Abdichtstruktur mit einer Mehrzahl Dichtungsglieder (**15**a, **15**b; **51**a, **51**b), von denen jedes die Form eines Streifens/Riemens hat und flexibel ist, wobei die Dichtungsglieder an Randabschnitten der Öffnung (**13**) der Außenabdeckung (**12**, **50**) angeordnet sind, um sich so gegenseitig zu überlappen, wodurch ein im Wesentlichen abgedichteter Zustand innerhalb der linearen Führungsvorrichtung erhalten wird.

2. Führungsvorrichtung (**11**) mit einer staubdichten Struktur nach Anspruch 1, bei der das bewegliche Glied (**14**, **40**) eine Führungsstruktur besitzt, die mit einem scharfkantigen Endabschnitt versehen ist, um die sich überlappenden Dichtungsglieder (**15**a, **15**b; **51**a, **51**b) gemäß einer Vorwärtsbewegung des beweglichen Gliedes zu trennen und seitwärts zu drücken, wobei die Führungsstruktur mit einem Seitenteil (**14**b, **40**b) versehen ist, das in der zur Bewegungsrichtung des beweglichen Gliedes (**14**, **40**) entgegengesetzten Richtung graduell nach außen verbreitert ist.

3. Führungsvorrichtung mit einer staubdichten Struktur nach Anspruch 2, bei der die Führungsstruktur mit dem beweglichen Glied (**14**, **40**) als ein Teil hergestellt ist.

4. Führungsvorrichtung mit einer staubdichten Struktur nach Anspruch 2, bei der die Führungsstruktur als ein von dem beweglichen Glied (**14**, **40**) unabhängiges Glied ausgebildet ist.

5. Führungsvorrichtung mit einer staubdichten Struktur nach Anspruch 2, bei der das bewegliche Glied (**14**, **40**) mit einem Verschlußglied (**42**a, **42**b) versehen ist, um die Öffnung der Dichtungsglieder zu schließen.

6. Führungsvorrichtung mit einer staubdichten Struktur nach Anspruch 2, bei der eine Gleitfläche zwischen der Führungsstruktur und der Abdichtstruktur mit einem sich in ihrer Längsrichtung kontinuierlich erstrekkenden Vorsprung vorgesehen ist.

7. Führungsvorrichtung mit einer staubdichten Struktur, umfassend:
eine lineare Führungsvorrichtung mit einem ⊐-förmigen Querschnitt mit einer Öffnung;
eine Außenabdeckung (**12**, **50**), die an der linearen Führungsvorrichtung (**11**) befestigt ist, um die Öffnung der ⊐-förmigen Führungsvorrichtung abzudecken, und die mit einer Öffnung versehen ist, wobei die lineare Führungsvorrichtung ein bewegliches Glied (**14**, **40**) und ein lineares Glied umfasst, entlang dem das bewegliche Glied wechselseitig bewegt wird, wobei das bewegliche Glied (**14**, **40**) einen durch eine zwischen der Außenabdeckung (**12**, **50**) und der linearen Führungsvorrichtung gebildete Öffnung (**13**) nach außen hervorragenden Teil umfasst, um entlang der zwischen

der Außenabdeckung und der linearen Führungsvorrichtung gebildeten Öffnung bewegt werden zu können;
eine Abdichtstruktur mit einer Mehrzahl Dichtungsglieder (**15**a, **15**b; **51**a, **51**b), von denen jedes die Form eines Streifens/Riemens hat und flexibel ist, wobei die Dichtungsglieder an Randabschnitten der zwischen der Außenabdeckung und der linearen Führungsvorrichtung gebildeten Öffnung (**13**) angeordnet sind, um sich gegenseitig zu überlappen, wodurch die Öffnung zwischen der Außenabdeckung (**12**, **50**) und der linearen Führungsvorrichtung abgedeckt und ein im Wesentlichen abgedichteter Zustand innerhalb der linearen Führungsvorrichtung erhalten wird.

8. Führungsvorrichtung mit einer staubdichten Struktur nach Anspruch 7, bei der das bewegliche Glied (**14**, **960**) einen beweglichen Körper (**14**a, **40**a) umfasst, Seitenteile (**14**b, **40**b) die als die Vorsprünge auf beiden Seiten des beweglichen Gliedes ausgebildet sind, und Kupplungsteile (**14**c, **40**c), durch die der bewegliche Körper und die Seitenteile miteinander verbunden sind, wobei die Kupplungsteile in einem Niveau entsprechend der sich überlappenden Abschnitte der Dichtungsglieder (**15**a, **15**b; **51**a, **51**b) angeordnet sind.

9. Führungsvorrichtung mit einer staubdichten Struktur nach Anspruch 8, bei der die Kupplungsteile (**14**c, **40**c) in der Bewegungsrichtung des beweglichen Gliedes (**14**, **40**) scharfkantige Endabschnitte besitzen.

10. Führungsvorrichtung mit einer staubdichten Struktur nach Anspruch 8, bei der die Kupplungsteile (**14**c, **40**c) an deren beiden Endabschnitten entlang der Bewegungsrichtung des beweglichen Gliedes (**14**, **40**) mit Führungsteilen (**41**a, **41**b) versehen sind, wobei die Führungsteile jeweils einen scharfkantigen Endabschnitt in der Bewegungsrichtung des beweglichen Gliedes besitzen, um die sich überlappenden Dichtungsglieder gemäß einer Vorwärtsbewegung des beweglichen Gliedes seitwärts zu drücken und zu trennen, wobei das Führungsteil (**41**a, **41**b) mit einem Seitenteil versehen ist, das in einer zur Bewegungsrichtung des beweglichen Gliedes entgegengesetzten Richtung graduell nach außen verbreitert ist.

11. Führungsvorrichtung mit einer staubdichten Struktur nach Anspruch 10, bei der die Führungsteile (**41**a, **41**b) mit dem Kupplungsteil (**14**c, **40**c) des beweglichen Gliedes (**14**, **40**) als ein Teil hergestellt sind.

12. Führungsvorrichtung mit einer staubdichten Struktur nach Anspruch 10, bei der die Führungsteile (**41**a, **41**b) als Glieder ausgebildet sind, die von den Kupplungsteilen (**14**c, **40**c) des beweglichen Gliedes (**14**, **40**) unabhängig sind.

13. Führungsvorrichtung mit einer staubdichten Struktur nach Anspruch 8, bei der das bewegliche Glied (**14**, **40**) mit einem Verschlußglied (**42**a, **42**b) versehen ist, welches Verschlußglied zwei Paare stabförmiger Stifte umfasst, die an den Seitenteilen (**14**b, **40**b) des beweglichen Gliedes befestigt sind, um in einer sich gegenüberstehenden Weise auf beiden Seiten des beweglichen Gliedes in seiner Bewegungsrichtung nach innen vorzuragen, wobei die Stifte vordere Enden haben, die sich im Wesentlichen an die sich überlappenden Abschnitte der Dichtungsglieder (**15**a, **15**b; **51**a, **51**b) erstrecken.

14. Führungsvorrichtung mit einer staubdichten Struktur nach Anspruch 7, bei der die Dichtungsglieder (**15**a, **15**b; **51**a, **51**b) aus flexiblem Gummi hergestellt sind.

15. Führungsvorrichtung mit einer staubdichten Struktur nach Anspruch 7, bei der die Dichtungsglieder (**15**a, **15**b; **51**a, **51**b) aus flexiblem, synthetischem Harz hergestellt sind.

16. Führungsvorrichtung nach Anspruch 7, bei der die Dichtungsglieder (**15**a, **15**b; **51**a, **51**b) mittels eines Haftmittels an Seitenteilen der Außenabdeckung (**12**, **50**) angeordnet sind und jedes der Dichtungsglieder an ein vorderes Ende spitz zuläuft.

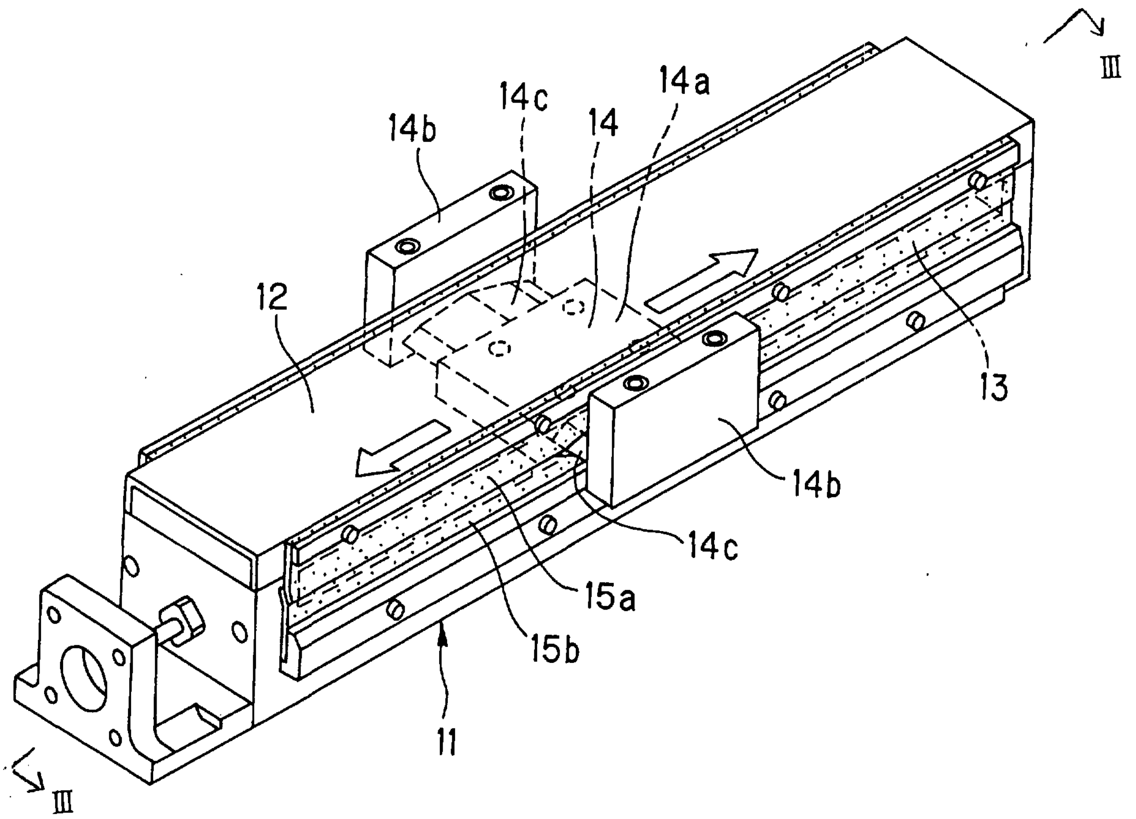
17. Führungsvorrichtung nach Anspruch 7, bei der die Außenabdeckung (**12**, **50**) mit Schwalbenschwanznuten (**62**) ausgebildet ist und die Dichtungsglieder (**15**a, **15**b; **51**a, **51**b) verbreiterte Endabschnitte besitzen, die in die Schwalbenschwanznuten der Außenabdeckung eingepaßt sind.

Hierzu 10 Seite(n) Zeichnungen

- Leerseite -

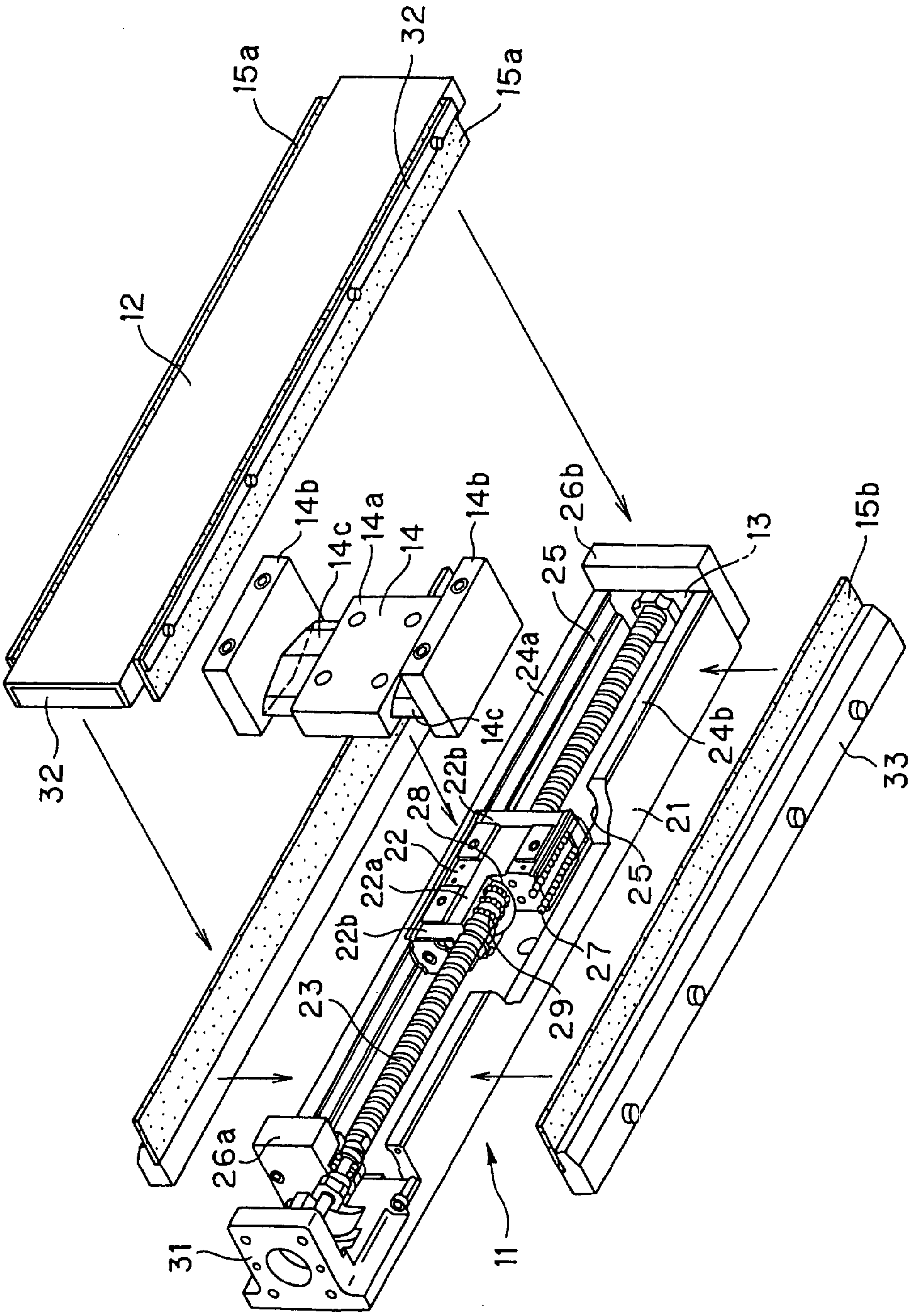
Nummer: **DE 100 05 765 A1**
Int. Cl.[7]: **F 16 C 29/08**
Offenlegungstag: 17. August 2000

FIG. 1



Nummer: **DE 100 05 765 A1**
Int. Cl.[7]: **F 16 C 29/08**
Offenlegungstag: 17. August 2000

FIG. 2



Nummer: **DE 100 05 765 A1**
Int. Cl.^{7}: **F 16 C 29/08**
Offenlegungstag: 17. August 2000

FIG. 3

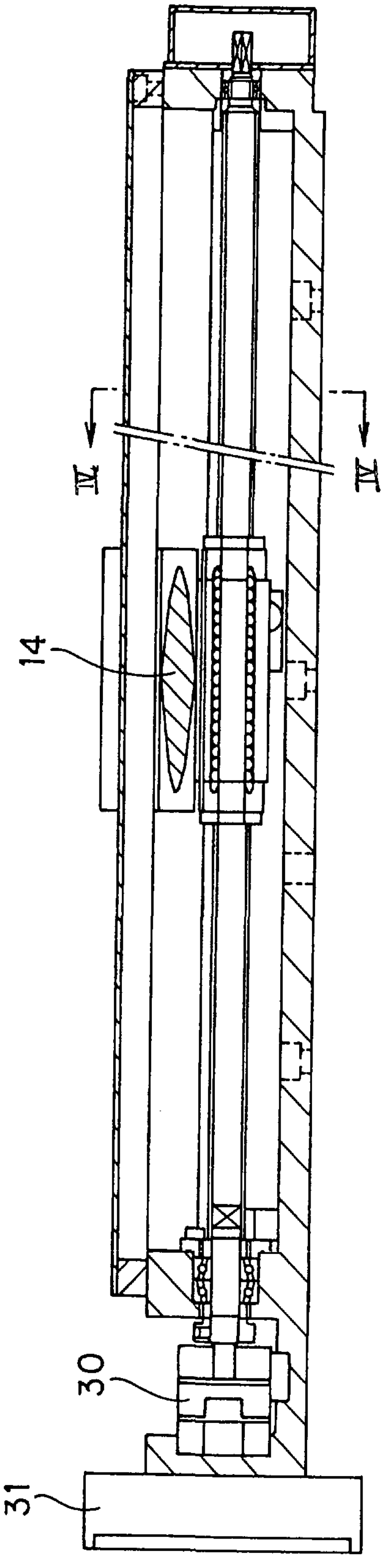
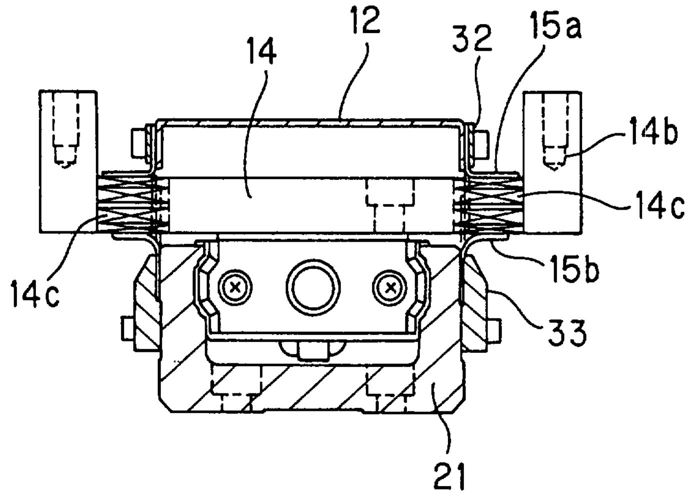


FIG. 4



Nummer: DE 100 05 765 A1
Int. Cl.[7]: F 16 C 29/08
Offenlegungstag: 17. August 2000

FIG. 5

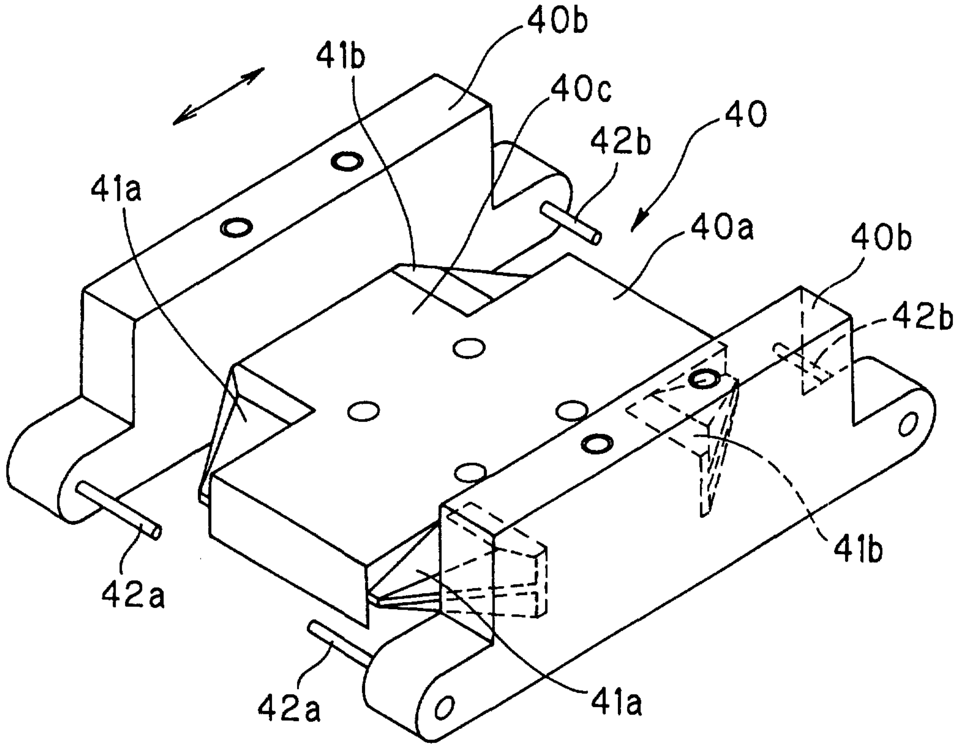


FIG. 6A

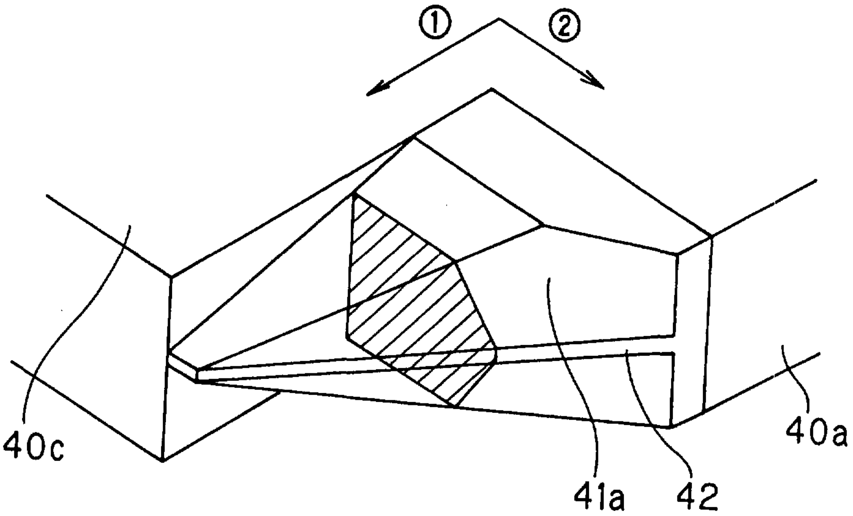


FIG. 6B

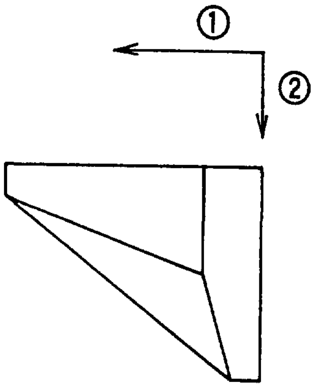
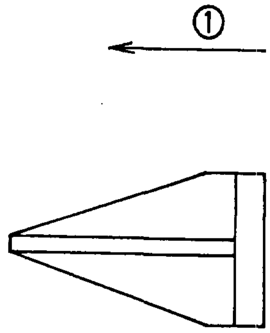


FIG. 6C



Nummer: **DE 100 05 765 A1**
Int. Cl.[7]: **F 16 C 29/08**
Offenlegungstag: 17. August 2000

FIG. 7

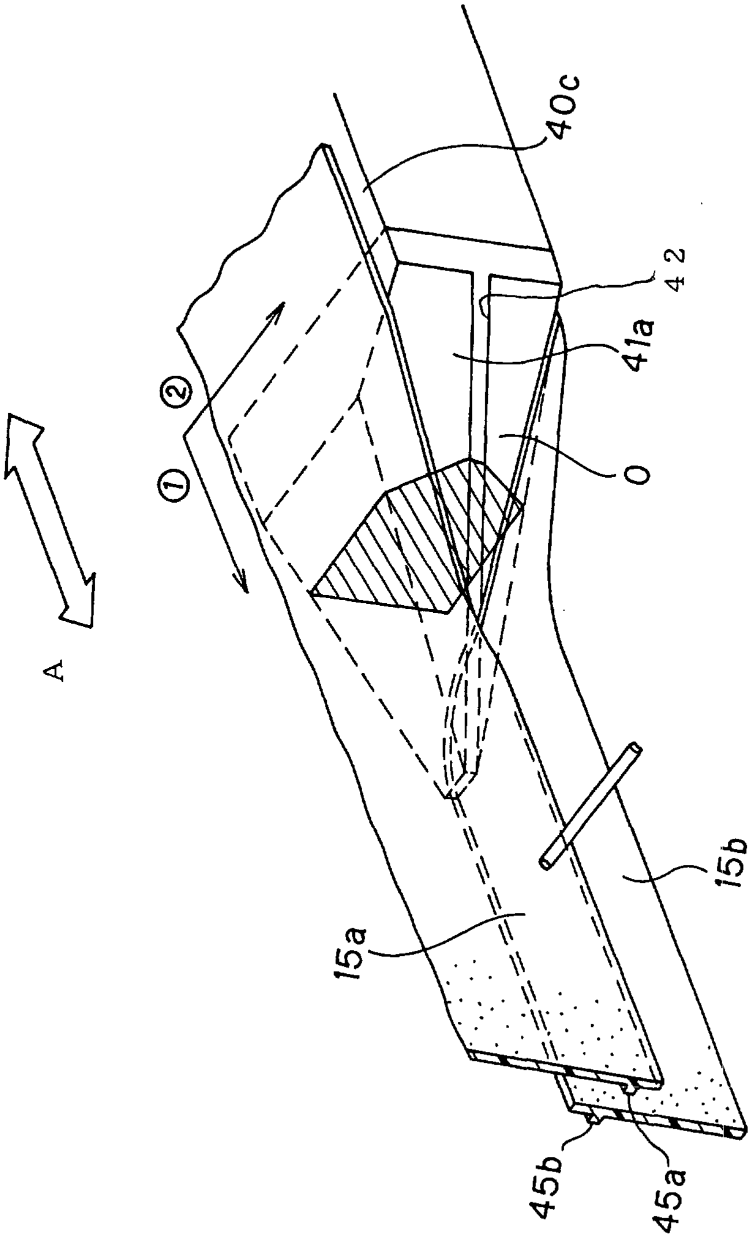


FIG. 8

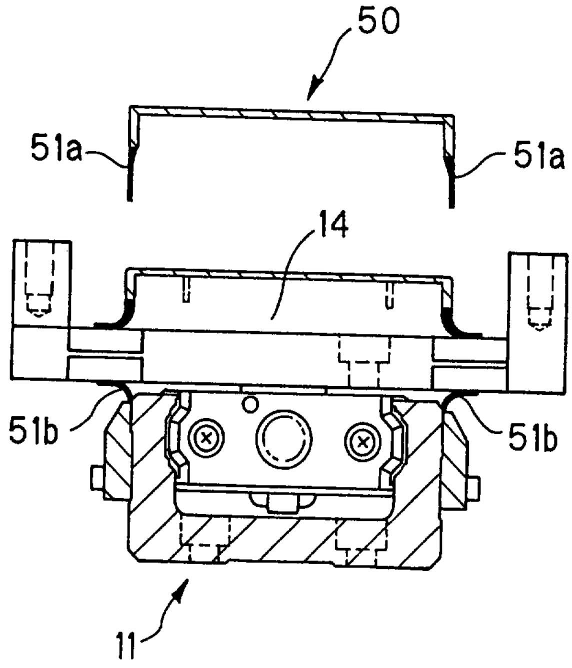
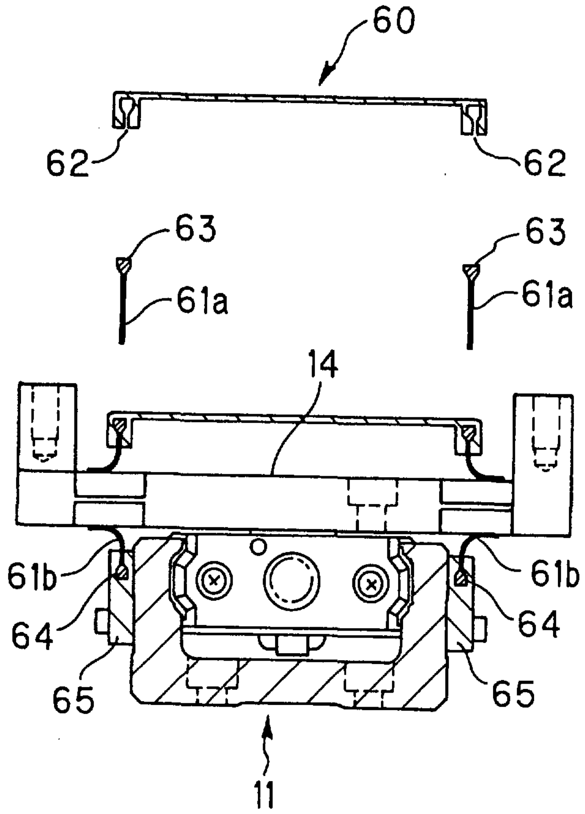


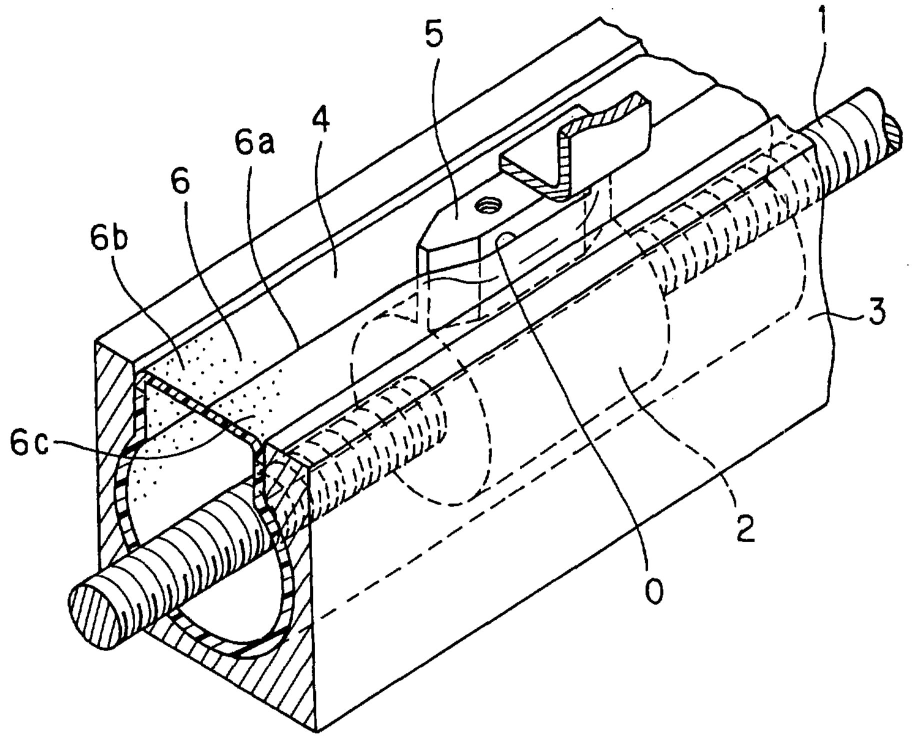
FIG. 9



Nummer: DE 100 05 765 A1
Int. Cl.[7]: F 16 C 29/08
Offenlegungstag: 17. August 2000

FIG.10

Stand der Technik



US 20060213272A1

(19) United States
(12) Patent Application Publication (10) Pub. No.: US 2006/0213272 A1
Yoshioka et al. (43) Pub. Date: Sep. 28, 2006

(54) CONDITION-DETECTING DEVICE, METHOD, AND PROGRAM, AND INFORMATION-RECORDING MEDIUM

(75) Inventors: **Takeo Yoshioka**, Yamanashi (JP); **Yoshiyuki Honjyo**, Yamanashi (JP); **Shigeo Watanabe**, Yamanashi (JP)

Correspondence Address:
WESTERMAN, HATTORI, DANIELS & ADRIAN, LLP
1250 CONNECTICUT AVENUE, NW
SUITE 700
WASHINGTON, DC 20036 (US)

(73) Assignee: **THK CO., LTD.**, Tokyo (JP)

(21) Appl. No.: **10/547,356**

(22) PCT Filed: **Feb. 27, 2004**

(86) PCT No.: **PCT/JP04/02398**

(30) **Foreign Application Priority Data**

Feb. 28, 2003 (JP) 2003-054293

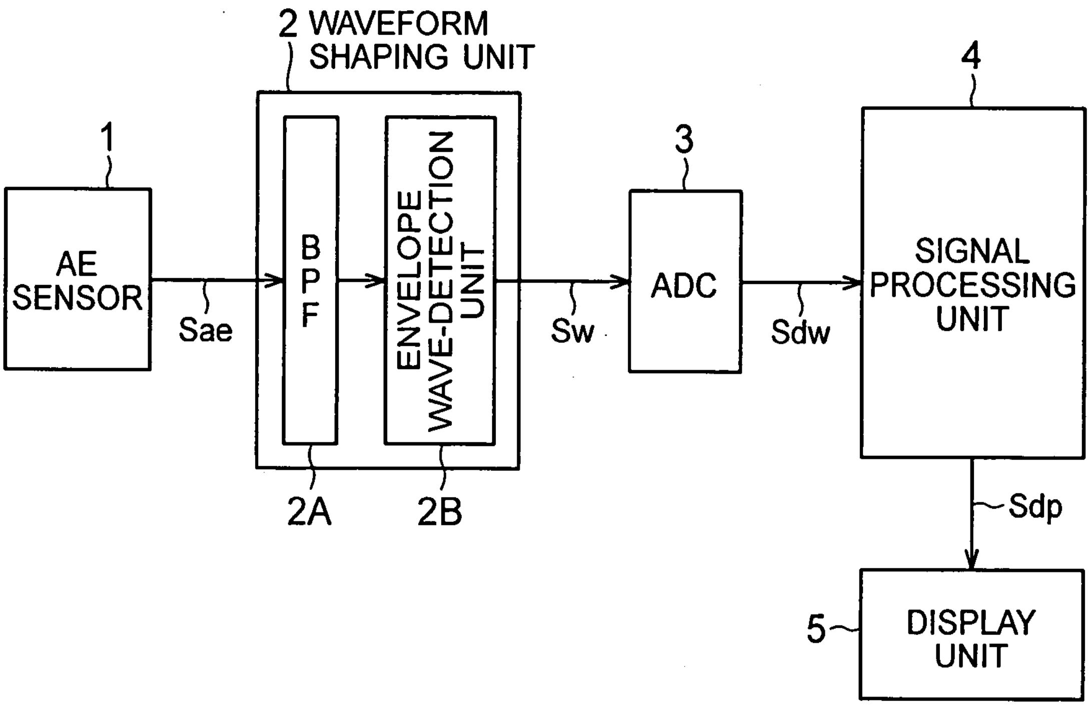
Publication Classification

(51) **Int. Cl.**
G01N 29/34 (2006.01)
G01H 1/12 (2006.01)
G01N 29/36 (2006.01)
G01N 29/44 (2006.01)
G01N 29/14 (2006.01)

(52) **U.S. Cl.** **73/580**; 702/56; 73/587

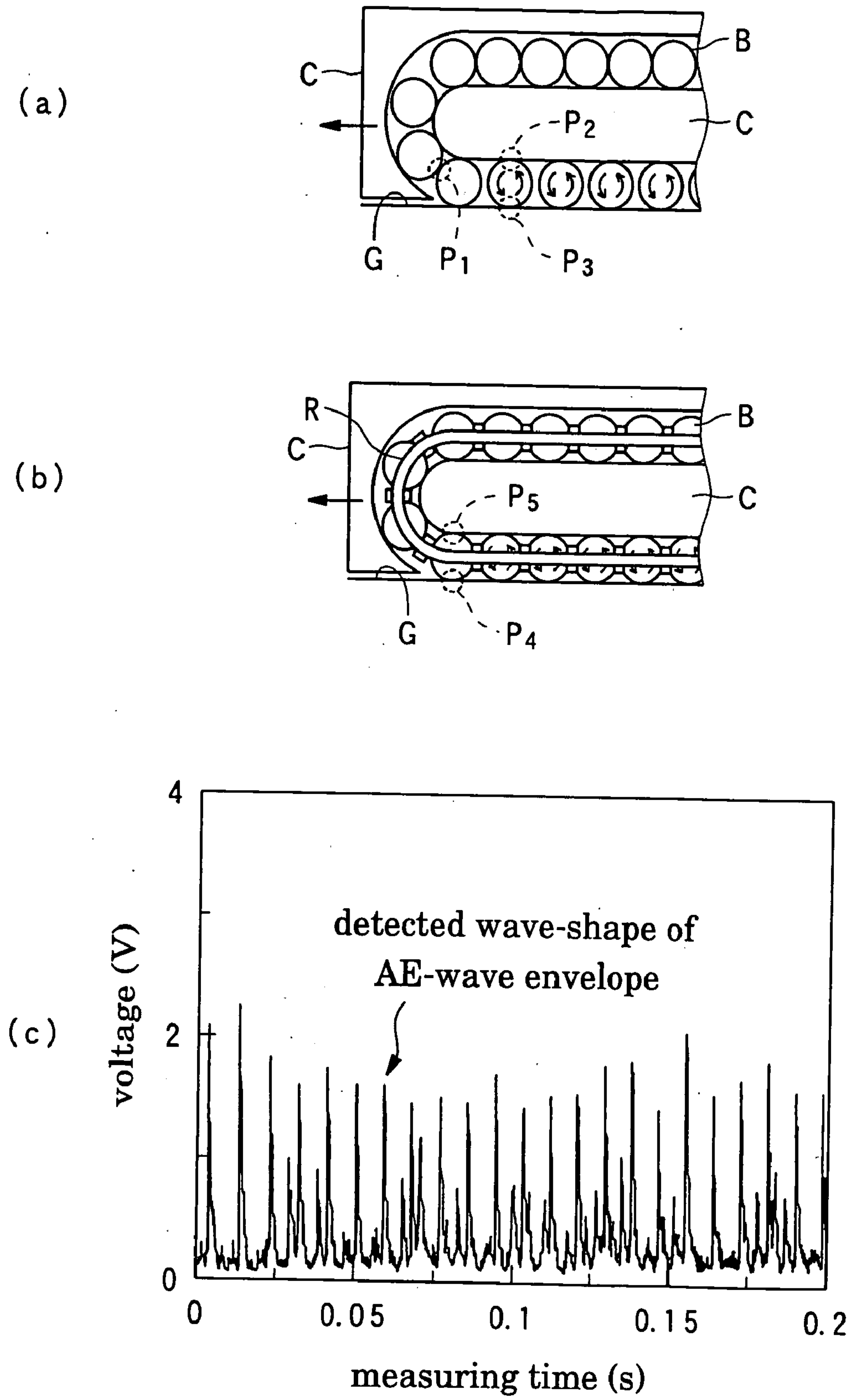
(57) **ABSTRACT**

There is provided a condition detection apparatus for detecting a present operating condition of a linear rolling motion guide apparatus, and the condition detection apparatus includes an AE sensor **1** for detecting a waveform elastically generated at least due to rolling of balls included in the linear rolling motion guide apparatus and mutual collision of the balls and generating an electric detection signal corresponding the detected waveform, a waveform shaping unit **2**, an A/D converter **3**, and a signal processing unit **4** judging a content of the operation condition in response to the generated detected signal Sae.



S

FIG.1



(a)
C
B
C
P2
G
P1
P3
(b)
R
C
B
P5
C
G
P4
(c)
4
2
0
voltage (V)
detected wave-shape of
AE-wave envelope
0
0.05
0.1
0.15
0.2
measuring time (s)

FIG.2

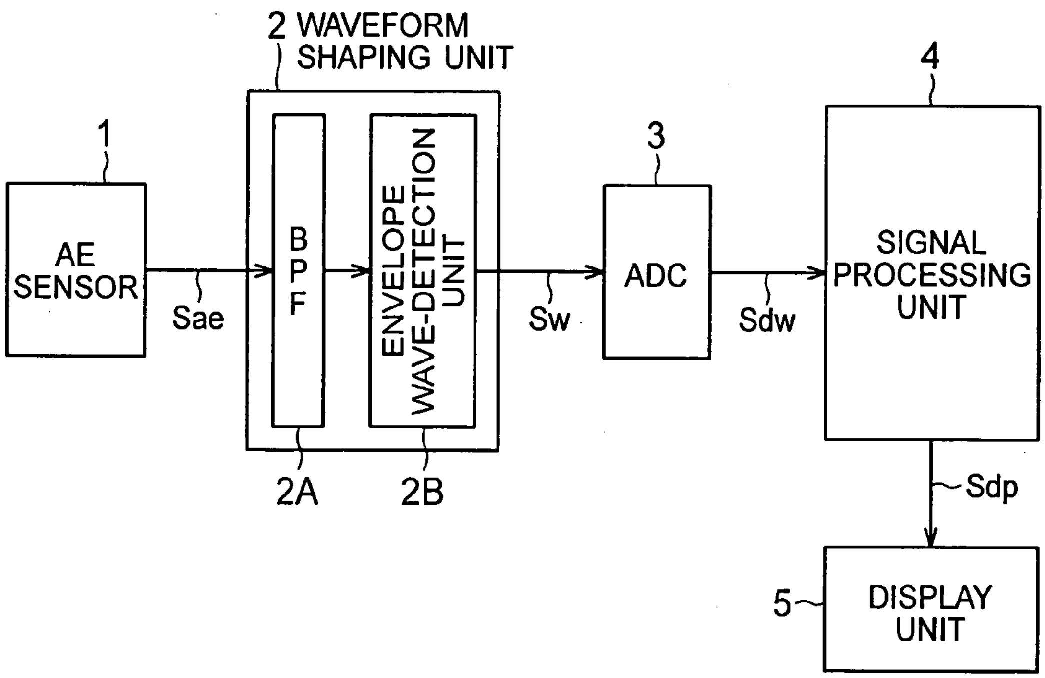

2 WAVEFORM
SHAPING UNIT
1
AE
SENSOR
Sae
BPF
ENVELOPE
WAVE-DETECTION
UNIT
2A
2B
Sw
3
ADC
Sdw
4
SIGNAL
PROCESSING
UNIT
Sdp
5
DISPLAY
UNIT

FIG.3

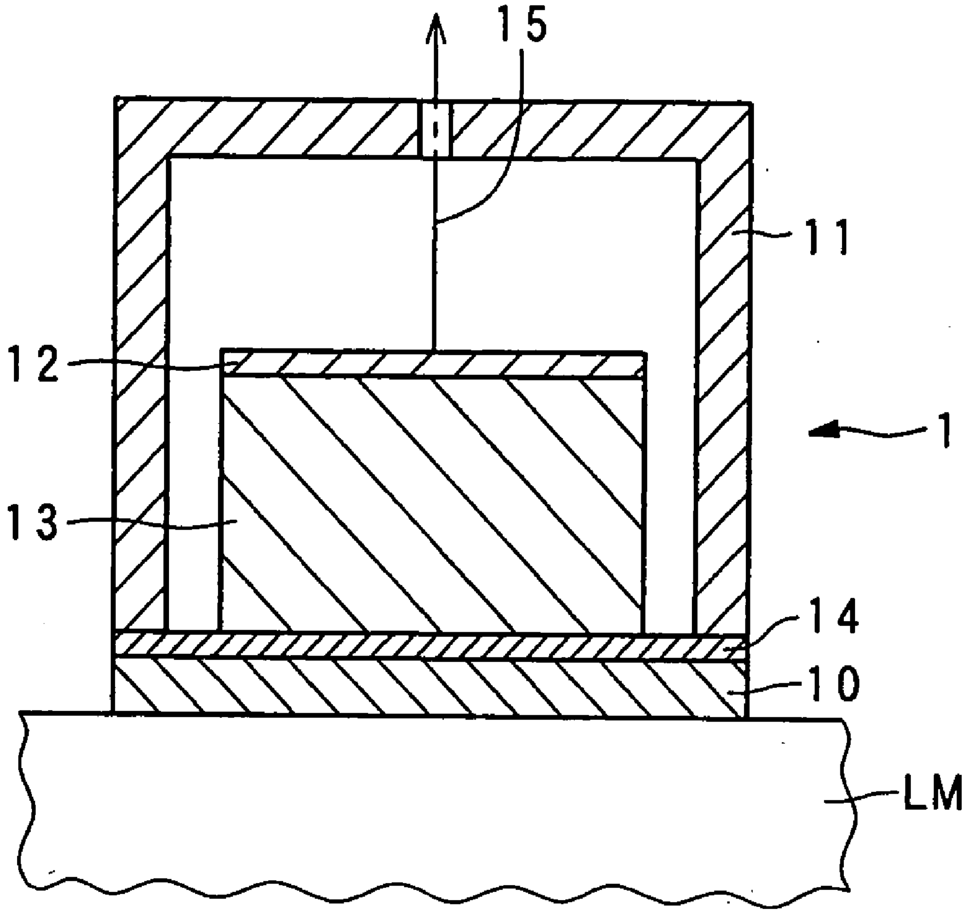


FIG.4

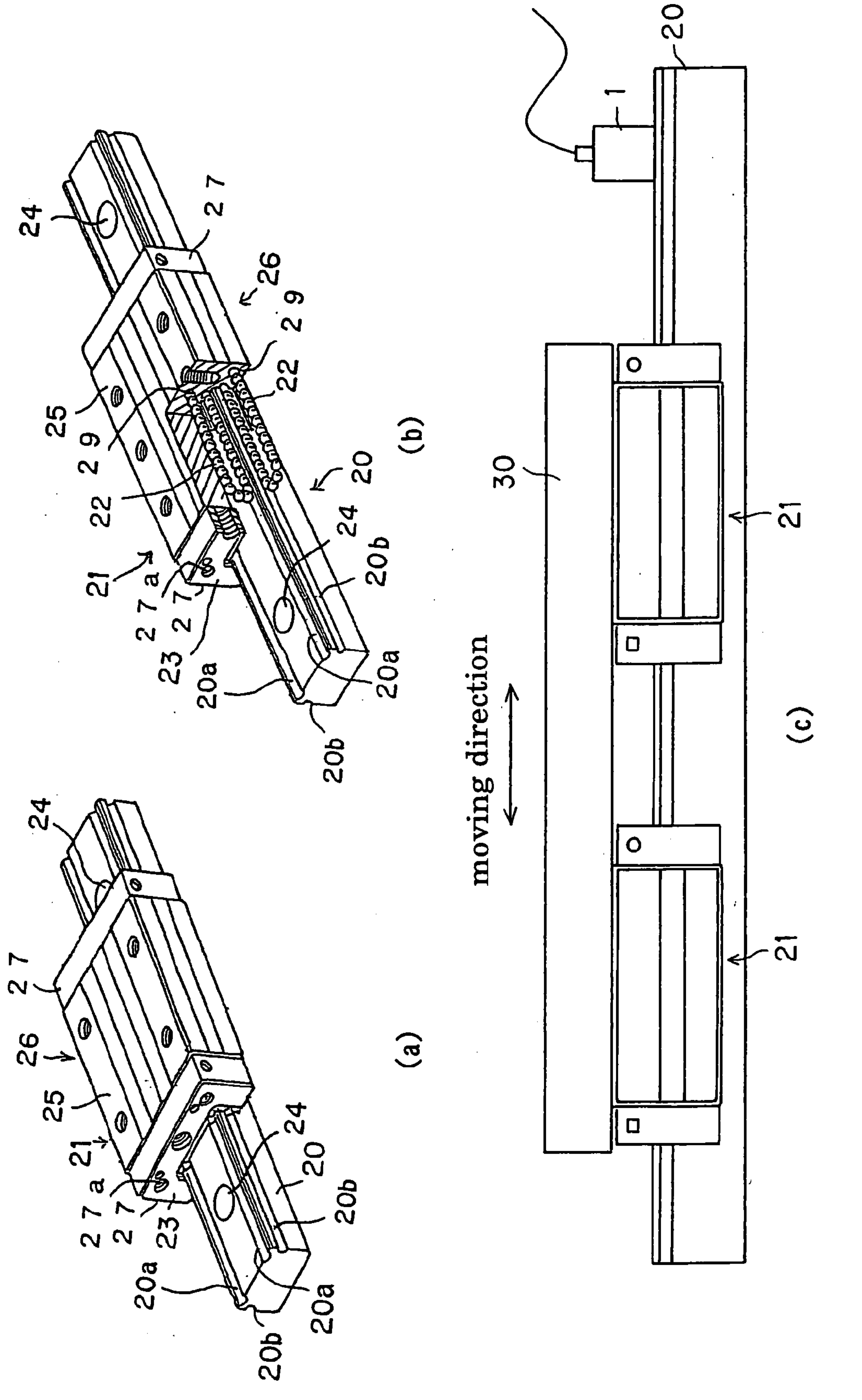


FIG.5

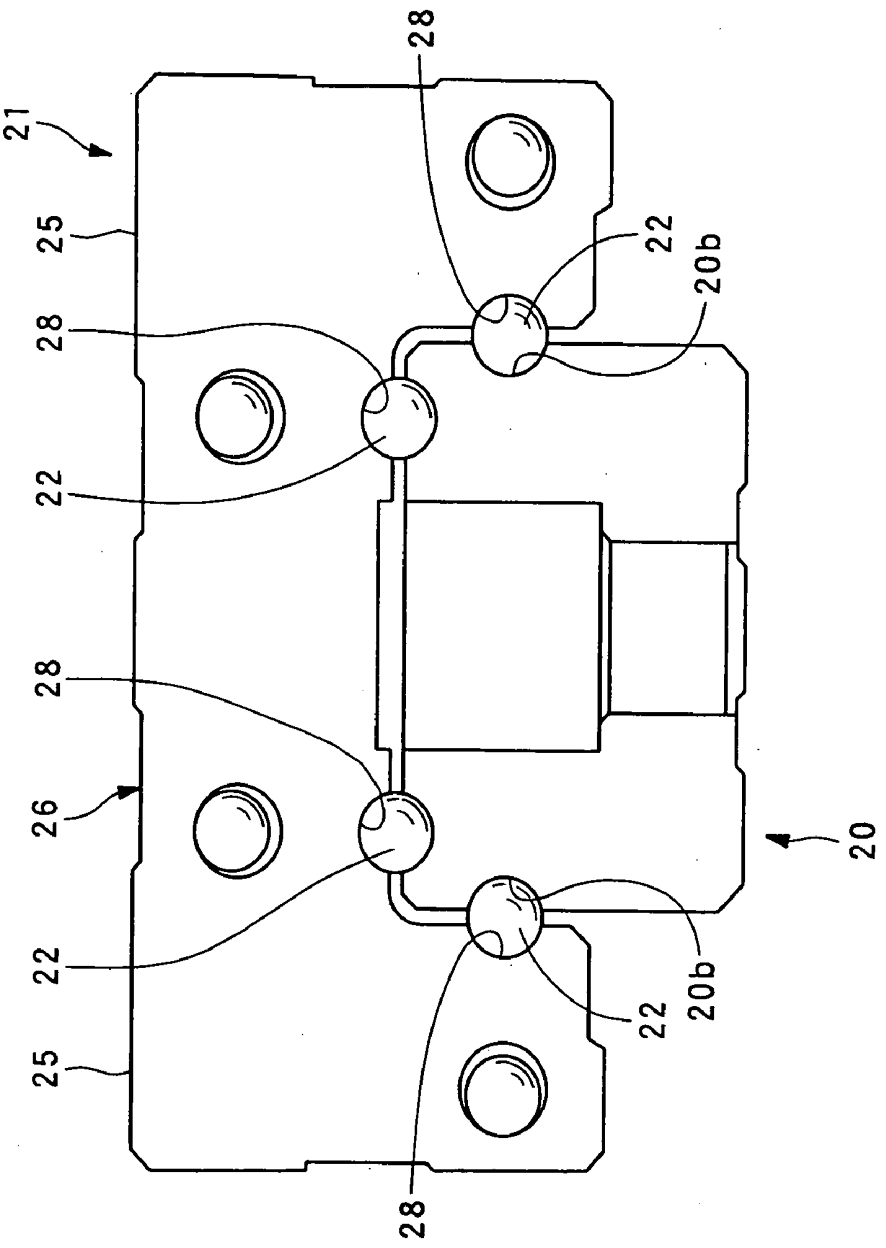


FIG.6

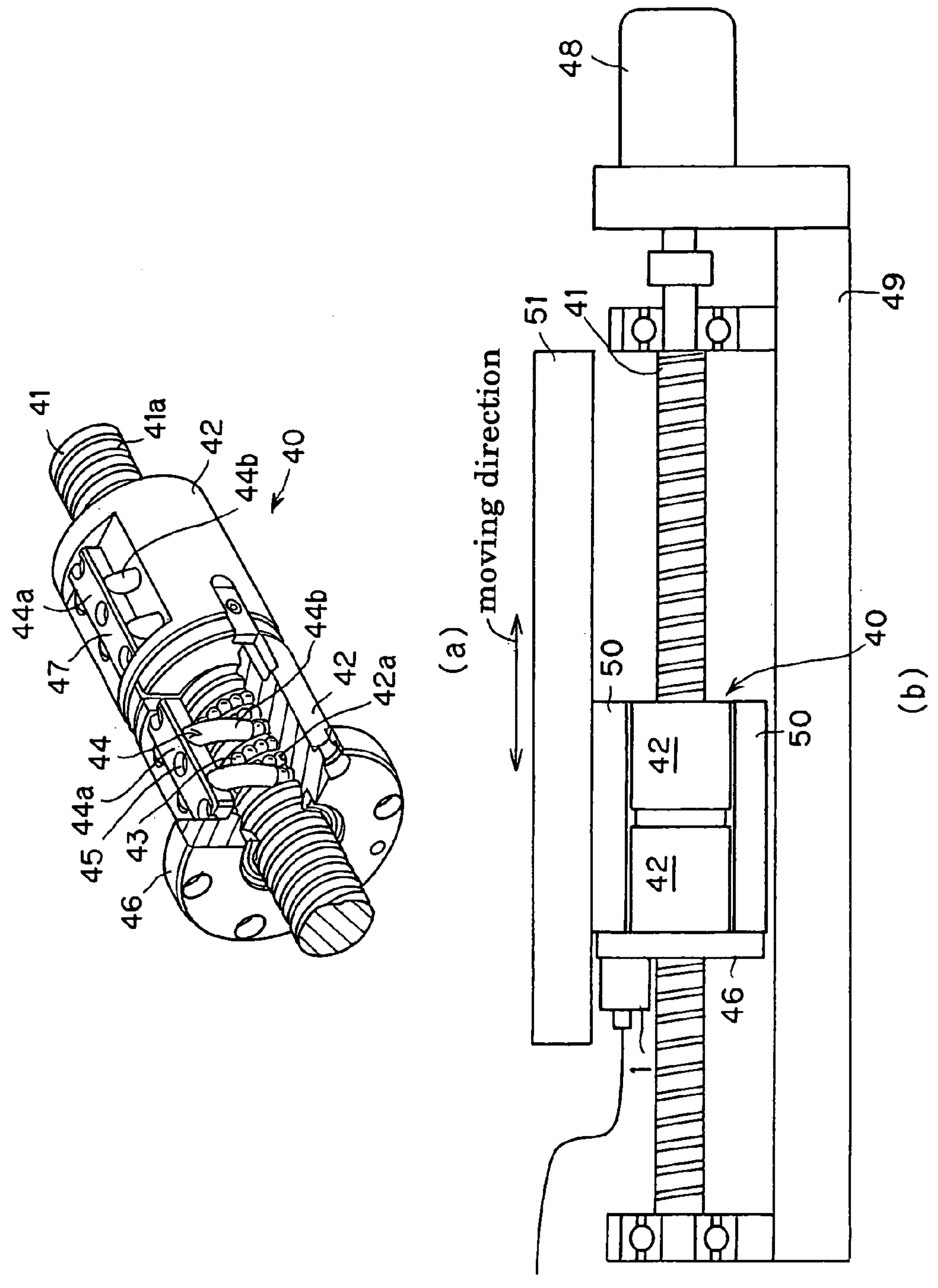
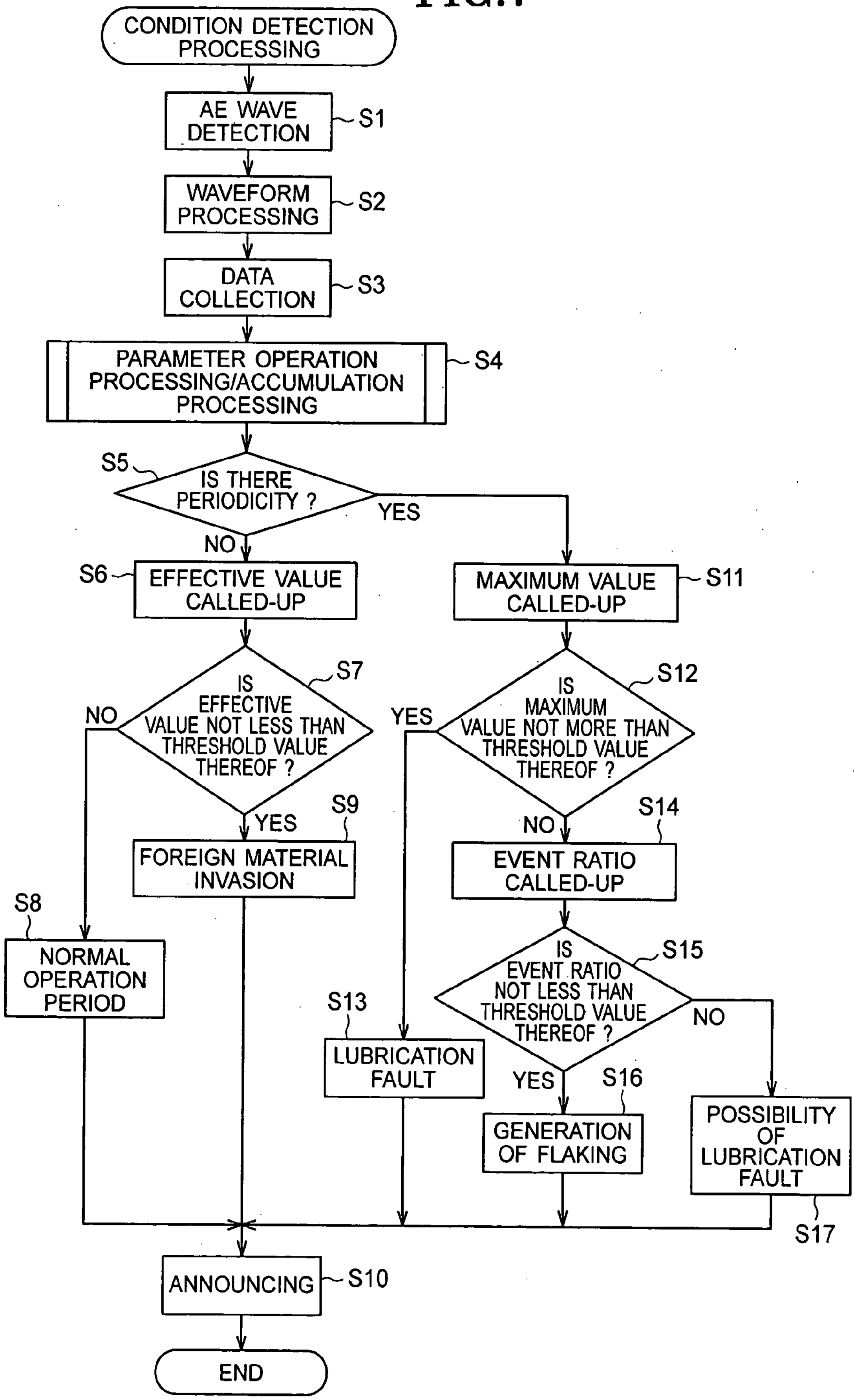

41
41a
42
44b
40
44a
47
44b
42
42a
44
44a
45
43
46
(a)
moving direction
48
51
41
49
50
40
42
50
42
46
1
(b)

FIG.7


CONDITION DETECTION PROCESSING
AE WAVE DETECTION
S1
WAVEFORM PROCESSING
S2
DATA COLLECTION
S3
PARAMETER OPERATION PROCESSING/ACCUMULATION PROCESSING
S4
S5
IS THERE PERIODICITY ?
YES
NO
S6
EFFECTIVE VALUE CALLED-UP
MAXIMUM VALUE CALLED-UP
S11
S7
IS EFFECTIVE VALUE NOT LESS THAN THRESHOLD VALUE THEREOF ?
NO
YES
S12
IS MAXIMUM VALUE NOT MORE THAN THRESHOLD VALUE THEREOF ?
YES
S9
FOREIGN MATERIAL INVASION
NO
S14
EVENT RATIO CALLED-UP
S8
NORMAL OPERATION PERIOD
S15
IS EVENT RATIO NOT LESS THAN THRESHOLD VALUE THEREOF ?
NO
S13
LUBRICATION FAULT
YES
S16
GENERATION OF FLAKING
POSSIBILITY OF LUBRICATION FAULT
S17
ANNOUNCING
S10
END

CONDITION-DETECTING DEVICE, METHOD, AND PROGRAM, AND INFORMATION-RECORDING MEDIUM

FIELD OF THE INVENTION

[0001] The present invention relates to a technical field of condition detection apparatus, condition detection method, condition detection program, and information recording medium, and more specifically, to a technical filed concerning condition detection apparatus and method for detecting a state in operation of a linear rolling motion guide apparatus when being driven and a condition detection program for detecting the operating condition thereof, and also to a technical field concerning an information recording medium recorded to be readable by a computer.

BACKGROUND ART

[0002] In the known art, there has been widely utilized a linear rolling motion guide apparatus including a rail, a movable block moving longitudinally on the rail, and a plurality of balls (rolling members) disposed between the rail and movable block for moving the movable block at a high accuracy while being rotating and circulating (revolving) itself. More specifically, such linear rolling motion guide apparatus has been utilized for a support member supporting three-dimensional motion of a work-table of a machine tool or supporting a pendulum motion of a pendulum electric car, or for an aseismatic structure of a building or like.

[0003] According to the widening of such usable fields of the linear rolling motion guide apparatus, there is an increased request for prevention of faults or like of the linear rolling motion guide apparatus from causing, and therefore, it has been required to provide a method of diagnosing an operation or operating condition thereof at a high accuracy.

[0004] Incidentally, general diagnostic methods of operating conditions of conventionally general machine systems, excluding the linear rolling motion guide apparatus, (for example, rotational rolling bearing including ball bearings and like) include: a vibration detecting method of diagnosing the operating condition by monitoring a vibration generating condition in the machine system; an oil evaluation method of diagnosing the operating condition by evaluating a quality of a lubrication oil used in the machine system; an electric resistance method of diagnosing the operating condition by measuring an electric resistance between members driven through the lubrication oil in the machine system; or a temperature measuring method of diagnosing the operating condition by measuring the temperature driven through the lubrication oil in the machine system by utilizing a thermocouple.

[0005] However, in a case where these diagnostic methods are applied to the linear rolling motion guide apparatus, the following problems have been raised.

[0006] That is, in the case of the vibration detecting method, when used for a linear rolling motion guide apparatus in which the balls as rolling members revolves in a circulation path while being rotated itself, so that many vibration generating sources exist other than an abnormal vibration generating source, and hence, the vibration which should be naturally detected cannot be accurately detected, thus providing a problem.

[0007] Further, in the case of the oil evaluation method, it is necessary to take out, for inspection, a lubrication oil before use in the linear rolling motion guide apparatus and a lubrication oil after the use therein, respectively, from the linear rolling motion guide apparatus as a target apparatus to be diagnosed, which requires much time for obtaining the diagnosed result, and it is also necessary to take out the lubrication oil by once stopping the operation of the linear rolling motion guide apparatus, thus reducing the working efficiency, also providing a problem.

[0008] Furthermore, the cases of the electric resistance method and the temperature measuring method are both not suitable to electric noises, and in addition, in a case where the movable block is moved at a low speed, the measurement itself is difficult, thus also providing a problem.

[0009] Accordingly, as mentioned above, in the conventional methods, it is difficult to accurately diagnose the operation or operating conditions of the linear rolling motion guide apparatus in a real time.

[0010] Then, present invention was therefore conceived in consideration of the above circumstances, and an object of the present invention is to provide a condition-detecting device and a condition-detecting method capable of foreseeing generation of fault in a linear rolling motion guide apparatus by accurately detecting an operation condition in a real time in the linear rolling motion guide apparatus, improving maneuverability, for user, of the linear rolling motion guide apparatus, elongating a usable life time and contributing to the quality improvement of devices or machineries incorporated with the linear rolling motion guide apparatus, to provide a program for the condition detection, and to provide an information recording medium in which the condition detection program is recorded to be readable by a computer.

DISCLOSURE OF THE INVENTION

[0011] In order to achieve the above object, the invention recited in claim **1** is a condition detection apparatus for detecting a present operation condition in a linear rolling motion guide apparatus comprising: detection means, such as AE (Acoustic Emission) sensor, for detecting a wave motion elastically generated on the basis of at least either one of contact or collision of a movable member or a track member to a rolling member contained in the linear rolling motion guide apparatus, contact or collision of a rolling surface to the rolling member contained in the linear rolling motion guide apparatus, or mutual contact or collision of the rolling members themselves, at a time when a plurality of rolling members contained in the linear rolling motion guide apparatus revolve in a circulation section therein, and generating an electric detection signal in accordance with the detected wave motion; and judgment means, such as signal processing unit, for judging a content of the present operation condition in response to the generated detection signal.

[0012] Accordingly, since the wave motion elastically generated by the operation of the linear rolling motion guide apparatus is detected to thereby detect the present operating condition thereof, the operating condition of the linear rolling motion guide apparatus can be detected in a real time without disassembling the apparatus while excluding influence of vibration caused by the operation of the apparatus.

[0013] In order to achieve the above object, the invention of claim **2** is the condition detection apparatus of claim **1**, in which the judgment means comprises: periodicity judgment means, such as signal processing unit, for judging presence or absence of a periodicity in the generated detection signal; maximum value detection means, such as signal processing unit, for detecting a maximum value in the generated detection signal at a time when it is judged that the periodicity is present; maximum value judgment means, such as signal processing unit, for judging whether or not the detected maximum value is not less than a preliminarily set threshold value of the maximum value; and condition judgment means, such as signal processing unit, for judging that, when the detected maximum value is not less than the threshold value of the maximum value, the linear rolling motion guide apparatus falls in a lubrication fault condition and then announcing that fact.

[0014] Accordingly, in the case when the generated detected signal has the periodicity and the maximum value at the detected signal is not less than the threshold value of the maximum value, it is judged that the linear rolling motion guide apparatus falls in a lubrication fault condition and that fact is then announced, so that the generation of the lubrication fault in the linear rolling motion guide apparatus can be easily and precisely detected in a real time during the operation of the apparatus.

[0015] In order to achieve the above object, the invention of claim **3** is the condition detection apparatus of claim **1**, in which the judgment means comprises: periodicity judgment means, such as signal processing unit, for judging presence or absence of a periodicity of the generated detection signal; maximum value detection means, such as signal processing unit, for detecting a maximum value in the generated detection signal at a time when it is judged that the periodicity is present; maximum value judgment means, such as signal processing unit, for judging whether or not the detected maximum value is not less than a preliminarily set threshold value of the maximum value; event ratio detection means, such as signal processing unit, for detecting an event ratio in the generated detection signal at a time when the detected maximum value is less than a threshold value of the maximum value; event ratio judgment means, such as signal processing unit, for judging whether or not the detected event ratio is not less than a preliminarily set threshold value of the event ratio; and condition judgment means, such as signal processing unit, for judging that, when the detected event ratio is less than the threshold value of the event value, the linear rolling motion guide apparatus is in a possibility of falling in a lubrication fault condition and then announcing that fact.

[0016] Accordingly, when the generated detected signal has the periodicity, the maximum value in the detected signal is less than the threshold value of the maximum value and the detected event ratio is less than the threshold value of the event value, it is judged that the linear rolling motion guide apparatus is in a possibility of falling in a lubrication fault condition and that fact is then announced, so that the possibility of the generation of the lubrication fault in the linear rolling motion guide apparatus can be detected easily and precisely in a real time during the operation of the apparatus.

[0017] In order to achieve the above object, the invention of claim **4** is the condition detection apparatus of claim **1**, in which the judgment means comprises: periodicity judgment means, such as signal processing unit, for judging presence or absence of a periodicity of the generated detection signal; maximum value detection means, such as signal processing unit, for detecting a maximum value in the generated detection signal at a time when it is judged that the periodicity is present; maximum value judgment means, such as signal processing unit, for judging whether or not the detected maximum value is not less than a preliminarily set threshold value of the maximum value; event ratio detection means, such as signal processing unit, for detecting an event ratio in the generated detection signal at a time when the detected maximum value is less than a threshold value of the maximum value; event ratio judgment means, such as signal processing unit, for judging whether or not the detected event ratio is not less than a preliminarily set threshold value of the event ratio; and condition judgment means, such as signal processing unit, for judging that, when the detected event ratio is not less than the threshold value of the event value, a flaking is generated in the linear rolling motion guide apparatus and then announcing that fact.

[0018] Accordingly, when the generated detected signal has the periodicity, the maximum value in the detected signal is less than the threshold value of the maximum value and the detected event ratio is not less than the threshold value of the event value, it is judged that a flaking is generated in the linear rolling motion guide apparatus and that fact is then announced, so that the generation of the flaking in the linear rolling motion guide apparatus can be detected easily and precisely in a real time during the operation of the apparatus.

[0019] In order to achieve the above object, the invention of claim **5** is the condition detection apparatus of claim **1**, in which the judgment means comprises: periodicity judgment means, such as signal processing unit, for judging presence or absence of a periodicity of the detected detection signal; effective value detection means, such as signal processing unit, for detecting an effective value of the detected detection signal at a time when it is judged that the periodicity is absent; effective value judgment means, such as signal processing unit, for judging whether or not the detected effective value is not less than a preliminarily set threshold value of the effective value; and condition judgment means, such as signal processing unit, for judging that, when the detected effective value is not less than the threshold value of the effective value, a foreign material invades in the linear rolling motion guide apparatus and then announcing that fact.

[0020] Accordingly, when the generated detected signal has no periodicity, and the effective value in the detected signal is not less than the threshold value of the effective value, it is judged that a foreign material is invaded in the linear rolling motion guide apparatus and that fact is then announced, so that the generation of the case of the invasion of the foreign material in the linear rolling motion guide apparatus can be detected easily and precisely in a real time during the operation of the apparatus.

[0021] In order to achieve the above object, the invention of claim **6** is the condition detection apparatus of claim **1**, in which the judgment means comprises: periodicity judgment means, such as signal processing unit, for judging presence or absence of a periodicity of the detected detection signal;

effective value detection means, such as signal processing unit, for detecting an effective value of the detected detection signal at a time when it is judged that the periodicity is absent; effective value judgment means, such as signal processing unit, for judging whether or not the detected effective value is not less than a preliminarily set threshold value of the effective value; and condition judgment means, such as signal processing unit, for judging that, when the detected effective value is less than the threshold value of the effective value, a present operation condition is normal, and then announcing that fact.

[0022] Accordingly, when the generated detected signal has no periodicity and the effective value in the detected signal is less than the threshold value of the effective value, it is judged that the present operating condition is normal and that fact is then announced, so that it can be detected easily and precisely in a real time whether or not the operating condition in the linear rolling motion guide apparatus is normal.

[0023] In order to achieve the above object, the invention of claim **7** is the condition detection method for detecting the present operating condition in the linear rolling motion guide apparatus, comprising: a detection step for detecting a wave motion elastically generated on the basis of at least either one of contact or collision of a movable member or a track member to a rolling member contained in the linear rolling motion guide apparatus, contact or collision of a rolling surface to the rolling member contained in the linear rolling motion guide apparatus, or mutual contact or collision of the rolling members themselves, at a time when a plurality of rolling members contained in the linear rolling motion guide apparatus revolve in a circulation section therein, and generating an electric detection signal in accordance with the detected wave motion; and a judgment step for judging a content of the present operation condition in response to the generated detection signal.

[0024] Accordingly, since the wave motion elastically generated by the operation of the linear rolling motion guide apparatus is detected to thereby detect the present operating condition thereof, the operating condition of the linear rolling motion guide apparatus can be detected in a real time without disassembling the apparatus while excluding influence of vibration caused by the operation of the apparatus.

[0025] In order to achieve the above object, the invention of claim **8** is the condition detection method of claim **7**, in which the judgment step comprises: a periodicity judgment step for judging presence or absence of a periodicity in the generated detection signal; a maximum value detection step for detecting a maximum value in the generated detection signal at a time when it is judged that the periodicity is present; a maximum value judgment step for judging whether or not the detected maximum value is not less than a preliminarily set threshold value of the maximum value; and a condition judgment step for judging that, when the detected maximum value is not less than the threshold value of the maximum value, the linear rolling motion guide apparatus falls in a lubrication fault condition and then announcing that fact.

[0026] Accordingly, in the case when the generated detected signal has the periodicity and the maximum value at the detected signal is not less than the threshold value of the maximum value, it is judged that the linear rolling motion guide apparatus falls in a lubrication fault condition and that fact is then announced, so that the generation of the lubrication fault in the linear rolling motion guide apparatus can be easily and precisely detected in a real time during the operation of the apparatus.

[0027] In order to achieve the above object, the invention of claim **9** is the condition detection method of claim **7**, in which the judgment means step comprises: a periodicity judgment step for judging presence or absence of a periodicity of the generated detection signal; a maximum value detection step for detecting a maximum value in the generated detection signal at a time when it is judged that the periodicity is present; a maximum value judgment step for judging whether or not the detected maximum value is not less than a preliminarily set threshold value of the maximum value; an event ratio detection step for detecting an event ratio in the generated detection signal at a time when the detected maximum value is less than a threshold value of the maximum value; an event ratio judgment step for judging whether or not the detected event ratio is not less than a preliminarily set threshold value of the event ratio; and a condition judgment step for judging that, when the detected event ratio is less than the threshold value of the event value, the linear rolling motion guide apparatus is in a possibility of falling in a lubrication fault condition and then announcing that fact.

[0028] Accordingly, when the generated detected signal has the periodicity, the maximum value in the detected signal is less than the threshold value of the maximum value and the detected event ratio is less than the threshold value of the event value, it is judged that the linear rolling motion guide apparatus is in a possibility of falling in a lubrication fault condition and that fact is then announced, so that the possibility of the generation of the lubrication fault in the linear rolling motion guide apparatus can be detected easily and precisely in a real time during the operation of the apparatus.

[0029] In order to achieve the above object, the invention of claim **10** is the condition detection method of claim **7**, in which the judgment step comprises: a periodicity judgment step for judging presence or absence of a periodicity of the generated detection signal; a maximum value detection step for detecting a maximum value in the generated detection signal at a time when it is judged that the periodicity is present; a maximum value judgment step for judging whether or not the detected maximum value is not less than a preliminarily set threshold value of the maximum value; an event ratio detection step for detecting an event ratio in the generated detection signal at a time when the detected maximum value is less than a threshold value of the maximum value; an event ratio judgment step for judging whether or not the detected event ratio is not less than a preliminarily set threshold value of the event ratio; and a condition judgment step for judging that, when the detected event ratio is not less than the threshold value of the event value, a flaking is generated in the linear rolling motion guide apparatus and then announcing that fact.

[0030] Accordingly, when the generated detected signal has the periodicity, the maximum value in the detected signal is less than the threshold value of the maximum value and the detected event ratio is not less than the threshold value of the event value, it is judged that a flaking is generated in the linear rolling motion guide apparatus and that fact is then announced, so that the generation of the flaking in the linear rolling motion guide apparatus can be detected easily and precisely in a real time during the operation of the apparatus.

[0031] In order to achieve the above object, the invention of claim **11** is the condition detection method of claim **7**, in which the judgment step comprises: a periodicity judgment step for judging presence or absence of a periodicity of the detected detection signal; an effective value detection step for detecting an effective value of the detected detection signal at a time when it is judged that the periodicity is absent; an effective value judgment step for judging whether or not the detected effective value is not less than a preliminarily set threshold value of the effective value; and a condition judgement step for judging that, when the detected effective value is not less than the threshold value of the effective value, a foreign material invades in the linear rolling motion guide apparatus and then announcing that fact.

[0032] Accordingly, when the generated detected signal has no periodicity, and the effective value in the detected signal is not less than the threshold value of the effective value, it is judged that a foreign material is invaded in the linear rolling motion guide apparatus and that fact is then announced, so that the generation of the case of the invasion of the foreign material in the linear rolling motion guide apparatus can be detected easily and precisely in a real time during the operation of the apparatus.

[0033] In order to achieve the above object, the invention of claim **12** is the condition detection method of claim **7**, in which the judgment step comprises: a periodicity judgment step for judging presence or absence of a periodicity of the detected detection signal; an effective value detection step for detecting an effective value of the detected detection signal at a time when it is judged that the periodicity is absent; an effective value judgment step for judging whether or not the detected effective value is not less than a preliminarily set threshold value of the effective value; and a condition judgement step for judging that, when the detected effective value is less than the threshold value of the effective value, a present operation condition is normal and then announcing that fact.

[0034] Accordingly, when the generated detected signal has no periodicity and the effective value in the detected signal is less than the threshold value of the effective value, it is judged that the present operating condition is normal and that fact is then announced, so that it can be detected easily and precisely in a real time whether or not the operating condition in the linear rolling motion guide apparatus is normal.

[0035] In order to achieve the above object, the invention of claim **13** is a condition detection program, wherein a condition detection apparatus for detecting a present operation condition in a linear rolling motion guide apparatus, which includes detection means for detecting a wave motion elastically generated on the basis of at least either one of contact or collision of a movable member or a track member to a rolling member contained in the linear rolling motion guide apparatus, contact or collision of a rolling surface to the rolling member contained in the linear rolling motion guide apparatus, or mutual contact or collision of the rolling members themselves, at a time when a plurality of rolling members contained in the linear rolling motion guide apparatus revolve in a circulation section therein, and generating an electric detection signal in accordance with the detected wave motion, includes a computer which is operated as judgment means for judging a content of the operation condition in response to the generated detected signal.

[0036] Accordingly, since the computer functions so as to detect the wave motion elastically generated by the operation of the linear rolling motion guide apparatus and to thereby detect the present operating condition thereof, the operating condition of the linear rolling motion guide apparatus can be detected in a real time without disassembling the apparatus while excluding influence of vibration caused by the operation of the apparatus.

[0037] In order to achieve the above object, the invention of claim **14** is an information recording medium, wherein the condition detection program as claimed in claim **13** is recorded to be readable by the computer.

[0038] Accordingly, at the time of reading out and executing the program for the condition detection by utilizing the computer, since the computer functions so as to detect the wave motion elastically generated by the operation of the linear rolling motion guide apparatus and to thereby detect the present operating condition thereof, the operating condition of the linear rolling motion guide apparatus can be detected in a real time without disassembling the apparatus while excluding influence of vibration caused by the operation of the apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] **FIG. 1** is one for explaining the principle of the present invention, in which (a) and (b) are views showing generation of en extended AE wave according to an embodiment of the present invention and (c) is one example of envelope detection wave-shape corresponding to the extended AE wave.

[0040] **FIG. 2** is a block diagram showing a structure of the condition detection apparatus according to the embodiment of the present invention.

[0041] **FIG. 3** is a elevational section of an AE sensor according to the embodiment of the present invention.

[0042] **FIG. 4** is one (I) representing an installation example of the AE sensor according to the embodiment of the present invention, in which (a) is a perspective view of an outer appearance showing a structure of an LM system including a movable block, (b) is a perspective view showing an inner structure thereof, and (c) is a side view of an outer appearance of one example of a position in a case where the AE sensor is set to the LM system.

[0043] **FIG. 5** is a side view of the LM system including the movable block according to the embodiment of the present invention.

[0044] **FIG. 6** is one (II) representing an installation example of the AE sensor according to the embodiment of the present invention, in which (a) is a perspective view of an outer appearance showing a structure of an LM system including a ball screw and (b) is a side view of an outer appearance of one example of a position in a case where the AE sensor is set to the LM system.

[0045] **FIG. 7** shows a flowchart representing an operating condition detection procedure.

BEST MODE FOR EMBODYING THE INVENTION

[0046] Hereunder, a preferred embodiment of the present invention will be described with reference to the accompanying drawings.

[0047] Further, embodiments described hereinafter are ones in which the present invention is applied to detection and diagnosis of an operational (or operating) condition in a linear rolling motion guide apparatus (hereinafter, merely called LM "Linear Motion" System, more specifically, including a linear motion system such as so-called an LM guide, ball spline and the like).

[0048] (I) Principle of the Invention

[0049] First, in advance of the concrete explanation of the embodiment of the present invention, the principle of the present invention will be described with reference to **FIG. 1**.

[0050] In a study of a diagnosis method of operating condition of an LM system of the type mentioned above, the inventor of the subject application was found that so-called an AE phenomenon could be utilized for the diagnosis of the operating condition of the LM system utilized for the diagnosis of fault of a conventional rolling roller bearing device.

[0051] That is, the inventor of the present invention was found through experiments that mutually different AE waves were caused in a case where the AE phenomena of different modes are caused with respect to various abnormal operating conditions (specifically, generation of lubrication defect and flaking (that is, peeling phenomenon on a ball surface as rolling member included in the LM system, or a guide surface as a track member to which the ball contacts), or mixing of foreign material), and according to such causing, various abnormal operating conditions were caused.

[0052] Here, such AE phenomena or phenomenon was defined in a conventional technology, as "phenomenon generating acoustic emission wave (AE wave) by releasing an elastic energy in accordance with destroy or deformation of a solid material" or "phenomenon generating an elastic wave following plastic deformation or crack generation inside a material". The inventor of the subject application, however, confirmed in addition thereto that the AE wave is also generated only by mutual collision of balls caused by the normal operation of the LM system through any plastic deformation or crack is not generated on the ball or guide surface.

[0053] More specifically, in the case of the LM system utilizing the movable block, as shown in **FIG. 1**(*a*), the ball B revolves, while rotating, in the rolling path formed in the movable block C, it was confirmed by the inventor that the AE wave is generated in each of the cases when the balls B collide with each other at the contact point P**1**, when the ball B and the movable block C collide at the contact point P**2**, and when the ball B and the rolling surface G collide at the contact point P**3**.

[0054] Further, as shown in **FIG. 1**(*b*), with respect to the case of the LM system utilizing the movable block, even in the case where not only the ball B but also so-called a retainer R is disposed in the rolling path, if the ball B revolves, while rotating, in the rolling path formed in the movable block C, it was confirmed by the inventor that the AE wave is generated in each of the cases when the ball B and the movable block C collide with each other at the contact point P**5** and when the ball B and the rolling surface G collide with each other at the contact point P**4**.

[0055] The inventor then found that the generation modes of such AE waves were different from each other in accordance with kinds or types of the abnormal operating conditions mentioned hereinabove.

[0056] Further, as mentioned above, in the present invention, the generation of the AE phenomenon in a range wider than that of the AE phenomenon according to the conventional definition is promised, so that, in the following description, the AE phenomenon applied to the present invention is referred to as extended AE phenomenon, and the AE wave generated based on this extended AE phenomenon is referred to as extended AE wave.

[0057] Further, an electric signal corresponding to the extended AE wave has a frequency higher than a vibration or oscillation generally generated at an operating period of the LM system, and accordingly, for example, as shown in **FIG. 1**(*c*), it is possible to detect it separately from that vibration by the so-called envelope detection wave method, and it is thereby possible to detect the operating condition in real time during the operation of the LM system.

[0058] (II) Exemplary Embodiment

[0059] Hereunder, the exemplary embodiment of the present invention based on the above principle will be specifically explained with reference to FIGS. **2** to **7**.

[0060] Herein, **FIG. 2** is a block diagram showing a general structure of a condition diagnosis apparatus according to the embodiment of the present invention, **FIG. 3** is an elevational section showing a general structure of an AE sensor detecting the extended AE wave according to the embodiment of the present invention, FIGS. **4** to **6** are views for explaining the LM system to which the present invention is applied, and **FIG. 7** shows a flowchart representing an operating condition detection procedure executed by the condition diagnosis apparatus according to the present embodiment.

[0061] As shown in **FIG. 2**, a condition diagnosis apparatus S according to the present embodiment comprises an AE sensor **1**, a waveform shaping unit **2** including a BPF (Band Pass Filter) **2**A and an envelope detection section **2**B, an A/D (analog-to-digital) converter **3**, a signal processing unit **4** serving as periodicity judging means, maximum value detecting means, maximum value judging means, condition judging means, event detection means, event judging means, effective value detecting means and effective value judging means, and a display unit **5** including a liquid crystal display and the like.

[0062] Next, operation of the embodiment will be described.

[0063] First, the AE sensor **1** is disposed at an optional position of the LM system which is an object to be diagnosed, for example, an end position of a rail or a position on a movable block as a movable member. The AE sensor **1** detects the extended AE wave generated by the operation of the LM system and outputs the detected AE wave to the waveform shaping unit **2** after the conversion into a detection signal Sae as analog signal.

[0064] Next, the BPF **2**A in the waveform shaping unit **2** serves to remove a frequency component other than the extended AE wave from the detection signal Sae and generate it to the envelope detection section **2**B. Herein, it is desirable to use an BPR, for example as a concrete example of this BPF **2**A, capable of passing the frequency component more than 100 kHz and less than 1 MHz as pass frequency band area with respect to the detection signal Sae in this BPF **2**A.

[0065] The envelope detection section **2**B serves to extract the envelope component based on the detection signal Sae and create an envelope signal Sw, which is then sent to the A/D converter **3**.

[0066] Next, the A/D converter **3** serves to digitalize the envelope signal Sw as analog signal and create a digital envelope signal Sdw, which is then sent to the signal processing unit **4**.

[0067] The signal processing unit **4** serves to judge the present operation (operating) condition in the LM system as the object to be diagnosed by the operation condition detection processing shown in **FIG. 7**, described hereinlater, based on the digital envelope signal Sdw, and a resulting judgment signal Sdp is created, which is then outputted to the display unit **5**.

[0068] According to the operations mentioned above, the display unit **5** serves to display its content based on the judgment signal Sdp, thereby making it possible to grasp the operating condition of the LM system by a user thereof.

[0069] Next, the structure of the AE sensor **1** and its setting mode to the LM system as the object to be diagnosed will be explained hereunder with reference to FIGS. **3** to **6**.

[0070] An inside structure of the AE sensor **1** will be first described with reference to **FIG. 3**.

[0071] As shown in **FIG. 3**, the AE sensor **1** has a circular cylindrical shape in its entire structure, and more specifically, is composed of a contact portion **10** arranged so as to contact a rail LM or like in the LM system, a casing **11**, a piezoelectric element **13**, silver evaporated thin films **12** and **14** deposited on upper and lower surfaces of the piezoelectric element **13**, and an external line **15** through which the detection signal Sae, mentioned above, is outputted to the waveform shaping unit **2**.

[0072] When the extended AE wave generated inside the LM system is transferred to the piezoelectric element **13** via the contact portion **10** and the silver thin film **14**, the shape of the piezoelectric element **13** is minutely deformed by the extended AE wave, and hence, an electric potential difference is caused between the silver thin films **12** and **14**, thus generating the detection signal Sae on the external line **15**.

[0073] The AE sensor **1** having the structure mentioned above is installed to the LM system in the following manner with reference to FIGS. **4** to **6**. Further, **FIG. 4** and **FIG. 5** are views representing examples at a time of installing the AE sensor **1** to the LM system using the movable block as an object to be diagnosed, and **FIG. 6** is a view representing an example at a time of installing the AE sensor **1** to the LM system using the ball screw as an object to be diagnosed.

[0074] First, the case where the AE sensor **1** is mounted to the LM sensor utilizing the movable block will be explained with reference to **FIGS. 4 and 5**.

[0075] The LM system shown in FIGS. **4**(*a*) and (*b*) is composed of a rail **20** provided with ball rolling grooves **20***a* and **20***b* along which balls **22** roll in the longitudinal direction as mentioned later, a movable block **21** engaged with the rail **20** through the number of balls **22** and provided, in its inside, with an endless circulation passage of the balls **22**, and seal members **23** applied to both end surfaces of the movable block **21** in its moving direction so as to seal the upper and both side surfaces of the rail **20**, and according to the circulation of the balls **22**, the movable block **21** is reciprocally moved on the rail **20**.

[0076] As shown in these figures, the rail **20** has substantially a rectangular shape in section and formed with attachment holes **24** for inserting fastening bolts, the holes being formed through out the rail **20** in its longitudinal direction at an appropriate interval between adjacent ones. In addition, two rows of ball rolling grooves **20***a* are formed on the upper surface of the rail **20** so as to sandwich the attachment holes **24** therebetween, and on the other hand, further two rows of ball rolling grooves **20***b* are formed to the side surfaces of the rail **20**, respectively. These four rows of ball rolling grooves are formed with a radius of curvature slightly larger than the radius of curvature of the spherical surface of the ball **22** so as to provide a relatively deep grope shape.

[0077] On the other hand, the movable block **21** is composed of a block body **26** provided with a mount surface **25** to which a movable member such as table **30**, mentioned hereinlater, is mounted, and a pair of end plates **27**, **27** fixed to both longitudinal end surface portions of the block body **26**, and the lower side of the movable block **21** has a straddle shape, in section, having a recessed portion in its lower side into which the rail **20** is idly fitted.

[0078] Then, as shown **FIG. 5**, the block body **26** has a pair of skirt portions extending downward from a base, to which the mount surface **25** mentioned before is formed, or both the end portions of the base so as to provide a saddle shape in section, and four rows of loaded rolling grooves **28** are formed to the inside surfaces of the skirt portions and the lower surface of the rail **20** so as to correspond respectively to the ball rolling grooves **20***a* and **20***b* formed thereto. The balls **20** roll between the loaded rolling grooves **28** and the ball rolling grooves **20***a* and **20***b* while being loaded, whereby the movable block **21** is moved on the rail **20**.

[0079] Now, back to FIGS. **4**(*a*) and (*b*), the base and the skirt portions of the block body **26** are pierced as ball return bores **29** corresponding to the loaded rolling grooves **28**, respectively, and these ball return bores **29** are coupled and communicated with the loaded rolling grooves **28**, respectively, through direction changing passages having substantially U-shape, not shown, formed to the end plates **27**, **27**. That is, the direction changing passages scoop up balls **22** which have rolled on the loaded rolling grooves **28** of the block body **26** and feed the balls **22** to the ball return bores **29**, and on the other hand, the direction changing passages also serve to feed the balls **22** from the ball return bores **29** again to the loaded rolling grooves **28**. Accordingly, by fastening the end plates **27**, **27** to the block body **26** by means of fastening bolts **21***a*, **21***a*, the endless circulation passage for the balls **22** is formed to the movable block **21**.

[**0080**] Further, when the AE sensor **1** of the present embodiment is set to the LM system shown in FIGS. **4**(*a*) and (*b*), as shown in **FIG. 4**(*c*) as an outer appearance side view, for example, in the case where the table **30** is set on a plurality of movable blocks **21** which linearly move on the track rail **20**, the AE sensor **1** is placed on a position of the rail **20** outside the moving range of the movable block **21**.

[**0081**] Next, the case where the AE sensor **1** is set to the LM system utilizing the ball screw will be explained with reference to **FIG. 6**.

[**0082**] As shown in **FIG. 6**(*a*), a ball screw **40** is provided with a screw shaft **41** having an outer peripheral surface in which a spiral ball rolling groove **41***a* is formed, a nut member **42** having an inner peripheral surface in which a spiral loaded rolling groove **42***a* is formed so as to correspond to the spiral ball rolling groove **41***a*, and a number of balls **43**, **43**, rolling between the ball rolling groove **41***a* and the loaded rolling groove **42***a*. A loaded rolling passage is formed by and between he ball rolling groove **41***a* of the screw shaft **41** and the loaded rolling groove **42***a* of the nut member **42**. The nut member **42** is mounted with two return pipes **44** as circulation members. The return pipes **44** connect one and the other ends of the loaded rolling passage so as to constitute a non-loaded return passage. The return pipes **44** has substantially gate-shaped arrangement having a central portion **44***a* and a pair of leg portions **44***b*, **44***b* on both sides of the central portion **44***a*. The paired leg portions **44***b*, **44***b* are inserted into the loaded rolling passage at a several-pitch interval. The return pipes **44** are fixed to the nut member **42** by coupling means such as bolts **45**.

[**0083**] The spiral ball rolling groove **41***a* of the screw shaft **41** is formed, through a grinding working, rolling working or like working, in the outer peripheral surface thereof so as to provide a semi-circular cross section with a constant lead. The nut member **42** has substantially a cylindrical shape and is provided with a flanged portion **46** at one end for mounting the ball screw **40** to a machine or like. The loaded rolling groove **42***a* having a semi-circular sectional shape corresponding to the ball rolling groove **41***a* of the screw shaft **41** is formed to the inner peripheral surface of the nut member **42**. The nut member **42** is provided with a flat surface portion **47** partially of an upper surface. A plurality of return pipe fitting holes, into which the leg portions **44***b*, **44***b* of the return pipes **44** are inserted, are formed to the flat surface portion **47** of the nut member **42**.

[**0084**] Then, when the AE sensor **1** of the present embodiment is set to the LM system shown in **FIG. 6**(*a*), in the case where the ball screw **41** driven by a motor **48** is rotatably supported by a table **49**, for example, as shown in **FIG. 6**(*b*) as an outer appearance view, and a table **51** is fixed to the ball screw **40** through a bracket **50**, the AE sensor **1** is mounted to a surface of the flanged portion **46** perpendicular to the central axis of the ball screw **40**.

[**0085**] In the followings, the operating condition detection processing according to the embodiment executed mainly by the signal processing unit **4** will be explained with reference to **FIGS. 1, 2** and **7**.

[**0086**] As shown in **FIG. 7**, in the case when the operating condition detection processing according to the embodiment of the present invention is executed during the operation of the LM guide being the object to be diagnosed, a required initial setting processing is first carried out. Next, the extended AE wave generated in accordance with the extended AE phenomenon during the LM system operation is detected by the AE sensor **1** (step S**1**), the detection signal Sae generated in response to the detected AE wave is subjected to the waveform shaping in the waveform shaping unit **2** (step S**2**), and the envelope signal Sw is created and sent as digital envelope signal Sdw, through the A/D converter **3**, to the signal processing unit **4**. Thereafter, the extended AE wave detection procedure (step S**1**) and the waveform shaping procedure (step S**2**) are repeated by required inspection times to thereby store the data concerning the digital envelope signal Sdw in a memory, not shown, in the signal processing unit **4** (step S**3**), and a parameter utilizing for respective judgments or discriminations are operated based on the stored data, which is then stored in the memory (step S**4**).

[**0087**] In this embodiment, this parameter specifically includes four parameters representing: presence or absence of periodicity of the data of the digital envelope signal Sdw; a maximum value in the digital envelop signal data in the detection period preliminarily set in accordance with the moving distance and moving speed in one direction in the movable block reciprocating motion, for example, included in the LM system as an object to be diagnosed; an effective value in the detection period; and the event ratio in the detection period.

[**0088**] More specifically, the periodicity of the data of the digital envelope signal Sdw is one that detected by means of frequency analysis of the frequency repeating contact to and separation from a rail surface in the case that the ball revolves in accordance with the operation of the LM system, which is specific to the case of detecting the operating condition of the LM system.

[**0089**] Further, the effective value mentioned above is obtained by squaring and then averaging the values of the digital envelope signals Sdw with respect to the detection period thereof.

[**0090**] Furthermore, the event ratio mentioned above is a parameter that represents the times (numbers), in one detection period, in which the value of the digital envelope signal Sdw exceeds the preset threshold value.

[**0091**] Upon the completion of the operation or calculation and accumulation of the respective parameters, it is judged or discriminated, in the signal processing unit **4**, whether or not there exists the periodicity with respect to the values of the digital envelope signal Sdw with reference to the preset frequency analysis value (step S**5**).

[**0092**] In the judgment in the step S**5**, in a case that the periodicity is not detected, (i.e., NO, in step S**5**), the effective value of the digital envelope signal Sdw is called up from the memory (step S**6**).

[**0093**] Then, it is judged whether the call-up effective value exceeds the threshold value of the effective value as a threshold value which was experimentally preset for the judgment whether a foreign material is included or operation is normally performed (step S**7**).

[**0094**] Next, in the judgment in the step S**7**, in a case that the called-up effective value is less than the threshold value of the effective value (i.e., NO in step S7), it is judged that the LM system now as an object to be diagnosed is normally operated at the present stage (step S**8**), and this effect is displayed by using the display unit **5** (step S**10**). Then, a series of operation (operating) condition detection procedures has been completed.

[**0095**] On the other hand, in the judgment in the step S7, in the judgment in the step S7, in a case that the called-up effective value is not less than the threshold value of the effective value (i.e., YES in step S7), it is judged that any foreign material is included in the LM system as an object to be diagnosed (step S9), and this effect is displayed by using the display unit **5** (step S**10**). Then, a series of operation (operating) condition detection procedures has been completed.

[**0096**] Further, in the judgment in the step S**5**, in the case that the periodicity is detected (i.e., YES in step S**5**), the maximum value in the digital envelope signal Sdw is called up from the memory (step S**11**), and then, it is judged whether the called-up maximum value exceeds the threshold value of the maximum value as a threshold value which was experimentally preset for the judgment whether any lubrication fault is caused at the present stage (step S**12**).

[**0097**] In this judgment, in the case that the called-up maximum value is not less than the threshold value of the maximum value (i.e., YES in step S**12**), it is judged that the lubrication fault is caused at the present stage in the LM system as an object to be diagnosed (step S**13**), and this effect is displayed by using the display unit **5** (step S**10**). Then, a series of operation (operating) condition detection procedures has been completed.

[**0098**] Next, in the judgment in the step S**12**, in the case that the called-up maximum value is less than the threshold value of the maximum value (i.e., NO in step S**12**), the event ratio mentioned before to the digital envelope signal Sdw is called up from the memory (step S**14**).

[**0099**] Then, in order to judge or discriminate whether there is a possibility of generation of the flaking or lubrication fault in the LM system as the object to be diagnosed, it is judged whether or not the called-up event ratio is not less than the threshold value of the event ratio experimentally preset (step S**15**).

[**0100**] Next, in the judgment in step S**15**, in the case that the called-up event ratio is less than the threshold value of the event ratio (i.e., NO in step S**15**), it is judged that there is high possibility of causing the lubrication fault at the present stage in the LM system as an object to be diagnosed (step S**17**), and this effect is displayed by using the display unit **5** (step S**10**). Then, a series of operation (operating) condition detection procedures has been completed. Further, the degree of the lubrication fault judged in the step S**17** differs from the degree of the lubrication fault judged in the step S**13**, and the former (case of the step S**17**) only judges the possibility of the causing of the lubrication fault, and on the other hand, the latter (case of the step S**13**) can judge the surly causing of the lubrication fault.

[**0101**] Moreover, in the judgment in the step S**15**, in the case that the called-up event ratio is not less than the threshold value of the event ratio (i.e., YES in step S**15**), it is judged that the flaking is generated at the present stage in the LM system as an object to be diagnosed (step S**16**), and this effect is displayed by using the display unit **5** (step S**10**). Then, a series of operation (operating) condition detection procedures has been completed.

[**0102**] Further, the described series of operation condition detection result is displayed, accumulated in the memory in the signal processing unit **4** and then statistically processed, thereby detecting worsening of the operating condition and obviating the generation of faults.

[**0103**] As mentioned above, according to the operation of the condition diagnosing apparatus S of the present embodiment, since the present operating condition of the LM system can be detected by detecting the extended AE wave generated in accordance with the operation of the LM system, the operating condition can be detected during the operation thereof in a real time, without disassembling the LM system, while excluding influence due to vibration based on the operation of the LM system.

[**0104**] Therefore, it becomes possible to foresee the generation or causing of faults in the LM system, thus improving the maneuverability for a user of the LM system and elongating the usable life time thereof and improving the quality of devices or machineries manufactured by utilizing this LM system.

[**0105**] Furthermore, in the case that the generated digital envelope signal Sdw has the periodicity and the maximum value of this digital envelope signal Sdw is not less than the threshold value of the maximum value, it is judged that the LM system now falls in lubrication fault condition, which is then announced, so that the generation of the lubrication fault condition in the LM system can be precisely detected in a real time during the operation thereof.

[**0106**] Still furthermore, in the case that the generated digital envelope signal Sdw has the periodicity and the maximum value of this digital envelope signal Sdw is less than the threshold value of the maximum value, and that the event ratio of the digital envelope signal Sdw is less than the threshold value of the event ratio, it is judged that the LM system may have a possibility of falling in the lubrication fault condition, which is then announced, so that the possibility of the generation of the lubrication fault condition in the LM system can be precisely detected in a real time during the operation thereof.

[**0107**] Still furthermore, in the case that the generated digital envelope signal Sdw has the periodicity and the maximum value of this digital envelope signal Sdw is less than the threshold value of the maximum value, and that the event ratio of the digital envelope signal Sdw is not less than the threshold value of the event ratio, it is judged that the flaking is caused in the LM system, which is then announced, so that the generation of the flaking in the LM system can be easily and precisely detected in a real time during the operation thereof.

[**0108**] Still furthermore, in the case that the generated digital envelope signal Sdw has no periodicity and the effective value of this digital envelope signal Sdw is not less than the threshold value of the effective value, it is judged that the foreign material invades in the LM system, which is then announced, so that the generation of the invasion of the foreign material into the LM system can be easily and precisely detected in a real time during the operation thereof.

[0109] Still furthermore, in the case that the generated digital envelope signal Sdw has no periodicity and the effective value of this digital envelope signal Sdw is less than the threshold value of the effective value, it is judged that the LM system is now in the normally operating condition, which is then announced, so that the it can be easily and precisely detected in a real time whether the operating condition at the digital envelope signal Sdw is normal or not.

[0110] Further, by recording a program corresponding to the flowchart shown in **FIG. 7** to an information recording medium such as flexible disk or hard disk, or recording the program obtained by means of network such as internet, and reading out and then executing the program by a general-use (general) micro-computer, this micro-computer can be operated as the signal processing unit **4** in this embodiment. In this case, the AE sensor **1**, the waveform shaping unit **2** and the A/D converter **3**, which are mentioned hereinbefore, will be connected to the micro-computer as external-type devices.

[0111] Furthermore, in the above-mentioned embodiment, the condition detection apparatus S shown in **FIG. 2** is constructed as an apparatus having single structure, and more specifically, this embodiment is applied to a case that the present condition diagnosis apparatus S is carried to a site such as factory in which the LM system as the object to be diagnosed and is utilized at that site for detecting and diagnosing the operating condition of the LM system.

[0112] Further, other than the above-mentioned embodiment, the condition detection apparatus S of this embodiment may be applied to a case of detecting and diagnosing the operating condition of the LM system by usually providing the condition diagnosing apparatus S to a site such as factory in which the LM system as the object to be diagnosed are set and remotely controlling the condition diagnosing apparatus S through a telephone line or like by a diagnosing staff from an isolated position.

[0113] Furthermore, the present invention may be applied to a case that the condition diagnosing apparatus S is usually provided to a site such as factory in which the LM system as the object to be diagnosed is set and used, the operating condition of the LM system is automatically detected and diagnosed in the condition diagnosing apparatus S, in parallel to this operation, the detected result is transferred to another place, then accumulated there, and an accumulative fault diagnosing is executed on the basis of the accumulated detected result.

[0114] Still furthermore, in the described embodiment, although the condition detection apparatus S is composed such that one waveform shaping unit **2**, one A/D converter **3**, one signal processing unit **4** and one display unit **5** are utilized for one AE sensor **1**, there may be provided another example of the structure, other than the above, in which the detection signals Sae from a plurality of AE sensors **1** are inputted through a switching circuit into one waveform shaping unit **2** and processed by utilizing one waveform shaping unit **2**, one A/D converter **3**, one signal processing unit and one display unit **5**. In such example, it becomes necessary to synchronize the executing timing of the detection processing utilizing the waveform shaping unit **2**, the A/D converter **3**, the signal processing unit **4** and the display unit **5** with the take-in timing of the detection signal Sae from the corresponding AE sensor **1**.

EXAMPLES

[0115] A specific example will be shown hereunder with respect to the frequency analysis value, the threshold value of the effective value, the threshold value of the maximum value and the threshold value of the event ratio, all mentioned hereinbefore, as the basis of the judgments in the steps S**5**, S**7**, S**12** and S**15**, respectively.

[0116] Further, it is to be noted that examples of the respective threshold values shown hereunder are ones in the case where a mold of mold number SN55LR manufactured by the applicant is utilized as LM guide to which the AE sensor is set, an external load to the movable block is 0.1 C (14 kN), a stroke as moving distance of the movable block is 250 mm, a moving speed thereof is 24 m/min., the DTE26-type lubrication oil manufactured by Moville Oil. Ltd. is supplied as lubrication oil intermittently by a constant amount, a sample rate to the detection signal Sae is 10 kHz, and a measuring time is 0.4 second.

[0117] In accordance with the above respective conditions, as one example of the frequency analysis value, it is judged to have the periodicity in a case that a square voltage value (so-called V**2** value) obtained through the FFT conversion of the digital envelope signal Sdw and, then, frequency analysis (power spectrum) exceeds 1.0×10^{-9} (V**2**), and on the other hand, in a case of less than this value, it is judged not to have the periodicity.

[0118] Further, as one example of the threshold value of the effective value, as the effective value at the digital envelope signal Sdw, a value of 1.0×10^{-4} (V) is suitable.

[0119] Furthermore, as one example of the threshold value of the maximum value, as the maximum value at the digital envelope signal Sdw, a value of 2.0×10^{-3} (V) is suitable.

[0120] Finally, as one example of the threshold value of the event ratio, 5 to 7 times, at which the threshold value of the event ratio shows a value higher than a value of 5.0×10^{-4} (V) at the digital envelope signal Sdw is suitable.

[0121] Further, the respective values in the above examples specifically change in accordance with the change of conditions, excluding the load with respect to the movable block and the stroke of the movable block from the conditions mentioned hereinabove.

[0122] Possibility of Industrial Usage

[0123] As mentioned above, according to the invention of claim **1**, since the wave motion elastically generated by the operation of the linear rolling motion guide apparatus is detected to thereby detect the present operating condition thereof, the operating condition of the linear rolling motion guide apparatus can be detected in a real time without disassembling the apparatus while excluding influence of vibration caused by the operation of the apparatus.

[0124] Accordingly, the generation of a fault in the linear rolling motion guide apparatus can be foreseen, whereby the maintenance performance of the user using the linear rolling motion guide apparatus can be improved. In addition, the usable life time thereof can be elongated, and apparatus, machineries and the like manufactured by utilizing such linear rolling motion guide apparatus can be improved in their qualities.

[0125] According to the invention of claim **2**, in addition to the effects of the invention of claim **1**, in the case when the generated detected signal has the periodicity and the maximum value at the detected signal is not less than the threshold value of the maximum value, it is judged that the linear rolling motion guide apparatus falls in a lubrication fault condition and that fact is then announced, so that the generation of the lubrication fault in the linear rolling motion guide apparatus can be easily and precisely detected in a real time during the operation of the apparatus.

[0126] According to the invention of claim **3**, in addition to the effects of the invention of claim **1**, when the generated detected signal has the periodicity, the maximum value in the detected signal is less than the threshold value of the maximum value and the detected event ratio is less than the threshold value of the event value, it is judged that the linear rolling motion guide apparatus is in a possibility of falling in a lubrication fault condition and that fact is then announced, so that the possibility of the generation of the lubrication fault in the linear rolling motion guide apparatus can be detected easily and precisely in a real time during the operation of the apparatus.

[0127] According to the invention of claim **4**, in addition to the effects of the invention of claim **1**, when the generated detected signal has the periodicity, the maximum value in the detected signal is less than the threshold value of the maximum value and the detected event ratio is not less than the threshold value of the event value, it is judged that a flaking is generated in the linear rolling motion guide apparatus and that fact is then announced, so that the generation of the flaking in the linear rolling motion guide apparatus can be detected easily and precisely in a real time during the operation of the apparatus.

[0128] According to the invention of claim **5**, in addition to the effects of the invention of claim **1**, when the generated detected signal has no periodicity, and the effective value in the detected signal is not less than the threshold value of the effective value, it is judged that a foreign material is invaded in the linear rolling motion guide apparatus and that fact is then announced, so that the generation of the case of the invasion of the foreign material in the linear rolling motion guide apparatus can be detected easily and precisely in a real time during the operation of the apparatus.

[0129] According to the invention of claim **6**, in addition to the effects of the invention of claim **1**, when the generated detected signal has no periodicity and the effective value in the detected signal is less than the threshold value of the effective value, it is judged that the present operating condition is normal and that fact is then announced, so that it can be detected easily and precisely in a real time whether or not the operating condition in the linear rolling motion guide apparatus is normal.

[0130] According to the invention of claim **7**, since the wave motion elastically generated by the operation of the linear rolling motion guide apparatus is detected to thereby detect the present operating condition thereof, the operating condition of the linear rolling motion guide apparatus can be detected in a real time without disassembling the apparatus while excluding influence of vibration caused by the operation of the apparatus.

[0131] Accordingly, the generation of a fault in the linear rolling motion guide apparatus can be foreseen, whereby the maintenance performance of the user using the linear rolling motion guide apparatus can be improved. In addition, the usable life time thereof can be elongated, and apparatus, machineries and the like manufactured by utilizing such linear rolling motion guide apparatus can be improved in their qualities.

[0132] According to the invention of claim **8**, in addition to the effect of claim **7**, in the case when the generated detected signal has the periodicity and the maximum value at the detected signal is not less than the threshold value of the maximum value, it is judged that the linear rolling motion guide apparatus falls in a lubrication fault condition and that fact is then announced, so that the generation of the lubrication fault in the linear rolling motion guide apparatus can be easily and precisely detected in a real time during the operation of the apparatus.

[0133] According to the invention of claim **9**, in addition to the effect of claim **7**, when the generated detected signal has the periodicity, the maximum value in the detected signal is less than the threshold value of the maximum value and the detected event ratio is less than the threshold value of the event value, it is judged that the linear rolling motion guide apparatus is in a possibility of falling in a lubrication fault condition and that fact is then announced, so that the possibility of the generation of the lubrication fault in the linear rolling motion guide apparatus can be detected easily and precisely in a real time during the operation of the apparatus.

[0134] According to the invention of claim **10**, in addition to the effect of claim **7**, when the generated detected signal has the periodicity, the maximum value in the detected signal is less than the threshold value of the maximum value and the detected event ratio is not less than the threshold value of the event value, it is judged that a flaking is generated in the linear rolling motion guide apparatus and that fact is then announced, so that the generation of the flaking in the linear rolling motion guide apparatus can be detected easily and precisely in a real time during the operation of the apparatus.

[0135] According to the invention of claim **11**, in addition to the effect of claim **7**, when the generated detected signal has no periodicity, and the effective value in the detected signal is not less than the threshold value of the effective value, it is judged that a foreign material is invaded in the linear rolling motion guide apparatus and that fact is then announced, so that the generation of the case of the invasion of the foreign material in the linear rolling motion guide apparatus can be detected easily and precisely in a real time during the operation of the apparatus.

[0136] According to the invention of claim **12**, in addition to the effect of claim **7**, when the generated detected signal has no periodicity and the effective value in the detected signal is less than the threshold value of the effective value, it is judged that the present operating condition is normal and that fact is then announced, so that it can be detected easily and precisely in a real time whether or not the operating condition in the linear rolling motion guide apparatus is normal.

[0137] According to the invention of claim **13**, by reading out and executing the program for the condition detection by using the computer, the computer functions so as to detect the wave motion elastically generated by the operation of the linear rolling motion guide apparatus and to thereby detect the present operating condition thereof, so that the operating condition of the linear rolling motion guide apparatus can be detected in a real time without disassembling the apparatus while excluding influence of vibration caused by the operation of the apparatus.

[0138] Accordingly, the generation of a fault in the linear rolling motion guide apparatus can be foreseen, whereby the maintenance performance of the user using the linear rolling motion guide apparatus can be improved. In addition, the usable life time thereof can be elongated, and apparatus, machineries and the like manufactured by utilizing such linear rolling motion guide apparatus can be improved in their qualities.

[0139] According to the invention of claim **14**, the program for the condition detection of claim **13** is recorded to be readable by the computer, and by reading out and executing the program for the condition detection by utilizing the computer, the computer functions so as to detect the wave motion elastically generated by the operation of the linear rolling motion guide apparatus and to thereby detect the present operating condition thereof, so that the operating condition of the linear rolling motion guide apparatus can be detected in a real time without disassembling the apparatus while excluding influence of vibration caused by the operation of the apparatus.

1. A condition detection apparatus for detecting a present operation condition in a linear rolling motion guide apparatus comprising:

detection means for detecting a wave motion elastically generated on the basis of at least either one of contact or collision of a movable member or a track member to a rolling member contained in the linear rolling motion guide apparatus, contact or collision of a rolling surface to the rolling member contained in the linear rolling motion guide apparatus, or mutual contact or collision of the rolling members themselves, at a time when a plurality of rolling members contained in the linear rolling motion guide apparatus revolve in a circulation section therein, and generating an electric detection signal in accordance with the detected wave motion; and

judgment means for judging a content of the present operation condition in response to the generated detection signal.

2. The condition detection apparatus according to claim 1, wherein said judgment means comprises:

periodicity judgment means for judging presence or absence of a periodicity in the generated detection signal;

maximum value detection means for detecting a maximum value in the generated detection signal at a time when it is judged that the periodicity is present;

maximum value judgment means for judging whether or not the detected maximum value is not less than a preliminarily set threshold value of the maximum value; and

condition judgment means for judging that, when the detected maximum value is not less than the threshold value of the maximum value, the linear rolling motion guide apparatus falls in a lubrication fault condition, and then announcing that fact.

3. The condition detection apparatus according to claim 1, wherein said judgment means comprises:

periodicity judgment means for judging presence or absence of a periodicity of the generated detection signal;

maximum value detection means for detecting a maximum value in the generated detection signal at a time when it is judged that the periodicity is present;

maximum value judgment means for judging whether or not the detected maximum value is not less than a preliminarily set threshold value of the maximum value;

event ratio detection means for detecting an event ratio in the generated detection signal at a time when the detected maximum value is less than a threshold value of the maximum value;

event ratio judgment means for judging whether or not the detected event ratio is not less than a preliminarily set threshold value of the event ratio; and

condition judgment means for judging that, when the detected event ratio is less than the threshold value of the event value, the linear rolling motion guide apparatus is in a possibility of falling in a lubrication fault condition, and then announcing that fact.

4. The condition detection apparatus according to claim 1, wherein said judgment means comprises:

periodicity judgment means for judging presence or absence of a periodicity of the generated detection signal;

maximum value detection means for detecting a maximum value in the generated detection signal at a time when it is judged that the periodicity is present;

maximum value judgment means for judging whether or not the detected maximum value is not less than a preliminarily set threshold value of the maximum value;

event ratio detection means for detecting an event ratio in the generated detection signal at a time when the detected maximum value is less than a threshold value of the maximum value;

event ratio judgment means for judging whether or not the detected event ratio is not less than a preliminarily set threshold value of the event ratio; and

condition judgment means for judging that, when the detected event ratio is not less than the threshold value of the event value, a flaking is generated in the linear rolling motion guide apparatus, and then announcing that fact.

5. The condition detection apparatus according to claim 1, wherein said judgment means comprises:

periodicity judgment means for judging presence or absence of a periodicity of the detected detection signal;

effective value detection means for detecting an effective value of the detected detection signal at a time when it is judged that the periodicity is absent;

effective value judgment means for judging whether or not the detected effective value is not less than a preliminarily set threshold value of the effective value; and

condition judgment means for judging that, when the detected effective value is not less than the threshold value of the effective value, a foreign material invades in the linear rolling motion guide apparatus, and then announcing that fact.

6. The condition detection apparatus according to claim 1, wherein said judgment means comprises:

periodicity judgment means for judging presence or absence of a periodicity of the detected detection signal;

effective value detection means for detecting an effective value of the detected detection signal at a time when it is judged that the periodicity is absent;

effective value judgment means for judging whether or not the detected effective value is not less than a preliminarily set threshold value of the effective value; and

condition judgment means for judging that, when the detected effective value is less than the threshold value of the effective value, a present operation condition is normal, and then announcing that fact.

7. A condition detection method for detecting a present operation condition in a linear rolling motion guide apparatus comprising:

a detection step for detecting a wave motion elastically generated on the basis of at least either one of contact or collision of a movable member or a track member to a rolling member contained in the linear rolling motion guide apparatus, contact or collision of a rolling surface to the rolling member contained in the linear rolling motion guide apparatus, or mutual contact or collision of the rolling members themselves, at a time when a plurality of rolling members contained in the linear rolling motion guide apparatus revolve in a circulation section therein, and generating an electric detection signal in accordance with the detected wave motion; and

a judgment step for judging a content of the present operation condition in response to the generated detection signal.

8. The condition detection method according to claim 7, wherein said judgment step comprises:

a periodicity judgment step for judging presence or absence of a periodicity in the generated detection signal;

a maximum value detection step for detecting a maximum value in the generated detection signal at a time when it is judged that the periodicity is present;

a maximum value judgment step for judging whether or not the detected maximum value is not less than a preliminarily set threshold value of the maximum value; and

a condition judgment step for judging that, when the detected maximum value is not less than the threshold value of the maximum value, the linear rolling motion guide apparatus falls in a lubrication fault condition, and then announcing that fact.

9. The condition detection method according to claim 7, wherein said judgment means step:

a periodicity judgment step for judging presence or absence of a periodicity of the generated detection signal;

a maximum value detection step for detecting a maximum value in the generated detection signal at a time when it is judged that the periodicity is present;

a maximum value judgment step for judging whether or not the detected maximum value is not less than a preliminarily set threshold value of the maximum value;

an event ratio detection step for detecting an event ratio in the generated detection signal at a time when the detected maximum value is less than a threshold value of the maximum value;

an event ratio judgment step for judging whether or not the detected event ratio is not less than a preliminarily set threshold value of the event ratio; and

a condition judgment step for judging that, when the detected event ratio is less than the threshold value of the event value, the linear rolling motion guide apparatus is in a possibility of falling in a lubrication fault condition, and then announcing that fact.

10. The condition detection method according to claim 7, wherein said judgment step comprises:

a periodicity judgment step for judging presence or absence of a periodicity of the generated detection signal;

a maximum value detection step for detecting a maximum value in the generated detection signal at a time when it is judged that the periodicity is present;

a maximum value judgment step for judging whether or not the detected maximum value is not less than a preliminarily set threshold value of the maximum value;

an event ratio detection step for detecting an event ratio in the generated detection signal at a time when the detected maximum value is less than a threshold value of the maximum value;

an event ratio judgment step for judging whether or not the detected event ratio is not less than a preliminarily set threshold value of the event ratio; and

a condition judgment step for judging that, when the detected event ratio is not less than the threshold value of the event value, a flaking is generated in the linear rolling motion guide apparatus, and then announcing that fact.

11. The condition detection method according to claim 7, wherein said judgment step comprises:

a periodicity judgment step for judging presence or absence of a periodicity of the detected detection signal;

an effective value detection step for detecting an effective value of the detected detection signal at a time when it is judged that the periodicity is absent;

an effective value judgment step for judging whether or not the detected effective value is not less than a preliminarily set threshold value of the effective value; and

a condition judgement step for judging that, when the detected effective value is not less than the threshold value of the effective value, a foreign material invades in the linear rolling motion guide apparatus and then announcing that fact.

12. The condition detection method according to claim 7, wherein said judgment step comprises:

a periodicity judgment step for judging presence or absence of a periodicity of the detected detection signal;

an effective value detection step for detecting an effective value of the detected detection signal at a time when it is judged that the periodicity is absent;

an effective value judgment step for judging whether or not the detected effective value is not less than a preliminarily set threshold value of the effective value; and

a condition judgement step for judging that, when the detected effective value is less than the threshold value of the effective value, a present operation condition is normal and then announcing that fact.

13. A condition detection program, wherein a condition detection apparatus for detecting a present operation condition in a linear rolling motion guide apparatus, which includes detection means for detecting a wave motion elastically generated on the basis of at least either one of contact or collision of a movable member or a track member to a rolling member contained in the linear rolling motion guide apparatus, contact or collision of a rolling surface to the rolling member contained in the linear rolling motion guide apparatus, or mutual contact or collision of the rolling members themselves, at a time when a plurality of rolling members contained in the linear rolling motion guide apparatus revolve in a circulation section therein, and generating an electric detection signal in accordance with the detected wave motion, includes a computer which is operated as judgment means for judging a content of the operation condition in response to the generated detected signal.

14. An information recording medium, wherein the condition detection program as claimed in claim 13 is recorded to be readable by the computer.

* * * * *

US 20050169559A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2005/0169559 A1

Mochizuki et al. (43) Pub. Date: Aug. 4, 2005

(54) SEAL DEVICE FOR A GUIDE DEVICE AND GUIDE DEVICE

(75) Inventors: **Hiroaki Mochizuki**, Yamanashi (JP); **Tetsuhiro Nishide**, Tokyo (JP)

Correspondence Address:
WESTERMAN, HATTORI, DANIELS & ADRIAN, LLP
1250 CONNECTICUT AVENUE, NW
SUITE 700
WASHINGTON, DC 20036 (US)

(73) Assignee: **THK CO., LTD.**, Tokyo (JP)

(21) Appl. No.: **11/053,439**

(22) Filed: **Feb. 9, 2005**

Related U.S. Application Data

(62) Division of application No. 10/247,630, filed on Sep. 20, 2002, now Pat. No. 6,877,900.

(30) **Foreign Application Priority Data**

Sep. 21, 2001 (JP) P2001-288247
Jun. 28, 2002 (JP) P2002-190931

Publication Classification

(51) **Int. Cl.**[7] **F16C 33/00**
(52) **U.S. Cl.** **384/15**

(57) **ABSTRACT**

A seal device fixed to an end portion of a slider of a guide device includes: a casing; a plurality of seal members; and elastic members, wherein each seal member has a recess portion in which a rail penetrates. An inner circumferential face of the recess portion comes into contact with an outer surface of the rail when the seal member is pushed onto one side of the rail by the elastic members. The plurality of seal members are arranged in the casing in such a manner that when a seal portion of one seal member is pushed by the elastic member and contacted with one side of the rail, a seal portion of the next seal member is pushed by the elastic member and contacted with the other side of the rail.

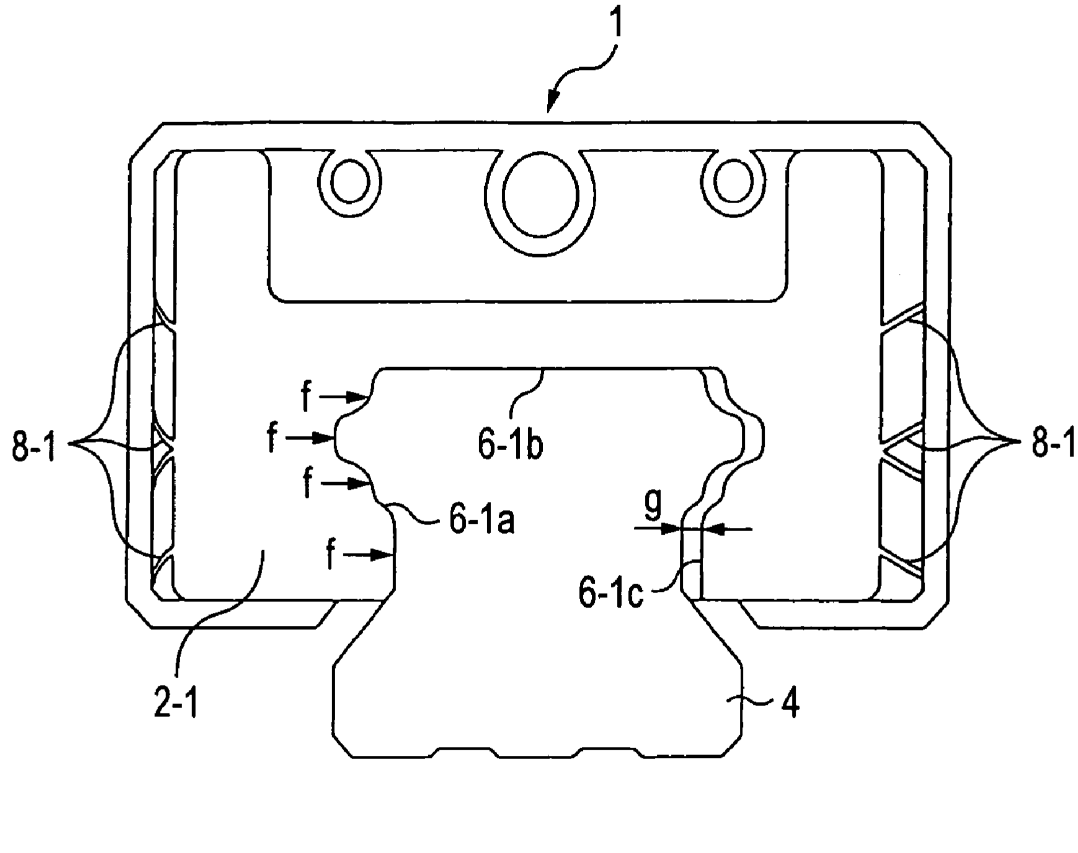


FIG. 1 (a)

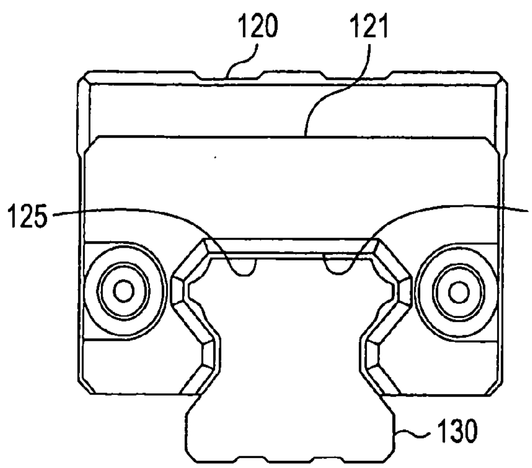


FIG. 1 (b)

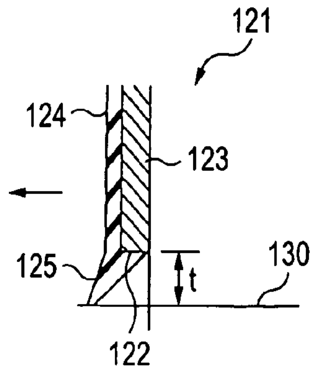


FIG. 2

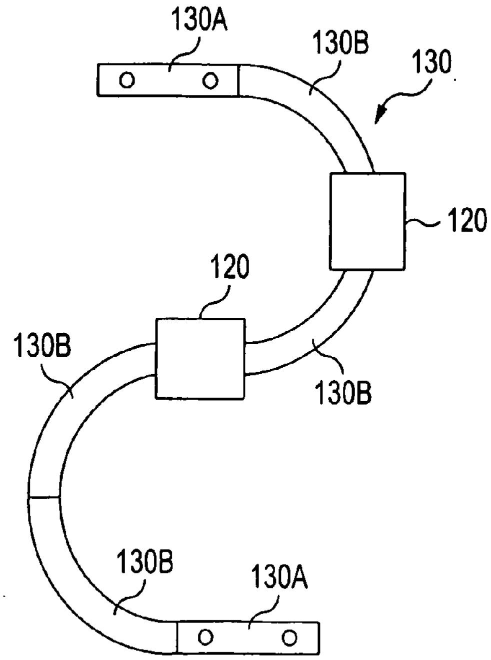


FIG. 3

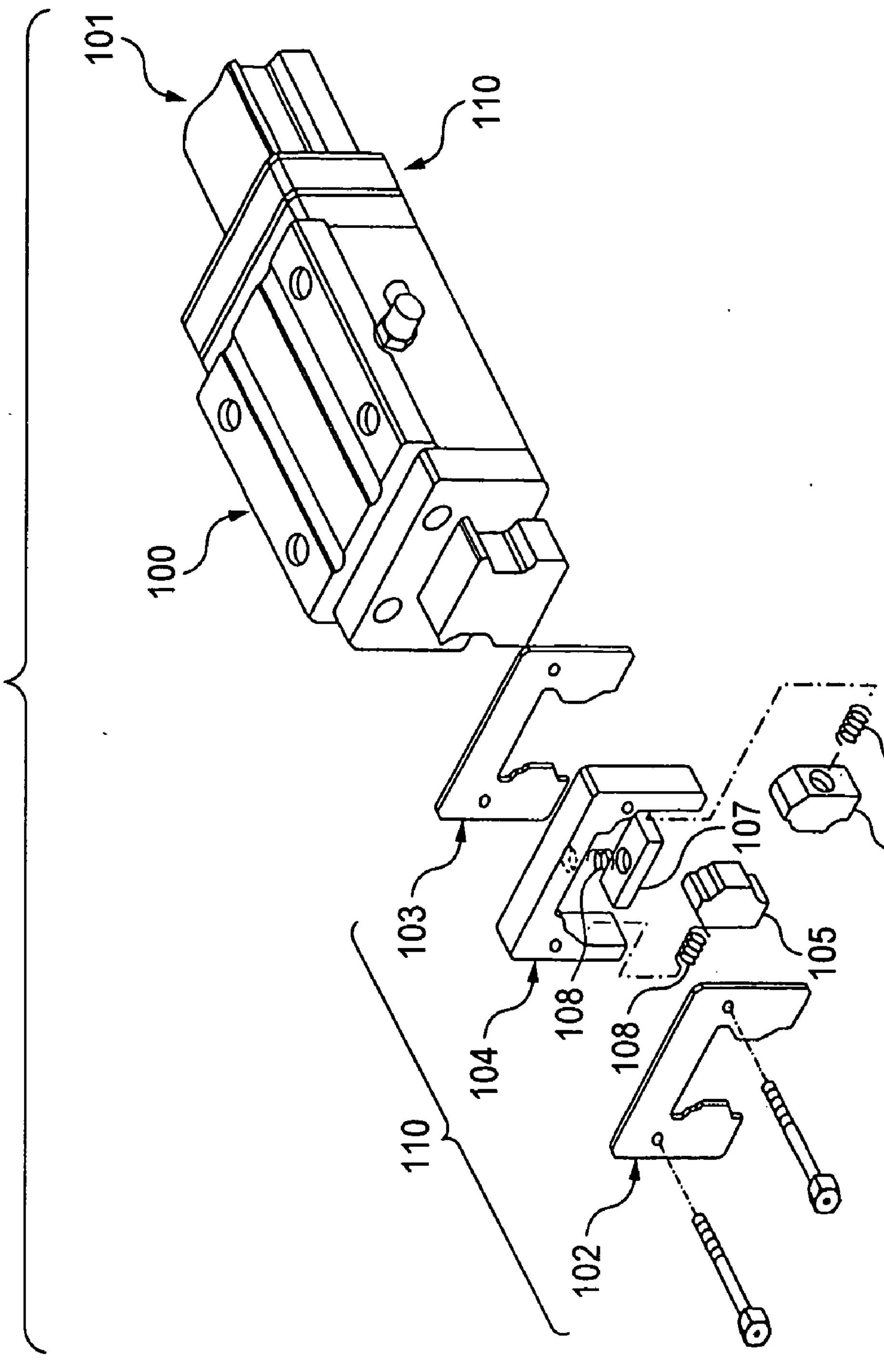


FIG. 4

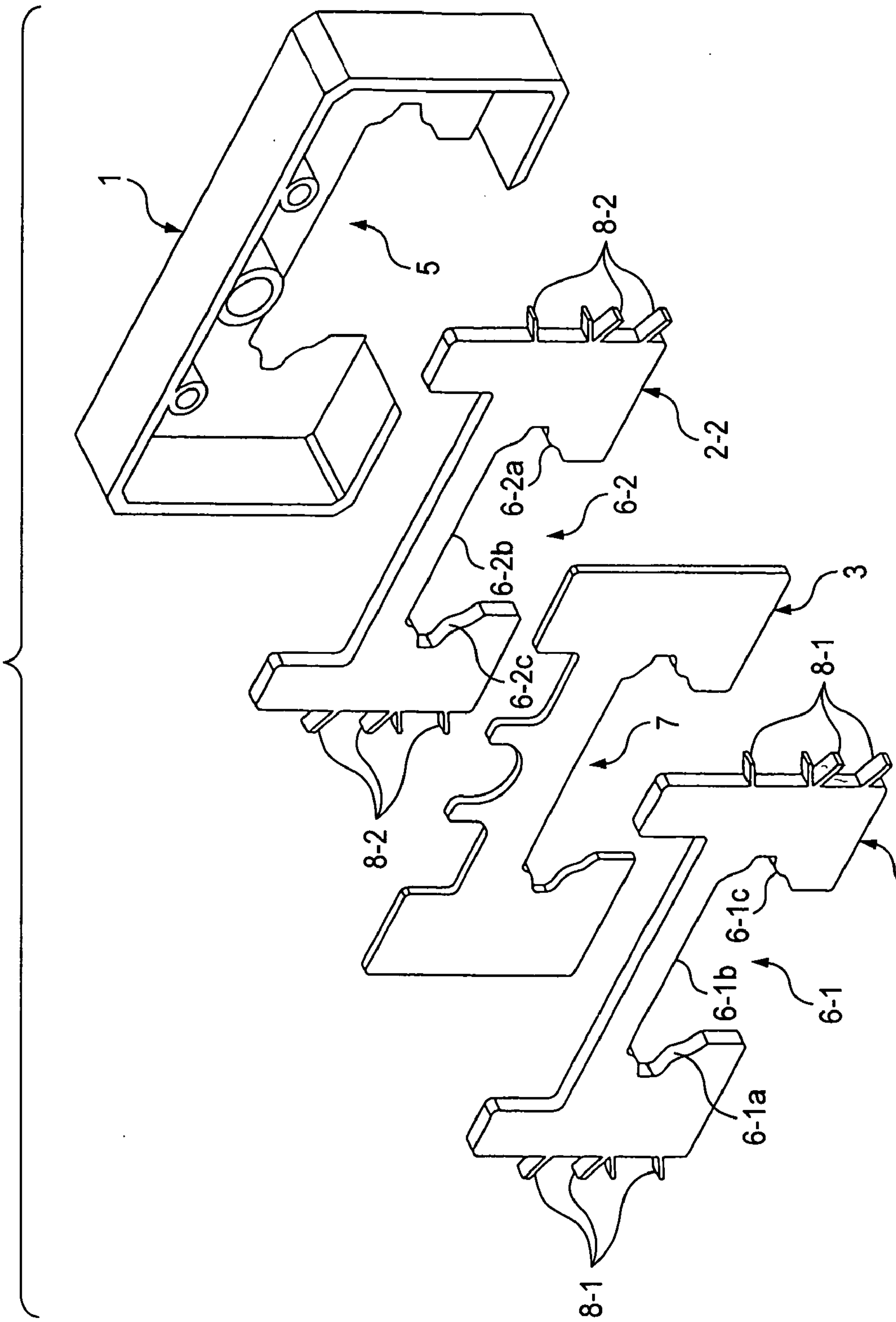


FIG. 5

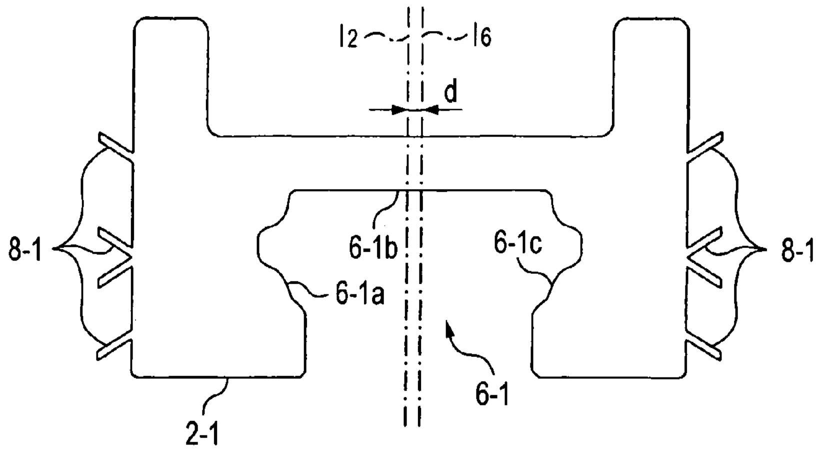


FIG. 6

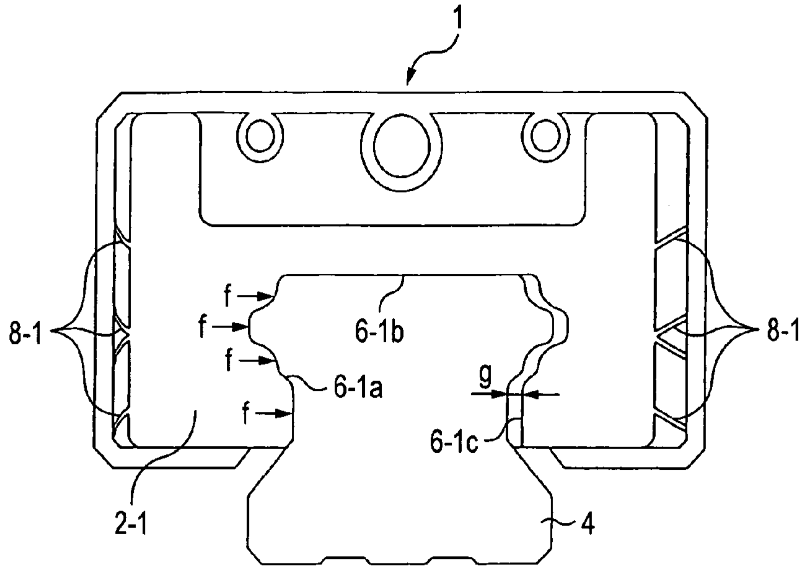


FIG. 7

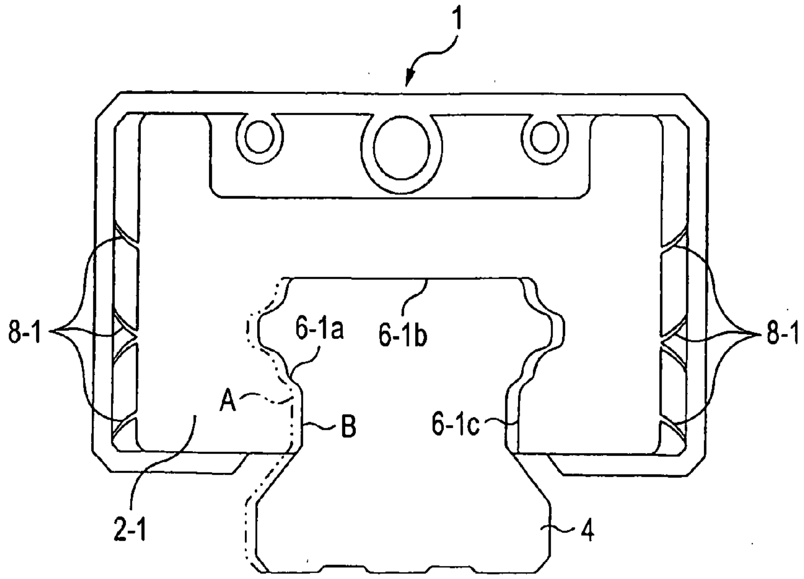


FIG. 8

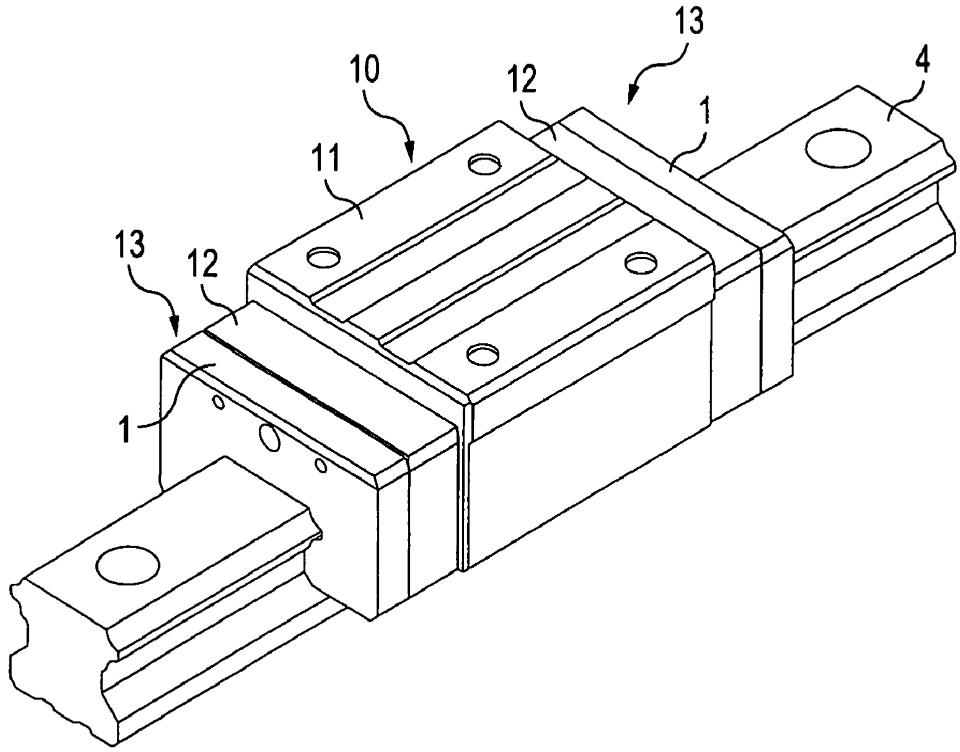


FIG. 9

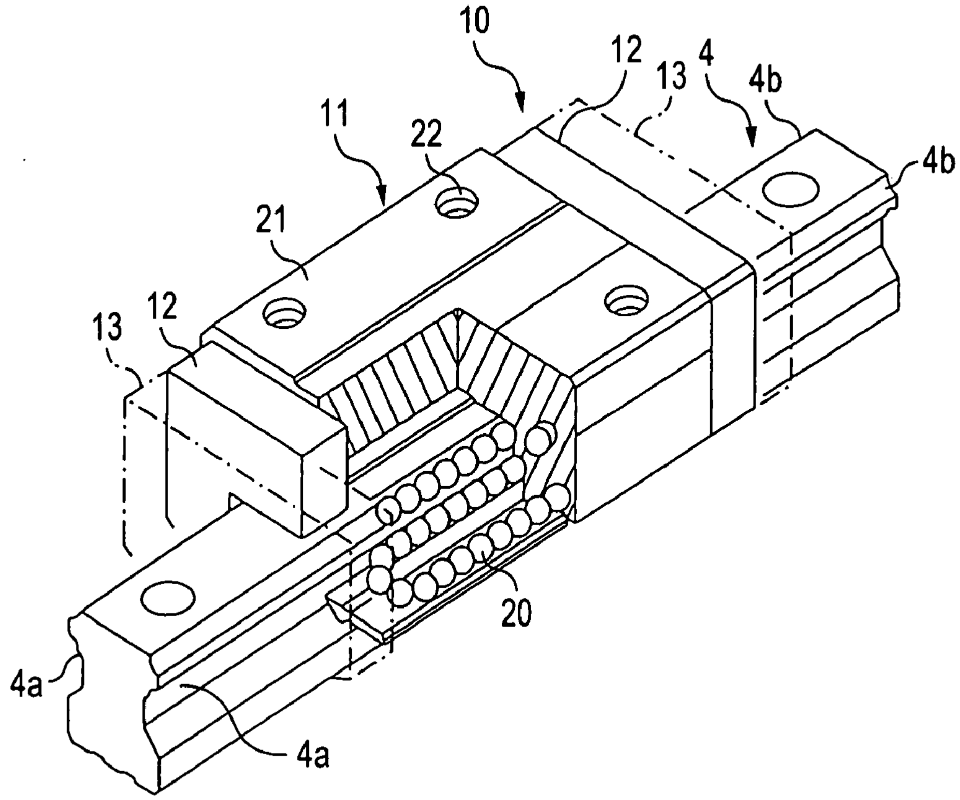


FIG. 10

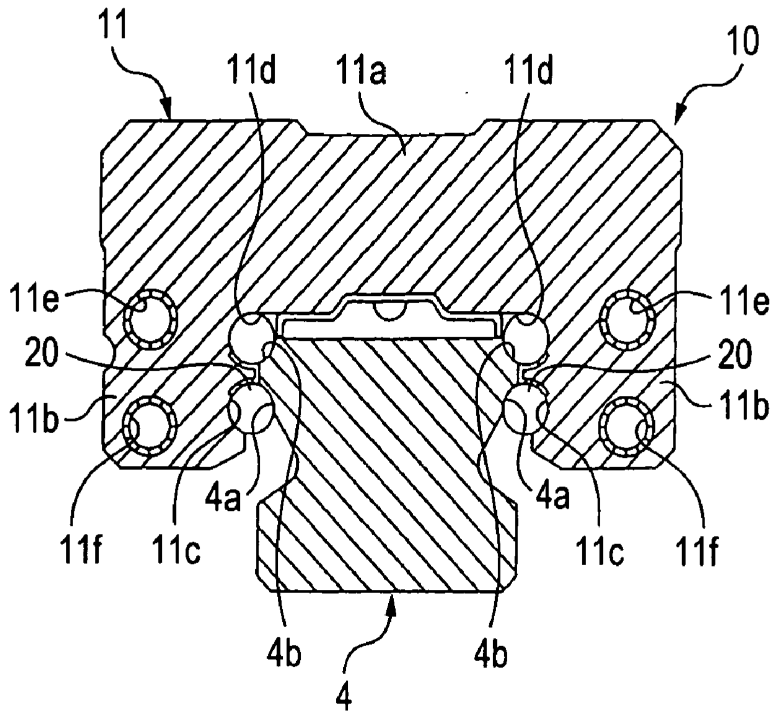
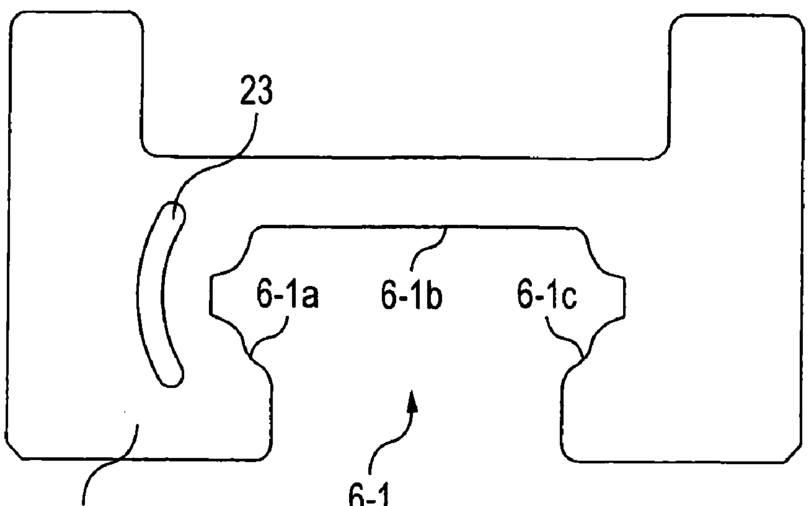

11
11d
11a
11d
10
11e
20
11b
11f
11c
4a
4b
4
4b
4a
11c
11f
11b
20
11e

FIG. 11


23
6-1a
6-1b
6-1c
2-1
6-1

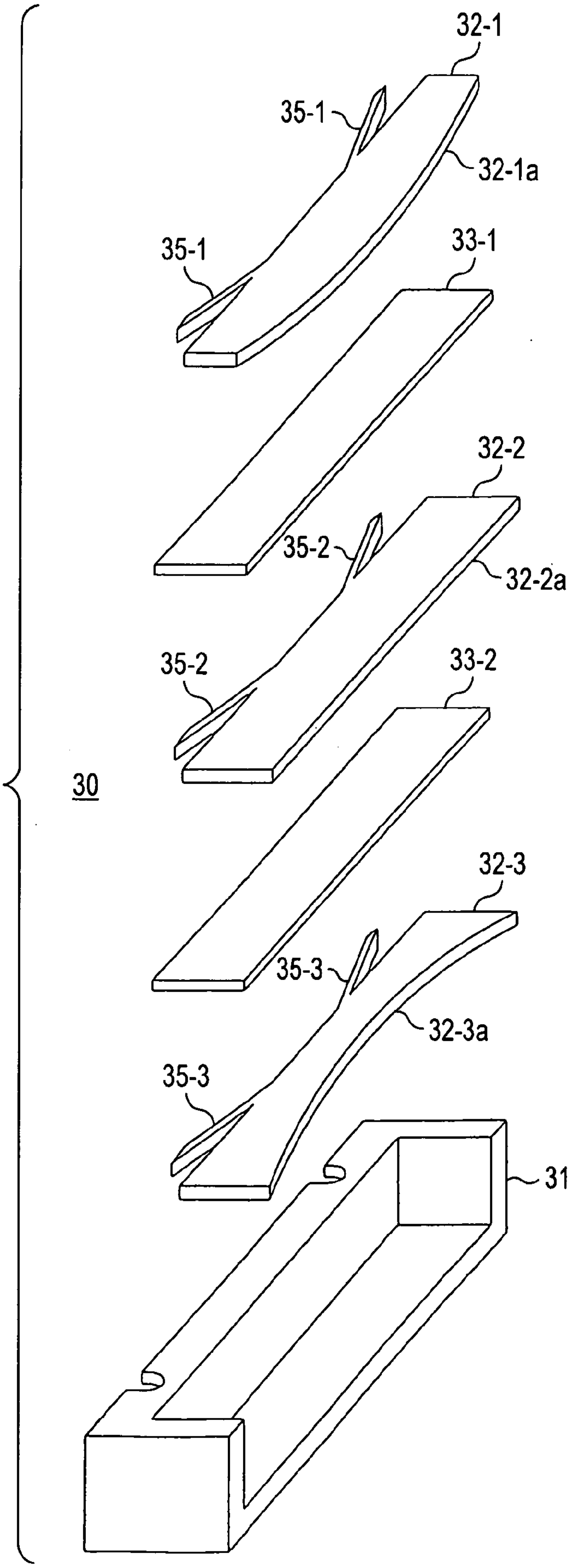


FIG. 12

FIG. 13 (a)

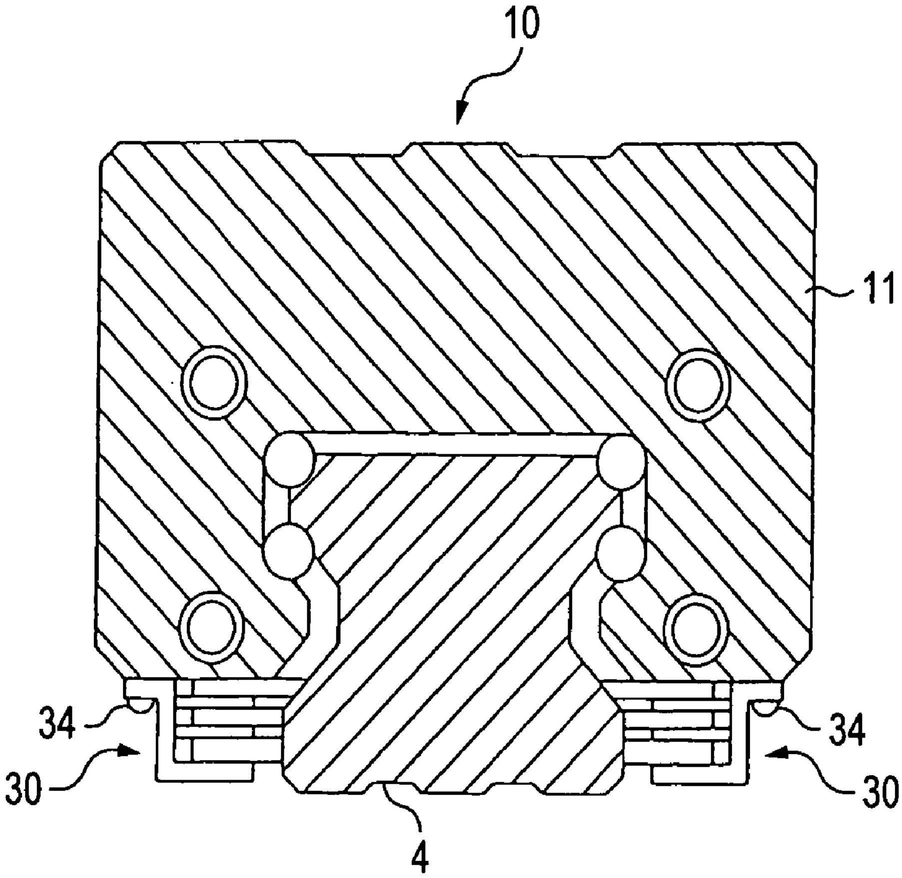


FIG. 13 (b)

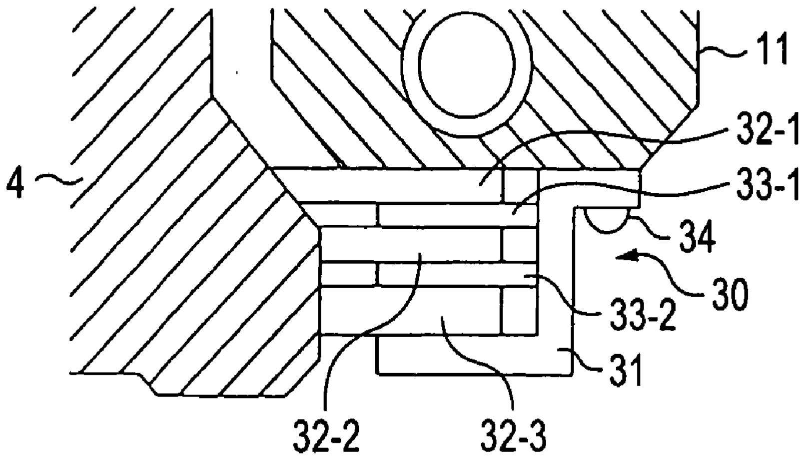


FIG. 14 (a)

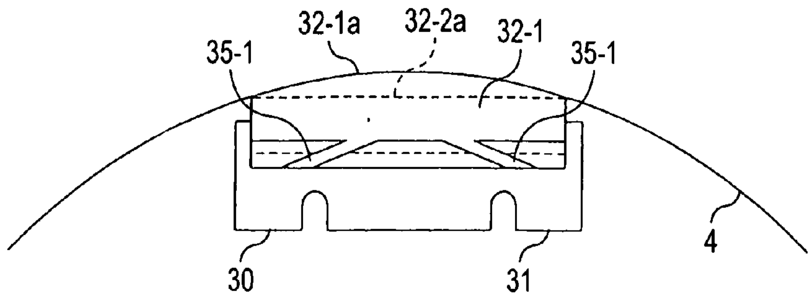


FIG. 14 (b)

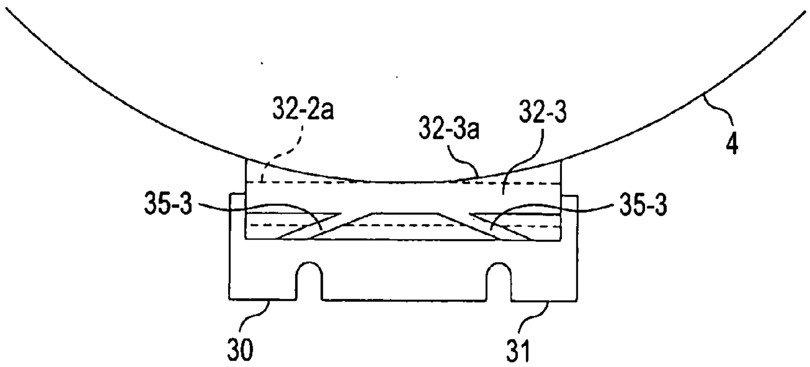


FIG. 14 (c)

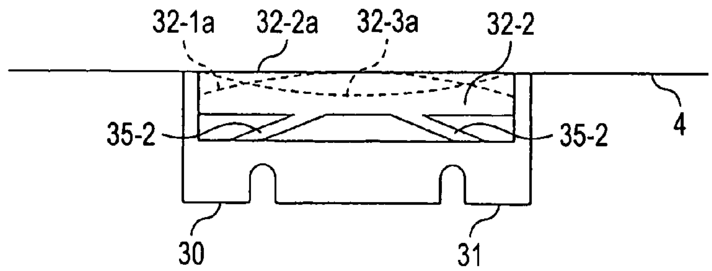


FIG. 15

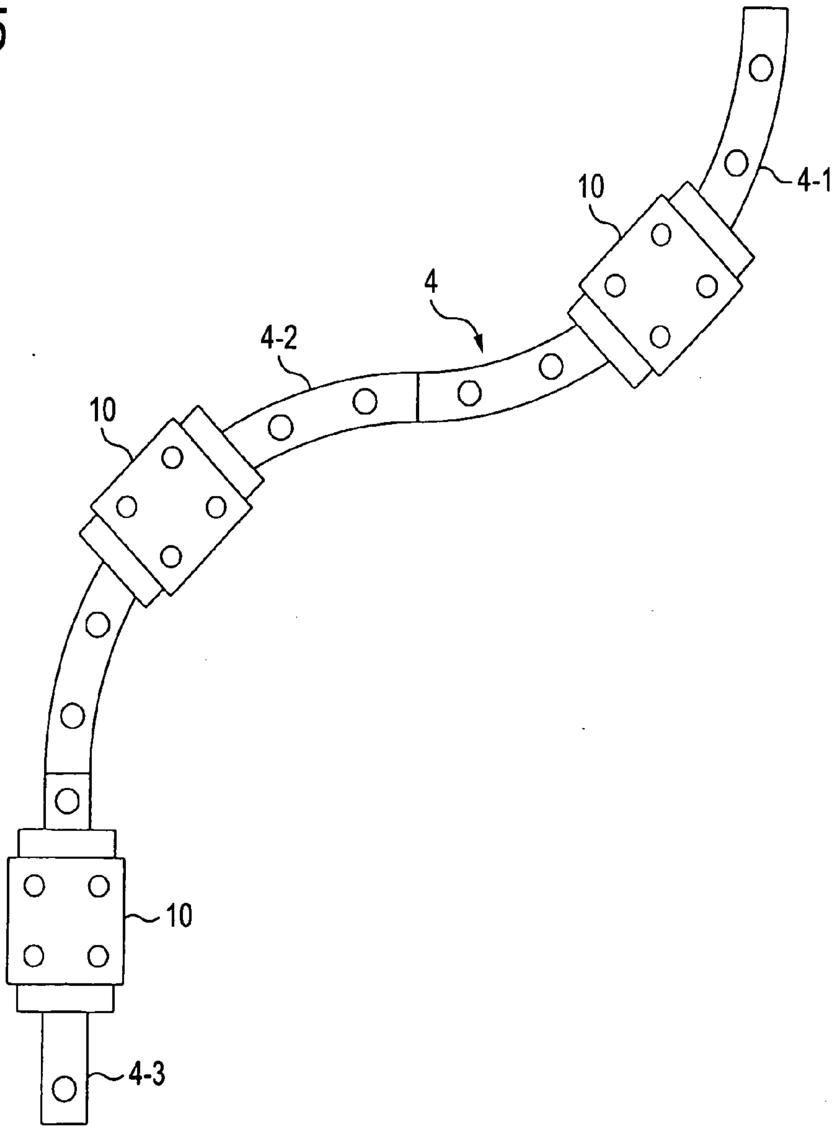


FIG. 16

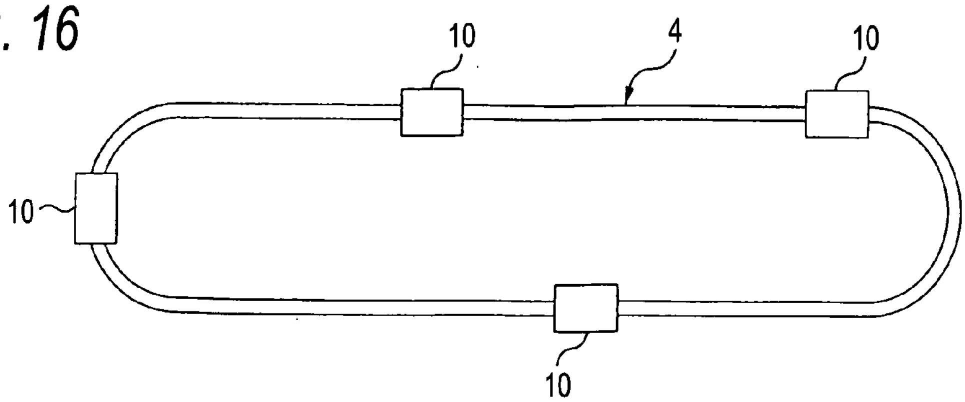


FIG. 17

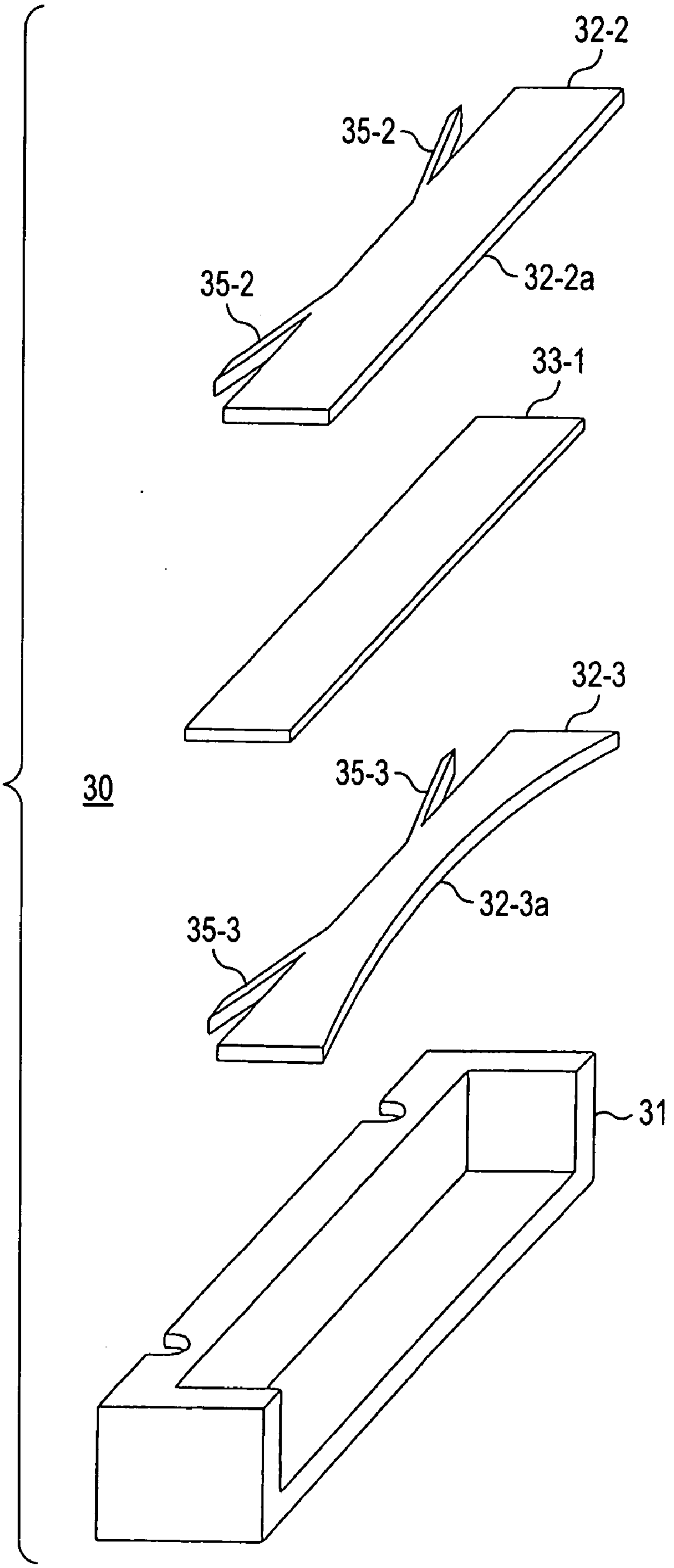
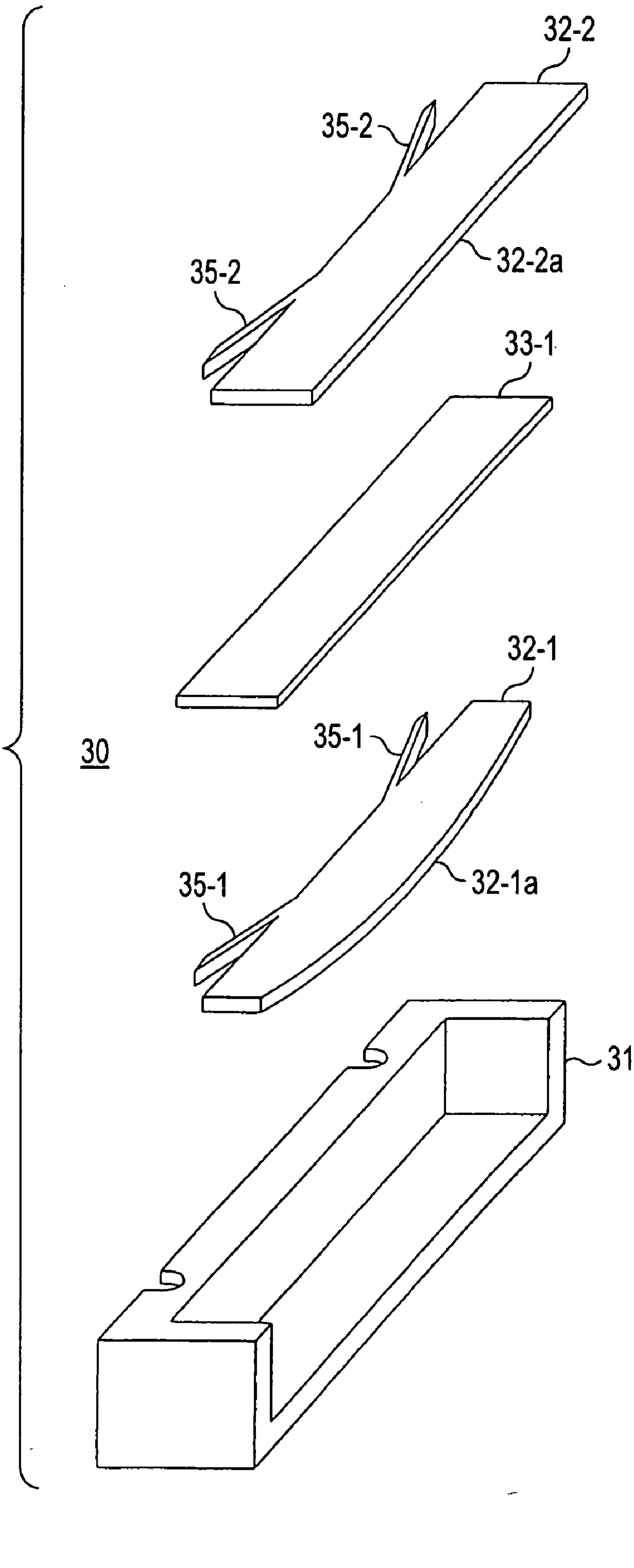


FIG. 18



SEAL DEVICE FOR A GUIDE DEVICE AND GUIDE DEVICE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a seal device for a guide device used for a moving portion of various machine tools, industrial robots or various common machines. Particularly, the present invention relates to a seal device for a guide device in which a slider striding over a rail is guided along the rail. More particularly, the present invention relates to a seal device which effectively exhibits a sealing function even in a guide device in which the rail width is partially different. The present invention also relates to a guide device in which the seal device is used.

[0003] 2. Description of the Related Art

[0004] Conventionally, there is provided a seal device for a guide device shown in FIGS. **1**(*a*) and **1**(*b*). In the drawings, reference numeral **121** is referred to as an end seal attached to an end portion of the slider **120** arranged striding over the rail **130** and moved along the rail **130**. This end seal **121** is composed in such a manner that a rubber member **124** is coated on a plate-shaped core metal **123**. The core metal **123** has a recess portion **122** in which the rail **130** penetrates. A seal portion **125**, which is called a lip, is formed at the inner circumferential edge of the recess portion **122**. Since a forward end portion of the seal portion **125** closely comes into contact with the outer circumferential face of the rail **130** and moves together with the slider **120**, foreign objects such as dust does not get into the slider **120**. **FIG. 1**(*a*) is a front view of the slider **120** and end seal **121**, and **FIG. 1**(*b*) is a sectional view of the inner circumferential portion of the end seal **121**.

[0005] In the conventional seal device, the following problem may be encountered. The dimension t (interval between the inner circumferential face of the core metal **123** and the outer circumferential face of the rail **130**) of the seal portion **125** of the end seal **121** is 1 to 2 mm. In case where the width of the rail **130** is different as shown in **FIG. 2**, for example, a transport device described in Japanese Unexamined Patent Publication No. 2001-99152 in which the slider **120** moves on the rail **130**, the rail width of the curved portion **130**B of the rail **130** is smaller than that of the straight portion **130**A, it is impossible for the elastic extension and contraction of the seal portion **125** to absorb a change in the width of the rail **130**. That is, it is impossible for the elastic extension and contraction of the seal portion **125** to absorb a reduction of the width in the small width portion. Therefore, the forward end portion of the seal portion **125** is separated from the outer circumferential face of the rail **130**, which results in a defective sealing function.

[0006] In order to solve the above problem, Japanese Patent Publication No. 2939846 discloses a seal device as shown in **FIG. 3**. This seal device **110** includes a pair of end face plates **102, 103** made of metal arranged at the end portions of the slider **100** in the moving direction. The end face plates **102, 103** have an inside shape formed into the same profile as that of the outer face of the rail **101**. A small gap is formed between the inside of the end face plates **102, 103** and the rail **101**. The seal device further includes a support member **104** interposed between the end plates **102, 103**; two side seal members **105, 106** and one upper seal member **107** made of bearing metal and arranged in a cut-out portion provided inside the support member **104**. The two side seal members **105, 106** and one upper seal member **107** are formed in shapes that correspond to the profile of the outer face of the rail **101**. The two side seal members **105, 106** and one upper seal member **107** are restricted to move by the pair of end face plates **102, 103**. The seal device further includes compression springs **108** for elastically pushing the seal members **105, 106, 107** onto the outer face of the rail **101**.

[0007] However, even in the seal device **110** composed as described above, the following problems may be encountered. In case where the slider **100** is guided along the rail **101** in which a straight portion and curved portion are continuously connected with each other, a gap is caused between the rail **101** and the side seal members **105, 106** by an inner wheel difference of the curved portion, which deteriorates the sealing function of the seal member. Further, since the seal member is divided into three pieces of the side seal members **105, 106** and the upper seal member **107** so that the seal members do not come into contact with each other, a gap is caused at each of the intersections (opposing faces) of the divided seal members. Further, in case where the inner wheel difference is caused in the curved portion of the rail **101**, it is impossible to absorb the inner wheel difference. Further, this device is disadvantageous in that the number of parts is large and the structure becomes complicated. For example, when such a structure is adopted that the divided seal members come into contact with each other, a gap is formed by the abrasion caused between the divided seal members.

[0008] In the conventional-guide device, the end seal **121** is arranged at the end of the slider **120**, and the seal device **110** is arranged at the end of the moving member (slider) **100** as described above. However, no seal devices are arranged in the side portions of the slider **120** and the moving member (slider) **100**, that is, no seal devices are arranged in the portions opposed to the side of the rail **130**. Therefore, problems may be encountered in which dust gets into the slider from the side portion. Therefore, it is impossible to apply the conventional guide device, for example, to a wood working machine used in a dusty place.

SUMMARY OF THE INVENTION

[0009] The present invention has been accomplished to solve the above problems. It is an object of the present invention to provide a seal device for a guide device and a guide device which enable a simple structure and exhibit not only a sealing function of the slider end portion but also a sealing function of the slider side portion even in case where the rail width is changed and the shape of the rail is changed from a straight line to a curved line.

[0010] According to a first aspect of the present invention, there is provided a seal device for a guide device which is fixed to an end portion of a slider of the guide device so as to prevent foreign objects such as dust from getting into the seal device, the slider being arranged striding over a straight and/or curved rail and guided along the rail, the seal device comprising: a casing; a plurality of plate-shaped seal members accommodated in the casing; and an elastic member for pushing the seal members onto the rail, wherein each seal member has a recess portion in which the rail penetrates, an inner circumferential face of the recess portion includes a seal portion which comes into contact with an outer surface of the rail, and wherein the plurality of seal members are arranged in the casing in such a manner that the seal members are pushed by the elastic member, the seal portion of one seal member comes into contact with one side of the rail, and the seal portion of the next seal member comes into contact with the other side of the rail.

[0011] As described above, when the seal portion formed in the recess portion of one seal member in a plurality of seal members provided in the casing is pushed by the elastic member and contacted with one side of the guide rail, the seal portion formed in the next seal member is pushed onto the other side of the guide rail, that is, the plurality of seal members are arranged in the casing while the phase of the seal portion formed in the recess portion of one seal member and the phase of the seal portion formed in the recess portion of the other seal member are alternately changed from each other. Due to the above structure, sealing is performed in such a manner that the seal portions of a plurality of seal members (at least two seal members) slide on the circumferential face of the rail on which the slider moves. Therefore, a perfect sealing function can be provided. Especially when the rail width is locally different, for example even when the width of a curved portion is smaller than that of a straight portion, a difference in the width can be absorbed when the seal member is moved while being pushed by the elastic member. Therefore, the seal portion can be always contacted with the outer circumferential face of the guide rail, and the sealing function is not impaired.

[0012] According to a second aspect of the present invention, the elastic members are integrally formed on the outer periphery of the seal members.

[0013] When the elastic member is integrally formed in the outer periphery of the seal member, the number of parts composing the seal device can be decreased, and the assembling work can be easily performed.

[0014] According to a third aspect of the present invention, an isolation plate is arranged between the seal members.

[0015] When the isolation plate is arranged between the seal members as described above, each seal member can be smoothly moved regardless of the rail width by the function of the elastic member without interfering with the other seal members, and the seal portion comes into contact with the outer circumferential face of the guide rail. Therefore, the sealing function is effectively performed.

[0016] According to a fourth aspect of the present invention, there is provided a seal device for a guide device which is fixed to a side portion of a slider of the guide device so as to prevent foreign objects such as dust from getting into the seal device, the slider being arranged striding over a straight and/or curved rail and guided along the rail, the seal device comprising: a casing; a plurality of plate-shaped seal members accommodated in the casing; and an elastic member for pushing the seal members onto the rail, wherein a side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex or concave shape of a predetermined radius of curvature, a side of at least one seal member slidably coming into contact with the side of the rail is formed into a straight shape, and wherein the seal members are pushed by the elastic member and at least one portion of the side of each seal member comes into contact with the side of the rail.

[0017] As described above, the side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex or concave shape of a predetermined radius of curvature, and the side of at least one seal member slidably coming into contact with the side of the rail is formed into the straight shape. Therefore, in the straight portion of the rail, the straight side of the seal member closely comes into contact with the side of the rail, and in the curved portion of the seal member, the side of the seal member, which is formed into a convex or concave of a predetermined radius of curvature, closely comes into contact with the side of the rail. Therefore, even if the rail profile is changed from a straight shape to a curved shape, no foreign objects get into the slider from the side portion.

[0018] According to a fifth aspect of the invention, there is provided a seal device for a guide device which is fixed to a side portion of a slider of the guide device so as to prevent foreign objects such as dust from getting into the seal device, the slider being arranged striding over a straight and/or curved rail and guided along the rail, the seal device comprising: a casing; a plurality of plate-shaped seal members accommodated in the casing; and an elastic member for pushing the seal members onto the rail, wherein a side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex shape of a predetermined radius of curvature, a side of at least one seal member slidably coming into contact with the side of the rail is formed into a concave shape of a predetermined radius of curvature, and a side of at least one seal member slidably coming into contact with the side of the rail is formed into a straight shape, and wherein the seal members are pushed by the elastic member and at least one portion of the side of each seal member comes into contact with the side of the rail.

[0019] As described above, the side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex shape of a predetermined radius of curvature, and the side of at least one seal member slidably coming into contact with the side of the rail is formed into a concave shape of a predetermined radius of curvature, and further the side of at least one seal member slidably coming into contact with the side of the rail is formed into a straight-line-shape. Due to the above structure, in the straight rail portion, the straight side of the seal member closely comes into contact with the rail side. In the curved rail portion, the convex side of the seal member of a predetermined radius of curvature or the concave side of the seal member closely comes into contact with the rail side. In the portion where the rail is curved in the other direction, the concave side of the seal member of a predetermined radius of curvature or the convex side of the seal member closely comes into contact with the rail side. Therefore, even if the rail is curved from a straight shape to a curved shape which is curved to either the right or the left, no foreign objects get into the slider from the side portion of the slider.

[0020] According to a sixth aspect of the present invention, the elastic members of a guide device according to the fourth or fifth aspect are integrally formed on the outer periphery of the seal members.

[0021] When the elastic member is integrally formed in the outer periphery of the seal member, the number of parts composing the seal device can be decreased, and the assembling work can be easily performed.

[0022] According to a seventh aspect of the present invention, an isolation plate is arranged between the seal members of a guide device according to one of the fourth to sixth aspects.

[0023] When the isolation plate is arranged between the seal members as described above, each seal member can be smoothly moved regardless of the rail width by the function of the elastic member without interfering with the other seal members, and the seal portion comes into contact with the outer circumferential face of the guide rail. Therefore, the sealing function is effectively performed.

[0024] According to a eighth aspect of the present invention, there is provided a guide device comprising: a straight and/or curved rail; and a slider arranged striding over the rail, the slider having seal devices arranged at both end portions and both side portions respectively for preventing foreign objects from getting into the slider, wherein the seal device attached to both end portions of the slider is the seal device according to one of the first to third aspects, and the seal device attached to both side portions is the seal device according to one of the fourth to seventh aspects.

[0025] As described above, when the seal device attached to both end portions of the slider is the seal device according to one of the first to third aspects, and the seal device attached to both side portions is the seal device according to one of the fourth to seventh aspects, both end portions and both side portions of the slider are sealed. Accordingly, no foreign objects get into the slider.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] **FIG. 1**(*a*) is a front view showing a conventional seal device and **FIG. 1**(*b*) is a sectional view of an inner circumferential portion of an end seal;

[0027] **FIG. 2** is a plan view showing a conventional guide device using a rail in which a straight portion and curved portion are combined with each other;

[0028] **FIG. 3** is an exploded perspective view showing the conventional guide device;

[0029] **FIG. 4** is an exploded perspective view showing a seal device of a guide device of the present invention;

[0030] **FIG. 5** is a front view showing a seal member of the seal device of the guide device;

[0031] **FIG. 6** is a front view showing the seal device of the guide device;

[0032] **FIG. 7** is a front view showing an operation of the seal device of the guide device;

[0033] **FIG. 8** is a perspective view showing the guide device;

[0034] **FIG. 9** is a partially cutaway perspective view showing the guide device;

[0035] **FIG. 10** is a sectional view showing the guide device;

[0036] **FIG. 11** is a front view showing a seal member of a seal device of a second embodiment of the present invention;

[0037] **FIG. 12** is an exploded perspective view showing a seal device of a third embodiment of the present invention;

[0038] FIGS. **13**(*a*) and **13**(*b*) are sectional views showing the seal device;

[0039] FIGS. **14**(*a*) to **14**(*c*) are plan views showing an operation of the seal device;

[0040] **FIG. 15** is a plan view showing the guide device;

[0041] **FIG. 16** is a plan view showing the guide device;

[0042] **FIG. 17** is an exploded perspective view showing a seal device of a fourth embodiment of the present invention; and

[0043] **FIG. 18** is an exploded perspective view showing a seal device of a fifth embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFFERD EMBODIMENTS

[0044] Referring to the drawings, embodiments of the present invention will be described below. **FIG. 4** is an exploded perspective view showing an arrangement of a seal device of a guide device of the present invention. As shown in the drawing, this seal device includes: a casing **1**; a plurality of seal members **2-1**, **2-2** accommodated in the casing **1** (In the drawing, two seal members are shown.); and an isolation plate **3** interposed between the seal members **2-1**, **2-2**. In the casing **1**, there is formed a recess portion **5** in which the rail (shown in **FIG. 6**) penetrates. In the seal members **2-1**, **2-2**, there are respectively formed recess portions **6-1**, **6-2** in which the rail **4** penetrates. In the isolation plate **3**, there is formed a recess **7** in which the rail **4** penetrates.

[0045] At both side portions of each seal member **2-1**, **2-2**, there are integrally provided elastic members **8-1**, **8-1**. As shown in **FIG. 5**, the center line l_6 of the recess portion **6-1** of the seal member **2-1** in the width direction is shifted from the center line l_2 of the seal member **2-1** itself in the width direction by the distance d. The inner circumferential face **6-1***a* on one side and the inner circumferential face **6-1***b* on the upper side are formed into a shape closely coming into contact with the outer circumferential face of the rail **4**. Although not shown in the drawing, the structure of the seal member **2-2** is the same as that of the seal member **2-1**, and the inner circumferential face **6-2***a* on one side and the inner circumferential face **6-2***b* on the upper side are formed into a shape closely coming into contact with the outer circumferential face of the rail **4**.

[0046] **FIG. 6** is a view showing a positional relation of the seal member **2-1** with the rail **4** in the case where the seal member **2-1** is accommodated in the casing **1** and the rail **4** is inserted into its recess portion **6-1**. As shown in **FIG. 5**, the center line l_6 of the recess portion **6-1** (not shown in **FIG. 6**) of the seal member **2-1** in the width direction is shifted from the center line l_2 of the seal member **2-1** itself in the width direction by the distance d. Therefore, when the seal member **2-1** is accommodated in the casing **1** and the rail **4** is inserted into its recess portion **6-1**, the elastic member **8-1** on one side (on the left in the drawing) contracts and pushes the seal member **2-1** as shown by the arrow f, however, the elastic member **8-1** on the other side (on the right in the drawing) does not contract but extends. Due to the foregoing, the inner circumferential face **6-1***a* on one side of the recess portion **6-1** composing the seal portion closely comes into contact with the outer circumferential face on one side of the rail **4**, however, a gap g is formed between the inner circumferential face **6-1***c* on the opposite side of the recess portion **6-1** and the outer circumferential face on the opposite side of the rail **4**.

[0047] The seal member **2-2** is arranged in the casing **1** interposing the isolation plate **3** while the phase is shifted (inverted by 180°) as follows. On the contrary to the seal member **2-1**, the inner circumferential face **6-2***a* on one side of the recess portion **6-2** composing the seal portion closely comes into contact with the outer circumferential face on one side on the opposite side of the rail **4**, so that the gap g can be formed between the inner circumferential face **6-2***c* on one side of the recess portion **6-2** and the outer circumferential face on the opposite side of the rail **4**.

[0048] Due to the above structure, the inner circumferential faces **6-1***a*, **6-2***a* on one side composing the seal portion of the seal members **2-1**, **2-2**, which are arranged on both sides of the isolation plate **3** in the casing, are pushed by the elastic members **8-1**, **8-2** and respectively contacted with the opposed outer circumferential face of the rail **4**. Under the above condition, the inner circumferential faces **6-1***a*, **6-2***a* on one side composing the seal portion of the seal members **2-1**, **2-2** are moved on the rail **4** together with the slider. Therefore, foreign objects such as dust are removed from the outer circumferential face of the rail **4** by the seal portion of the seal members **2-1**, **2-2**. Accordingly, no foreign objects get into the slider. The inner circumferential faces **6-1***a*, **6-2***a* on side of the seal members **2-1**, **2-2** are contacted with the outer circumferential face of the rail **4** on the opposed side when they are pushed by the elastic members **8-1**, **8-2**. Therefore, even if the width of the rail **4** differs within the expansion and contraction range of the elastic members **8-1**, **8-2**, the width difference can be absorbed in this expansion and contraction range. Accordingly, no gaps are formed between the seal portion and the outer circumferential face of the rail **4**. Therefore, the sealing function is not impaired.

[0049] **FIG. 7** is a view to explain a sealing function in the case where the seal device of the present invention is applied to a guide device in which the rail width of a curved portion is smaller than the rail width of a straight portion like the transport device (shown in **FIG. 2**) described in Japanese Unexamined Patent Publication No. 2001-99152. In the drawing, two-dotted chain line A expresses an outer circumference of the rail **4** in the straight portion, and solid line B expresses an outer circumference of the rail **4** in the curved portion. As shown in the drawing, since the seal member **2-1** is pushed onto the rail side by the elastic member **8-1**, the inner circumferential face **6-1***a* on one side composing the seal portion always closely comes into contact with and slides on the outer circumferential face in either the straight portion (portion shown by two-dotted chain line A) in which the width of the rail **4** is large or the curved portion (portion shown by solid line B) in which the width of the rail **4** is small. Although not shown in the drawing, the seal member **2-2** is also pushed by the elastic member **8-2**, and the inner circumferential face **6-2***a* on one side always closely comes into contact with and slides on the outer circumferential face of the rail **4** in either the straight portion or the curved portion of the rail **4**.

[0050] Due to the foregoing, the inner circumferential faces **6-1***a*, **6-2***a* on-one side of the seal members **2-1**, **2-2** and the upper side inner circumferential faces **6-1***b*, **6-2***b* always slidably come into contact with both the outer side faces and the upper face of the rail **4** irrespective of the width of the rail. Therefore, a sufficiently high sealing performance can be exhibited. In the above example, the width of the curved portion of the rail **4** is different from that of the straight portion. The seal device of the present invention is capable of exhibiting a sufficiently high sealing performance even in the case where the width is different within the curved portion and in the case where the width is different within the straight portion.

[0051] The seal members **2-1**, **2-2** are made of elastic material such as rubber or resin formed into a felt-shape, however, materials to compose the seal members **2-1**, **2-2** are not limited to the above specific examples. As far as the material is easily conformed to and seldom seized to and easily fitted to the rail **4**, any material such as resin or metal, for example, white metal used for a bearing metal may be used for the seal members **2-1**, **2-2**. In the above example, the cross sections of the inner circumferential faces **6-1***c*, **6-2***c* on one side of the seal members **2-1**, **2-2** which do not compose the seal portion are made to be similar to the cross section of the outer circumferential face of the rail **4**, however, the cross sections of the inner circumferential faces **6-1***c*, **6-2***c* are not limited to the above specific example.

[0052] **FIG. 8** is a view showing an appearance of the guide device to which the seal device of the present invention is applied. In the view, reference numeral **10** is a slider which is arranged striding over the rail. The slider **10** comprises a block **11**, the detail of which will be described later, and end plates **12**. The seal devices **13** of the present invention are arranged outside the end plates **12** which are attached to both ends of the slider **10**. The slider **10** is moved in the longitudinal direction of the rail **4**. When the slider **10** is moved, the inner circumferential faces **6-1***a*, **6-2***a* on one side of the seal members **2-1**, **2-2** (shown in **FIGS. 4 and 6**) and the inner circumferential faces **6-1***b*, **6-2***b* on the upper side of the seal members composing the seal device **13** closely-come into contact with and slide on both the side faces and the upper face of the rail **4**. Due to the foregoing, foreign objects such as dust can be prevented from getting into the slider **10** from the surface of the rail **4**.

[0053] **FIGS. 9 and 10** are a partially cutaway perspective view and lateral sectional view showing a composition of the guide device from which the seal device **13** is removed. The cross section of the rail **4** is formed into a substantial rectangle. Four ball running grooves **4***a*, **4***b*, in which the balls **20** are running, are formed in the longitudinal direction. These ball running grooves **4***a*, **4***b* are formed on both side faces and at both edge portions on the upper face of the rail **4**. The ball running grooves **4***a* located on both side faces are formed downward by the angle of about 30° with respect to the lateral direction on the surface of **FIG. 9**. On the other hand, the ball running grooves **4***b* on the upper face are formed upward in the vertical direction.

[0054] The slider **10** includes: a block **11** having an attaching face **21**, onto which the movable body such as a table is attached, and tap holes **22** in which bolts for fixing the movable body are screwed; and a pair of end plates **12**, **12** attached (fixed) to both end portions of the block **11**. When the end plates **12**, **12** are attached, an infinite circulating path for the balls **20** is composed in the slider **10**.

[0055] The block **11** includes: a horizontal portion **11***a* on which the attaching face **21** is formed; and a pair of skirt portions **11***b*, **11***b* which are hanging from the horizontal portion **11***a*. The cross section of the block **11** is substantially formed into a saddle. On the lower face side of the horizontal portion **11***a* and on the inside of each skirt portion **11***b*, four straight load running grooves **11***c*, **11***d*, which are opposed to the ball running grooves **4***a*, **4***b* of the rail **4**, are formed. In the horizontal portion **11***a* and each skirt portion **11***b*, the ball returning holes **11***e*, **11***f* respectively corresponding to the load running grooves **11***c*, **11***d* are formed. By the U-shaped direction converting paths formed on the end plates **12**, **12**, the load running grooves **11***c*, **11***d* and the corresponding ball returning holes **11***e*, **11***f* are connected with each other, so that the infinite circulating path of the balls can be formed.

[0056] Due to the foregoing, the balls **20** are running as follows. The balls **20**, which bear a load between the ball running grooves **4***a*, **4***b* of the rail **4** and the load running grooves **11***c*, **11***d* of the block **11**, run in the load running grooves **11***c*, **11***d* according to the movement of the slider **10** and are released from the load. Then the balls **20** get into the direction converting path formed on one end plate **12** and run in the opposite direction to the running direction of the load running grooves **11***c*, **11***d* while no load is being given to the balls **20**. In this way, the balls **20** run in the ball returning holes **11***e*, **11***f* formed in the block **11**. After the balls **20** have run in the ball returning holes **11***e*, **11***f*, they get between the rail **4** and the block **11** again via the direction converting path formed on the other end plate **12**. Then, while the balls **20** are bearing a load, they run in the load running grooves **11***c*, **11***d*.

[0057] The above-described guide device is an example of the guide device into which the seal device of the present invention is incorporated. Therefore, the guide device of the present invention is not limited to the above specific example. After all, as far as the guide device is composed in such a manner that the slider is arranged striding over a straight and/or curved rail and guided along the rail and the seal device of the present invention is fixed to the end portion of the slider, it is possible to exhibit a sealing function by which foreign objects such as dust can be prevented from getting into the slider.

[0058] In the seal device of the above structure, two seal members **2-1**, **2-2** are arranged while the isolation plate **3** is being interposed between them. However, the number of the seal members is not limited to two, that is, not less than three seal members may be arranged. The isolation plate **3** is not necessarily required. In the case where each seal member can be smoothly moved even when the seal members **2-1**, **2-2** are contacted with each other, the isolation plate **3** may be omitted. In the above example, the elastic members **8-1**, **8-2** are respectively arranged on both side portions of the seal members **2-1**, **2-2** integrally with the seal members **2-1**, **2-2**. However, the elastic members **8-1**, **8-2** are not necessarily arranged integrally with the seal members **2-1**, **2-2**. As far as each seal member **2-1**, **2-2** can be individually pushed toward the rail **4**, the elastic members **8-1**, **8-2** may be composed separately from the seal members **2-1**, **2-2**.

[0059] The elastic members are not necessarily formed separately from the seal members **2-1**, **2-2**. The following structure may be adopted. When the seal members **2-1**, **2-2** are made of elastic material, the inner circumferential face **6-1***a*, **6-2***a* on one side can be always contacted with the outer circumferential face of the rail by the elastic extension and contraction caused between the one side of the seal members **2-1**, **2-2** and the inner circumferential faces **6-1***a*, **6-2***a* on one side even if the rail width is changed. Further, the following structure may be adopted. For example, as shown in **FIG. 11**, a predetermined shape of hole **23** is formed in the seal member **2-1**. Since the shape of the hole **23** can be deformed, the inner circumferential face **6-1***a* on one side composing the seal portion of the recess portion **6-1** can be always contacted with the outer circumferential face of the rail even if the rail width is changed. Although not shown in the drawing, the situations are the same in the case of the seal member **2-2**.

[0060] **FIG. 12** is an exploded perspective view showing an example of the arrangement of the seal device of the guide device of the present invention. As shown in the drawing, the seal device **30** includes: a casing **31**; a plurality of (three in the case shown in the drawing) plate-shaped seal members **32-1**, **32-2**, **32-3**; and two isolation plates **33-1**, **33-2** interposed between the seal member **32-1** and the seal member **32-2** and between the seal member **32-2** and the seal member **32-3**. The seal members **32-1**, **32-2**, **32-3** and the isolation plates **33-1**, **33-2** are superposed to each other and accommodated in the casing **31**. As shown in FIGS. **13**(*a*) and **13**(*b*), the seal members **32-1**, **32-2**, **32-3** and the isolation plates **33-1**, **33-2** are attached (fixed) to both side bottom portions of the block **11** of the slider **10** by screws **34**. The seal members **32-1**, **32-2**, **32-3** are pushed onto the sides of the rail **4** by the elastic members, and the sides are slidably contacted with the side faces of the rail **4** as described later. **FIG. 13**(*a*) is a lateral sectional view of the rail **4** and slider **10** of the guide device, and **FIG. 13**(*b*) is an enlarged sectional view of the neighborhood portion of the seal device **30**.

[0061] The side **32-1***a* of the seal member **32-1** slidably coming into contact with the side of the rail **4** is formed into a convex (an arcuate shape) of a predetermined radius of curvature, the side **32-2***a* of the seal member **32-2** slidably coming into contact with the side of the rail **4** is formed into a straight shape, and further the side **32-3***a* of the seal member **32-3** slidably coming into contact with the side of the rail **4** is formed into a concave (an arcuate shape) of a predetermined radius of curvature. On the sides of the seal members **32-1**, **32-2**, **32-3** arranged on the side opposite to the rail **4**, the elastic members **35-1**, **35-1**, **35-2**, **35-2**, **35-3**, **35-3** are respectively integrally arranged. When the thus composed seal device **30** is attached to both side bottom portions of the block **11** of the slider **10**, the seal members **32-1**, **32-2**, **32-3** are pushed by the elastic members **35-1**, **35-1**, **35-2**, **35-2**, **35-3**, **35-3**.

[0062] Since the side **32-1***a* of the seal member **32-1** is formed into a convex (an arcuate shape) of a predetermined radius of curvature, the side **32-2***a* of the seal member **32-2** is formed into a straight shape, and further the side **32-3***a* of the seal member **32-3** is formed into a concave (an arcuate shape) of a predetermined radius of curvature, in a portion where the rail **4** is curved convex by a predetermined radius of curvature as shown in **FIG. 14**(*a*), the side **32-1***a* of the seal member **32-1** closely comes into contact with the side of the rail **4** so as compose the seal portion. In a portion where the rail **4** is curved concave by a predetermined radius of curvature as shown in **FIG. 14**(*b*), the side **32-3***a* of the seal member **32-3** closely comes into contact with the side of the rail **4** so as compose the seal portion. In a portion where the rail **4** is straight as shown in **FIG. 14**(*c*), the side **32-2***a* of the seal member **32-2** closely comes into contact with the side of the rail **4** so as compose the seal portion.

[**0063**] In the case where the rail **4** snakes as shown in **FIG. 15**, the rail **4** is composed of curved portions **4-1**, **4-2** and a straight portion **4-3**, wherein the curved portions **4-1**, **4-2** are respectively formed into arcs, the radiuses of curvature of which are predetermined. Therefore, the convex (arcuate) side **32-1***a* of the seal member **32-1** and the concave (arcuate) side **32-3***a* of the seal member **32-3** are previously manufactured according to the radiuses of curvature of these curved portions **4-1**, **4-2**. Due to the foregoing, when the seal device **30** in which the seal members **32-1**, **32-2**, **32-3** are superposed as shown in **FIG. 12** is attached to both side bottom portions of the block **11** of the slider **10** as shown in **FIG. 13**, if the slider **10** is moved on the snaking rail **4**, either of the sides **32-1***a*, **32-2***a*, **32-3***a* of the seal members **32-1**, **32-2**, **32-3** closely comes into contact with the side of the rail **4**, so that the seal portion can be formed.

[**0064**] The seal members **32-1**, **32-2**, **32-3** can be made of the same material as that of the seal members **2-1**, **2-2**. The isolation plates **33-1**, **33-2** can be made of the same material as that of the above isolation plate **3**.

[**0065**] In the seal device **30** of the above structure, three seal members **32-1**, **32-2**, **32-3** are arranged while the isolation plates **33-1**, **33-2** are being interposed between them, however, the number of the seal members is not limited to three. That is, not less than three seal members may be arranged. The isolation plates are not necessarily required. In the case where each seal member can be smoothly moved even when the seal members **32-1**, **32-2**, **32-3** are contacted with each other, the isolation plates may be omitted. In the above example, the elastic members **35-1**, **35-2**, **35-3** are respectively arranged on side portions of the seal members **32-1**, **32-2**, **32-3** integrally with the seal members **32-1**, **32-2**, **32-3**. However, the elastic members **35-1**, **35-2**, **35-3** are not necessarily arranged integrally with the seal members **32-1**, **32-2**, **32-3**. As far as each seal member **32-1**, **32-2**, **32-3** can be individually pushed toward the rail **4**, the elastic members **35-1**, **35-2**, **35-3** may be composed separately from the seal members **32-1**, **32-2**, **32-3**.

[**0066**] In the case of the guide device shown in **FIG. 15**, the rail **4** is snaking. However, for example, in the case where the rail **4** is annularly formed into an ellipse as shown in. **FIG. 16**, the seal device located outside the annular rail **4** is the seal device **30** composed as shown in **FIG. 17**, and the seal device located inside the annular rail **4** is the seal device **30** composed as shown in **FIG. 18**. The seal device **30** shown in **FIG. 17** is composed in such a manner that the side **32-2***a* slidably coming into contact with the outer circumferential side face of the rail **4** is the straight seal member **32-2**, the isolation plate is the isolation plate **33-1**, and the side **32-3***a* slidably coming into contact with the outer circumferential side face of the rail **4** is the seal member **32-3** of a concave (arc) of a predetermined radius of curvature. The seal device **30** shown in **FIG. 18** is composed in such a manner that the side **32-2***a* slidably coming into contact with the inner circumferential side face of the rail **4** is the straight seal member **32-2**, the isolation plate is the isolation plate **33-1**, and the side **32-1***a* slidably coming into contact with the inner circumferential side face of the rail **4** is the seal member **32-1** of a convex (arc) of a predetermined radius of curvature.

[**0067**] As described above, the seal device **30** located outside the annular rail **4** is composed as shown in **FIG. 17**, and the seal device **30** located inside the annular rail **4** is composed as shown in **FIG. 18**. Due to the above structure, in the seal device **30** located outside, either the straight side **32-2***a* of the seal member **32-2** or the concave (arcuate) side **32-3***a* of the seal member **32-3** closely comes into contact with the outer circumferential side of the rail **4**, so that the seal portion can be formed. In the seal device **30** located inside, either the straight side **32-2***a* of the seal member **32-2** or the convex (arcuate) side **32-1***a* of the seal member **32-1** closely comes into contact with the inner circumferential side of the rail **4**, so that the seal portion can be formed. Accordingly, there is no possibility that foreign objects get into the slider **10** from the bottom side portion.

[**0068**] When the seal device **30** composed as shown in **FIG. 4** is arranged at both end portions of the slider **10** of the guide device and when the seal device **30** composed as shown in **FIG. 12** or the seal device **30** composed as shown in **FIGS. 17 and 18** is arranged at both side portions of the bottom portion of the slider **10**, it becomes possible to provide a guide device incorporated into a wood working machine used in a dusty environment in which both end portions and both side portions of the slider **10** are sealed so that no foreign objects can not get into the slider **10**.

[**0069**] As explained above, according to each aspects of the present invention, it is possible to provide the following excellent effects.

[**0070**] According to the first aspect of the invention, a plurality of seal members are arranged in the casing so that the phase of arranging the plurality of seal members can be alternately changed in such a manner that when a seal portion of one seal member is pushed by the elastic member and contacted with one side of the rail, a seal portion of the next seal member is pushed by the elastic member and contacted with the other side of the rail. Accordingly, the seal portions of the plurality of seal members (at least two seal members) conduct sealing while they are sliding on the outer circumferential face of the rail on which the slider moves. Therefore, it is possible to provide a perfect sealing function. Especially when the rail width is locally different, for example even when the width of a curved portion is smaller than the width of a straight portion, a difference in the width can be absorbed when the seal member is, moved while being pushed by the elastic member. Therefore, the seal portion can be always contacted with the outer circumferential face of the guide rail. Accordingly, the sealing function is not impaired.

[**0071**] According to the second aspect of the invention, when the elastic member is formed in the outside portion of the seal member integrally with the seal member as described above, the number of parts composing the seal device can be decreased, and the assembling work can be easily performed.

[0072] According to the third aspect of the invention, the isolation plate is arranged between the seal members. Therefore, each seal member can be smoothly moved according to the rail width without interfering with the other seal members by the action of the elastic member, and the seal portion comes into contact with the outer circumferential face of the guide rail. Therefore, the sealing function can be effectively performed.

[0073] According to the fourth aspect of the invention, the side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex or concave of a predetermined radius of curvature, and the side of at least one seal member slidably coming into contact with the side of the rail is formed into the straight-line-shape. Therefore, in the straight portion of the rail, the straight side of the seal member closely comes into contact with the side of the rail, and in the curved portion of the seal member, the side of the seal member, which is formed into a convex or concave of a predetermined radius of curvature, closely comes into contact with the side of the rail, so that the seal portion can be formed. Therefore, even if the rail profile is changed from a straight shape to a curved shape, no foreign objects get into the slider from the side portion.

[0074] According to the fifth aspect of the invention, the side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex of a predetermined radius of curvature, and the side of at least one seal member slidably coming into contact with the side of the rail is formed into a concave of a predetermined radius of curvature, and further the side of at least one seal member slidably coming into contact with the side of the rail is formed into a straight shape. Due to the above structure, in the straight rail portion, the straight side of the seal member closely comes into contact with the rail side, so that the seal portion can be formed. In the curved rail portion, the convex side of the seal member of a predetermined radius of curvature or the concave side of the seal member closely comes into contact with the rail side, so that the seal portion can be formed. In the portion where the rail is curved in the other direction, the concave side of the seal member of a predetermined radius of curvature or the convex side of the seal member closely comes into contact with the rail side, so that the seal portion can be formed. Therefore, even if the rail is curved from a straight shape to a curved shape which is curved to either the right or the left, no foreign objects gets into the slider from the side portion of the slider.

[0075] According to the sixth aspect of the invention, the elastic members are formed on the outside of the seal members integrally with the seal members. Therefore, the number of parts composing the seal device can be reduced, and the assembling work can be easily performed.

[0076] According to the seventh aspect of the invention, the isolation plate is arranged between the seal members. Therefore, each seal member is pushed by the elastic member and smoothly moved according to the curved rail without interfering with the other seal members, and the side of the seal member comes into contact with the rail side. Therefore, the sealing function can be effectively performed.

[0077] According to the eighth aspect of the invention, when the seal device attached to both end portions of the slider is the seal device according to one of the first to third aspects and the seal device attached to both side portions is the seal device according to the fourth to seventh aspects, both end portions and both side portions of the slider are sealed. Accordingly, it becomes possible to provide a guide device, into the slider of which no foreign objects get.

1-4. (canceled)

5. A seal device for a guide device which is fixed to a side portion of a slider of the guide device so as to prevent foreign objects such as dust from getting into the seal device, the slider being arranged striding over a straight and/or curved rail and guided along the rail, the seal device comprising:

a casing;

a plurality of plate-shaped seal members accommodated in the casing; and

an elastic member for pushing the seal members onto the rail,

wherein a side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex or concave shape of a predetermined radius of curvature, a side of at least one seal member slidably coming into contact with the side of the rail is formed into a straight shape, and

wherein the seal members are pushed by the elastic member and at least one portion of the side of each seal member comes into contact with the side of the rail.

6. A seal device for a guide device which is fixed to a side portion of a slider of the guide device so as to prevent foreign objects such as dust from getting into the seal device, the slider being arranged striding over a straight and/or curved rail and guided along the rail, the seal device comprising:

a casing;

a plurality of plate-shaped seal members accommodated in the casing; and

an elastic member for pushing the seal members onto the rail,

wherein a side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex shape of a predetermined radius of curvature, a side of at least one seal member slidably coming into contact with the side of the rail is formed into a concave shape of a predetermined radius of curvature, and a side of at least one seal member slidably coming into contact with the side of the rail is formed into a straight shape, and

wherein the seal members are pushed by the elastic member and at least one portion of the side of each seal member comes into contact with the side of the rail.

7. A seal device for a guide device according to claim 5, wherein the elastic member is integrally formed on the outer periphery of each seal member.

8. A seal device for a guide device according to claim 6, wherein the elastic member is integrally formed on the outer periphery of each seal member.

9. A seal device for a guide device according to claim 5, further comprising an isolation plate arranged between the seal members.

10. A seal device for a guide device according to claim 6, further comprising an isolation plate arranged between the seal members.

11. A seal device for a guide device according to claim 7, further comprising an isolation plate arranged between the seal members.

12. A seal device for a guide device according to claim 8, further comprising an isolation plate arranged between the seal members.

13. A guide device comprising:

a straight and/or curved rail; and

a slider arranged striding over the rail, the slider having seal devices arranged at both end portions and both side portions respectively for preventing foreign objects from getting into the slider,

wherein the seal device attached to both side portions is the seal device described in claim 5.

14. A guide device comprising:

a straight and/or curved rail; and

a slider arranged striding over the rail, the slider having seal devices arranged at both end portions and both side portions respectively for preventing foreign objects from getting into the slider,

wherein the seal device attached to both side portions is the seal device described claim 6.

15. A seal device for a guide device according to claim 5, wherein the side of said at least one seal member slidably coming into contact with the side of the rail is formed into a convex shape of a predetermined radius of curvature.

16. A seal device for a guide device according to claim 5, wherein the side of said at least one seal member slidably coming into contact with the side of the rail is formed into a concave shape of a predetermined radius of curvature.

* * * * *

US 20050042054A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2005/0042054 A1**

Suzuki et al. (43) **Pub. Date: Feb. 24, 2005**

(54) **METHOD AND APPARATUS FOR CUTTING LONG SCALE HARDENED STEEL**

(76) Inventors: **Kiyoshi Suzuki**, Yokohama-shi (JP); **Takeki Shirai**, Tokyo-to (JP); **Chandra Shekhar Sharuma**, Tokyo-to (JP)

Correspondence Address:
WESTERMAN, HATTORI, DANIELS & ADRIAN, LLP
1250 CONNECTICUT AVENUE, NW
SUITE 700
WASHINGTON, DC 20036 (US)

(21) Appl. No.: **10/952,724**

(22) Filed: **Sep. 30, 2004**

Related U.S. Application Data

(62) Division of application No. 10/297,947, filed on Dec. 26, 2002, filed as 371 of international application No. PCT/JP02/04132, filed on Apr. 25, 2002.

(30) **Foreign Application Priority Data**

Apr. 27, 2001 (JP) P2001-133504

Publication Classification

(51) **Int. Cl.^{7}** **B23D 1/00**

(52) **U.S. Cl.** **409/337**

(57) **ABSTRACT**

The present invention mainly aims to provide cutting method and cutting apparatus for manufacturing a guide rail of a rolling guide device by efficiently cut-working a long scale hardened steel. In order to achieve such object, there is provided a cutting method of linearly cutting a work surface (**3**) of the long scale hardened steel (**2**) along the longitudinal direction thereof. In this process, it is desired to arrange a plurality of CBN tools (**7**) along the longitudinal direction of the long scale hardened steel (**2**) to thereby sequentially cut the work surface (**3**). Furthermore, a cutting apparatus of the present invention comprises a fixing device (**4**) for fixing the long scale hardened steel (**2**), a tool rest (**5**) which is guided by a guide device (**6**) disposed along the longitudinal direction of the fixing device (**4**) and the CBN tool (**7**) cut-working the work surface (**3**) of the long scale hardened steel (**2**) held by the tool rest (**5**).

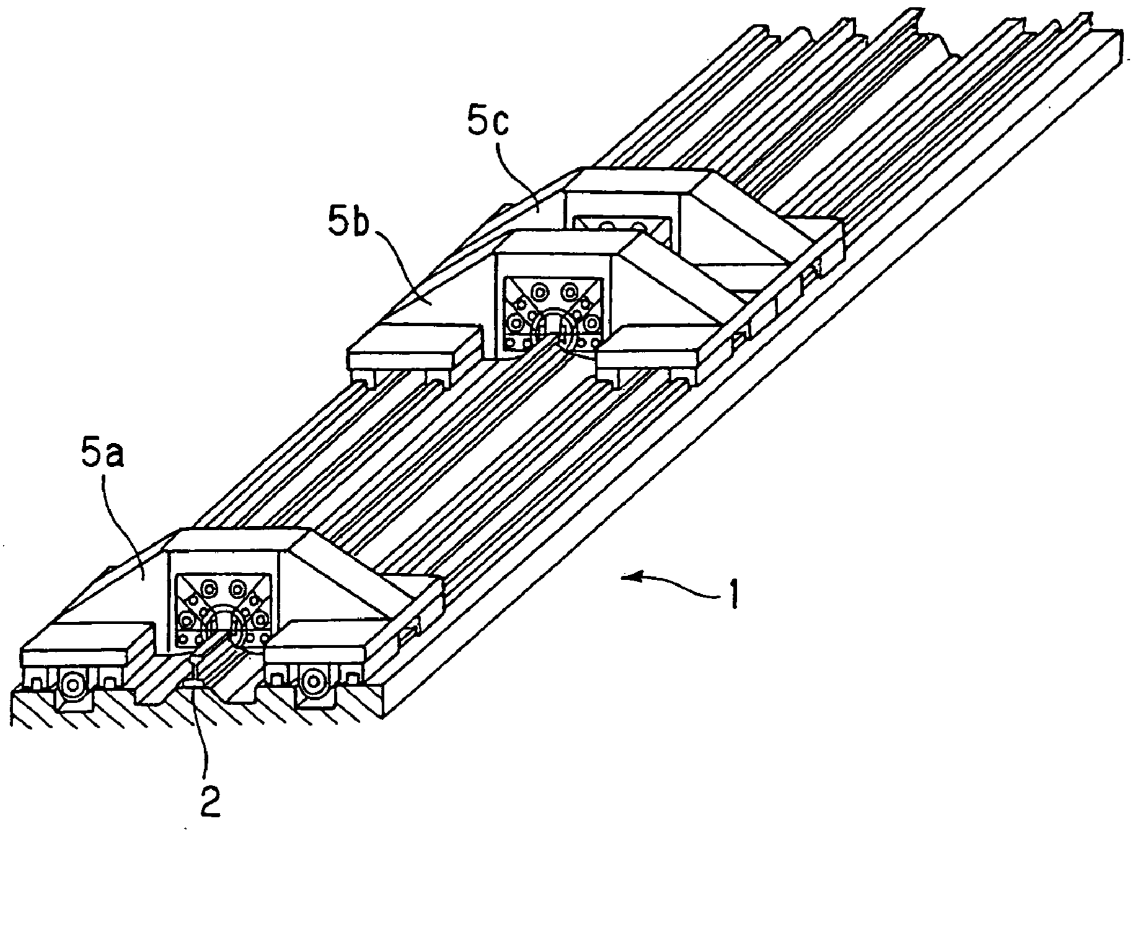


FIG. 1

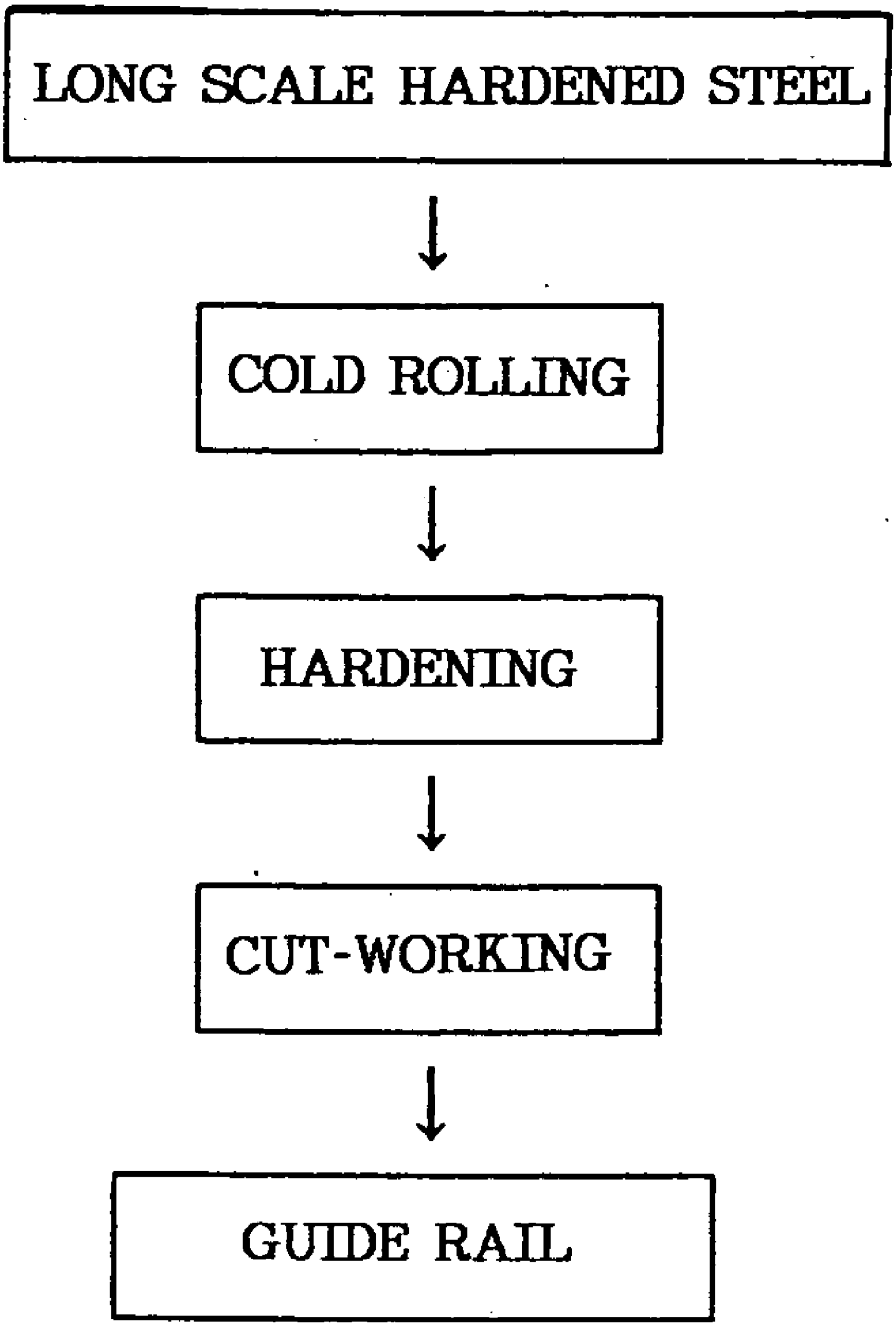

LONG SCALE HARDENED STEEL
COLD ROLLING
HARDENING
CUT-WORKING
GUIDE RAIL

FIG. 2

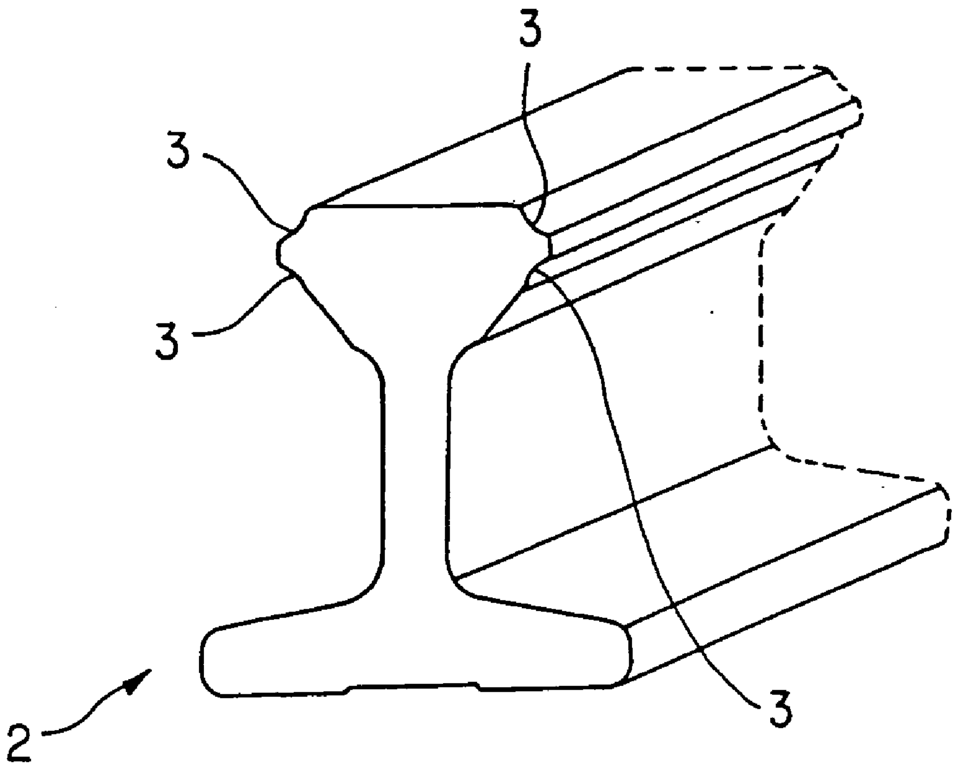


FIG. 3

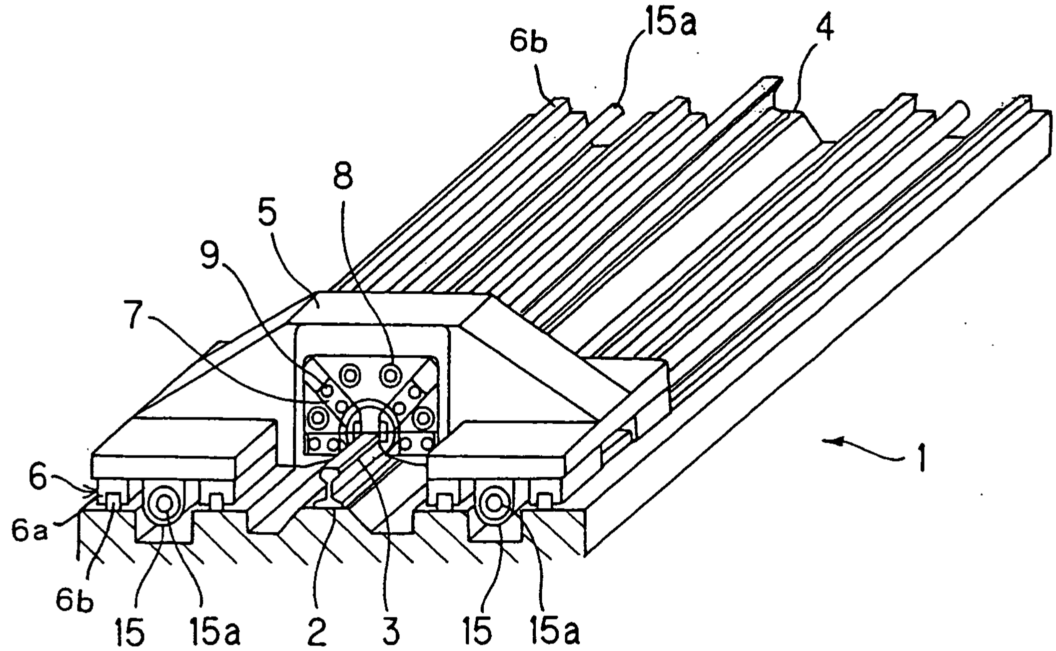


FIG. 4

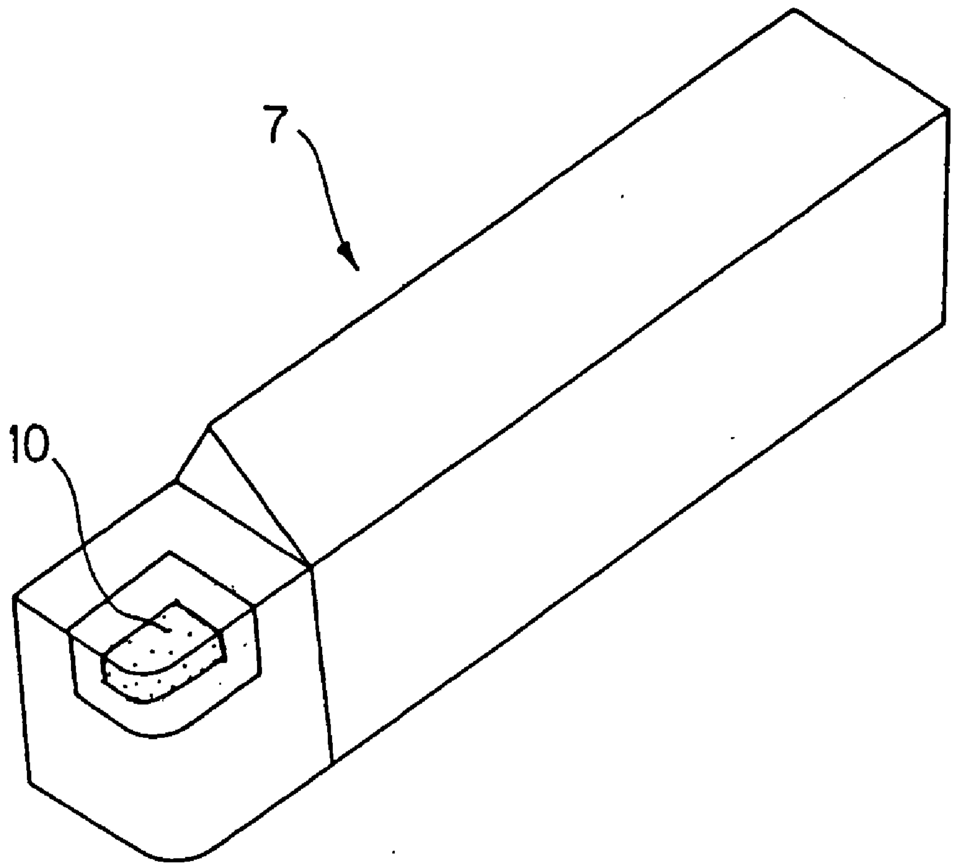


FIG.5(A)

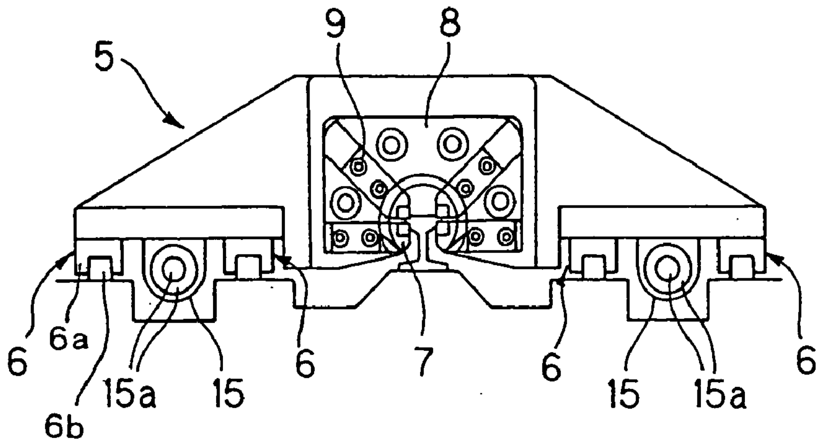


FIG.5(B)

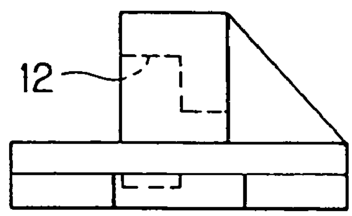


FIG.5(C)

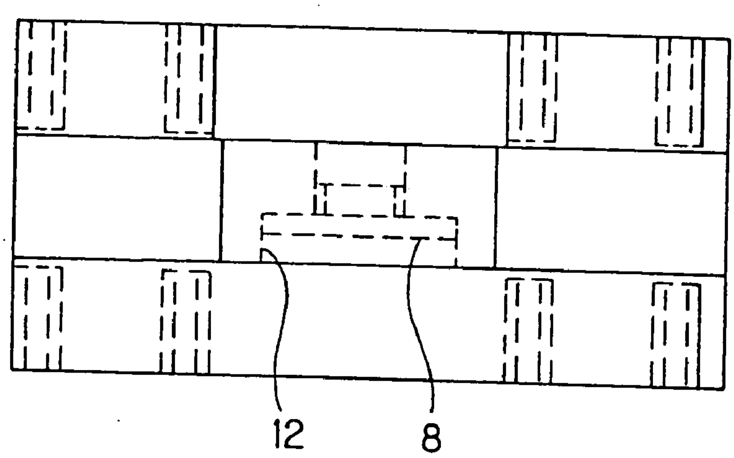


FIG. 6

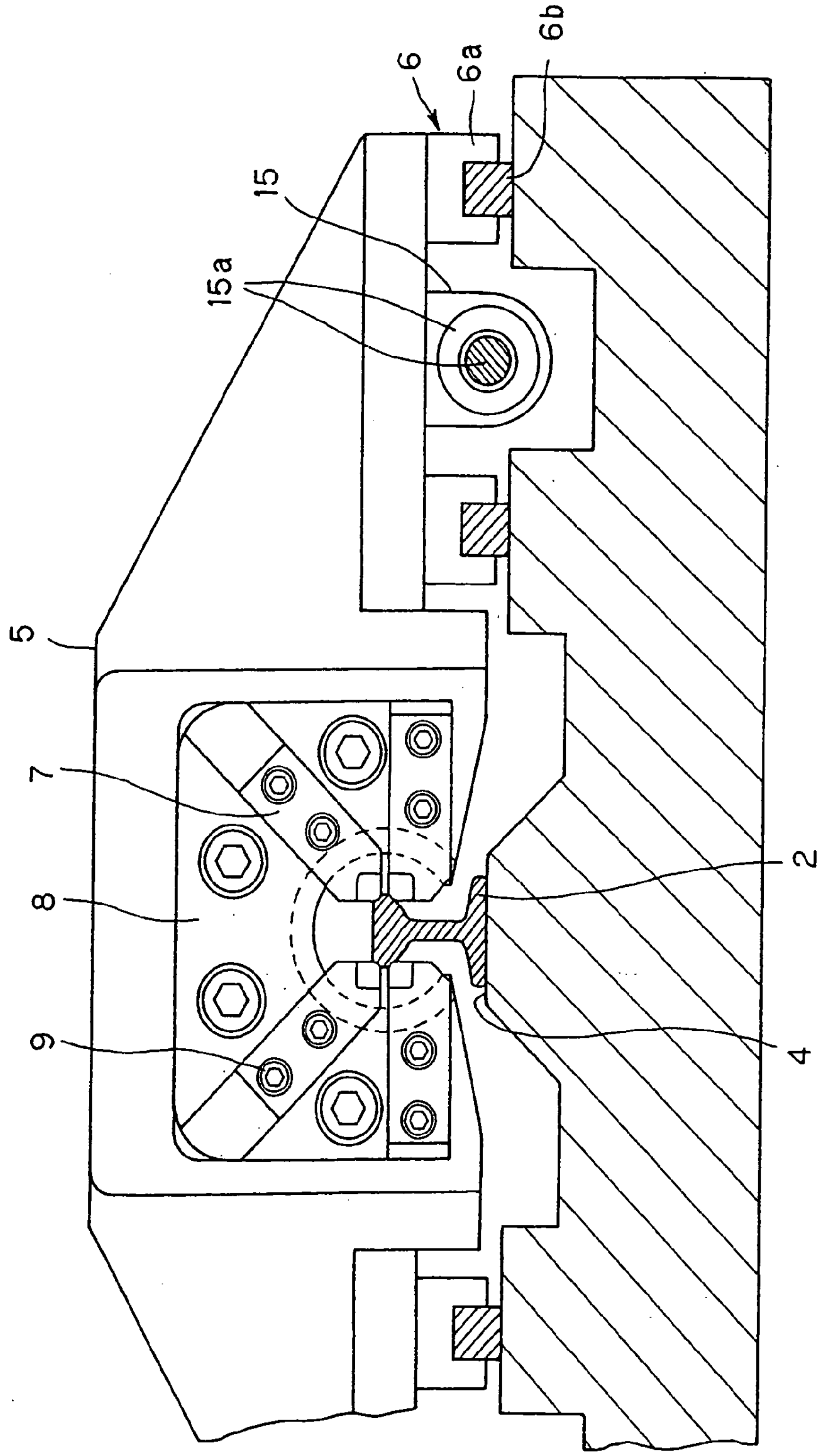


FIG.7(A)

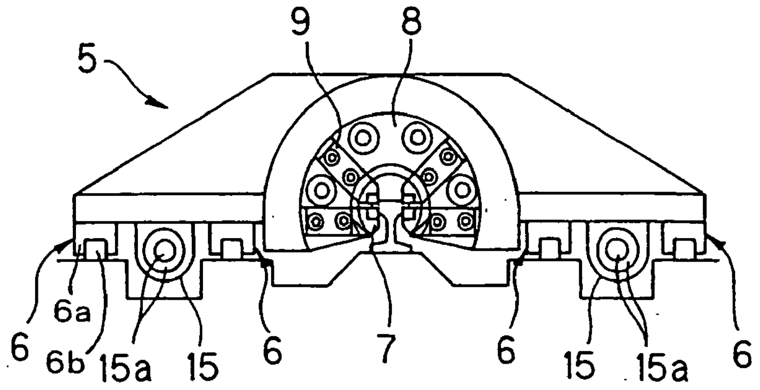


FIG.7(B)

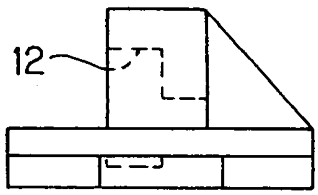


FIG.7(C)

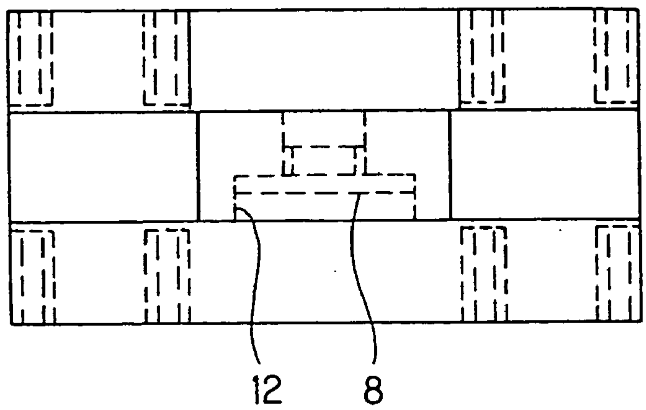


FIG. 8(A)

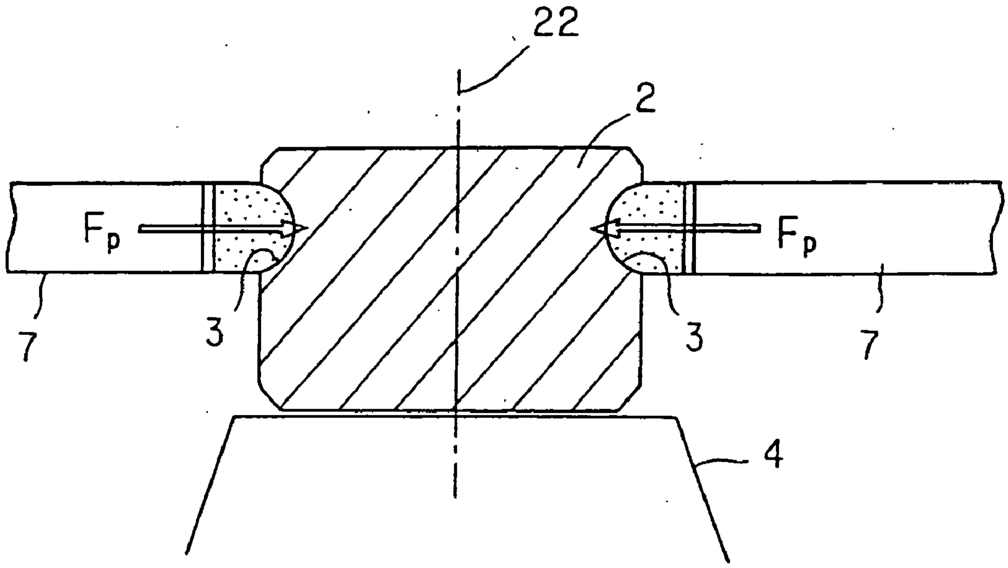


FIG. 8(B)

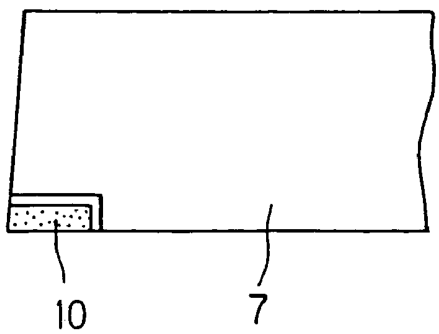


FIG. 9

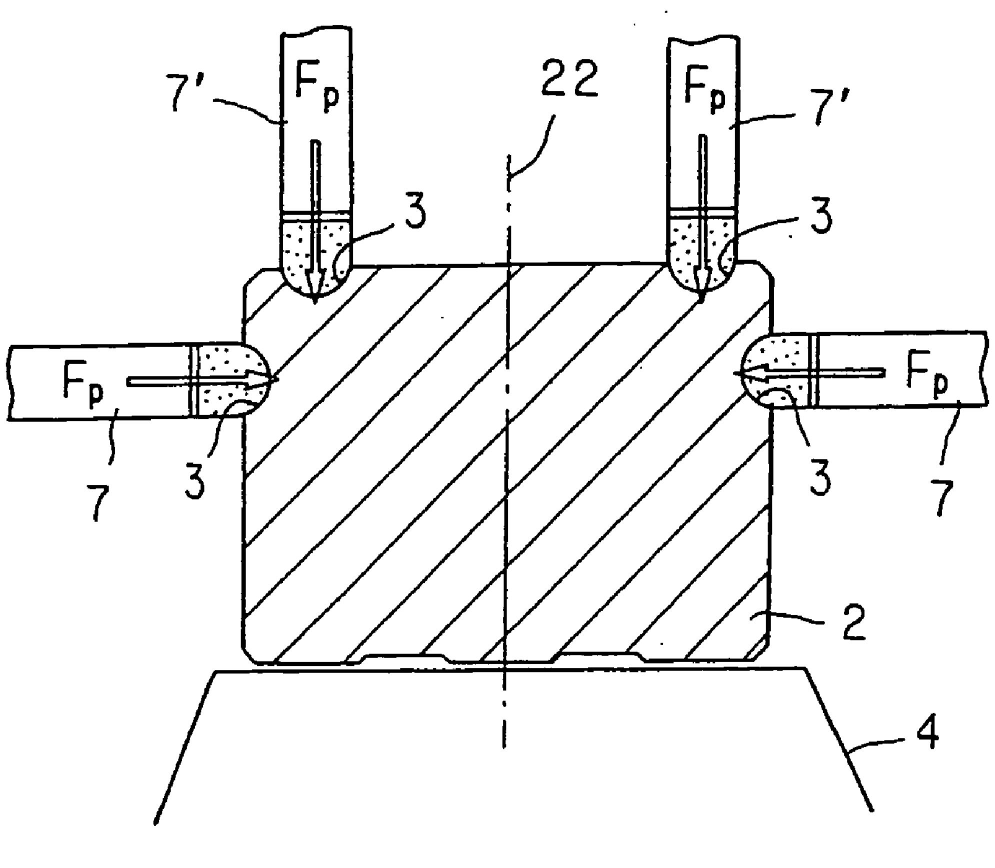


FIG. 10

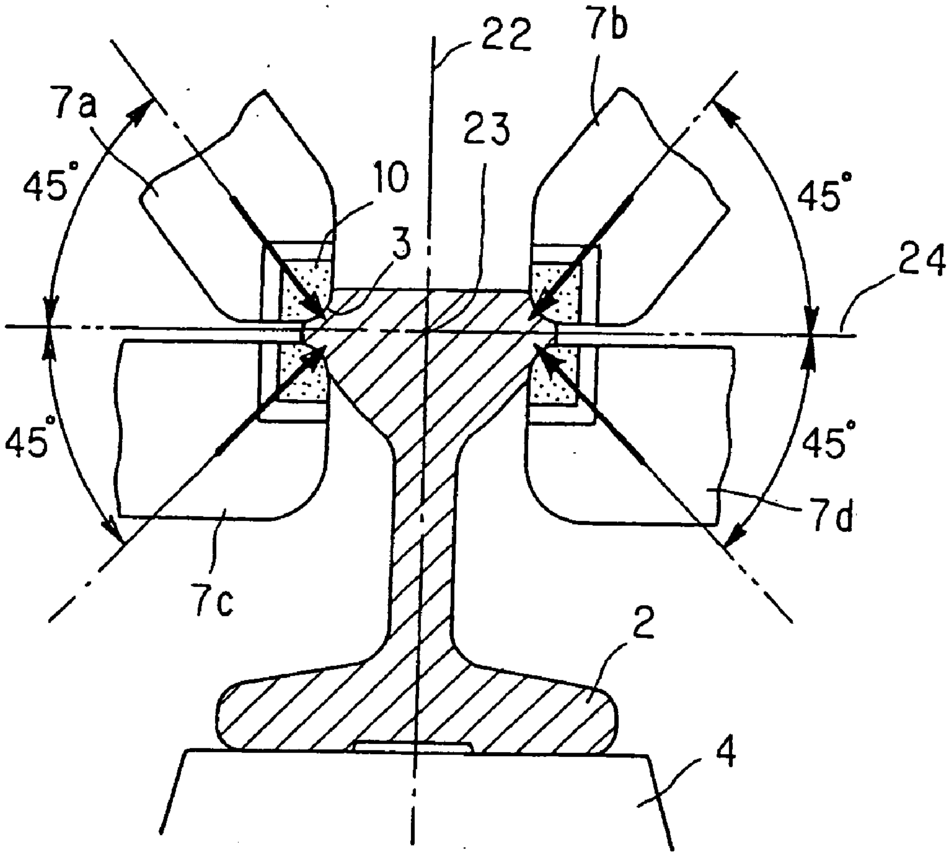


FIG. 11

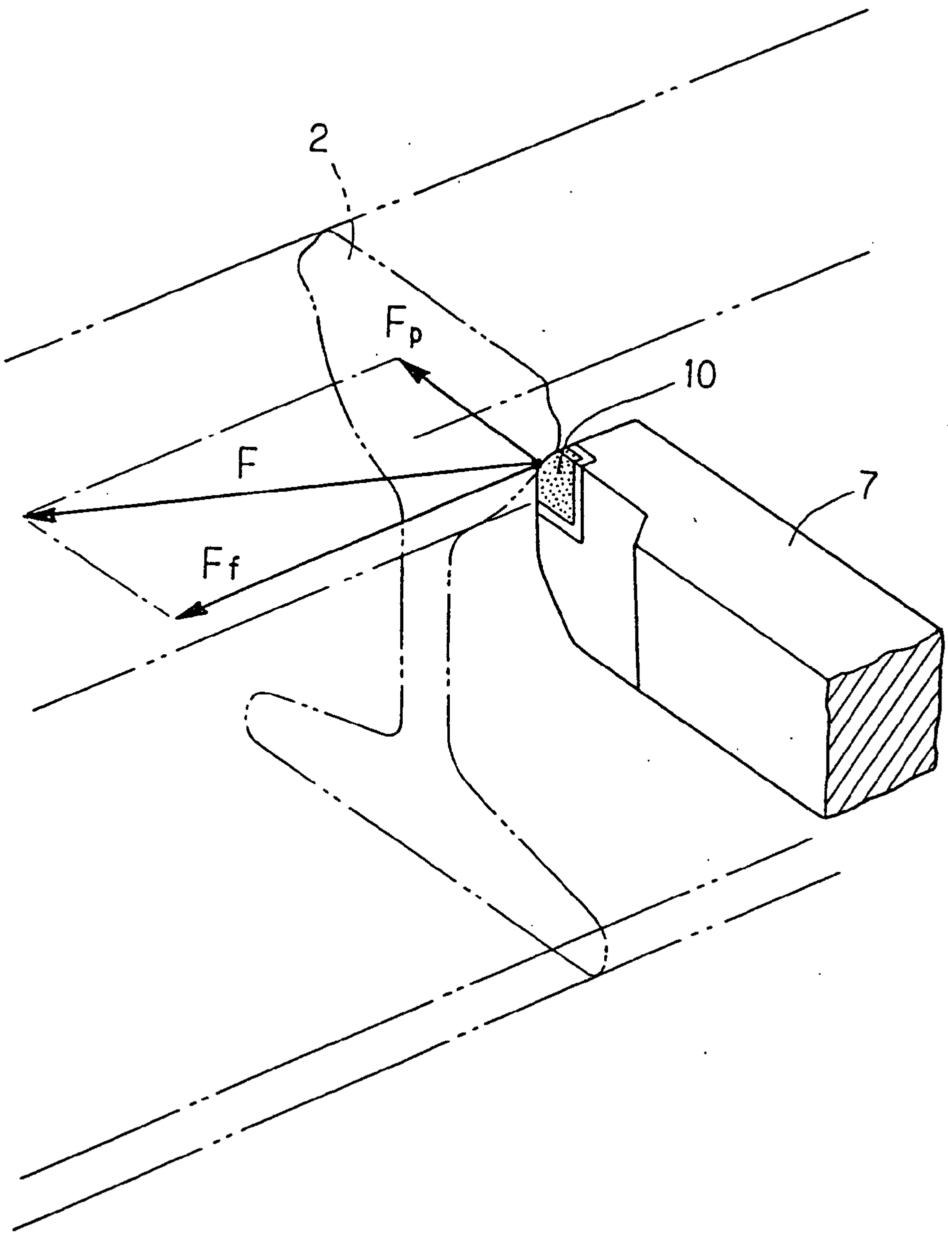


FIG. 12

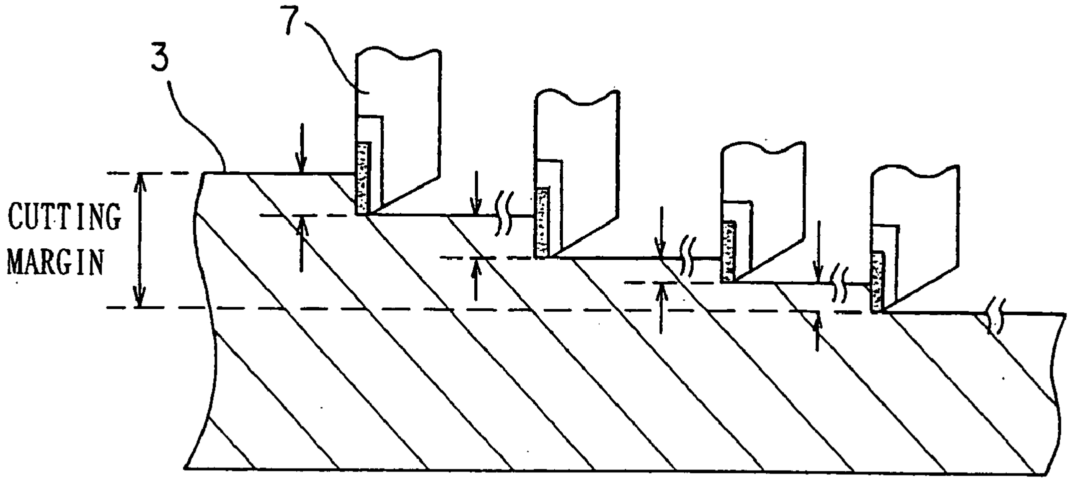


FIG. 13

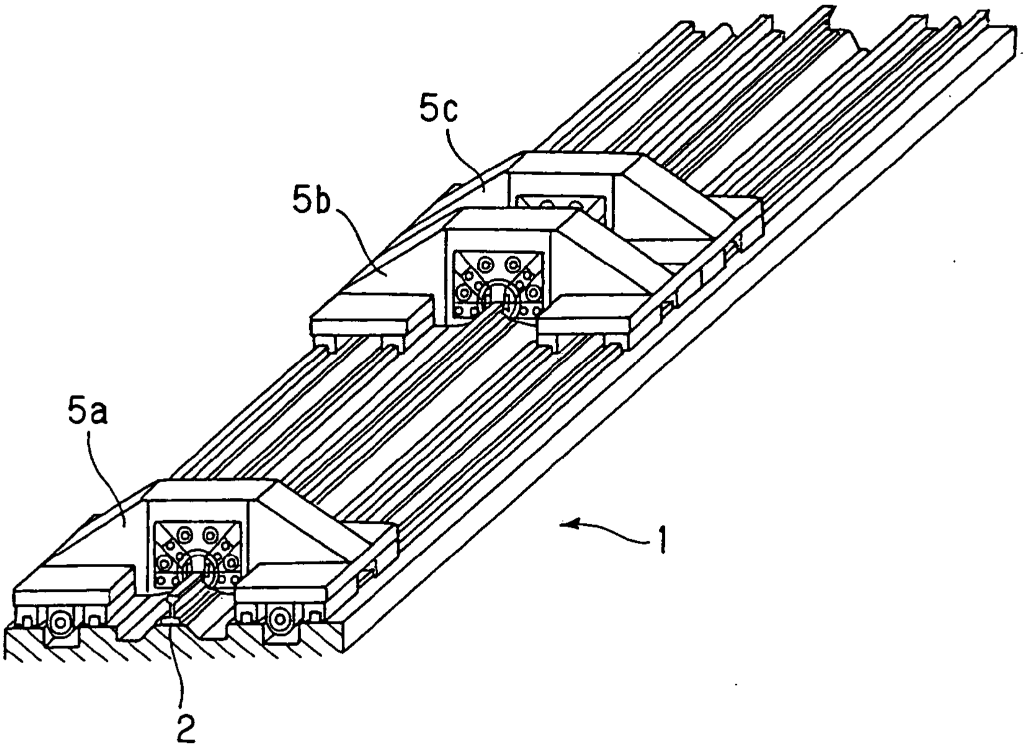


FIG. 14

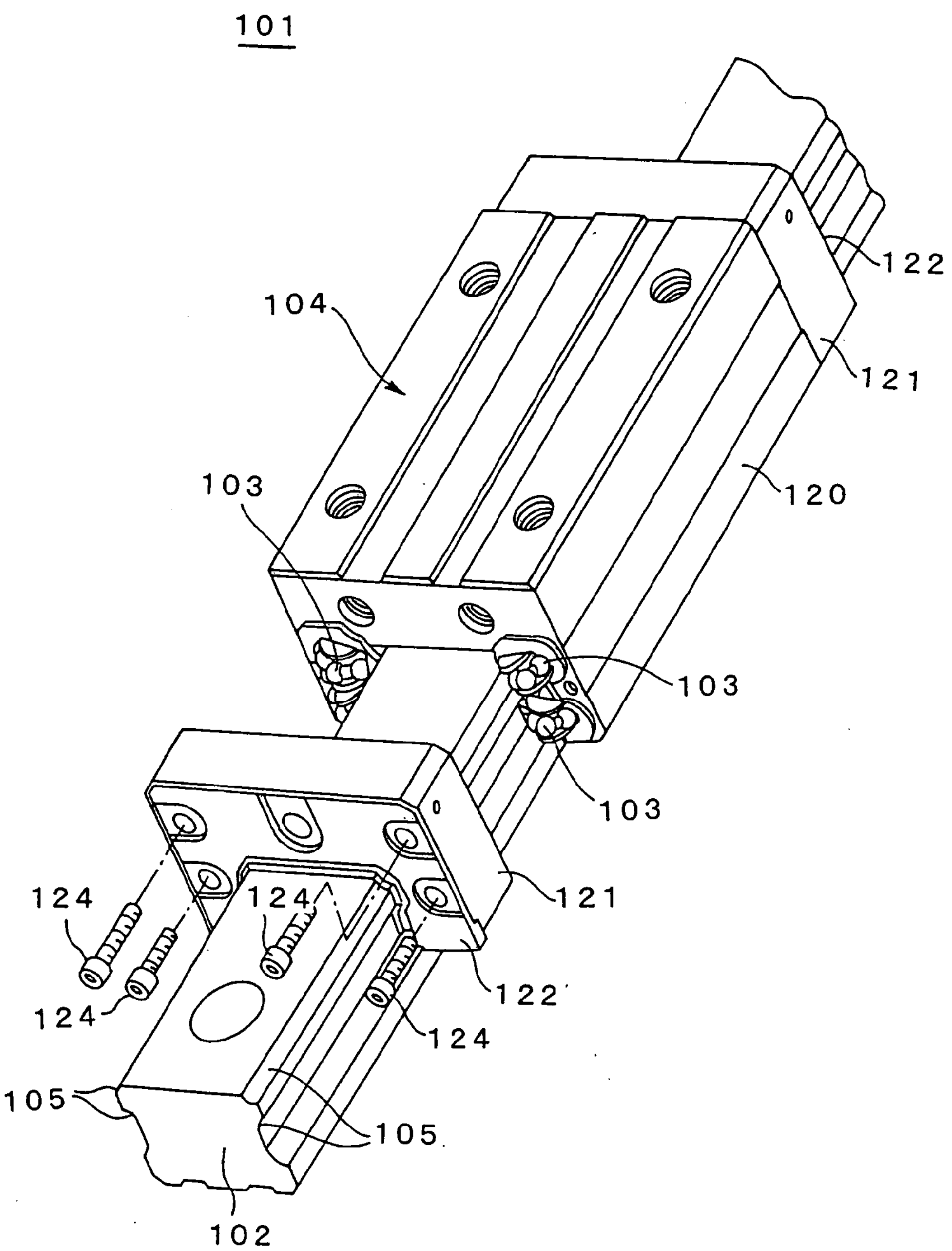

101
104
122
121
103
120
103
103
121
124
124
124
122
124
105
105
102

FIG. 15

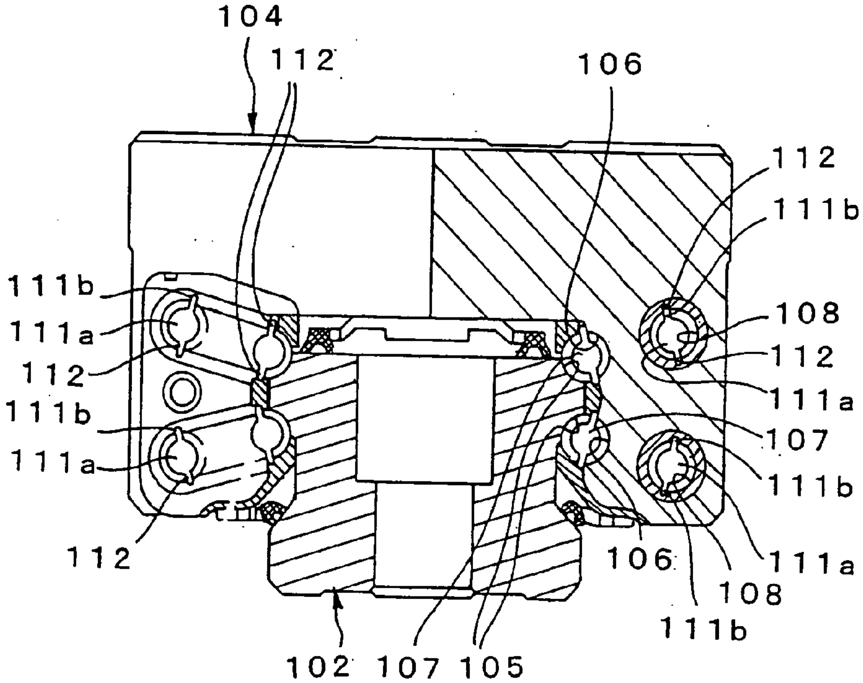
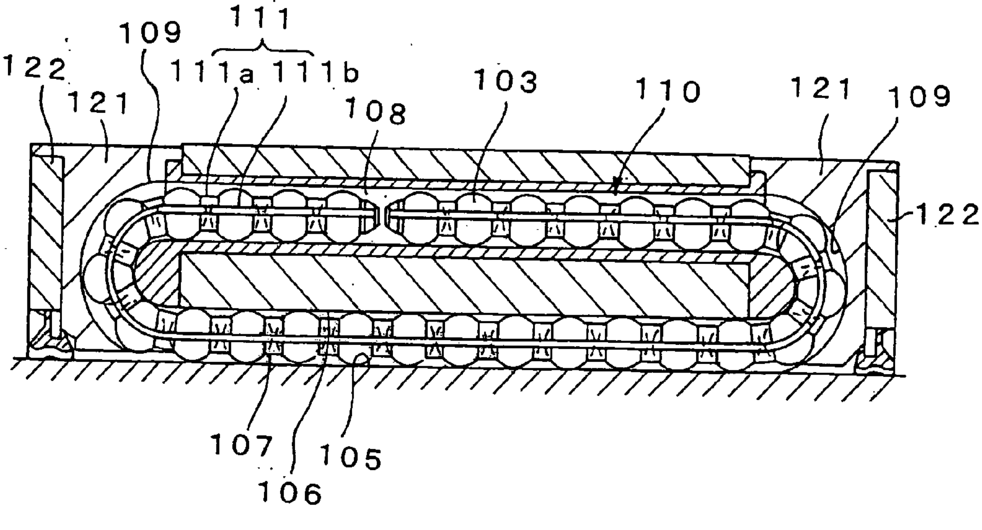

104
112
106
112
111b
111b
111a
112
111b
111a
108
112
111a
107
111b
112
106
111a
108
111b
102
107
105

FIG. 16


111
109
122
121
111a
111b
103
110
108
121
109
122
107
106
105

METHOD AND APPARATUS FOR CUTTING LONG SCALE HARDENED STEEL

[0001] This application is a divisional of application Ser. No. 10/297,947 filed Dec. 26, 2002.

TECHNICAL FIELD OF THE INVENTION

[0002] The present invention relates to a cutting method and cutting apparatus for cutting extremely efficiently a hardened steel material having a long scale (called hereinlater "long scale hardened steel" or merely "hardened steel") used as work piece such as guide rail of a rolling guide device.

BACKGROUND ART

[0003] As shown in FIGS. **14** to **16**, a rolling guide device **101** for guiding a table carrying work piece mounted to a machine tool comprises a track table **102** having a rolling member rolling surface (which may be called "rolling member rolling groove") **105** formed along a longitudinal direction thereof, an endless circulation passage **110** including a loaded rolling member rolling passage **107** corresponding to the rolling member rolling surface **105**, and a movable table **104** to be mounted to the track table **102** through a number of rolling members **103** arranged in the endless circulation passage **110**. The track table **102** and the movable table **104** are constructed to be relatively movable by the rolling motion of the rolling members **103**.

[0004] In such rolling guide device **101**, the track table **102** has a complicated sectional shape such as a long scale hardened steel **2** shown in **FIG. 2**. It is required for the track table **102** to be formed, with high dimensional precision, the rolling member rolling surface **105** having a predetermined surface hardness. Such track table **102** is manufactured by a method of shaping a long scale round steel into a product having dimension and shape similar to those of a final product by drawing it through the hole in a modified die, hardening it to obtain a predetermined surface hardness and, then, finely finishing it so as to obtain a predetermined dimension and shape through cut-working.

[0005] In the track table manufacturing method of conventional art, there is adopted the drawing working capable of shaping a work with high precision having a complicated sectional shape and the cutting working capable of finely finishing it so as to have a predetermined dimension, so that the track table having a dimension with high accuracy can be manufactured.

[0006] The conventional track table, however, has been manufactured through the drawing working and cutting working which have required much working time and provided problem on working efficiency. According to this view, the track table could not efficiently manufactured.

DISCLOSURE OF THE INVENTION

[0007] The present invention was conceived to solve the above subjects and to provide cutting method and cutting apparatus for manufacturing, with high efficiency and high performance, a long scale hardened steel utilized as a work for a guide rail of a rolling guide device.

[0008] A cutting method of cutting a long scale hardened steel, for achieving the above object, is characterized in that a work surface of a long scale hardened steel along a longitudinal direction thereof is linearly cut by a CBN tool at a cutting speed of approximately 30 m/min. to 160 m/min.

[0009] According to this invention, the wearing amount of the CBN tool can be reduced by linearly cutting the long scale hardened steel at such cutting speed, so that the long scale hardened steel can be cut with extremely high efficiency and high precision in dimension, and as a result, a guide rail of a rolling guide device or like can be extremely efficiently manufactured.

[0010] In the cutting method of the long scale hardened steel of the present invention, it is preferred that a plurality of work surfaces of a long scale hardened steel along a longitudinal direction thereof are linearly cut simultaneously by a plurality of CBN tools. According to this invention, a plurality of work surfaces can be extremely efficiently cut-worked.

[0011] In the cutting method of the long scale hardened steel of the present invention, it is preferred that a plurality of CBN tools are arranged along the longitudinal direction of the long scale hardened steel and the work surface of the long scale hardened steel is cut sequentially along the longitudinal direction thereof. According to this invention, by moving the CBN tools arranged along the longitudinal direction of the long scale hardened steel from one side in the longitudinal direction thereof towards the other side, the work surface can be cut-worked in extremely short time.

[0012] In the cutting method of the long scale hardened steel of the present invention, it is preferred that the long scale hardened steel is a hardened steel for a guide rail of a rolling guide device. According to this invention, the guide rail of the rolling guide device can be extremely efficiently manufactured.

[0013] In the cutting method of the long scale hardened steel of the present invention, it is preferred that a plurality of CBN tools are arranged on a virtual plane normal to the longitudinal direction of the long scale hardened steel so as to provide linear symmetric or point symmetric arrangement. In this case, it is also preferred that at least one pair of CBN tools for cutting the work surface of the long scale hardened steel are arranged so that radial forces of cutting resistance thereof are mutually balanced. According to this invention, since the CBN tools are arranged so that the radial forces due to the cutting resistance in the cutting operation of the symmetrically arranged CBN tools are balanced, the generation of deflection of the long scale hardened steel and the CBN tools can be controlled, and as a result, the working accuracy of the work surface can be improved. In addition, since the combined force of the radial forces due to the cutting resistance of at least one pair of CBN tools are balanced and cancelled mutually, the generation of the deflection of the long scale hardened steel and the CBN tools can be suppressed and the working accuracy of the work surface can be further improved.

[0014] The cutting apparatus for cutting a long scale hardened steel according to the present invention for achieving the above object is characterized by comprising a fixing device for fixing a long scale hardened steel, a tool rest which is guided by a guide device disposed along the longitudinal direction of the fixing device, and a CBN tool for cutting a work surface of the long scale hardened steel.

According to this invention, a work surface of a long scale hardened steel can be cut-worked with extremely high efficiency by the CBN tool held by the tool rest, and as a result, a guide rail of a rolling guide device can be manufactured with extremely high efficiency.

[0015] In the cutting apparatus of the long scale hardened steel of the present invention, it is preferred that the tool rest is provided, to be detachable, with a holding member for holding the CBN tool. According to this invention, the CBN tool can be easily changed through a detachable mounting of the holding member.

[0016] In the cutting apparatus of the long scale hardened steel of the present invention, it is preferred that the holding member is provided with a position adjusting means for adjusting a fixing position of the CBN tool. According to this invention, the position of the CBN tool, for example, can be finely adjusted to thereby adjust the cut amount of the CBN tool.

[0017] In the cutting apparatus for the long scale hardened steel of the present invention, it is preferred that a plurality of CBN tools are arranged on a virtual plane normal to the longitudinal direction of the long scale hardened steel so as to provide linear symmetric or point symmetric fashion. In this case, it is also preferred that at least one pair of CBN tools for cutting the work surface of the long scale hardened steel are arranged so that radial forces of cutting resistance thereof are mutually balanced. According to this invention, since the generation of deflection of the long scale hardened steel and the CBN tools can be controlled, the long term use of the guide device can be realized, and in addition, the cutting apparatus can be driven smoothly for a long time. Thus, by the cut-working of such cutting apparatus, the working accuracy of the work surface can be further improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] **FIG. 1** is a view showing a flowchart of one example of a manufacturing method of a guide rail of a rolling guide apparatus, including a cutting method of a long scale hardened steel, according to the present invention.

[0019] **FIG. 2** is a perspective view showing one example of a long scale hardened steel to which the cutting method and cutting apparatus of the present invention is applicable.

[0020] **FIG. 3** is a perspective view showing one example of the cutting method and cutting apparatus of one embodiment of the present invention.

[0021] **FIG. 4** is a perspective view showing one example of a CBN tool.

[0022] **FIG. 5** includes **FIG. 5**(A) showing a front view of one example of a tool rest provided with a CBN tool, **FIG. 5**(B) showing a side view thereof and **FIG. 5**(C) showing a plan view thereof.

[0023] **FIG. 6** is a front view in an enlarged scale of the tool rest shown in **FIG. 5**.

[0024] **FIG. 7** includes **FIG. 7**(A) showing a front view of another example of a tool rest provided with a CBN tool, **FIG. 7**(B) showing a side view thereof and **FIG. 7**(C) showing a plan view thereof.

[0025] **FIG. 8** includes **FIG. 8**(A) illustrating a schematic sectional view of one example in which CBN tools are arranged to both work surfaces in linear symmetry and **FIG. 8**(B) showing a CBN tool used at the cutting time.

[0026] **FIG. 9** is an illustration of sectional view showing one example of the CBN tools which are arranged, in a linear symmetry, to oppose to side surfaces of the work and to work surfaces opposing to a guide device.

[0027] **FIG. 10** is an illustrated sectional view of one example in which the CBN tools are arranged to the work surface in a point symmetric manner.

[0028] **FIG. 11** is an illustration explaining a component force of cutting resistance in the cutting step.

[0029] **FIG. 12** is an illustration showing a case in which the work surface is cut by steps of more than two times.

[0030] **FIG. 13** is a perspective view showing arrangement of a plurality of tool rests along the longitudinal direction thereof.

[0031] **FIG. 14** is a perspective view showing one example of a rolling guide device provided with a guide rail which has been cut.

[0032] **FIG. 15** is a sectional view of the device viewed in a direction normal to a guiding direction of the rolling guide device.

[0033] **FIG. 16** is a sectional view explaining an endless circulation passage viewed from a direction along the guiding direction of the rolling guide device shown in **FIG. 15**.

BEST MODE FOR EMBODYING THE INVENTION

[0034] Hereunder, method and apparatus for cutting a long scale hardened steel according to the present invention will be described with reference to the accompanying drawings.

[0035] (1) Cutting Method and Cutting Apparatus

[0036] The cutting method of the present invention is a method of linearly cutting a work surface of a long scale hardened steel along its longitudinal direction at a cutting speed of about 30 m/min. to 160 m/min. by using a CBN tool, and the apparatus for cutting a long scale hardened steel of the present invention is an apparatus for realizing such cutting method (hereinlater, these method and apparatus may be called (cutting method and apparatus of the present invention). According to such cutting method and apparatus, long scale hardened steel or steel members can be extremely effectively cut or cut-worked. Moreover, by applying the present invention to the manufacturing of a guide rail, for example, of a rolling guide device as represented by a flowchart of **FIG. 1**, the guide rail or like can be manufactured extremely efficiently with high precision, thus reducing the working time and decreasing manufacturing cost while maintaining high quality.

[0037] **FIG. 2** is a perspective view showing one example of a long scale hardened steel **2** to which the cutting method and cutting apparatus according to the present invention are applicable, in which four rows of work surfaces **3** extending along the longitudinal direction of the hardened steel **2** are arranged in the symmetric fashion with each other. This example represents an exemplary embodiment of a track table **102** of a rolling guide device **101** shown in FIGS. **14** to **16**, which will be mentioned hereinlater, and the work surface **3** in FIG. **2** attains a function as a rolling member rolling surface **105** along which a rolling member **103** circulates endlessly. Further, it is to be noted that the work surface **3** mentioned herein is a surface to be cut and worked in accordance with the cutting method using the cutting apparatus of the present invention, and includes a surface having any shape which is not specifically limited. For example, the surface **3** includes a flat surface composed of a plane, a rectangular surface composed of combination of planes, a groove composed of curved surface and a composite surface composed of combination of plane and curved surface.

[**0038**] The cutting method and apparatus of the present invention is utilized preferably for the working of a hardened steel of which surface is hardened through hardened or quenching process or like. Such hardened steel is not limited in its type or kind as far as its surface is hardened through the quenching process, and for example, it is desirable to be applied to a hardened steel utilized for satisfying requirement of anti-abrasion property such as long scale linear rail or curved rail constituting a rolling guide device.

[**0039**] The cutting method and apparatus of the present invention has a characteristic feature such that it is especially applicable to the long scale hardened steel. Although a length of such hardened steel is not specifically limited, in a case where a long scale linear rail or curved rail of the rolling guide device is manufactured, it may be preferable for such rail member to have a work surface having length of about 2 m to 3 m. When the present invention is applied to a hardened steel having such length as mentioned above, the cutting efficiency can be improved and worked products can be manufactured with high productivity.

[**0040**] With reference to the cutting method and apparatus **1** which are applied to a linear rail or curved rail of the linear rolling guide device, as shown in **FIG. 3**, the long scale hardened steel **2**, having a work surface of a length of about 2 m to 3 m, for the rolling guide device is fixed to a fixing device **4**, and the work surface **3** extending along the longitudinal direction of the long scale hardened steel **2** is cut and worked by means of a CBN tool **7** mentioned hereinlater. Further, this fixing device **4** is provided, as mentioned hereinlater, with at least a mount table and fixing means and is adapted to fix the long scale hardened steel **2**.

[**0041**] As means for fixing the long scale hardened steel **2** to the fixing device **4**, there will be adopted a various clamps or chucks. Further, a power chuck may be also adopted, and for example, as a power chuck, hydraulic chuck, pneumatic chuck, electromagnetic chuck or like may be listed up.

[**0042**] The long scale hardened steel **2** fixed to the fixing device **4** is cut and worked by the CBN tool **7** holded by a tool rest **5**. The CBN tool **7** is formed from a sintered material of cubic boron nitride (CBN) and by sintering, under a high temperature and an extreme high pressure, a mixture of CBN powder with Co, Tic and like. The CBN tool **7** has superiority of high hardness, high elastic coefficiency and high heat transfer property, so that the CBN tool **7** can be preferably utilized for the cutting of high hardness material, hardened (quenched) steel, heat-resistant alloy and the like.

[**0043**] The CBN tool **7** is a tool, to be more specific as shown in **FIG. 4**, in shape of rod and is provided with a CBN sintered member **10** in form of chip at its front end. This, however, is not necessarily limited to one having the shape shown in **FIG. 4**, and an optimum one of conventionally known shapes such as one shown in **FIG. 8**(B), conforming with the shape of the work surface **3**, can be optionally selected. Further, it is desirable that the CBN sintered member **10** directly related to the cut-working utilizing the CBN tool **7** has a chip shape substantially the same as the shape of the work surface **3** of the long scale hardened steel **2**. By using the CBN tool **7** having the CBN sintered member **10** having such a chip shape as that mentioned above, the work surface **3** can be easily and precisely formed so as to provide substantially the same shape as that of the CBN sintered body **10** through the cutting working, thus reducing the number of cutting workings. As a result, the cutting working can be performed with extremely high efficiency and precision. Further, the use of such CBN tool **7** can make it possible to cut the work surface through a dry-type cutting working which is different from a conventionally known wet-type cutting working, thus being advantageous.

[**0044**] The tool rest **5** is one for mounting the CBN tool **7**, as shown in FIGS. **5** to **7**, which is a member for mounting the CBN tool **7**, and guided by the guide device **6** in form of rail arranged along the longitudinal direction of the fixing device **4** and driven by a driving means **15**. Further, it is to be noted that the shape or like of the tool rest **5** is not limited to a specific one and it is possible to adopt a structure which is movable along the longitudinal direction of the long scale hardened steel **2** fixed to the fixing device **4** and which can cut the work surface **3** of the long scale hardened steel **2** in its longitudinal direction. Furthermore, there will also be adopted with no specific limitation, as the tool rest **5**. it may be possible to adopt one to which one or more than one CBN tools **7** can be directly mounted, or one to which a holder member **8** holding one or more than one CBN tools **7** can be held.

[**0045**] Movement of the tool rest **5** is performed by the guidance of the guide device **6** and driving power applied by the driving means **15**. As such guide device **6**, there will be usable a device for guiding the tool rest **5** utilizing rolling contact such as shown in FIGS. **14** to **16**. One typical example of such guide device **6** performing the guiding motion by the rolling contact comprises a guide rail **6*b*** having a rolling member rolling surface extending along its longitudinal direction and a sliding block **6*a*** having an endless circulation passage including a loaded rolling member rolling surface corresponding to the rolling member rolling surface, the sliding block **6*a*** being mounted to the guide rail **6*b*** through a number of rolling members disposed and aligned in the endless circulation passage. The guide rail **6*b*** and the sliding block **6*a*** can be relatively movable at the high cutting speed of such as 30 m/min. to 160 m/min. by the rolling motion of the rolling members. Further, a guide device other than the guide device **6** utilizing the sliding contact may be usable, and furthermore, as the driving means **15**, although a ball screw **15*a*** and a motor, not shown, applying a driving force to the ball screw **15*a*** are utilized in the described embodiment, another means such as linear motor may be also used.

[**0046**] The holding member **8** for holding the CBN tool **7** is mounted to be detachable to the tool rest **5** (see FIGS. **5** to **7**). By the detachable mounting of the holding member **8**, it becomes possible to change the CBN tool **7** more easily by the integral detaching of the holding member **8**. As mentioned, the technique that the CBN tool **7**, which has been mounted to the holding member **8**, is then mounted to the tool rest **5** makes it possible, particularly, in the case of mounting a plurality of CBN tools **7**, to improve the dimensional adjustment and precision between the respective CBN tools **7** and to realize an excellent cut-working with high performance.

[**0047**] The dimensional adjustment in the case of mounting the CBM tool **7** to the holding member **8** is performed, as shown in FIGS. **5** to **7**, by a position adjusting means **9** for adjusting the fixing position of the CBN tool **7**. As such position adjusting means **9**, means composed of slot and a bolt which is slidably fitted to the slot is usually used, but any other means may be adopted. In the meantime, although, in a case where a desired cutting margin is cut by one cutting operation, manual or automatic means may be used as such position adjusting means **9**, in a case where the desired cutting margin is cut by two or more than two cutting operations, it is desired for the position adjusting means **9** to be automatically controlled.

[**0048**] The holding member **8** is fastened to a predetermined mount position **12** of the tool rest **5** by, for example, means of bolt. Such holding member **8** may, as shown in FIGS. **5** to **7**, have approximately a rectangular shape or semi-circular shape, which will not be limited thereto. The holding member **8** can be positioned only by inserting and fitting the holding member **8** to the mount position **12** by adopting the shape of the mount position **12** conforming with the shape of the holding member **8**. Moreover, the CBN tool **7** mounted to the holding member **8** is adjusted to the predetermined position, so that the cut-working excellent in the working precision can be realized.

[**0049**] One or more than one CBN tools **7** will be mounted to the holding member **8**. In the case of mounting a plurality of CBN tools **7**, since a plurality of work surfaces **3** along the longitudinal direction of the long scale hardened steel **2** can be simultaneously cut, a plurality of work surfaces **3** corresponding to the number of the CBN tools **7** can be extremely effectively cut and worked.

[**0050**] In the case of mounting a plurality of CBN tools **7**, it is desired to consider balance of load stress between the CBN tools **7** and the work surfaces **3**. More specifically, as shown in FIGS. **8** to **10**, it is desired to arrange the plural CBN tools **7** at linear symmetric or point symmetric portions on a virtual plane, which is a plane perpendicular in the longitudinal direction of the long scale hardened steel **2**. In such case, since the plural CBN tools **7** are arranged on the virtual plane in linear symmetry or point symmetry relation, radial forces Fp of cutting resistance in the cutting operation as shown in **FIG. 11** are balanced (see FIGS. **8** to **10**). In an example in which the radial forces Fp are balanced, the respective radial forces Fp elastically deform the tool rest **5**. However, such elastic deformation merely generates an inner stress to the tool rest **5** and is not transmitted as an external force with respect to the guide device **6**. Accordingly, by arranging the CBN tools **7** in the manner mentioned above in order to balance the radial forces Fp, the generation of deflection of the long scale hardened steel **2** and/or CBN tools **7** can be suitably controlled. Further, with reference to **FIG. 11**, Ff represents a feed force, Fp is a radial force and F represents a resultant force (Ff+Fp) of cutting resistance.

[**0051**] Here, the mode of "arranged in linear symmetric manner" means arrangement in a mirror relation with respect to a reference line, and on the other hand, the mode of "arranged in point symmetric manner" means arrangement in opposed-angle relation with respect to a reference point. As such reference line and reference point, a center line **22** or **24** and specific point **23** in FIGS. **8** to **10** will be indicated.

[**0052**] Especially, it is desired, as shown in **FIG. 8**(A), that at least one pair of CBN tools **7**, **7** are arranged on a virtual plane so as to provide a linear symmetry with respect to the center line **22** of the long scale hardened steel **2**. According to this technology, the resultant force of the radial forces Fp of the cutting resistance are balanced mutually and cancelled by each other, the deflection of the long scale hardened steel **2** and that of the CBN tools **7** due to the radial forces Fp at the cut working operation can be suppressed or substantially prevented from generating, and hence, the working performance of the work surface **3** can be further improved, thus being effective. Further, **FIG. 8**(B) is a plan view showing one example of the CBN tool **7**.

[**0053**] Furthermore, it is also desired that, as shown in **FIG. 9**, in the arrangement of a plurality of CBN tools, at least one pair of CBN tools **7** are arranged on the virtual plane so as to provide a linear symmetry with respect to the center line **22** of the long scale hardened steel **2** so as to mutually cancel the radial forces Fp of the cutting resistance and the other CBN tools **7'**, **7'** are arranged on the virtual plane so as to provide a linear symmetry with respect to the center line **22** of the long scale hardened steel **2**. According to such arrangement, as mentioned hereinabove, the generation of deflection of the long scale hardened steel **2** and that of the CBN tools **7** due to the radial forces Fp in the cut working operation can be controlled or substantially prevented as much as possible, and hence, the working performance of the work surface **3** can be further improved. In such occasion, the CBN tools **7'**, **7'** are not arranged so as to cancel the resultant force of the radial forces Fp, but the respective CBN tools **7'**, **7'** are arranged in the lateral symmetry with respect to the center line. For this reason, the radial forces Fp applied to the guide device **6** is made equivalent in the lateral direction, and radial loads having the same amount are applied with respect to the guide device **6**. As a result, since the loads applied to the guide device **6** can be laterally balanced, usable life time of the guide device **6** can be elongated and, in addition, the cutting device **1** can be used smoothly and safely for a long term, thus being effective. Moreover, the working performance or precision of the surface of the work to be cut-worked can be improved by working the long scale hardened steel **2** by using such cutting device **1**.

[**0054**] Furthermore, **FIG. 10** shows an arrangement mode in which CBN tools **7***a*, **7***b*, **7***c* and **7***d* are arranged on a virtual plane so as to provide point symmetry with respect to a specific point **23**. In addition to that the four CBN tools **7***a*, **7***b*, **7***c* and **7***d* are arranged on a virtual plane so as to provide point symmetry with respect to a specific point **23**, the CBN tools **7***a* and **7***c* and the CBN tools **7***b* and **7***d* are arranged in linear symmetry on the virtual plane with respect to the center line **22** of the long scale hardened steel **2**, and furthermore, the CBN tools **7***a* and **7***b* and the CBN tools **7***c* and **7***d* are arranged in linear symmetry on the virtual plane with respect to the line **24** parallel to the fixing device **4**. By arranging these four NBC tools in the described arrangement mode, the radial forces Fp of the respective CBN tools will be cancelled. As a result, as mentioned above, the usable life time of the guide device **6** can be achieved, the cutting device **1** can be driven smoothly and safely for a long term, and the working performance to the work surface **3** can be further improved. Further, it is to be noted that, although angles of the radial forces Fp of the CBN tools are respectively of 45°, these angles are not limited to specific angles, and may be optionally set in accordance with the structure of the long scale hardened steel **2** and the shape of the work surface **3** under the condition that the CBN tools are arranged at positions so that the radial forces Fp thereof are cancelled by each other.

[0055] In the present invention, a plurality of tool rests **5** may be arranged to the guide device **6**. For example, a plurality of tool rests **5** are arranged along the longitudinal direction of the long scale hardened steel **2**. Then, as shown in **FIGS. 12 and 13**, first, the cutting operation through the first stage is carried out by moving the first tool rest **5***a*, then, the cutting operation through the second stage is carried out by moving the second tool rest **5***b*, next, the cutting operation throug the third stage is carried out by moving the third tool rest **5***c*, and thereafter, succeeding cutting operations are carried out in the same manner. As mentioned above, by successively feeding these plural tool rests from one side towards the other side in the longitudinal direction by the guide device **6**, the work surface **3** having a predetermined cutting margin can be cut in an extremely short time. Particularly, by mounting the plural CBN tools **7** mentioned hereinbefore to such tool rests **5**, work surfaces **3** of a plurality of works can be extremely efficiently cut, thus achieving remarkable effects.

[0056] In the present invention, it is preferred to linearly cut the work surface **3** of the long scale hardened steel **2** at a speed of about 30 m/min. to 160 m/min., and more preferably, to linearly cut it at a speed of about 80 m/min. to 120 m/min. The reason why the linear cutting speed is prescribed to such range resides in the relation to wearing amount of the CBN tool **7**, and in this range, the wearing of the CBN tool **7** less occurs. In the case of the linear cutting speed of less than about 30 m/min., the cutting resistance becomes large and heat amount to be transferred to the CBN tool **7** will be increased, and as a result, the wearing of the CBN tool **7** will be increased in amount and the cutting efficiency will be deteriorated. On the other hand, in the case of the linear cutting speed of more than about 160 m/min., the CBN tool **7** will be also much worn.

[0057] The long scale hardened steel **2**, which has been cut-worked into predetermined dimensions by cutting the predetermined cutting margin (i.e., cutting amount), is cut as it is or thereafter so as to form a linear rail or curved rail having a predetermined length. Further, although a range of the cutting margin is not generally mentioned because the range of the cutting margin relates to the hardness of the work surface **3** of the hardened steel and the number of cutting of the CBN tool **7** mentioned above. As the cutting margin capable of being cut one time with excellent cutting efficiency, the range is generally of 0.05 to 0.3 mm. In a case where the cutting margin is cut in two or more than two times, the cutting margin can be changed in every cutting operation as shown in **FIG. 8**. For example, the work surface **3** to be cut having the cutting margin of 0.7 mm will be cut with cutting margin of 0.3 mm (first time), 0.3 mm (second time), 0.05 mm (third time) and 0.05 mm (fourth time). According to the cutting method and cutting apparatus of the present invention, different from a wet-type cut-working in prior art, the cut-working can be advantageously performed by the dry-type system, but as occasion demands, water-soluble working solution may be utilized or pneumatic air may be also utilized.

[0058] As mentioned hereinabove, the long scale hardened steel **2** worked by the cutting method and cutting apparatus of the present invention can be preferably utilized as a guide rail of a rolling guide device. According to the present invention, it is also possible to cut the hardened steel by the predetermined amount of the cutting margin through one working operation, so that the cut-working time can be shortened in comparison with prior art in which the work surface is worked particularly through the cutting operation. In addition, in the cutting apparatus of the present invention, since the tool rest on which the CBN tool is mounted can be moved, the tool rest can be made light in weight based on its structure, and hence, a faster cutting speed such as mentioned above can be easily realized. Furthermore, by moving, at predetermined speed, the tool rest mounted with at least the CBN tool, the work surface of the long scale hardened steel placed on the fixing device can be cut-worked, so that the size or dimension of the apparatus itself and complicated control function of the apparatus can be eliminated. As a result, the cutting apparatus can be made compact in size and manufacturing cost thereof can be reduced.

[0059] A guide rail or like worked in accordance with such cutting method by using such cutting apparatus as mentioned above can be manufactured extremely efficiently, thus easily manufacturing the apparatus, producing a product having merit in cost and preferably providing it in market.

[0060] Hereunder, an experimental example will be described.

[0061] First, a round steel material for a linear motion rail of a rolling guide device (material corresponding to S55C, medium carbon manganese steel) was cold-rolled, and thereafter, hardened to thereby form a work material (worked member) having a desired surface hardness.

[0062] The work material was fixed on a fixing device by means of clamp and a CBN tool (Manufactured by De Beers as DBA80). On the cut working, any cutting solution was not used and dry-type process was adopted. As conditions for the cutting operation, a linear cut working was performed at a cutting speed of 60 m/min. by changing the cutting rate within a range of 0.1 to 0.5 mm with each cut-working being performed by single-pass.

[0063] The evaluation to the cutting workability was done by considering the condition of the CBN tool (visual observation of defect, wearing and like) and the condition of the worked surface (visual observation of gouge, chatter, roughness and like).

[0064] As a result, under the cutting condition mentioned above, no defect and wearing was observed to the CBN tool.

There caused no phenomenon providing a problem with respect to the worked surface condition.

[0065] (2) Rolling Guide Device

[0066] According to the cutting method and apparatus for cutting a long scale hardened steel of the present invention, a track table (i.e., guide rail) as a constitutional member of a rolling guide device is manufactured. Hereunder, a rolling guide device provided with such track table, will be explained.

[0067] **FIG. 14** shows one example of such rolling guide device. The rolling guide device **101** is composed of a track table **102** and a movable block (member) **104** through a number of spherical rolling members **103**, **103**, - - - , **103** interposed therebetween.

[0068] The track table **102** is manufactured according to the cutting method by using the cutting apparatus of the present invention of the characters mentioned hereinbefore, and in the embodiment shown in **FIG. 14**, the track rail **102** is a long scale member having approximately a rectangular section. On both the side surfaces of the track table **102**, respectively two rolling member rolling surfaces **105**, **105** - -, each having a circular cross section, for rolling the rolling members **103** are disposed along the entire length thereof. Further, the number of the rolling member rolling surfaces **105** is not limited to two rows, and one, three in bilateral combination, or four rows may be adopted. Such rolling member rolling surfaces **105** can be worked with high precision and efficiency by utilizing the CBN tools arranged in predetermined positions in accordance with the cutting method and apparatus of the present invention mentioned hereinbefore.

[0069] The movable block **104** is composed of a movable block body **120** having a gate shape of one surface in a direction perpendicular to the moving direction of the movable block **104** and lid members **121** provided at both end portions in the moving direction of the movable block **104**.

[0070] Four rows (each two rows) of rolling member rolling surfaces **106**, each having approximately a semi-circular shape in cross section, are formed to inside surfaces of the movable block body **120**, as shown in **FIG. 15**, so as to oppose to the rolling member rolling surfaces **106**, **106**, - - - , respectively. These rolling member rolling surfaces **105** and **106** constitute four loaded rolling passages are formed between the track table **102** and the movable block **104**. The movable block **104** is also formed with return passages **108**, **108**, - - - , each having a circular cross section, so as to extend from one end to the other end in the moving direction of the movable block **104**.

[0071] On the other hand, as shown in **FIG. 16**, each of the lid member **121** is formed with a direction changing passage, for changing the rolling direction of the rolling members, on a surface opposing to the movable block body **120** of the lid member **121** so as to communicate the loaded ball rolling passage **107** and the return passage **108**. These loaded rolling passage **107**, the return passage **108** and the direction changing passage **109** constitute the endless circulation passage **110** for endlessly rolling the rolling members **103**, **103**, - - - , **103**.

[0072] A number of spherical rolling members **103**, **103**, - - - , **103** are disposed in the endless circulation passage so as to provide a continuous bead-like form by means of connection member **111**. The connection member is composed of a number of spacers **111***a* disposed between the respective rolling members **103**, **103**, - - - , **103** and belt-like portions in form of thin plate disposed so as to connect the respective spacers **111***a* and hold them from their both sides to be rotatable.

[0073] The endless circulation passage **110** is also formed therein with connection member guide grooves **112**, **112** to which the belt like portions **112***b*, **112***b* are fitted to be slidable for slidably guiding the connection members **111** therein.

[0074] The rolling members **103**, **103**, - - - , **103** roll in the loaded rolling passage **107** from its one end towards its other end. Thereafter, the rolling members are scooped by the direction changing passage **107**, guided toward one end of the return passage **108** and then guided to other end of the other return passage **108**. Thereafter, the rolling members **103** are again guided to the loaded rolling passage **107** through the direction changing passage **109**. By repeating the above rolling motions, the rolling members **103**, **103**, - - - , **103** are moved and circulated in the endless circulation passage **110** in accordance with the movement of the movable block **104**. The track table **102** manufactured by the cutting method and apparatus of the present invention has the rolling member rolling surface **105** which can be worked with high performance by using the CBN tool, so that the rolling members **103**, **103**, - - - , **103** can be smoothly circulated in the endless circulation passage **110**.

[0075] Furthermore, as shown in **FIG. 14**, end plates **122**, **122** are attached to the outer side surfaces of the lid members **121**, **121**. Each of these end plates **122** has substantially gate-shape and is attached, by means of screws **124**, **124**, - - - , **124**, to the lid member **121**.

PROVABILITY OF INDUSTRIAL USAGE

[0076] According to the long scale hardened steel cutting method and cutting apparatus of the present invention, since the long scale hardened steel can be extremely efficiently cut, the present invention can be contributed to the efficient manufacturing of a guide rail by applying, for example, to the manufacturing of the guide rail of a rolling guide apparatus

1. An apparatus for cutting a long scale hardened steel, comprising a fixing device for fixing a long scale hardened steel, a tool rest which is guided by a guide device disposed along the longitudinal direction of the fixing device, and a CBN tool for cutting a work surface of the long scale hardened steel.

2. The apparatus for cutting a long scale hardened steel according to claim 1, wherein said tool rest is provided, to be detachable, with a holding member for holding the CBN tool.

3. The apparatus for cutting a long scale hardened steel according to claim 2, wherein said holding member is provided with a position adjusting means for adjusting a fixing position of the CBN tool.

4. The apparatus for cutting a long scale hardened steel according to any one of claims 1 to 3, wherein a plurality of CBN tools are arranged on a virtual plane normal to the longitudinal direction of the long scale hardened steel so as to provide linear symmetric or point symmetric fashion.

5. The apparatus for cutting a long scale hardened steel according to claim 4, wherein at least one pair of CBN tools for cutting the work surface of the long scale hardened steel are arranged so that radial forces of cutting resistance thereof are mutually balanced.

* * * * *

US 20040184685A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2004/0184685 A1

Michioka et al. (43) Pub. Date: Sep. 23, 2004

(54) ROLLING ELEMENT INTERFERENCE PREVENTER AND A GUIDE DEVICE

(75) Inventors: **Hidekazu Michioka**, Tokyo (JP); **Katsuya Iida**, Yamanashi (JP); **Tomozumi Murata**, Tokyo (JP); **Yoshiyuki Honjyo**, Tokyo (JP)

Correspondence Address:
WESTERMAN, HATTORI, DANIELS & ADRIAN, LLP
1250 CONNECTICUT AVENUE, NW
SUITE 700
WASHINGTON, DC 20036 (US)

(73) Assignee: **THK Co., Ltd.**, Tokyo (JP)

(21) Appl. No.: **10/810,586**

(22) Filed: **Mar. 29, 2004**

Related U.S. Application Data

(62) Division of application No. 10/212,093, filed on Aug. 6, 2002, now Pat. No. 6,733,179.

(30) **Foreign Application Priority Data**

Aug. 7, 2001 (JP) P.2001-239592

Publication Classification

(51) **Int. Cl.**^{7} **F16C 29/06**; F16C 33/60

(52) **U.S. Cl.** **384/44**

(57) **ABSTRACT**

A rolling element interference preventer for a guide device prevents a number of rolling elements rolling at regular intervals in a continuous circulation path of the guide device from interfering with each other. The rolling element interference preventer is formed of a thermoplastic resin elastomer having a physical property in accordance with an expression, $(A\times B)\div C\geqq 18$, where A represents a 10% elongation stress, B represents a tensile strength, and C represents a bending modulus of elasticity.

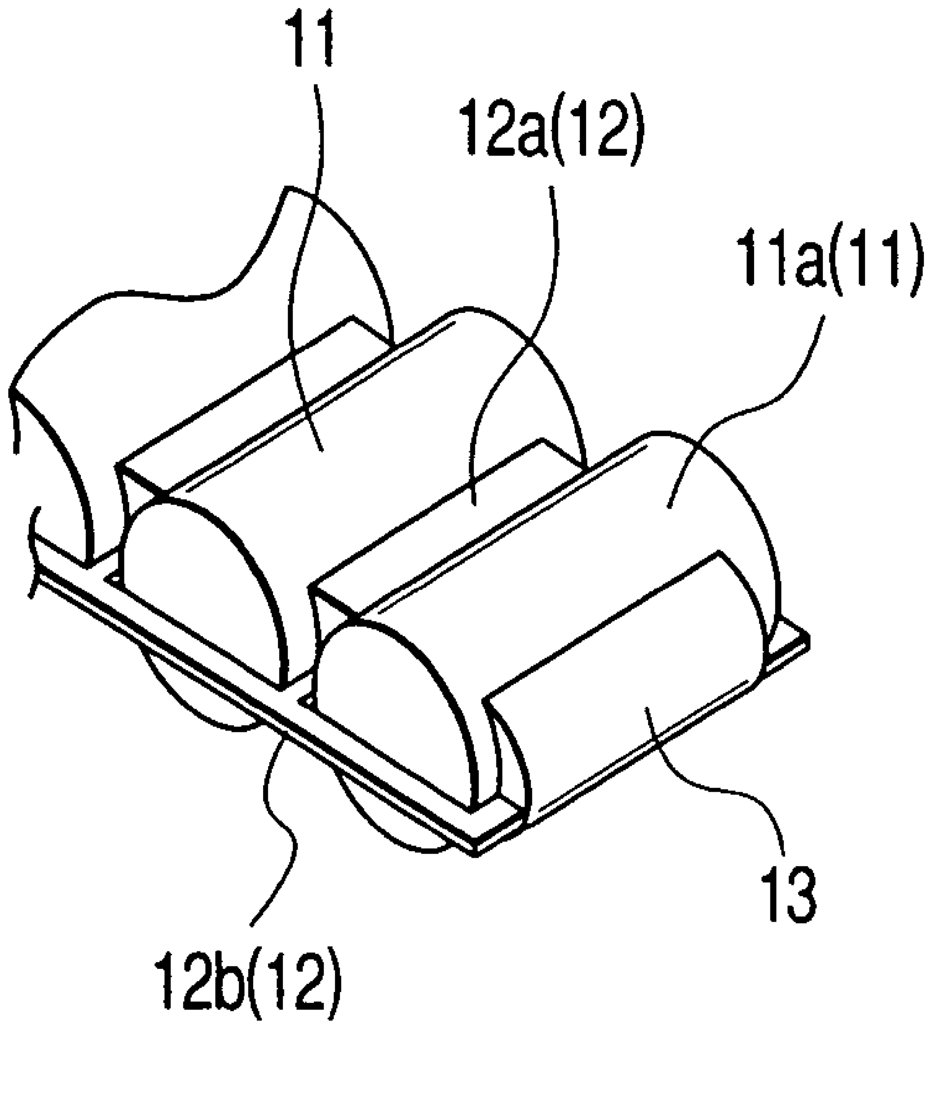


FIG. 1

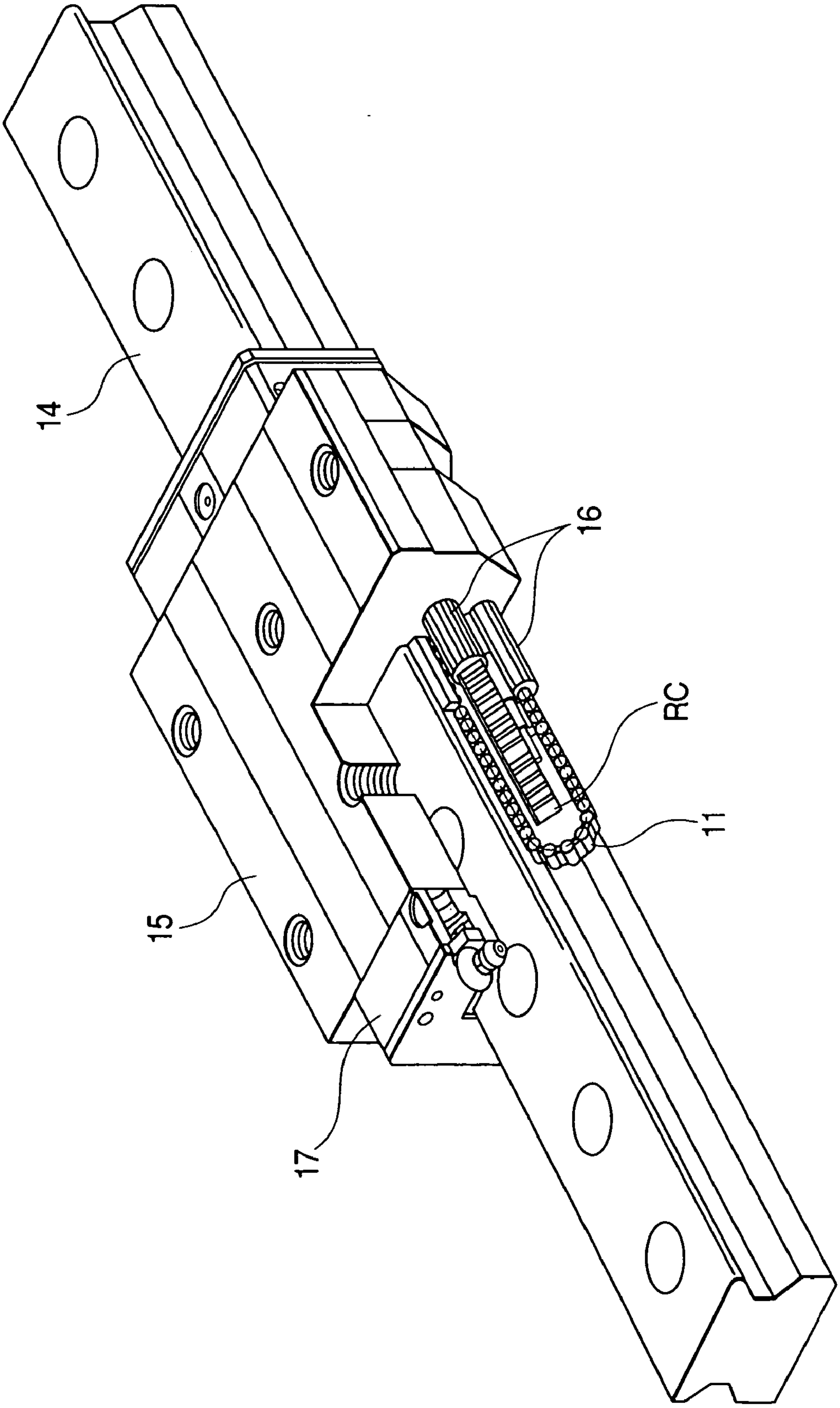


FIG. 2

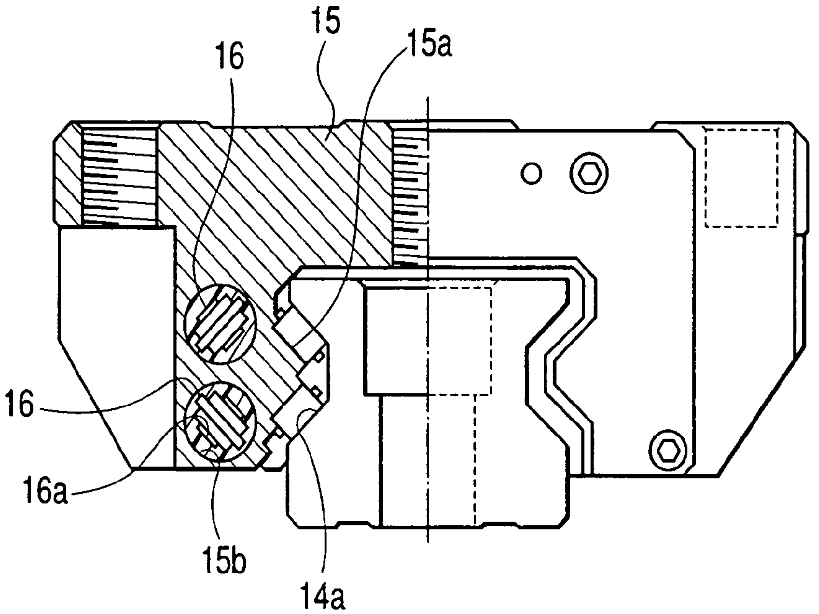


FIG. 3

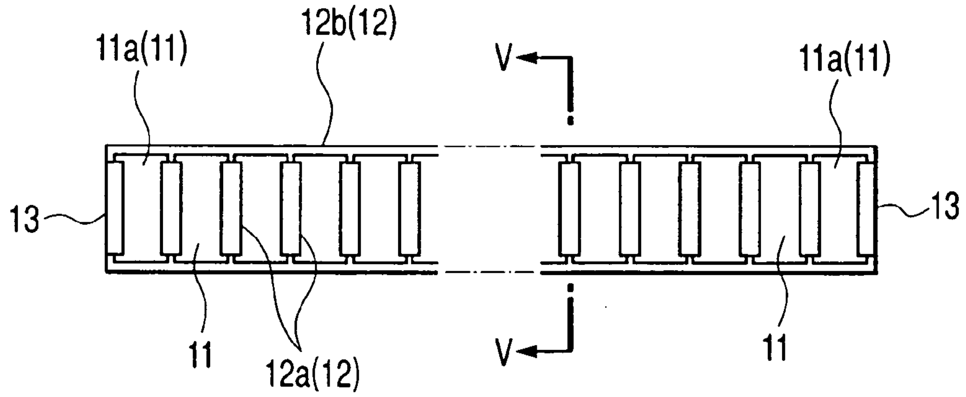


FIG. 4

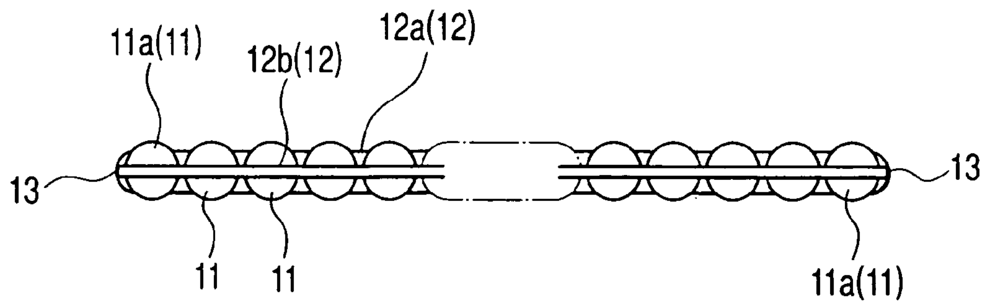


FIG. 5

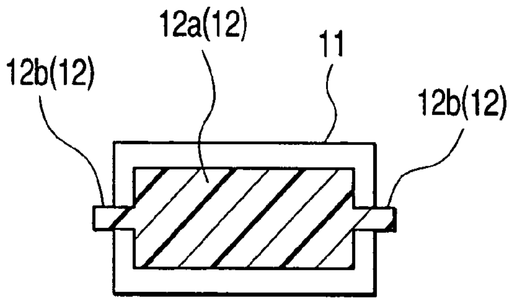


FIG. 6

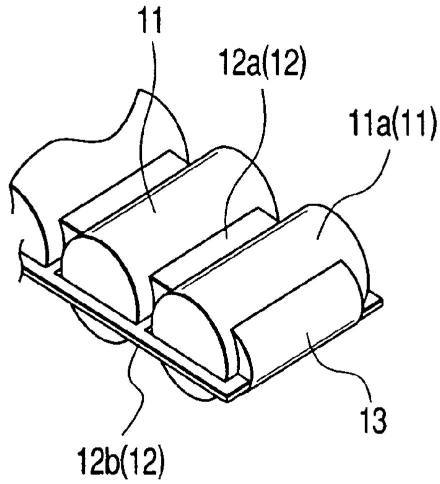


FIG. 7

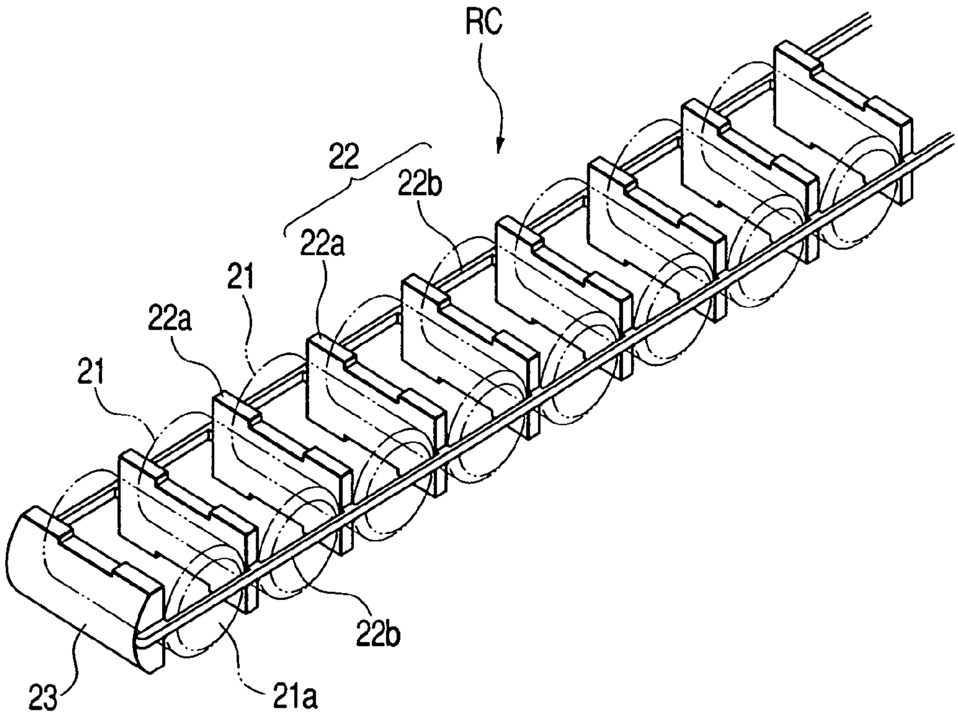


FIG. 8

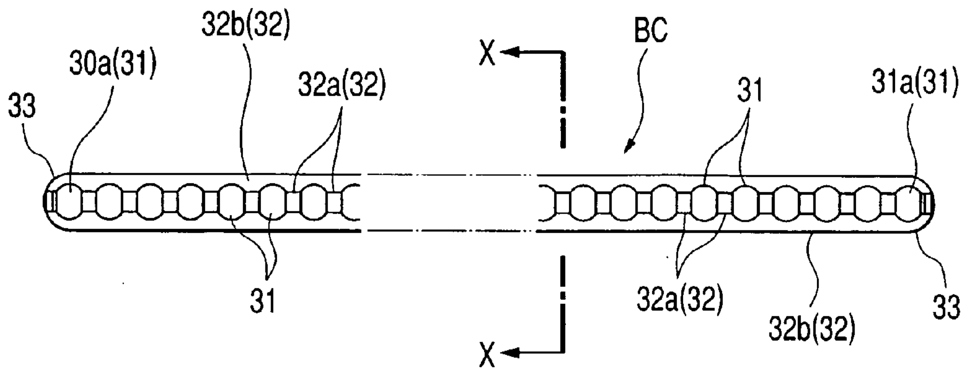


FIG. 9

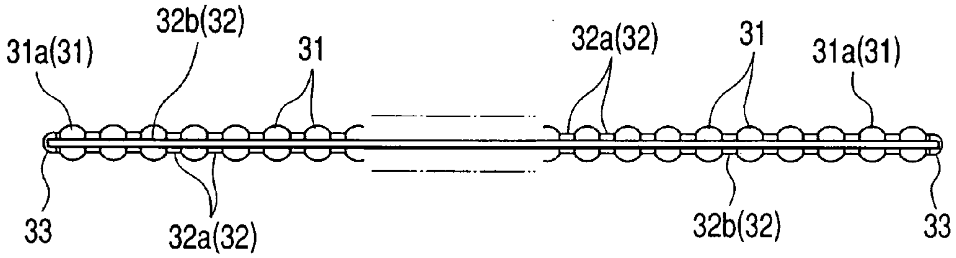


FIG. 10

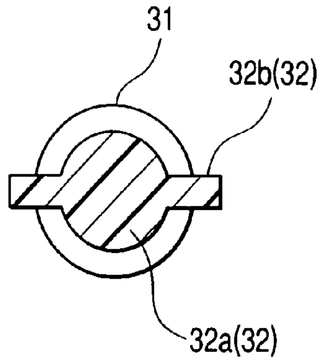


FIG. 11

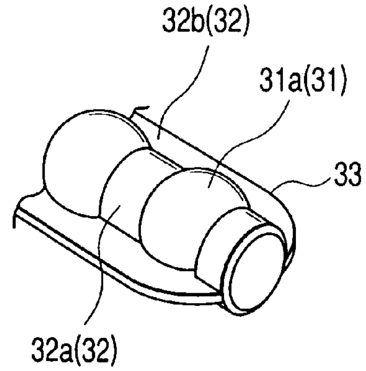


FIG. 12

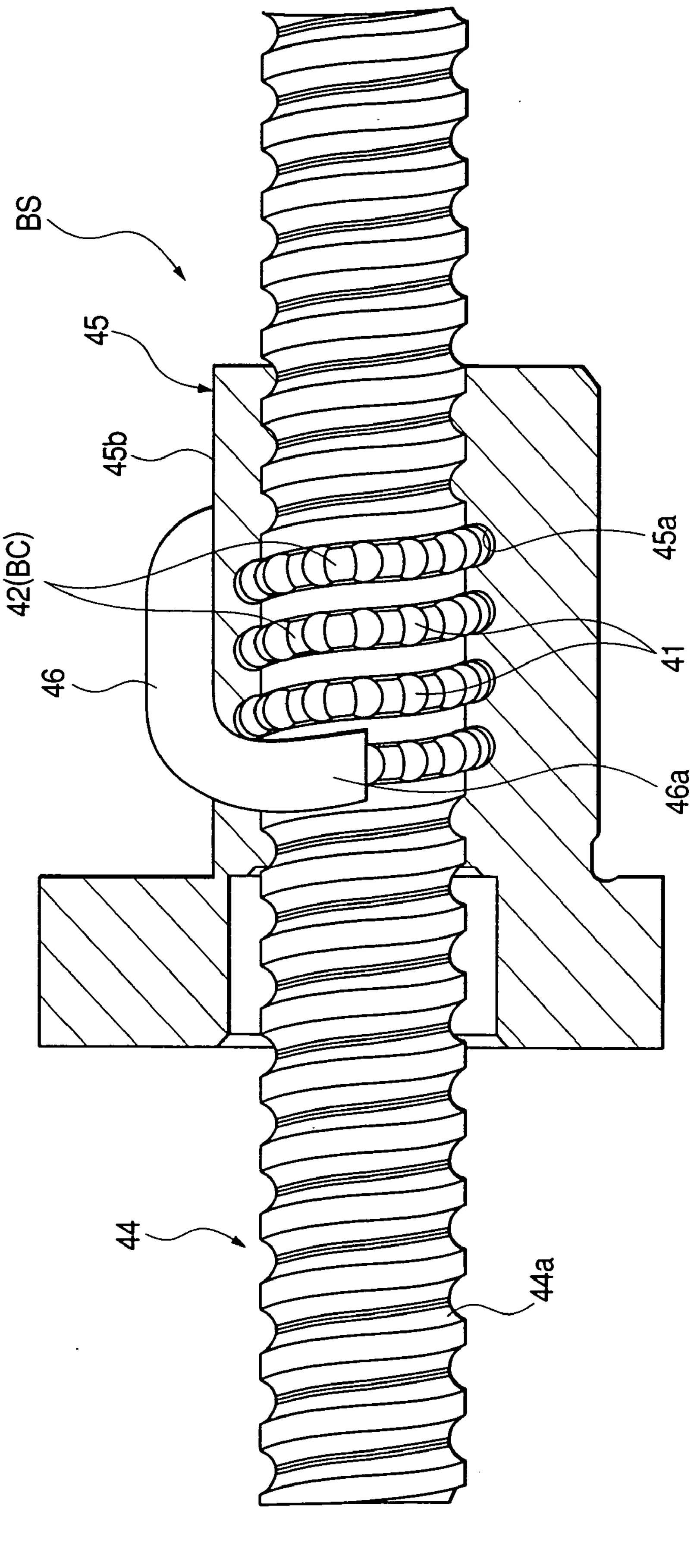


FIG. 13

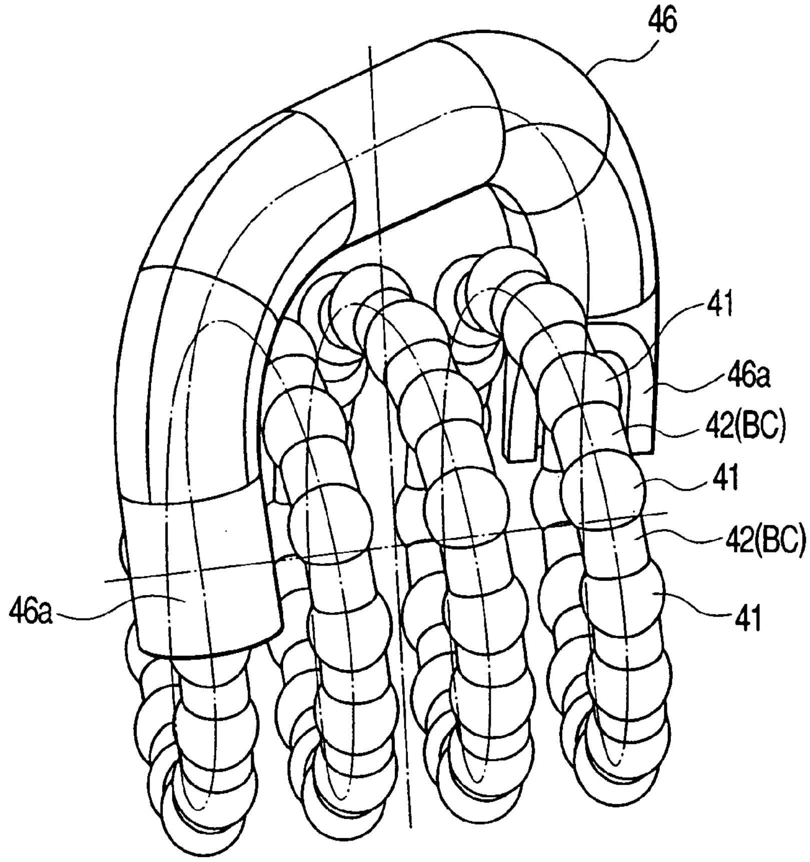


FIG. 14

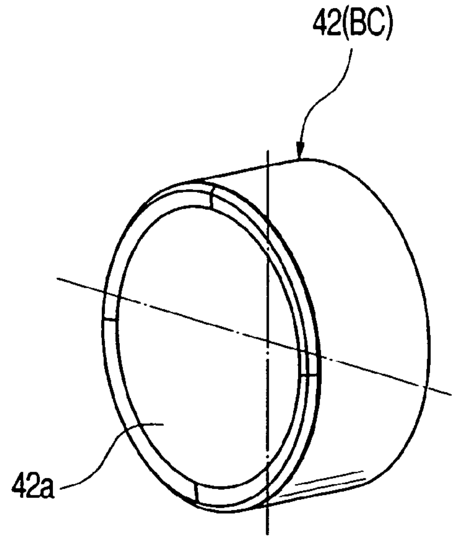


FIG. 15

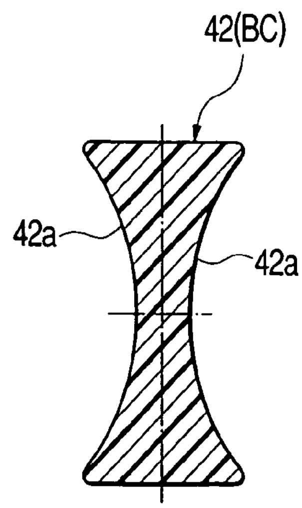


FIG. 16

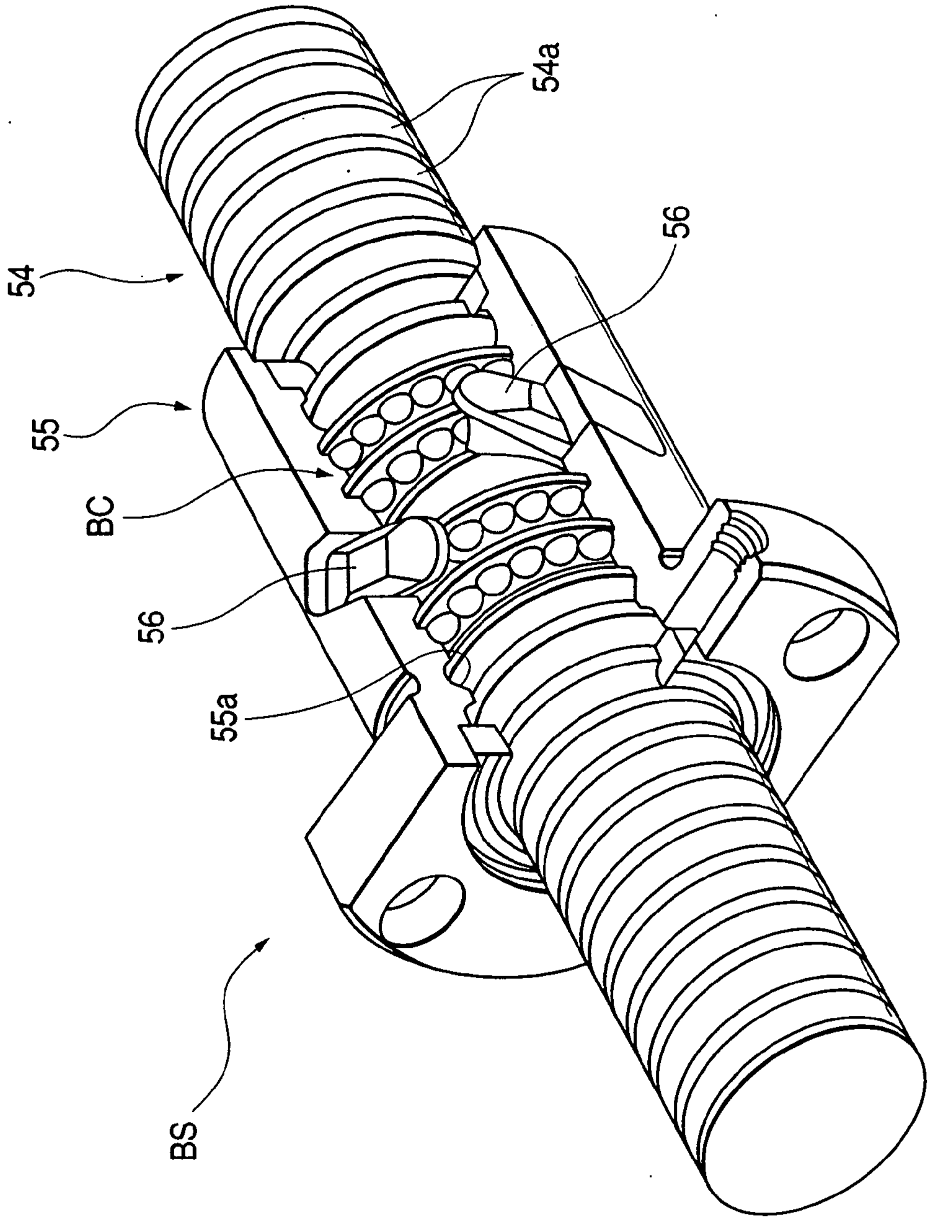


FIG. 17

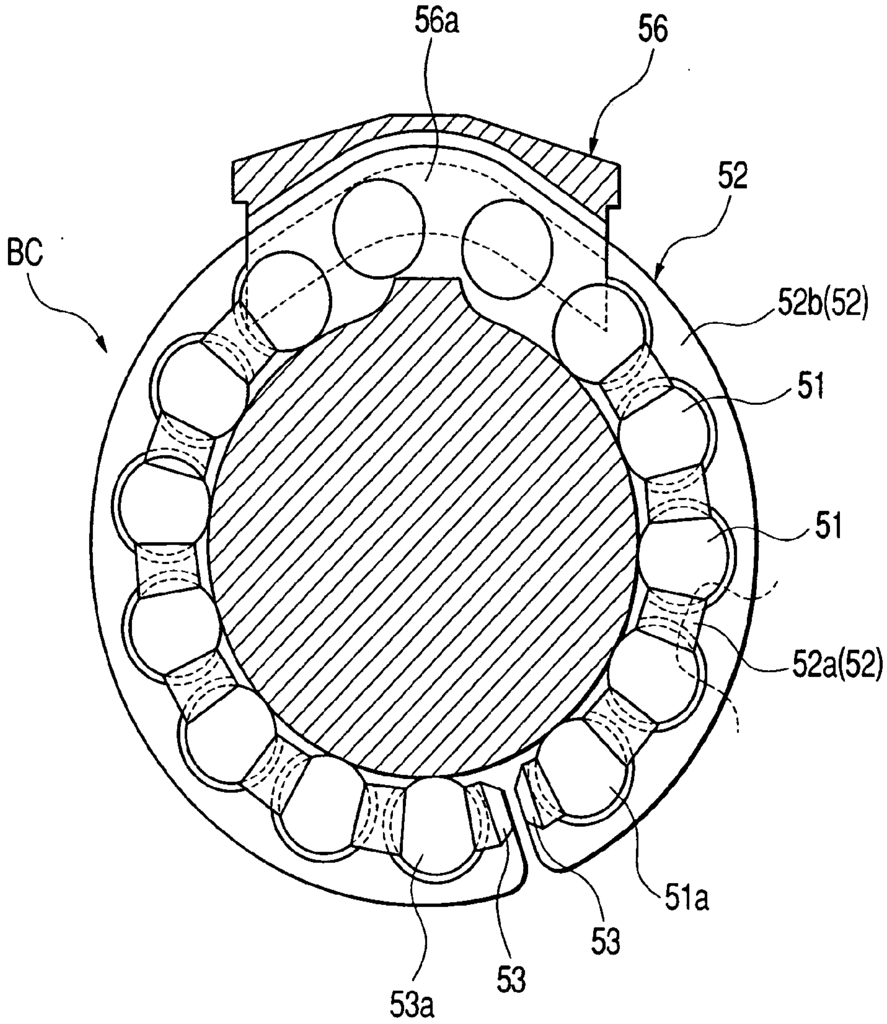
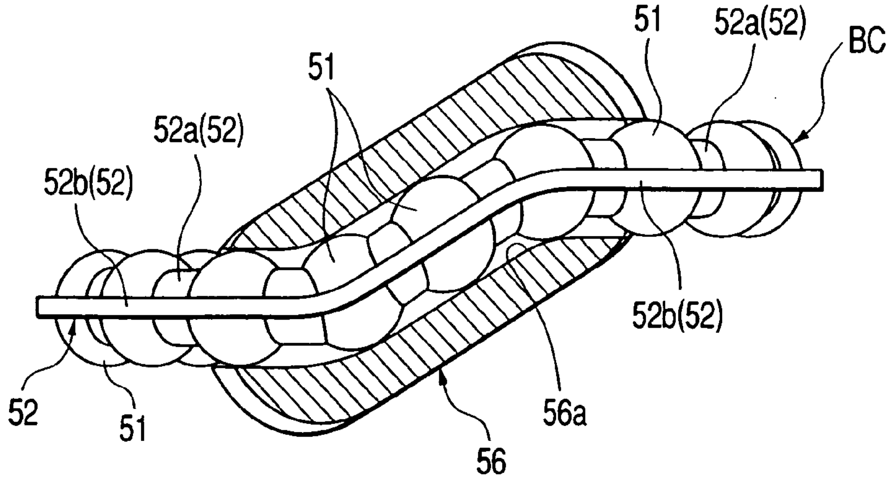

56a
56
52
BC
52b(52)
51
51
52a(52)
51a
53
53
53a

FIG. 18


51
52a(52)
BC
51
52a(52)
52b(52)
52b(52)
52
51
56a
56

ROLLING ELEMENT INTERFERENCE PREVENTER AND A GUIDE DEVICE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a rolling element interference preventer for a guide device, such as a linear guide device having an continuous circulation path for rolling elements, a swing bearing, a ball screw, and a spline. The rolling element interference preventer prevents the rolling elements rolling at regular intervals within the continuous circulation path formed between a pair of bearing races from interfering with each other.

[0003] 2. Description of the Related Art

[0004] In various rolling guide devices having a bearing, a linear motion or rotation of a pair of bearing races is enabled by use of the rolling motion of rolling elements consisting of balls or rollers carried between the bearing races. To reduce the frictional resistance by avoiding the contact between each rolling element and to produce the smooth motion by arranging each rolling element at predetermined position, it is common practice that a number of rolling elements are incorporated between bearing races, using a metallic retainer.

[0005] In the conventional guide device using the metallic retainer, since a cage has a number of pockets and rolling elements are put rotatably into these pockets, there is an advantage that the operation of incorporating a number of rolling elements into the guide device is facilitated. However, it is required to hold a number of rolling elements incorporated into the pockets of the cage not to fall off, resulting in a problem that it takes a lot of time to fabricate the cage itself.

[0006] Thus, to solve this problem, a ball interference preventer (rolling element interference preventer) for use in a guide device to prevent interference between each ball has been proposed. The endless guide device includes a track rail having a rolling path, a sliding board having a rolling groove mutually opposed to the rolling path and moving along the track rail, and a number of balls (rolling elements). With a load applied, the balls roll in a continuous circulation path formed between the rolling path of the track rail and the rolling groove of the sliding board. The ball interference preventer is composed of a flexible resin connector having an interposing portion interposed between each ball and a connecting portion for connecting between the interposing portions, and holding each ball in an arranged state and rollably. Thereby, many appreciable results were achieved including 1) attaining low noise and good sound quality by removing the metallic sound due to collision between the balls (low noise), 2) reducing the wear of ball and increasing the retention of grease (maintenance free for long term), 3) attaining excellent high speed by decreasing the relative friction velocity (high speed), and 4) smoothing the motion by greatly reducing the roiling fluctuation (sliding property) (JP-B-6-56181, JP-A-5-52217, JP-A-5-126149, JP-A-5-196036, JP-A-5-196037, and JP-A-9-14264).

[0007] By the way, thus structured ball interference preventer composed of the resin connector is immersed in, or subjected to grease, lubricating oil, or coolant in the environment where the preventer is incorporated in the circulation path for the rolling guide device. Also, the ball interference preventer undergoes actions such as bending, tension, compression, twisting, or contact friction with the ball at any time. When reciprocated in the circulation path at high speed, this ball interference preventer undergoes an operation of bending, tension and compression severely and repeatedly. Further, when the ball interference preventer composed of the resin connector is immersed in, or subjected to grease, lubricating oil, or coolant, it absorbs water and oil to swell, causing a circulation failure in the circulation path and ablation of the preventer, and degrading the durability, sliding property and wear resistance.

[0008] Therefore, the rolling element interference preventer composed of the resin connector is required to have the excellent chemical strength of oil resistance, water resistance, and chemical resistance to the grease, lubricating oil and coolant, in addition to the mechanical strength of durability, sliding property and wear resistance. In view of the life of the guide device, it is required to be so durable and resistant to wear as to run about 30,000 km or more, with small sliding resistance variation, as well as resistant to oil, water and chemicals.

[0009] Moreover, the rolling element interference preventer composed of the resin connector was not too problematical in that an unnatural load was applied only on a part of the resin connector during the use, because the minimum radius of curvature for the continuous circulation path formed in the guide device was relatively large, the ball was employed as the rolling element, and the shape of the resin connector was devised. In recent years, however, the guide device is demanded for smaller size and higher speed, and the roller is employed as the rolling element, resulting in a problem that the durability, wear resistance and sliding property may be impaired.

SUMMARY OF THE INVENTION

[0010] The present inventors made researches to attain more excellent durability and wear resistance without impairing various features (low noise, maintenance free for long term, high speed, and sliding property) of the rolling element interference preventer, especially when subjected to severe and repetitive actions of bending, tension and compression, and found that the rolling element interference preventer should be produced using a thermoplastic resin elastomer having specific balance (relation) for a 10% elongation stress, a tensile stress and a bending modulus of elasticity to achieve the aim, thus completing this invention.

[0011] Accordingly, it is an object of the invention to provide a rolling element interference preventer for a guide device, which prevents a number of rolling elements rolling at regular intervals in a continuous circulation path of the guide device from interfering with each other. The rolling element interference preventer is not only excellent in low noise, maintenance free for long term, high speed and sliding property, but also excellent in durability and wear resistance, and can be used stably over the long term.

[0012] The present invention provides a rolling element interference preventer for a guide device to prevent a number of rolling elements rolling at regular intervals in a continuous circulation path of the guide device from interfering with each other, wherein the rolling element interference preventer is formed of a thermoplastic resin elastomer having a physical property in accordance with an expression, $(A\times B)\div C\geqq 18$, where A is a 10% elongation stress, B is a tensile strength, and C is a bending modulus of elasticity.

[0013] As the thermoplastic resin elastomer, polyamide resin elastomer, polyester resin elastomer, polyurethane resin elastomer, styrene resin elastomer, and olefine resin elastomer are exemplified. They should be highly resistant to oil, water and chemicals in the service environment of the rolling guide device, especially in the service environment where the guide device is immersed in, or subjected to grease, lubricating oil, or coolant. The coefficient of water absorption measured in the environment of equilibrium moisture percentage 23° C., 65% RH is 1.5 wt % (% by weitht) or less, and preferably 0.5 wt % or less. The swelling factor measured in an immersion test of chemical at a temperature of 85° C. for 672 hours is 3% or less. Furthermore, the tensile strength retention in an immersion test of boiling water at 100° C. is 70% or more after ten days, and preferably 80% or more.

[0014] In this invention, the thermoplastic resin elastomers satisfying a physical property in accordance with the expression, $(A\times B)\div C\geqq 18$ (A: 10% elongation stress, B: tensile strength, and C: bending modulus of elasticity) are employed. Though slightly different depending on the type of the rolling guide device and whether the rolling element is a ball or a roller, the 10% elongation stress A is from 60 to 200 kgf/cm^2, and preferably from 90 to 160 kgf/cm^2, the tensile strength B is from 340 to 460 kgf/cm^2, and preferably from 360 to 430 kgf/cm^2, and the bending modulus of elasticity C is from 1000 to 5000 kgf/cm^2, and preferably from 1200 to 2700 kgf/cm^2.

[0015] If the 10% elongation stress of the thermoplastic resin elastomer is not less than 60 kgf/cm^2, the shape of the rolling element interference preventer is maintained against a centrifugal force acting on the rolling element of the guide device in the fast operation, resulting in that the sliding resistance decreases in the continuous circulation path of the guide device. On the contrary, if it is not more than 200 kgf/cm^2, a problem of flexure fatigue failur is prevented. If the tensile strength is not less than 340 kgf/cm^2, the durability is increased, or conversely if it is not more than 460 kgf/cm^2, the problem of flexure fatigue failure is prevented. Moreover, if the bending modulus of elasticity is not less than 1000 kgf/cm^2 and not more than 5000 kgf/cm^2, the sliding property is increased.

[0016] Herein, it is needed that the guide device for use with the rolling element interference preventer of the invention has a pair of bearing races, and the continuous circulation path for the rolling elements rolling with a load applied between the pair of bearing races, and the guide device may be a linear guide device for endless track, a swing bearing, a ball screw, and a spline, for example.

[0017] And the rolling element interference preventer of this invention can take various forms, depending on the type of guide device to which it is applied. For example, in a case where the guide device is a linear guide device for endless track having a track rail (one bearing race) having a rolling path, a sliding board (other bearing race) having a rolling groove mutually opposed to the rolling path and moving along the track rail, and a number of rolling elements rolling with a load applied between the rolling path of the track rail and the rolling groove of the sliding board, it is preferred that the rolling element interference preventer consists of a flexible resin connector having an interposing portion interposed between each rolling elements, and a connecting portion for connecting each interposing portions, and preferably can hold a number of rolling elements rollably by the interposing portions and the connecting portion.

[0018] Moreover, in the case where the rolling element interference preventer is made up of this flexible resin connector, the resin connector may be provided with a chamfer guide portion at either terminal end to guide the top end portion of the resin connector, whereby when the guide device is moved in the continuous circulation path, especially when the top end portion of the rolling element interference preventer enters a direction converting path of the circulation path, or exits from the direction converting path, the top end portion is guided to move the guide device smoothly. By forming the chamfer guide portion at either terminal end of the resin connector, the rolling element interference preventer can be guided smoothly in any of forward and backward directions in the reciprocating motion of the guide device.

[0019] The length of the rolling element interference preventer to be molded is decided in consideration of the length of the circulation path for the guide device using it. However, if the guide device is increased in size and the length of circulation path is great, the rolling element interference preventer may be divided into two or three for molding, whereby the size of mold can be reduced. In this case, each resin connector constituting each of two or three parts divided from the rolling element interference preventer is formed with a chamfer guide portion at either terminal end.

[0020] In the case where the rolling element interference preventer of the invention is applied to the linear guide device for endless track, if the rolling elements are balls, the thermoplastic resin elastomer forming the resin connector has the properties that the 10% elongation stress A is from 60 to 150 kgf/cm^2, and preferably from 90 to 130 kgf/cm^2, the tensile strength B is from 340 to 400 kgf/cm^2, and preferably from 350 to 380 kgf/cm^2, and the bending modulus of elasticity C is from 1000 to 2000 kgf/cm^2, and preferably from 1200 to 1800 kgf/cm^2. By employing the values in the above ranges for the 10% elongation stress A, tensile strength B and bending modulus of elasticity C, the ball interference preventer can exhibit the excellent and balanced performances (low noise, maintenance free for long term, high speed, sliding property, durability and wear resistance).

[0021] In the case where the rolling element interference preventer of this invention is applied to the linear guide device for endless track, if the rolling elements are rollers, the thermoplastic resin elastomer forming the resin connector has the properties that the 10% elongation stress A is from 80 to 200 kgf/cm^2, and preferably from 100 to 1160 kgf/cm^2, the tensile strength B is from 380 to 460 kgf/cm^2, and preferably from 430 to 460 kgf/cm^2, and the bending modulus of elasticity C is from 1500 to 5000 kgf/cm^2, and preferably from 2000 to 4000 kgf/cm^2. By employing the values in the above ranges for the 10% elongation stress A, tensile strength B and bending modulus of elasticity C, the roller interference preventer can exhibit the excellent and balanced performances (low noise, maintenance free for long term, high speed, sliding property, durability and wear resistance).

[0022] Moreover, in the case where the guide device is a ball screw having a screw axis (one bearing race) with a helical rolling path for a ball, a nut (other bearing race) with a helical rolling groove mutually opposed to the helical rolling path, and a number of balls rolling with a load applied between the helical rolling path of the screw axis and the helical rolling groove of the nut, the ball interference preventer may be the resin connector like that of the linear guide device for endless track, or a spacer interposed between each balls.

[0023] The rolling element interference preventer of this invention can be produced by conventional well-known methods, using the thermoplastic resin elastomer as described above. For example, in a case where the rolling element interference preventer is made up of the resin connector, a number of rolling elements can be produced as a core by injection molding or a so-called insert molding (as described in JP-A-6-56181, JP-A-5-52217, JP-A-5-126149, JP-A-5-196036, JP-A-5-196037, and JP-A-9-14264), or other methods.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] **FIG. 1** is a perspective and detailed portion broken view, showing a linear sliding roller bearing having incorporated a roller interference preventer according to a first embodiment of the prevent invention;

[0025] **FIG. 2** is a partial cross-sectional side view of the linear sliding roller bearing of **FIG. 1**;

[0026] **FIG. 3** is a plan view showing the roller interference preventer of **FIG. 1**;

[0027] **FIG. 4** is a front view of the roller interference preventer of **FIG. 3**;

[0028] **FIG. 5** is a cross-sectional view of the roller interference preventer, taken along the line V-V in **FIG. 3**;

[0029] **FIG. 6** is an enlarged perspective view showing a top end portion of the roller interference preventer shown in **FIG. 3**;

[0030] **FIG. 7** is a perspective view showing a roller interference preventer according to a second embodiment of the invention;

[0031] **FIG. 8** is a plan view showing a ball interference preventer according to a third embodiment of the invention;

[0032] **FIG. 9** is a front view of the ball interference preventer of **FIG. 8**;

[0033] **FIG. 10** is a cross-sectional view of the ball interference preventer, taken along the line X-X in **FIG. 8**;

[0034] **FIG. 11** is an enlarged perspective view showing a top end portion of the ball interference preventer shown in **FIG. 8**;

[0035] **FIG. 12** is a cross-sectional view of a ball screw having incorporated a ball interference preventer according to a fourth embodiment of the invention;

[0036] **FIG. 13** is a perspective view showing how the balls of **FIG. 12** circulate;

[0037] **FIG. 14** is a perspective view showing the ball interference preventer (spacer) of **FIG. 12**;

[0038] **FIG. 15** is a cross-sectional view of the ball interference preventer of **FIG. 14**;

[0039] **FIG. 16** is a perspective and detailed portion broken view, showing a ball screw having incorporated a ball interference preventer according to a fifth embodiment of the invention;

[0040] **FIG. 17** is a plan view showing a state in which the ball interference preventer incorporated into the ball screw of **FIG. 16** circulates in the ball circulation path; and

[0041] **FIG. 18** is a perspective view showing a state in which the ball interference preventer incorporated into the ball screw of **FIG. 16** circulates in the ball circulation path.

DETAILED DESCRIPTION OF THE PREFFERD EMBODIMENTS

[0042] The preferred embodiments of the present invention will be described below with reference to the accompanying drawings.

[0043] First Embodiment

[0044] FIGS. **1** to **6** show a roller interference preventer RC according to a first embodiment of the invention and a linear sliding roller bearing having incorporated the roller interference preventer RC.

[0045] This roller interference preventer RC includes a flexible resin connector **12** having interposing portions **12***a* interposed between each of a number of rollers **11** made of bearing steel (SUJ2) disposed at regular intervals, and a pair of connecting portions **12***b* connecting each interposing portions **12***a*, and carrying a number of rollers **11** in linear state and rollably, as shown particularly in FIGS. **3** to **6**. At either terminal end of the resin connector **12**, a chamfer guide portion **13** having an almost similar shape of a roller **11***a* is formed to surround the roller **11***a* located at the terminal end, as shown in **FIG. 6**.

[0046] The linear sliding roller bearing having incorporated the roller interference preventer RC fundamentally includes a metallic track rail (one bearing race) **14** having rigidity, a metallic sliding board (other bearing race) **15** having rigidity, a roller guide member **16** made of synthetic resin and attached in a hole **15***b* punched along the longitudinal direction in the sliding board **15**, a lid **17** made of synthetic resin and attached on the sliding board **15** together with the roller guide member **16**, and a number of rollers **11** carried like a chain by the resin connector **12**, as shown in **FIGS. 1 and 2**.

[0047] In this first embodiment, the track rail **14** is formed with a plain surface-like rolling path **14***a* for the roller **11** at either shoulder portion, and the sliding board **15** is formed with a load roller rolling path **15***a* for the roller **11** applying a load. Further, the roller guide member **16** is formed with a no-load roller guide bore **16***a* for guiding the roller **11** to roll in no-load state, and the lid **17** is formed with a direction converting path, not shown, constituting the continuous circulation path of the roller **11** by linking the load roller rolling path **15***a* of the sliding board **15** and the no-load roller guide bore **16***a* of the roller guide member **16**.

[0048] Second Embodiment

[0049] **FIG. 7** shows a roller interference preventer RC according to a second embodiment of the invention. This roller interference preventer RC includes of a flexible resin connector **22** having plate-like interposing portions **22***a* interposed between each of a number of rollers **21** made of bearing steel (SUJ2) disposed at regular intervals, and a pair of connecting portions **22***b* connecting each interposing portions **22***a* on either side of the roller **21**, and arranging a number of rollers **21** in linear state and rollably. At either terminal end of the resin connector **22**, a chamfer guide portion **23** having a semi-cylindrical shape and the almost same radius of curvature as the roller **21***a* is formed.

[0050] The roller interference preventer RC according to the second embodiment does not carry the rollers **21** by using the resin connector **22**, but is incorporated into the continuous circulation path of the linear sliding roller bearing in the same manner as the roller interference preventer RC of the first embodiment, whereby the rollers **21** are prevented from contacting and interfering with each other.

[0051] Third Embodiment

[0052] FIGS. **8** to **11** shows a ball interference preventer BC according to a third embodiment of the invention. This ball interference preventer BC includes of a flexible resin connector **32** having interposing portions **32***a* interposed between each of a number of balls **31** made of bearing steel (SUJ2) disposed at regular intervals, and a pair of connecting portions **32***b* for connecting each interposing portions **32***a*, and carrying a number of balls **21** in linear state and rollably. At either terminal end of the resin connector **32**, a chamfer guide portion **33** having the almost same shape as the ball **31***a* is formed to surround the ball **31***a* located at the terminal end.

[0053] This ball interference preventer BC is also incorporated into the continuous circulation path of the linear sliding ball bearing in the same manner as the roller interference preventer RC of the first embodiment.

[0054] Fourth Embodiment

[0055] FIGS. **12** to **15** show a ball interference preventer BC according to a fourth embodiment of the invention and a ball screw BS with the ball interference preventer BC incorporated.

[0056] This ball interference preventer BC includes a number of spacers **42** having a spherical concave portion **42***a* for receiving a ball **41** partly on the front face and the rear face. The ball interference preventer BC is incorporated into a continuous circulation path of the ball screw including a screw axis (one bearing race) **44** having a helical rolling path **44***a* for the ball **41**, a nut (other bearing race) **45** with a helical rolling groove **45***a* mutually opposed to the helical rolling path, and a number of balls **41** rolling between the helical rolling path **44** of the screw axis **44** and the helical rolling groove **45***a* of the nut **45** with a load applied, and is placed between adjacent balls **41** to prevent the balls **41** from contacting and interfering with each other.

[0057] In this fourth embodiment, the nut **45** has a return pipe **46** of almost U-character shape attached on a clamp face **45***b* formed by cutting away a part of the outer circumferential portion. Both end portions of the return pipe **46** penetrate through a peripheral wall of the nut **44** to open into the helical rolling groove **45***a* mutually opposed to the helical rolling path **44***a* of the screw axis **44**. Further, at either end, ball pickup portions **46***a* are formed to pick up the balls **41** rolling between the helical rolling path **44***a* and the helical rolling groove **45***a* with a load applied into the return pipe **46**, and to feed the balls **41** rolling through the return pipe **46** to between the helical rolling path **44***a* and the helical rolling groove **45***a*. The continuous circulation path of the ball **41** is made up of the screw axis **44**, the nut **45** and the return pipe **46**.

[0058] The spacer **42** constituting the ball interference preventer BC of the fourth embodiment is located between adjacent balls **41** incorporated into the continuous circulation path of the ball screw, circulates in this circulation path together with the balls **41**, and prevents the balls **41** from contacting and interfering with each other.

[0059] Fifth Embodiment

[0060] FIGS. **16** to **18** show a ball interference preventer BC incorporated into a ball screw BS in the same manner as in the fourth embodiment of the invention.

[0061] This ball interference preventer BC, unlike that of the fourth embodiment but like that of the third embodiment, includes a flexible resin connector **52** having interposing portions **52***a* interposed between each of a number of balls **51** disposed at regular intervals, and a connecting portion **52***b* connecting each interposing portions **52***a*, and carrying a number of balls **51** rollably. At either terminal end of the resin connector **52**, there is formed a chamfer guide portion **53** to surround the ball **51***a* located at the terminal end.

[0062] In FIGS. **16** to **18**, the ball rolling groove **54***a* is formed in the screw axis **54**, and the no-load rolling groove **55***a* is formed in the nut **55**. Further, a deflector **56** attached to the nut **54** and forming the continuous circulation path between the screw axis **54** and the nut **55** is formed with a ball return groove **56***a*, whereby a number of balls connected by the resin connector **52** can roll in the circulation path formed by the ball rolling groove **54***a* of the screw axis **54**, the no-load rolling groove **55***a* of the nut **55**, and the ball return groove **56***a* of the deflector **56**, with a load applied.

[0063] This ball interference preventer BC of the fifth embodiment prevents the balls **51** from contacting and interfering with each other, like the ball interference preventer BC of the fourth embodiment.

EXAMPLES

[0064] The present invention will be described below more specifically on the basis of some experimental examples (examples and comparative examples).

Experimental Examples 1 to 4

[0065] Using polyester resin elastomer (trade name Perplene EN1000, EN2000, EN3000 and EN5000 made by TOYOBO Co., Ltd.) as listed in Table 1 as the thermoplastic resin elastomer, 75 rollers made of bearing steel (SUJ2) as large as 4 mmϕ×7 mm were produced as a core by injection molding, and released from the mold, together with a number of rollers, thereby molding the roller interference preventer having a length of about 340 mm and a shape as shown in FIGS. **3** to **6** for the first embodiment.

[0066] The obtained roller interference preventer of each of experimental examples 1 to 4 was investigated for the durability, sliding property, wear resistance, water absorptivity, swelling property and water resistance.

[0067] The results are listed below in Table 1.

[0068] Durability

[0069] As shown in **FIGS. 1 and 2**, the roller interference preventer of each of experimental examples 1 to 4 was incorporated into the continuous circulation path of the linear sliding roller bearing, with its track rail fixed, and the sliding board was reciprocated under the conditions with a speed f of 200 m/min, a stroke St of 2500 mm, and acceleration **1**G. The durability was evaluated at three levels, in which ○ indicates no abnormality after running 30,000 km, Δ indicates some damage in part after running 30,000 km but no abnormality for running, and x indicates abnormality such as breakage after running less than 30,000 km.

[0070] Sliding property

[0071] In the same manner as the measurement of durability, the roller interference preventer of each of experimental examples 1 to 4 was incorporated into the continuous circulation path of the linear sliding roller bearing, with its track rail fixed, and the sliding board was pushed by a load cell to measure the rolling resistance of the sliding board in the track rail at a sampling frequency of 500 Hz for this load cell. The sliding property was evaluated at three levels, in which ○ is suitable for service because the resistance variation is 25% or less of the rolling resistance, Δ is usable for service though the resistance variation is beyond 25% of the rolling resistance in part, and x is unusable because the resistance variation is totally beyond 25% of the rolling resistance.

[0072] Wear resistance

[0073] In the same manner as the measurement of durability, the roller interference preventer of each of experimental examples 1 to 4 was incorporated into the continuous circulation path of the linear sliding roller bearing, with its track rail fixed, and the sliding board was reciprocated under the conditions with a speed f of 200 m/min, a stroke St of 2500 mm, and acceleration **1**G to measure the wear amount at the top end corner of the resin connector for the roller interference preventer. The wear resistance was evaluated at three levels, in which ○ is no abnormality in wear, Δ is some initial wear but no progressive wear, and x is progressive wear at the top end while running to lead to breakage.

[0074] Water absorptivity

[0075] Using four kinds of polyester resin elastomer employed in each of the experimental examples 1 to 4 as listed in Table 1, a dumbbell specimen of JIS 3 type was produced in conformance with JIS K6251, and the size variation of the dumbbell specimen was measured in the environment of equilibrium moisture percentage 23° C., 65% RH, and the water absorptivity was evaluated at three levels in which ○ is 0.5% or less, Δ is from 0.5% to 1.5%, and x is more than 1.5%.

[0076] Swelling property

[0077] In the same manner as the test of water absorptivity, a dumbbell specimen of JIS 3 type was produced, and the dumbbell specimen was immersed in the test oil at a temperature of 85° C. for 672 hours, employing synthetic coolant (Synthylo made by Castorol), soluble coolant (Microcut 3850-LH made by Japan Quakerchemical), and emulsion coolant (Yushiroken EC50T-3 made by Yushiro Chemical Industries) as test oils, and using an environmental test machine (made by KATO: SSE740RA). The swelling factor was calculated from the values of size variation of the dumbbell specimen due to swelling and evaluated at three levels in which ○ is 1.5% or less, Δ is from 1.5% to 3%, and x is more than 3%.

[0078] Water resistance

[0079] In the same manner as the test of water absorptivity and swelling property, a dumbbell specimen of JIS 3 type was produced, and immersed in the boiling water at 100° C. for ten days to measure the tensile strength change (tensile strength: 500 mm/min) of the dumbbell specimen. The tensile strength retention was calculated from this tensile strength change, and evaluated at three levels in which ○ is the tensile strength retention of 80% or more after ten days, Δ is the tensile strength retention from 70% to 80% after ten days, and x is the tensile strength retention of less than 70% after ten days.

TABLE 1

	Roller interference preventer				
		Experimental example No.			
		1	2	3	4
Polyester resin elastomer	Elastomer trade name	Perplene			
	Grade	EN1000	EN2000	EN3000	EN5000
	10% elongation stress (kgf/cm^2)	69	80	158	193
	Tensile strength (kgf/cm^2)	360	370	430	455
	Bending modulus of elasticity(kgf/cm^2)	1200	1600	2700	4800
	Value of $(A \times B) \div C$	20.7	18.5	25.2	18.2
Evaluation	Durability	○	Δ	○	○
	Sliding property	○	○	○	Δ
	Wear resistance	○	○	○	Δ
	Water absorptivity	○	○	○	○
	Swelling property	Δ	○	○	○
	Water resistance	Δ	○	○	○

Experimental Examples 5 to 9

[0080] Using polyester resin elastomer (trade name Perplene EN1000, EN2000, EN3000 and EN5000 made by TOYOBO Co., Ltd.) as listed in Table 2 as the thermoplastic resin elastomer, a 10% elongation stress a of 54 kgf/cm^2, a tensile strength b of 220 kgf/cm^2, a bending modulus of elasticity c of 1100 kgf/cm^2, $(A \times B) \div C = 10.8$), 34 balls made of bearing steel (SUJ2) as large as 3.969 mmϕ were produced as a core by injection molding, and released from the mold, together with a number of balls, thereby molding the ball interference preventer with a shape as shown in FIGS. **8** to **11**.

[0081] The obtained ball interference preventer of each of experimental examples 5 to 9 was investigated for the durability, sliding property, wear resistance, water absorptivity, swelling property and water resistance in the same manner as in the previous experimental examples 1 to 4.

[0082] The results are listed below in Table 2.

TABLE 2

ball interference preventer

		Experimental example No. 5	6	7	8	9
Polyester resin elastomer	Elastomer trade name	Perplene				—
	Grade	EN1000	EN2000	EN3000	EN5000	
	10% elongation stress (kgf/cm^2)	69	80	158	193	54
	Tensile strength (kgf/cm^2)	360	370	430	455	220
	Bending modulus of elasticity(kgf/cm^2)	1200	1600	2700	4800	1100
	Value of (A × B) ÷ C	20.7	18.5	25.2	18.2	10.8
Evaluation	Durability	Δ	○	○	Δ	Δ
	Sliding property	○	○	Δ	Δ	○
	Wear resistance	○	○	○	Δ	○
	Water absorptivity	○	○	○	○	Δ
	Swelling property	Δ	○	○	○	x
	Water resistance	○	○	○	○	Δ

[0083] With the rolling element interference preventer of the invention, in the guide device incorporating it, it is possible to exhibit the excellent low noise, maintenance free for long term, high speed and sliding property, and at the same time, the excellent durability and wear resistance, whereby the guide device can be stably employed over long term to deal with the reduction in size and increase in speed.

What is claimed is:

1. A rolling element interference preventer for a guide device having a continuous circulation path and a plurality of rolling elements rolling at regular intervals in the continuous circulation path, wherein the rolling element interference preventer prevents the rolling elements from interfering with each other, and

wherein the rolling element interference preventer is formed of a thermoplastic resin elastomer having a physical property in accordance with an expression, $(A\times B)\div C \geqq 18$, where A represents a 10% elongation stress, B represents a tensile strength, and C represents a bending modulus of elasticity.

2. The rolling element interference preventer according to claim 1, wherein the thermoplastic resin elastomer has the 10% elongation stress A of 60 to 200 kgf/cm^2, the tensile strength B of 340 to 460 kgf/cm^2, and the bending modulus of elasticity C of 1000 to 5000 kgf/cm^2.

3. The rolling element interference preventer according to claim 1, wherein a coefficient of water absorption for the thermoplastic resin elastomer is not more than 1.5 wt %.

4. The rolling element interference preventer according to claim 1, wherein a swelling factor of the thermoplastic resin elastomer is not more than 3%.

5. The rolling element interference preventer according to claim 1, wherein a tensile strength retention of the thermoplastic resin elastomer is not less than 70% after ten days in 100° C. boiling water immersion test.

6. A guide device comprising:

a track rail having a rolling path;

a sliding board having a rolling groove opposed to the rolling path and moving along the track rail;

a plurality of rolling elements rolling with a load applied between the rolling path and the rolling groove; and

a rolling element interference preventer including a flexible resin connector having a plurality of interposing portions interposed between each rolling elements, and a connecting portion for connecting each interposing portions,

wherein the rolling element interference preventer is formed of a thermoplastic resin elastomer having a physical property in accordance with an expression, $(A\times B)\div C \geqq 18$, where A represents a 10% elongation stress, B represents a tensile strength, and C represents a bending modulus of elasticity.

7. The guide device according to claim 6, wherein the resin connector carries the rolling elements in an arranged state and rollably by the interposing portions and the connecting portion.

8. The guide device according to claim 6, wherein the rolling elements are balls, and the thermoplastic resin elastomer has the 10% elongation stress A of 60 to 100 kgf/cm^2, the tensile strength B of 340 to 400 kgf/cm^2, and the bending modulus of elasticity C of 1000 to 2000 kgf/cm^2.

9. The guide device according to claim 6, wherein the rolling elements are rollers, and the thermoplastic resin elastomer has the 10% elongation stress A of 80 to 200 kgf/cm^2, the tensile strength B of 380 to 460 kgf/cm^2, and the bending modulus of elasticity C of 2000 to 5000 kgf/cm^2.

10. A guide device comprising:

a screw axis having a helical rolling path;

a nut having a helical rolling groove opposed to the helical rolling path;

a plurality of balls rolling between the helical rolling path and the helical rolling groove; and

a boll interference preventer,

wherein the ball interference preventer comprises a plurality of spacers interposed between each balls, and wherein the ball interference preventer

is formed of a thermoplastic resin elastomer having a physical property in accordance with an expression, $(A \times B) \div C \geqq 18$, where A represents a 10% elongation stress, B represents a tensile strength, and C represents a bending modulus of elasticity.

* * * * *

US 20040170343A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2004/0170343 A1

Michioka (43) Pub. Date: Sep. 2, 2004

(54) ROLLING MEMBER CONNECTION BELT AND MOTION GUIDE DEVICE PROVIDED WITH SAME

(75) Inventor: Hidekazu Michioka, Tokyo-to (JP)

Correspondence Address:
WESTERMAN, HATTORI, DANIELS & ADRIAN, LLP
1250 CONNECTICUT AVENUE, NW
SUITE 700
WASHINGTON, DC 20036 (US)

(73) Assignee: THK CO., LTD., Tokyo-to (JP)

(21) Appl. No.: 10/773,300

(22) Filed: Feb. 9, 2004

(30) Foreign Application Priority Data

Feb. 28, 2003 (JP) P2003-52936

Publication Classification

(51) Int. Cl.[7] F16C 29/06

(52) U.S. Cl. 384/45

(57) ABSTRACT

A motion guide device is provided with a rolling member connection belt for holding a series of rolling members which circulate in a circulation passage provided with a loaded rolling passage, a non-loaded return passage and a pair of rolling direction changing members connecting the loaded rolling passage and the non-loaded return passage to thereby constitute the circulation passage. The rolling member connection belt is formed from a metal plate member having a corrugated-shape, in section in a longitudinal direction thereof, formed at least to one portion thereof or entire portion thereof in the longitudinal direction, and the corrugated-shape has peak and valley portions each extending in a direction normal to the longitudinal direction of the metal plate member.

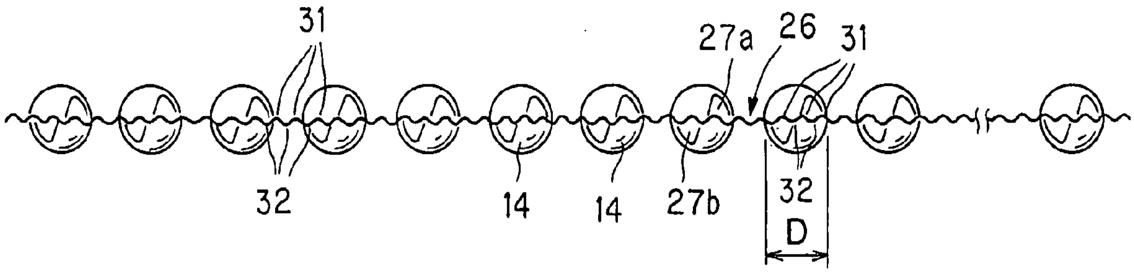


FIG. 1

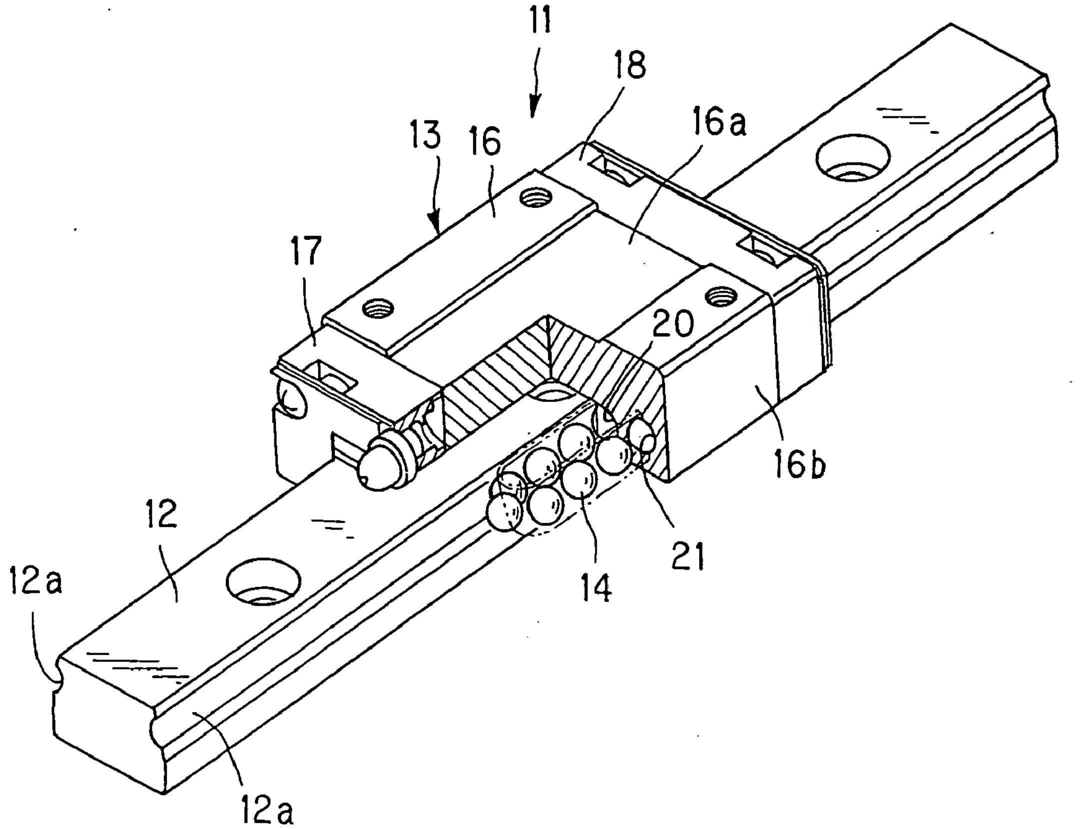


FIG. 2

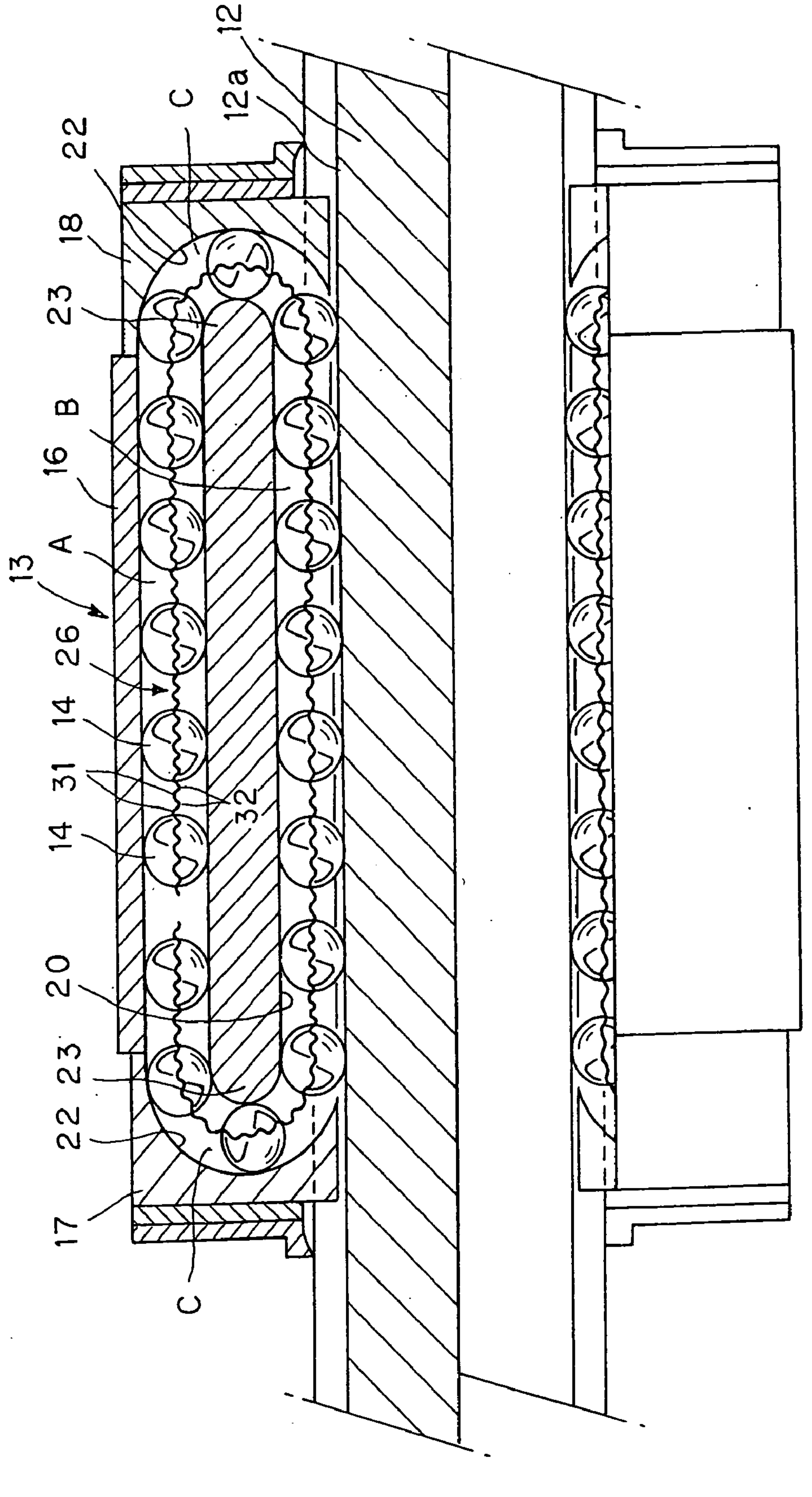


FIG. 3A

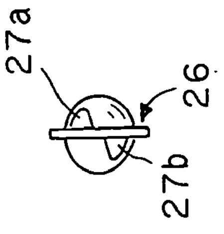


FIG. 3B

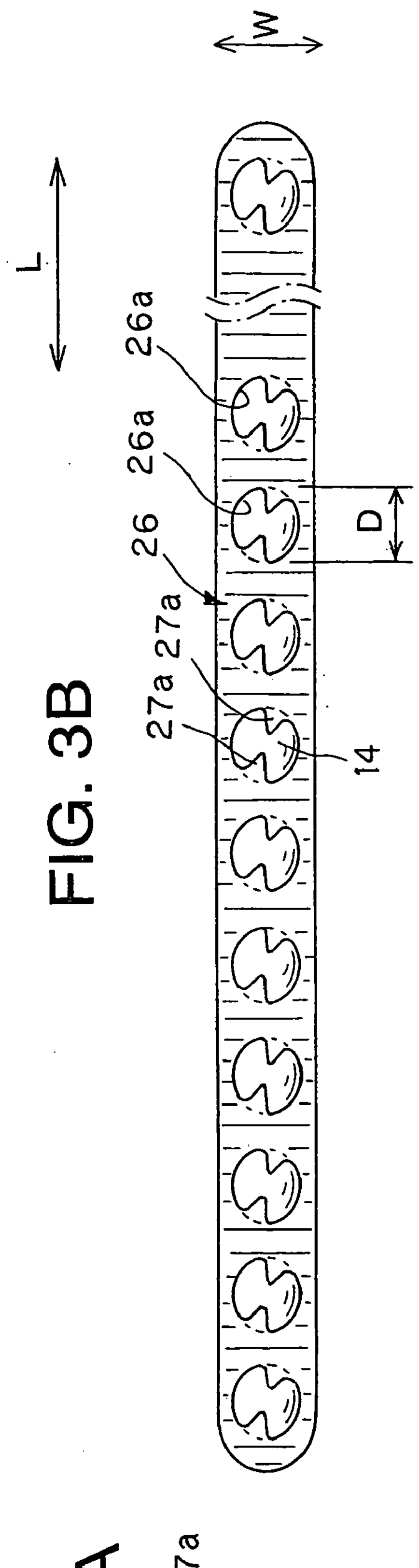


FIG. 3C

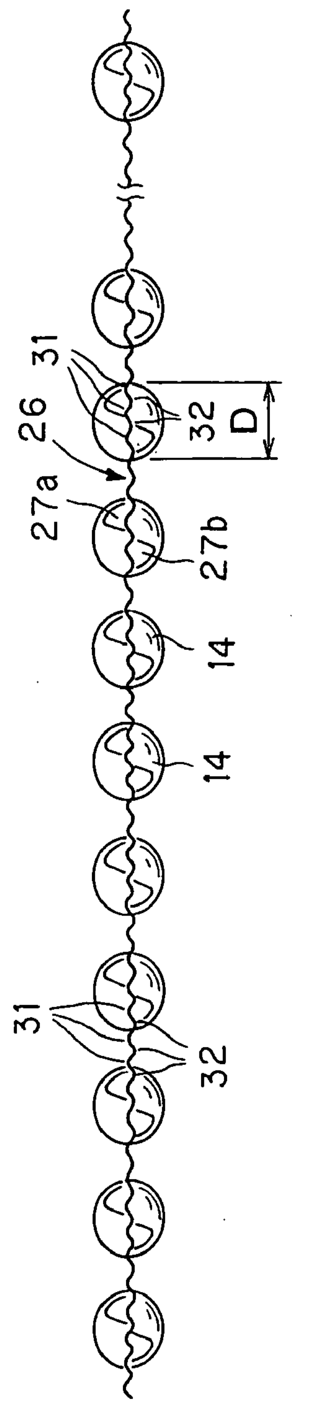


FIG. 4

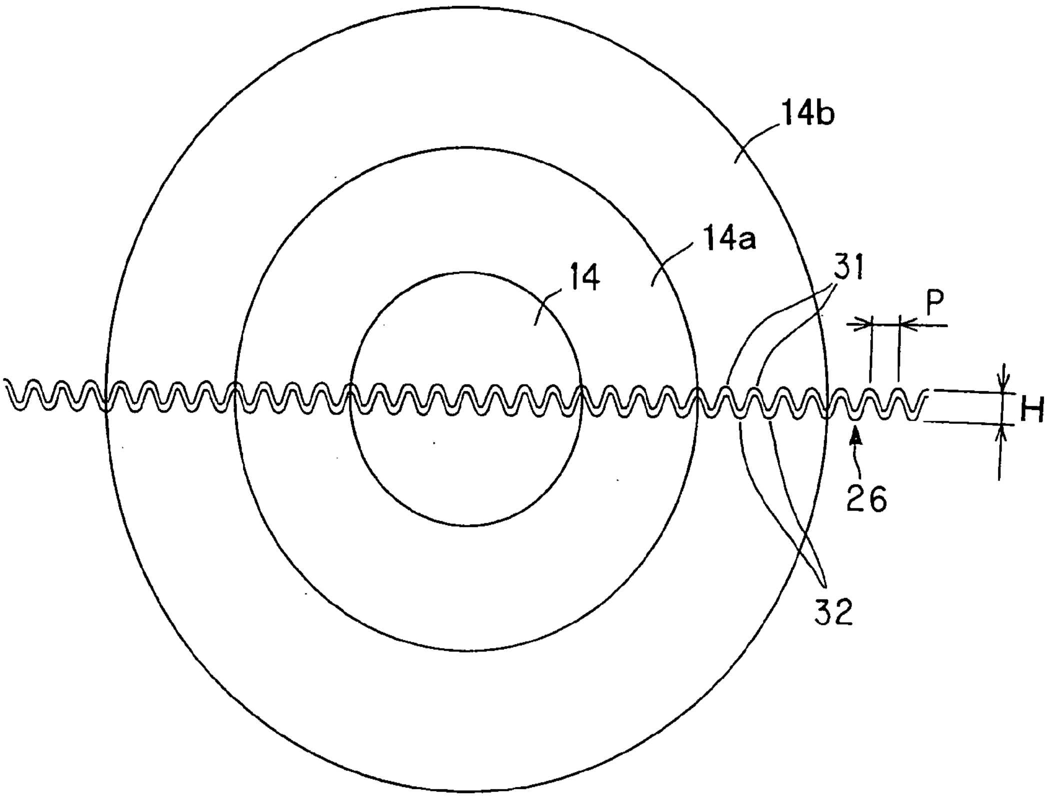


FIG. 5

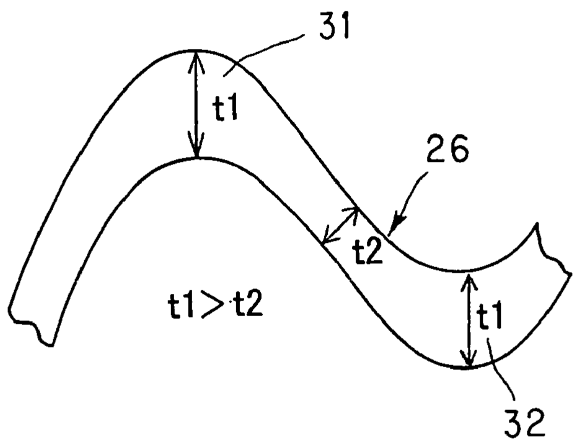


FIG. 6

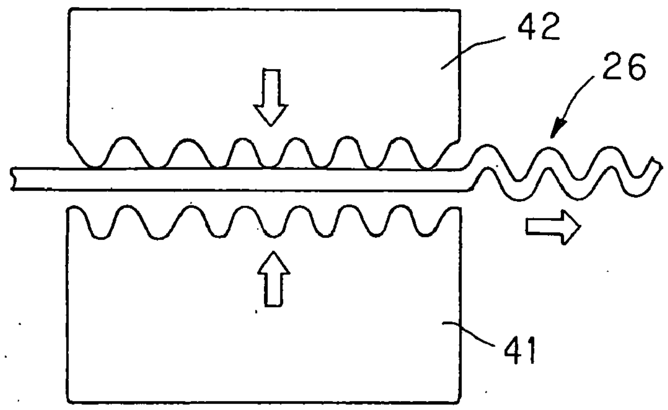


FIG. 7

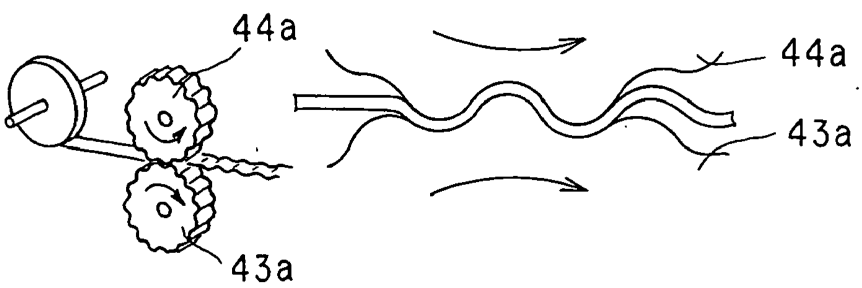


FIG. 8
PRIOR ART

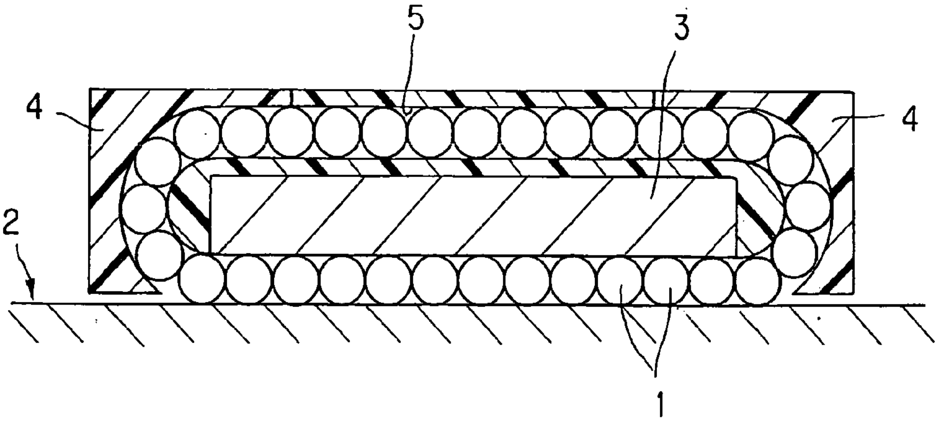
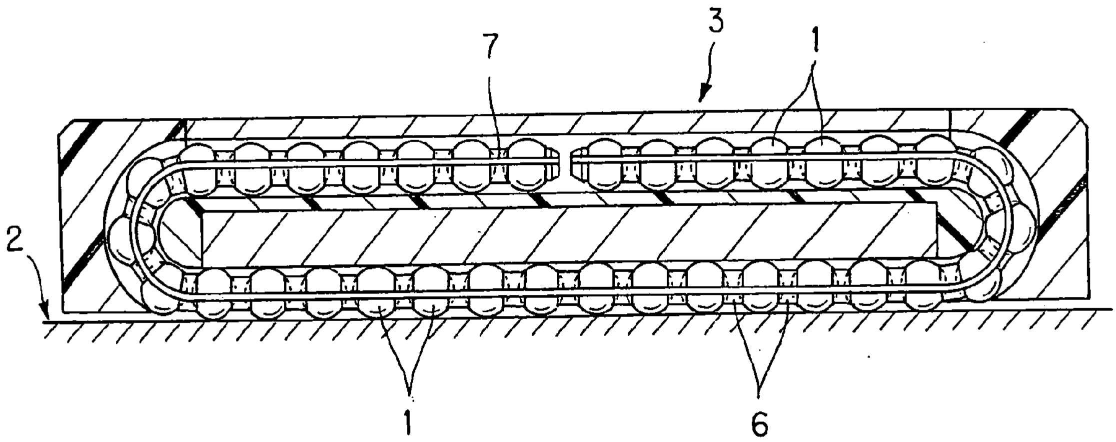


FIG. 9
PRIOR ART



ROLLING MEMBER CONNECTION BELT AND MOTION GUIDE DEVICE PROVIDED WITH SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a connection belt connecting rolling members for holding the rolling members, to be rotatably, rolling along a path defined by a track member and a movable member of, for example, a linear guide, ball spline and the like and also relates to a motion guide device provided with such rolling member connection belt.

[0003] 2. Related Art

[0004] A linear guide is generally composed of a track rail, a movable block assembled to the track rail to be movable relative to the track rail and a number of balls as rolling members disposed between the track rail and the movable block.

[0005] **FIG. 8** shows one example of such linear guide, in which balls **1** roll in a passage or path defined by the track rail **2** and the movable block **3** and are scooped up by an end cap **4** at each of the end portions of the movable block **3**. The balls **1** then roll in a ball return passage **5** formed in the movable block **3** and return to the ball rolling passage formed between the track rail **2** and the movable block **3** through another end cap **4** formed at the other end portion of the movable block **3**.

[0006] A rolling member retainer is a member for holding and retaining the balls **1** so that the balls **1** roll and move smoothly in the ball rolling passage without contacting to each other.

[0007] In a linear guide provided with a separate-type retainer, a plurality of retainers each disposed between the balls are arranged independently, i.e., separated from each other in arrangement.

[0008] On the other hand, in a linear guide provided with a connection-type retailer, as shown in **FIG. 9, a** plurality of retainers **6**, **6**, - - - disposed between the balls **1** are connected by a belt **7**. Each of these retailers **6** is disposed between adjacent balls **1** to thereby prevent the balls **1** from contacting each other. In such connection-type retainer, the balls **1** can be guided in the ball advancing direction with a constant distance being maintained between the adjacent balls **1**, thus the movable member being smoothly moved.

[0009] In general, such retainer for the rolling members (which may be called hereinlater merely "retainer") is manufactured through an injection molding process using a resin material such as elastomer. In the connection-type retailer, it has been required to make compact the retainer according to recent requirement of compact-sized linear guide. However, in the structure made to satisfy such requirement for compactness, there may often causes short-circuited and, moreover, it becomes difficult to carry out the injection molding. In addition, it is also difficult to ensure high strength at the connection portion of the retainer and the belt therefor.

[0010] In order to solve the defects or inconvenience described above, the applicant of the subject application has provided a rolling member retainer manufactured through a pressing working of a metal plate member such as disclosed in Japanese Patent Laid-open (KOKAI) Publication No. 2000-65053, in which the rolling member retainer made from the metal material is formed with a number of ball retaining (holding) holes at a predetermined distance between the adjacent ones and the ball is retained in each of the ball retaining holes to be rotatable.

[0011] Generally, as shown in **FIG. 8, a** circulation passage of a linear guide through which the balls circulates has a circuit structure configured such that a loaded rolling passage and a non-loaded return passage, both extending linearly, are connected, at both end portions, by a pair of U-shaped rolling direction changing passages. Because of such structure, the rolling member retainer circulates in the circulation passage in the linearly extending fashion in the loaded rolling passage and non-loaded return passage and also in the bent fashion in U-shape in the direction changing passages. The rolling member retainer is moved and circulated while repeatedly taking the above fashions in the circulation passage.

[0012] In the above meaning, if the rolling member retainer is made of metal material, there may cause a case that the retainer are not sufficiently bent in the desired shape during the circulating motion in the direction changing passages, and hence, the smooth circulation of the rolling members therein may be obstructed.

SUMMARY OF THE INVENTION

[0013] An Object of the present invention is therefore to substantially eliminate defects or inconveniences encountered in the prior art described above and to provide a rolling member connection belt made of metal material, for holding rolling members, capable of being bent with flexibility, during the circulation of corner portions in a circular passage.

[0014] Another object of the present invention is to provide a motion guide provided with such rolling member connection belt.

[0015] The above and other objects can be achieved according to the present invention by providing, in one aspect, a rolling member connection belt for holding, to be rotatable, a series of rolling members which circulate in a circulation passage provided with a loaded rolling passage composed of a rolling member rolling portion formed on a track member and another rolling member rolling portion formed on a movable member, a non-loaded return passage formed in the movable member and a pair of rolling direction changing members connecting the loaded rolling passage and the non-loaded return passage to thereby constitute the circulation passage,

> [0016] the rolling member connection belt being made of a metal plate member having a corrugated-shape, in section in a longitudinal direction thereof, formed at least at a portion in the longitudinal direction, the corrugated-shape having peak and valley portions each extending in a direction normal to the longitudinal direction of the metal plate member.

[0017] In a further aspect of the present invention, there is also provided a motion guide device comprising:

[0018] a track member formed with a rolling member rolling portion;

[0019] a movable member formed with another rolling member rolling portion and assembled to the track member to be rotatable relatively thereto;

[0020] a number of rolling members which circulate in a circulation passage provided with a loaded rolling passage composed of both the rolling member rolling portions formed on the track member and the movable member, a non-loaded return passage formed in the movable member and a pair of rolling direction changing members connecting the loaded rolling passage and the non-loaded return passage to thereby constitute the circulation passage; and

[0021] a rolling member connection belt holding the rolling members to be rotatable in the circulation passage,

[0022] the rolling member connection belt being made of a metal plate member having a corrugated-shape, in section in a longitudinal direction thereof, formed at least at a portion in the longitudinal direction, the corrugated-shape having peak and valley portions each extending in a direction normal to the longitudinal direction of the metal plate member.

[0023] According to the above aspects, the connection belt member has a good flexibility even formed from a metal plate, so that the rolling member connection belt can smoothly circulate in a circuit-shaped rolling member circulation passage. Furthermore, since the rigidity of the rolling member connection belt in its width direction is increased, the rolling members can sufficiently be suppressed from wandering during its circulation motion. Moreover, the moving (rolling) speed of the rolling member may be changed at the time when the rolling member moves from the non-loaded area to the loaded area or vise versa. Such speed changing can be effectively absorbed by forming the connection belt with corrugated peak-and-valley portions which extend in its width direction thereof and are flexible (contractable) in its longitudinal direction. Accordingly, the rolling member can be smoothly moved from the non-loaded area to the loaded area, thus being advantageous.

[0024] Furthermore, in preferred embodiments of the above aspects, the metal plate member is provided with a number of rolling member holding holes formed along the longitudinal direction thereof and a plurality of sets of peak-and-valley portions exist in each of the rolling member holding holes.

[0025] The rolling member holding hole is provided, at peripheral portions thereof, with a plurality of claw portions so as to surely hold the rolling member in the hole.

[0026] The peak-and-valley portions may be formed along an entire longitudinal direction of the connection belt.

[0027] According to these preferred embodiments, the rolling members can be held by the plural sets of peak-and-valley portions (corrugated structure) in the accommodation hole, so that the rolling members can be more surely held in comparison with the conventional structure in which the rolling members are supported by a flat-plate shaped connection belt member.

[0028] The natures and further characteristic features of the present invention will be made more clear from the following descriptions made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] In the accompanying drawings:

[0030] **FIG. 1** is a perspective view showing a linear guide provided with a rolling member connection belt as a retainer according to one embodiment of the present invention;

[0031] **FIG. 2** is a sectional view, in a longitudinal direction, of a track rail of the linear guide of **FIG. 1**;

[0032] **FIG. 3** shows a rolling member connection belt and includes **FIG. 3A** being a front view, **FIG. 3B** being a plan view and **FIG. 3C** being a side view;

[0033] **FIG. 4** is an illustrated side view showing another example of the rolling member connection belt;

[0034] **FIG. 5** is an illustrated side view showing a further example of the rolling member connection belt;

[0035] **FIG. 6** is an illustration showing one example of a method of manufacturing the rolling member connection belt;

[0036] **FIG. 7** is an illustration showing another example of a method of manufacturing the rolling member connection belt;

[0037] **FIG. 8** is an illustrated sectional view showing a ball circulation path of one example of a conventional linear guide; and

[0038] **FIG. 9** is a sectional view of the conventional linear guide showing a ball circulation state.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0039] Preferred embodiments of the present invention will be described in detail hereunder with reference to the accompanying drawings.

[0040] **FIG. 1** shows a linear guide **11** to which a rolling member connection belt as a retainer according to the present invention is assembled. The linear guide **11** is a motion guide device for guiding a linear or curvilinear motion of a member, such as table. The linear guide **11** is composed of a track rail **12** as a track member and a movable block **13** as a movable member which is assembled to be movable relative to the track rail **12**. The movable block **13** is mounted, as an object member for guidance, to the track rail **12**. A number of balls **14**, **14** - - - , as rolling members, are disposed between the track rail **12** and the movable member **13** to be rollable.

[0041] The track rail **12** has a linearly extending structure in the longitudinal direction thereof and having, for example, a rectangular section. The track rail **12** is formed with plural rows of ball rolling grooves **12*a***, **12*a*** - - - , as rolling member rolling portion, forming a track for the rolling of the balls **14**, **14**, - - - . Such track rail **12** is manufactured through machine workings including drawings, cutting, grinding and so on. Further, in a case where a curvilinear motion of an object member is guided, a track rail **12** having a curved structure will be utilized.

[0042] The movable block **13** entirely has a straddle-type structure having substantially ⊐-shaped cross-section, and the movable block **13** is composed of a movable block body **16** and end plates **17** and **18** disposed at both ends of the block body **16**. This movable block body **16** is provided with a flat horizontal portion **16***a* opposing to the upper surface of the track rail **12** and a pair of leg (skirt) portions **16***b* facing both side surfaces of the track rail **12** when the movable block **13** is assembled to the track rail **12**.

[0043] The lateral pair of leg portions **16***b* have inside surface portions formed with loaded ball rolling grooves **20**, as rolling member rolling portions, corresponding to ball rolling grooves **12***a* formed on the respective side surfaces of the track rail **12**. The lateral pair of leg portions **16***b* are also formed with ball return passages A, as rolling member returning passages, for returning the balls **14** rolling along the loaded ball rolling grooves **20** in parallel thereto. The ball returning passage A has substantially a circular section having an inner diameter slightly larger than that of the ball **14**.

[0044] Each of the end plates **17** and **18** has a sectional shape substantially identical to the cross-sectional shape of the movable block body **16**. As shown in **FIG. 2, a** rolling member rolling direction changing passage having U-shape is formed at each end portion of the movable block body **16** for guiding the balls **14** by scooping up the balls **14** rolling along the loaded ball rolling passage **20** to the ball return passage A or vise versa. That is, each rolling direction changing passage is composed of an outer peripheral side surface **22** formed in the end plate **17** (**18**) and an inner peripheral side surface as an R-piece portion **23** formed on each of both end portions of the movable block body **16** in the advancing direction. When the end plates **17** and **18** are mated each other and assembled to the movable block body **16**, these outer and inner peripheral side surfaces **22** and **23** constitute U-shaped direction changing passages C at both ends of the movable block body **16** so as to connect the non-loaded return passage A and the loaded ball rolling passage B (which is constituted by the ball rolling groove **12***a* and the non-loaded ball rolling groove **20**). Thus, as mentioned above, by combining the non-loaded return passage A, the loaded rolling passage B and the U-shaped direction changing passages C, the ball circulation passage in form of circuit is constituted.

[0045] The movable block body **16** may be formed through the injection molding of metal material, or manufactured by a machine working including drawing, cutting and/or grinding working. Further, the end plates **17** and **18** may be also manufactured by injection-molding metal material or resin material.

[0046] The plural balls **14, 14**, - - - disposed and arranged in the ball circulation passage are held by a rolling member connection belt **26** to be rotatable. The rolling member holding belt **26** is manufactured, for example, by press-molding a thin metal plate such as stainless steel plate for spring.

[0047] With reference to **FIG. 3 (FIGS. 3A and 3B)** showing the details of the rolling member connection belt **26**, the rolling member connection belt **26** has a shape extending in its longitudinal direction so as to hold a series of balls **14**. The longitudinal end portions thereof are formed to have round portions for smoothly inserting the rolling member connection belt **26** into the passage formed in the movable block **13**.

[0048] The rolling member connection belt **26** is formed with a plurality of ball accommodation holes **26***a* along its longitudinal direction. Claw portions **27***a*, **27***a*, **27***b*, **27***b*, - - - are formed to the peripheral portions of the ball accommodation holes **26***a* so as to surely hold the balls **14**, respectively. That is, four claws **27***a*, **27***a*, **27***b*, **27***b* are formed to each of the ball accommodation holes **26***a* so as to extend inside the hole **26***a* in a manner such that a pair of claws **27***a*, **27***a* arranged to diagonal positions are folded in one direction from a flat plane side on which the rolling member connection belt **26** lies and the other pair of claws **27***b*, **27***b* are also folded in the other direction to thereby form a ball holding structure.

[0049] As can be seen from **FIG. 3**, the rolling member connection belt **26** has a corrugated structure in which a plurality of peak portions **31, 31**, - - - and valley portions **32, 32**, - - - alternatively appear in sets in its longitudinal direction "L" in **FIG. 3A** so as to be expandable or contractable (flexible) in its longitudinal direction. Each of the peak and valley portions **31** and **32** extends in its width direction "W" normal to the longitudinal direction L. Within a range (diameter) "D" in the longitudinal direction of the ball accommodation hole **26***a* of the rolling member connection belt **26**, there exist a plurality of sets of the corrugated peak and valley portions **31** and **32** as shown in **FIG. 3B**. In other wards, the length "D" in the longitudinal direction of the hole **26***a* is larger than the pitch between the adjacent peaks **31** or valleys **32**.

[0050] Further, in an alternation, the rolling member connection belt **26** has such corrugated shape partially in its longitudinal direction in place of the entire length thereof. Furthermore, the corrugated shape is not limited to that shown in **FIG.** 3B and other shapes such as sine-curve shape, circular-arc shape or triangular-saw-teeth shape may be adopted as far as it includes plural sets of peak-and-valley arrangements.

[0051] **FIG. 4** shows another example of the rolling member connection belt **26**. In this example, the pitch P between the peak portions **31** or valley portions **32** is made substantially equal to the thickness H (i.e., height between the top of the peak portion **31** and the bottom of the valley portion **32**) of, for instance, 0.3 mm. This pitch P is made extremely small in comparison with various sizes of balls **14, 14***a*, **14***b*, - - - , and a plurality of peak and valley portions **31** and **32** exist within the range "D" of the ball accommodation hole **26***a* in the longitudinal direction of the rolling member (ball) connection belt **26**.

[0052] **FIG. 5** shows another example of the rolling member connection belt **26**. In this example, the thickness t1 of the rolling member connection belt **26** at the peak portion **31** and the valley portion **32** is larger than the thickness t2 (t1>t2) at an intermediate portion **33** connecting the peak and valley portions **31** and **32**. According to this example, the rolling member connection belt **26** is made to be more flexible or easily bendable at its intermediate portion **33** and, hence, the rolling member connection belt **26** will be more easily expanded or contracted in its longitudinal direction.

[0053] Incidentally, as shown in **FIG. 2** and as mentioned before, the circulation passage or path, along which the balls **14**, **14**, - - - roll, has a circuit structure composed of the linearly extending loaded rolling passage B, the linearly extending non-loaded return passage A and a pair of U-shaped direction changing passages C connecting the passages A and B. This circuit-shaped circulation passage lies in one plane, and the rolling member connection belt **26** is arranged so that the width direction "W" thereof is normal to the plane in which the ball circulation passage exists. The ball circulation passage is provided with a guide groove for guiding both lateral ends of the rolling member connection belt **26**.

[0054] According to the movement of the movable block **13** along the track rail **12**, the rolling member (ball) connection belt **26** together with the balls **14** is moved, while being loaded, from one end to the other end of the loaded rolling passage B, thereafter, scooped up by one end plate **18** at one end and then returned to the non-loaded return passage A via one direction changing passage C. The rolling member connection belt and the balls **14** are thereafter returned to the other one end of the loaded rolling passage B via the other direction changing passage C. Thus, the rolling member connection belt **26** is moved, in the linearly extending shape, in the loaded rolling passage B and the non-loaded return passage A, and on the other hand, is moved, in the bent fashion in the U-shaped direction changing passages C. During such circulation motion in the ball circulation passage, the rolling member connection belt **26** repeats the above-mentioned motion.

[0055] According to the described embodiments, the rolling member connection belt **26** has a corrugated shape having peak-and-valley portions **31** and **32** each extending in its width direction and arranged in its longitudinal direction, thus being easily bent in the direction changing passage. Accordingly, the rolling member connection belt **26** can easily and smoothly circulate in the circuit-shaped circulation passage. On the other hand, the rigidity in the width direction of the rolling member connection belt **26** increases, so that the balls **14** can be suppressed from being drifted or wandering during their circulation motion.

[0056] Further, the balls **14**, **14**, - - - may change in their speeds at the time when the balls **14** move from the non-loaded return passage A and the non-loaded area constituted by the direction changing passage C to the loaded area constituted by the loaded rolling passage B, or from the loaded area to the non-loaded area. In addition, because of the corrugated shape of the rolling member connection belt **26** expandable in its longitudinal direction, the change in speed can be absorbed and, hence, the transferring motion of the balls **14**, **14**, - - - from the non-loaded area to the loaded area will be smoothly performed.

[0057] Moreover, according to the embodiments of the rolling member connection belt **26** of the present invention, the injection molding of the resin material can be performed substantially with no difficulty for manufacturing a compact rolling member connection belt, and the strength at the connecting portion of the rolling member holding member (retainer) and the belt can be ensured substantially with no problem. Thus, the rolling member connection belt having compact and sufficient strength can be provided. Moreover, since the rolling member connection belt is formed of metal material, it is usable at a high temperature even of more than 100° C.

[0058] **FIGS. 6 and 7** represent a method of manufacturing the rolling member connection belt **26** of the structure mentioned above. The corrugated shape of the rolling member connection belt **26** is formed, for example, as shown in **FIG. 6**, through the press-working in which the flat connection belt is squeezed between lower and upper dies **41** and **42** to which corrugated shapes are formed. This press-working will be carried out after punching a metal plate into a flat belt shape or before punching the metal plate. Furthermore, the corrugated shape may be formed to the rolling member connection belt **26** by, as shown in **FIG. 7**, drawing out the metal belt from a roll and then clamping it between a pair of roll dies formed with corrugated shapes.

[0059] Further, it is to be noted that the present invention is not limited to the described embodiments and many other changes and modifications without departing from the scopes of the appended claims.

[0060] For example, although, in the described embodiment, single row of ball rolling groove is formed to each of the side surfaces of the track rail **12**, the number of rows and their arrangement may be optionally changed in consideration of magnitude of load and direction of loading. Furthermore, the sectional shape of the track rail **12** may be changed, and in addition, rollers may be utilized in place of balls as rolling members.

[0061] The present application claims priority under 35 U.S.C § 119 to Japanese Patent Application No. 2003-52936 filed Feb. 28, 2003 entitled "ROLLING MEMBER CONNECTION BELT AND MOTION GUIDE DEVICE PROVIDED WITH SAME". The contents of that application are incorporated herein by reference in their entirety.

What is claimed is:

1. A rolling member connection belt for holding, to be rotatable, a series of rolling members which circulate in a circulation passage provided with a loaded rolling passage composed of a rolling member rolling portion formed on a track member and another rolling member rolling portion formed on a movable member, a non-loaded return passage formed in the movable member and a pair of rolling direction changing members connecting the loaded rolling passage and the non-loaded return passage to thereby constitute the circulation passage,

said rolling member connection belt being made of a metal plate member having a corrugated-shape, in section in a longitudinal direction thereof, formed at least at a portion in the longitudinal direction, said corrugated-shape having peak and valley portions each extending in a direction normal to the longitudinal direction of the metal plate member.

2. A rolling member connection belt according to claim 1, wherein said metal plate member is provided with a number of rolling member holding holes formed along the longitudinal direction thereof and a plurality of sets of peak-and-valley portions exist in each of the rolling member holding holes.

3. A rolling member connection belt according to claim 2, wherein said rolling member holding hole is provided, at peripheral portions thereof, with a plurality of claw portions so as to surely hold the rolling member in the hole.

4. A rolling member connection belt according to claim 1, wherein said peak-and-valley portions are formed along an entire longitudinal direction of the connection belt.

5. A motion guide device comprising:

a track member formed with a rolling member rolling portion;

a movable member formed with another rolling member rolling portion and assembled to the track member to be rotatable relatively thereto;

a number of rolling members which circulate in a circulation passage provided with a loaded rolling passage composed of both the rolling member rolling portions formed on the track member and the movable member, a non-loaded return passage formed in the movable member and a pair of rolling direction changing members connecting the loaded rolling passage and the non-loaded return passage to thereby constitute the circulation passage; and

a rolling member connection belt holding the rolling members to be rotatable in the circulation passage,

said rolling member connection belt being made of a metal plate member having a corrugated-shape, in section in a longitudinal direction thereof, formed at least at a portion in the longitudinal direction, said corrugated-shape having peak and valley portions each extending in a direction normal to the longitudinal direction of the metal plate member.

6. A motion guide device according to claim 5, wherein said metal plate member is provided with a number of rolling member holding holes formed along the longitudinal direction thereof and a plurality of sets of peak-and-valley portions exist in each of the rolling member holding holes.

7. A motion guide device according to claim 5, wherein said peak-and-valley portions are formed along an entire longitudinal direction of the connection belt.

* * * * *

US 20040093970A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2004/0093970 A1

(43) Pub. Date: May 20, 2004

Iida et al.

(54) LINEAR ACTUATOR

(75) Inventors: **Katsuya Iida**, Yamanashi (JP); **Toshiaki Kadono**, Yamanashi (JP); **Takeomi Kawakami**, Yamanashi (JP); **Ryuji Furusawa**, Yamanashi (JP)

Correspondence Address:
ARMSTRONG, KRATZ, QUINTOS, HANSON & BROOKS, LLP
1725 K STREET, NW
SUITE 1000
WASHINGTON, DC 20006 (US)

(73) Assignee: **THK CO., LTD**, Tokyo 141-0031 (JP)

(21) Appl. No.: **10/415,097**

(22) PCT Filed: **Jul. 31, 2002**

(86) PCT No.: **PCT/JP02/07771**

(30) **Foreign Application Priority Data**

Aug. 30, 2001 (JP) 20011-262222

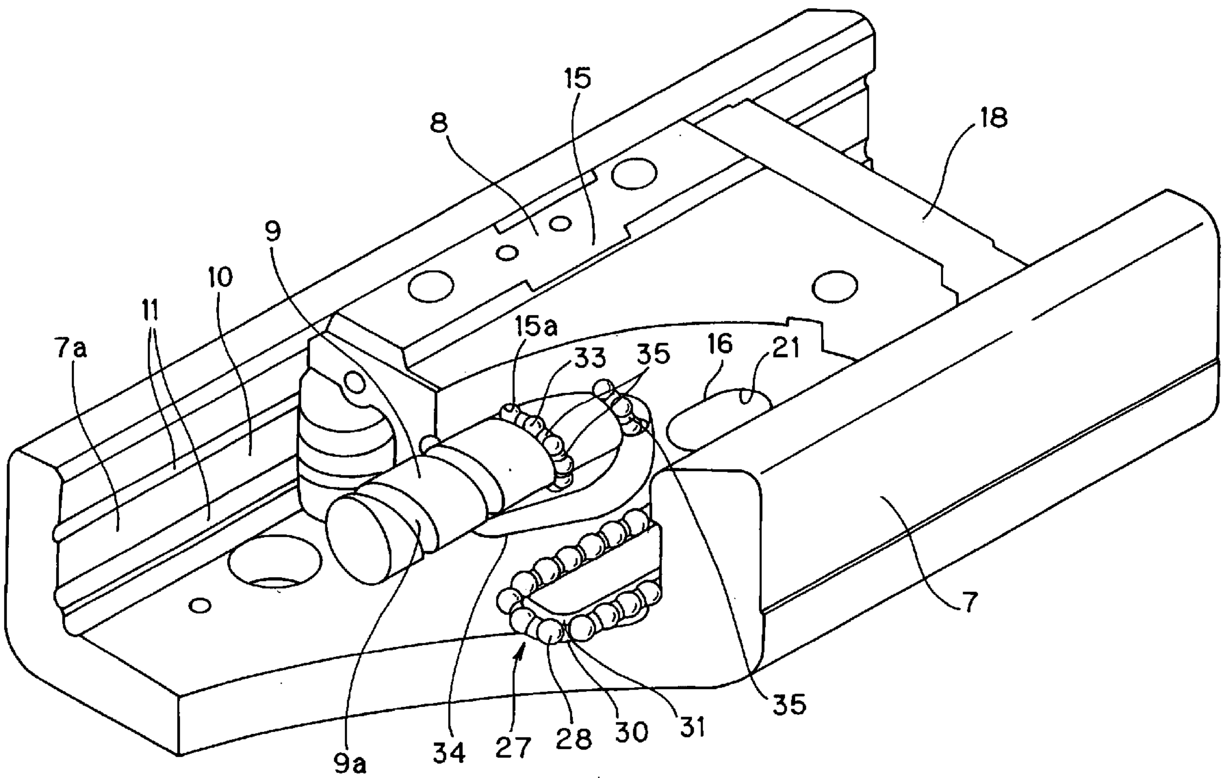
Publication Classification

(51) **Int. Cl.**^{7} **F16H 3/06**

(52) **U.S. Cl.** **74/89.33**; 74/424.88; 384/51

(57) **ABSTRACT**

A linear actuator realizing low generation of dust and low generation of noise and bearing a large axial load is provided. A plurality of spacers 30, - - - , each having at its both ends spherical recessed portions corresponding to curved surfaces of balls 28, - - - , are arranged between the balls 28, - - - of the guide portion of the linear actuator, and the spacers 30, - - - are connected to each other in series by belt-shaped members 31 having flexibility. On the other hand, a plurality of spacers 35, - - - , each having at its both ends spherical recessed portions corresponding to curved surfaces of balls 33, - - - for the screw shaft of a screw portion, are arranged between the balls 33, - - - in a manner separated from each other. By selecting a retainer 27 and the spacer 35 in accordance with the shapes of the guide portion and the screw portion, unnecessary contacting of the mutual balls and unnecessary contacting of the balls to the surrounding circulation passage can be prevented, thus realizing low generation of dust and low generation of noise.



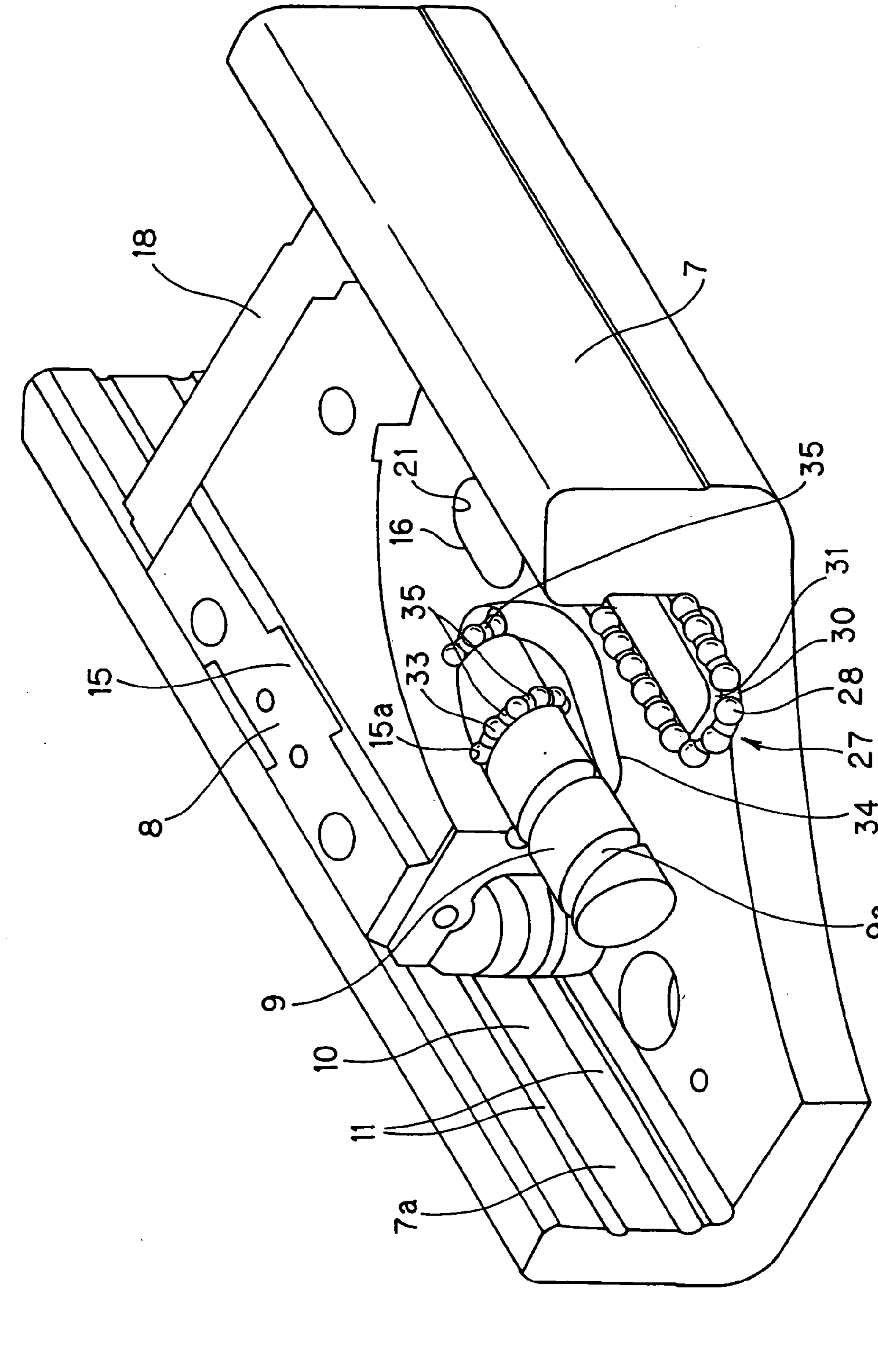


FIG. 1

FIG. 2

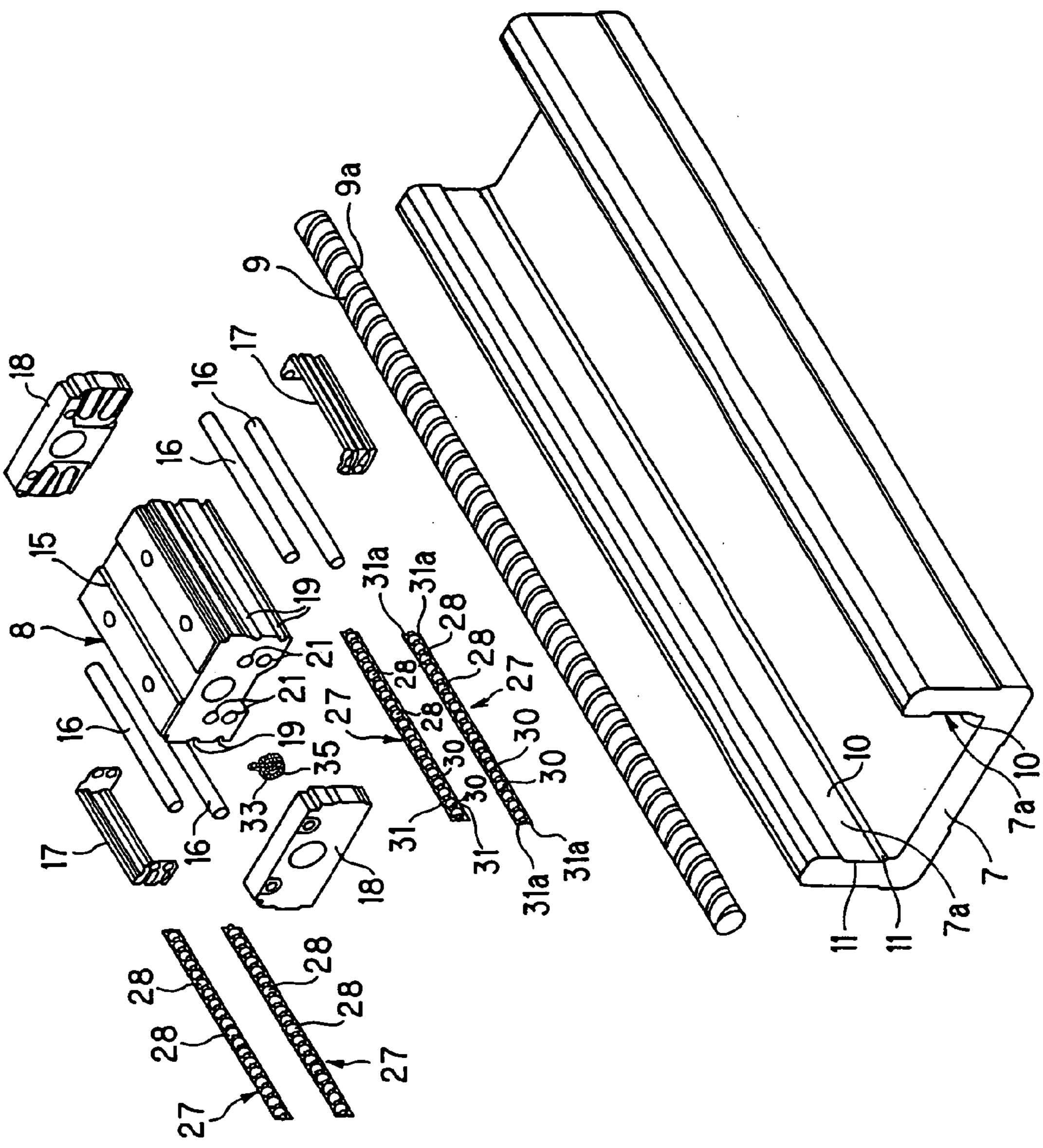


FIG. 3

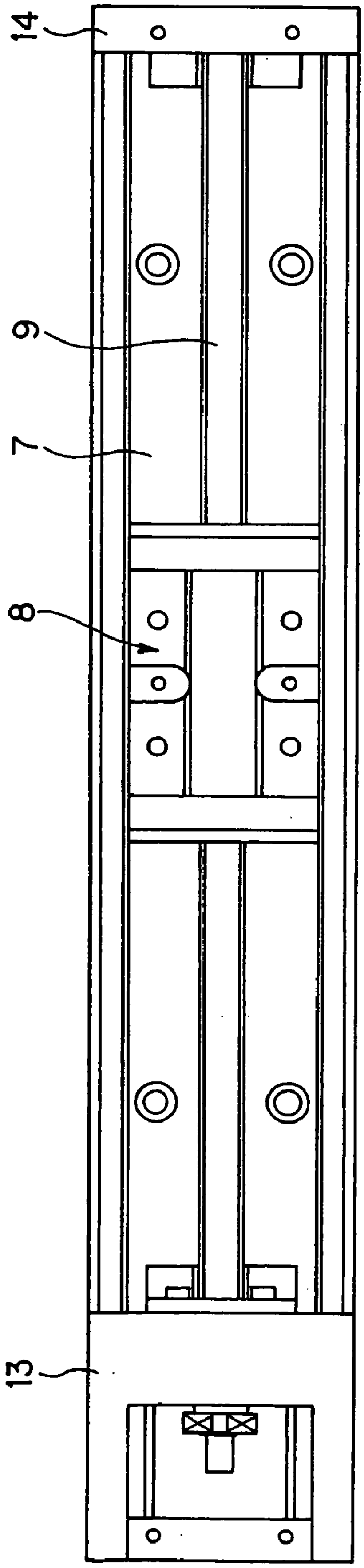


FIG. 4

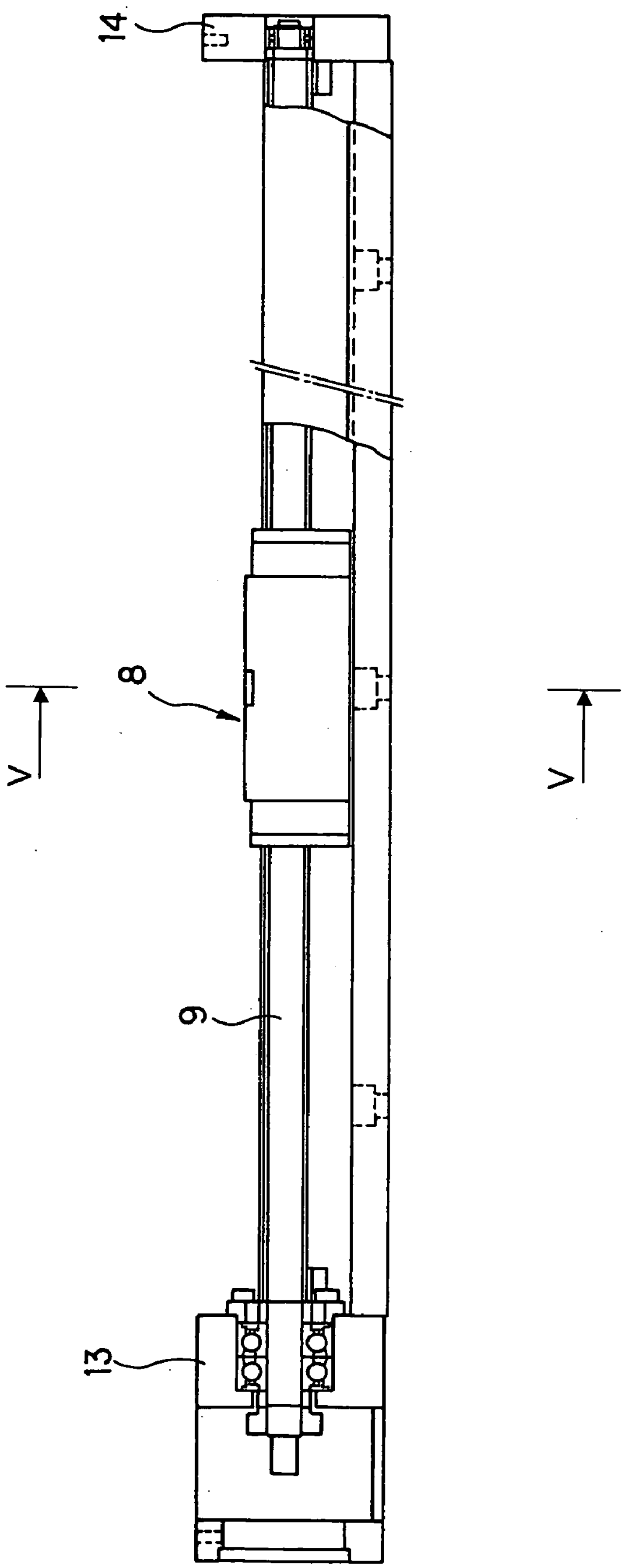


FIG. 5

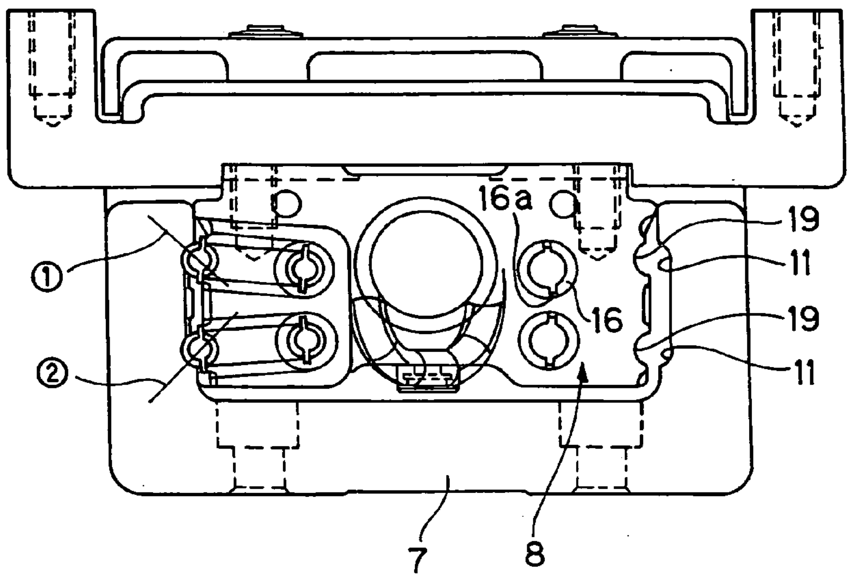


FIG. 6

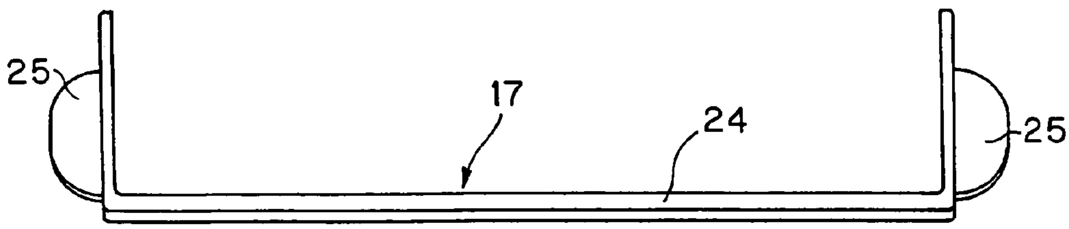


FIG. 7

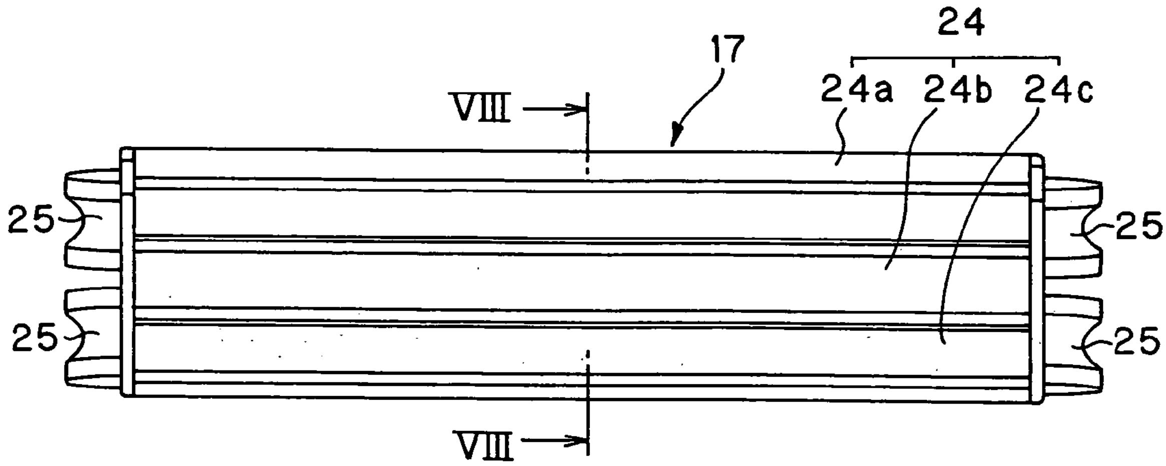


FIG. 8

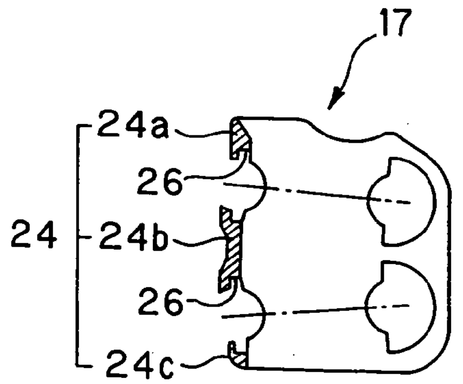


FIG. 9

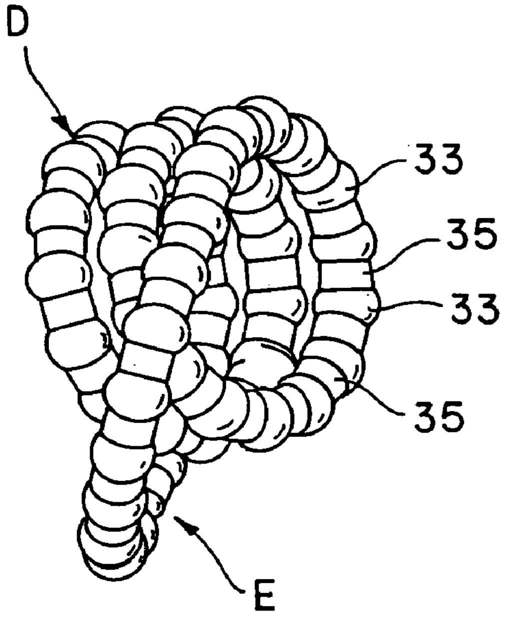


FIG. 10

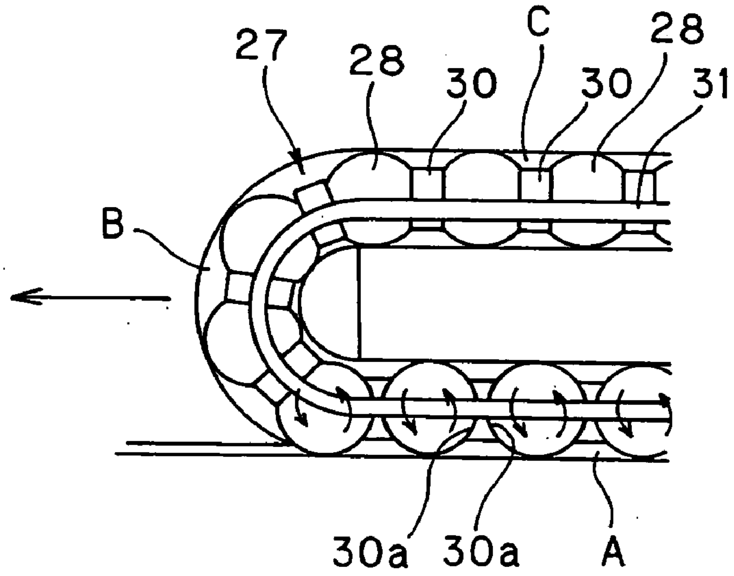
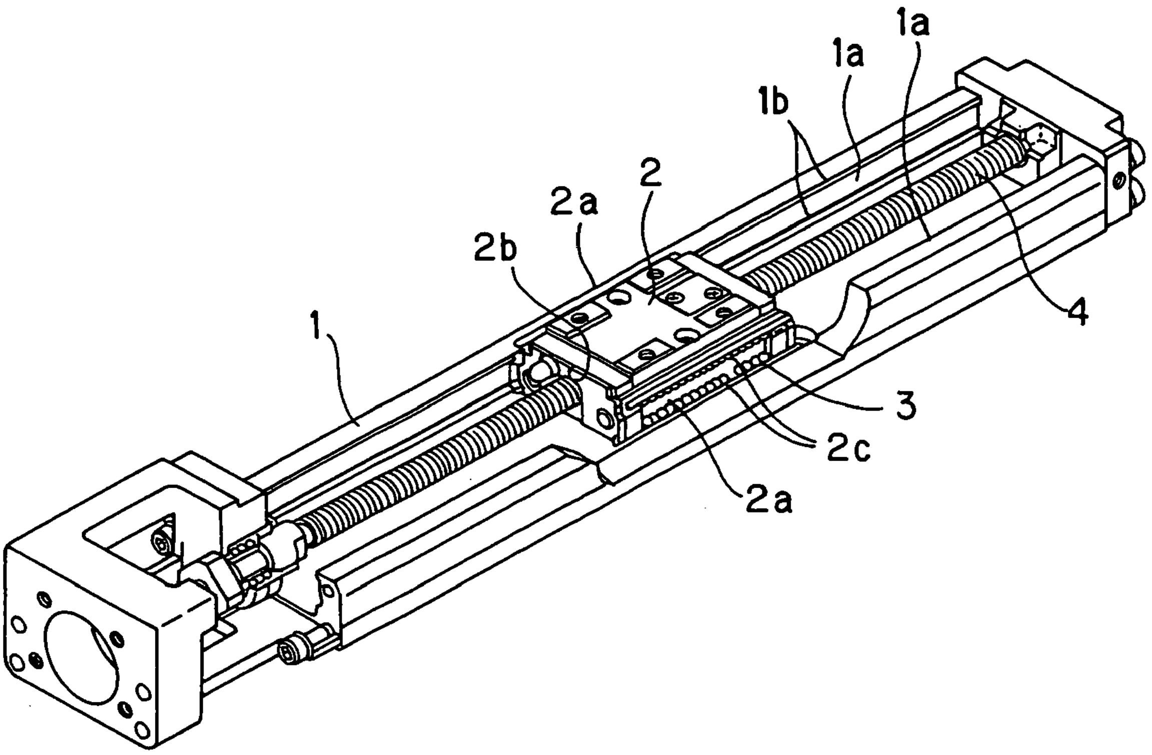


FIG. 11



LINEAR ACTUATOR

TECHNICAL FIELD

[0001] The present invention relates to an actuator comprising a track member having substantially U-shape in section and a movable member integrally provided with guide portions formed on both side surfaces thereof and a ball screw portion formed in a central portion thereof.

BACKGROUND OF THE INVENTION

[0002] As shown in **FIG. 11**, there is known a linear actuator provided with an outer rail **1** having substantially U-shape and an inner block **2** disposed inside the outer rail **1** and integrally provided with guide portions **2***a*, **2***a* formed on both side surfaces thereof and a ball screw portion **2***b* formed in a central portion thereof.

[0003] The guide portions **2***a*, **2***a* have the following structures. The outer rail **1** has a pair of opposing inner wall sections **1***a*, **1***a*, on which upper and lower two rows of ball rolling grooves **1***b*, **1***b* are formed, respectively. On the other hand, the inner block **2** disposed inside the outer rail **1** has both side surfaces, on which loaded ball rolling groove **2***c*, **2***c* are formed so as to oppose to the ball rolling grooves **1***b*, **1***b*, and a number of balls **3**, **3**, - - - are disposed to be movable between the mutually opposing ball rolling grooves **1***b*, **1***b* and loaded rolling grooves **2***c*, **2***c*.

[0004] The screw portion **2***b*, on the other hand, has the following structure. A screw shaft **4** penetrates the central portion of the inner block **2**. The screw shaft **4** is formed, on its outer peripheral surface, with a spiral ball rolling groove. A spiral loaded ball rolling groove corresponding to this spiral ball rolling groove is formed on a through hole of the inner block **2**.

DISCLOSURE OF THE INVENTION

[0005] Since such a linear actuator has a integrally-provided guide portions **2***a*, **2***a* and ball screw portion **2***b*, the actuator provides functions, as actuator, of high rigidity and high performance in the minimum space. Accordingly, such linear actuator has been mainly utilized for a semiconductor manufacturing system or a liquid crystal manufacturing system, or under a clean environment in a medical or like equipment. For such clean environment, it is required to generate less dust or less noise, or like.

[0006] In order to reduce the dust to be generated from the actuator, a driving portion including a guide member of the actuator is covered by a case, to which air-sucking may be further conducted. However, even if the driving portion including the guide member is covered by the case, dust is yet generated from a sliding portion, therefore it is not fundamentally solution.

[0007] Moreover, a preload is applied to the ball screw portion **2***b* of the linear actuator for enhancing the positioning performance. The inner block **2** of the linear actuator is, however, different from a ball screw composed of a screw shaft and a nut, and has a structure in which the guide portions **2***a*, **2***a* and the ball screw portion **2***b* are integrally formed. According to such structure, in a manufacturing process, there is not adopted a method or system for applying a preload, as like a general ball screw, by displacing a phase of a ball rolling groove formed to the nut, and in substitution therefor, there is adopted an over-size preloading method or system in which over-sized balls, each having a diameter slightly larger than a gap between the screw shaft **4** and the inner block **2**, are arranged. In the case where this over-size preloading method is adopted, a spacer ball, having a diameter slightly smaller than that of the over-size ball, is arranged between the over-sized balls for smooth circulation of the balls. However, the arrangement of such spacer balls reduces the number of the balls to which load is applied, and load in the axial direction to be loaded will be reduced.

[0008] Then, the present invention has an object to provide a linear actuator which can realize reduced dust generation and low noise generation and providing a large load in the axial direction to be loaded.

[0009] The present invention will be explained hereunder, in which although reference numerals on the accompanying drawings are added with parentheses in order for easy understanding of the invention, the present invention is not limited to an embodiment illustrated in the drawings by the added reference numerals.

[0010] The inventor of the subject application conceived to locate spacers between rolling members at a guide portion and a screw (thread) portion, the spacer having recessed portions, on both end portions of a rolling member, each having a shape corresponding to a curved surface of the rolling member, in order to prevent metal contact of the rolling members and to perform smoothly arranged movement of the rolling members. Furthermore, in view of the fact that circulation motion of the rolling member at the guide portion is a two-dimensional motion in a plane in which a linear loaded rolling passage and a linear return passage are connected through a U-shaped direction changing passage and the circulation motion of the rolling member at the screw portion is a complicated spiral three-dimensional motion, there was conceived that a plurality of spacers arranged in the guide portion are connected to each other in series by means of belt-shaped member and a plurality of spacers arranged in the screw portion are, on the contrary, separated from each other, thus preventing the rolling members from contacting with the circulation passages surrounding the rolling members.

[0011] More specifically, the above object can be achieved by providing a linear actuator of the invention of claim **1**, which comprises a track member **(7)**, having U-shape in section, provided with inner wall surfaces **(7***a*, **7***a***)** opposing to each other, a movable member **(8)** disposed between the inner wall surfaces **(7***a*, **7***a***)** and a screw shaft **(9)** penetrating the movable member **(8)**, in which rolling member rolling portions **(11)** are formed on the inner wall surfaces of the track member **(7)**; loaded rolling member rolling portions **(19)** are formed on both side surfaces of the movable member **(8)** so as to correspond to the rolling member rolling portions **(11)**; rolling member return passages (C) extending in parallel to each other with a predetermined distance from the loaded rolling member rolling portions **(19)** and direction changing passages (B) each connecting the loaded rolling member rolling portions **(19)** and the rolling member return passages (C) are formed in the movable member so as to circulate the rolling members **(28**, - - -) rolling between the rolling member rolling portions **(11)** and the loaded rolling member rolling portions **(19)**; a rolling member rolling portion (**9**a) for the screw shaft (**9**) in form of spiral is formed to an outer peripheral surface of the screw shaft (**9**); a loaded rolling member rolling passage (**15**a) for the screw shaft is formed on the through hole formed in the movable member so as to correspond to the rolling member rolling portion (**9**a) of the screw shaft; and a rolling member return passage (E) for circulating the rolling member (**33**, - - -) for the screw shaft rolling between the rolling member rolling portion (**9**a) for the screw shaft and the loaded rolling member rolling portion (**15**a) for the screw shaft is formed in the movable member,

[0012] wherein a plurality of spacers (**30**, - - -), each having, at both ends thereof, curved recessed portions (**30**a, - - -) corresponding to curved surface of the rolling member (**28**,- - -) are arranged between the rolling members, the plural spacers (**30**, - - -) being connected in series by belt-shaped members (**31**, **31**) having flexibility;

[0013] a plurality of spacers (**35**, - - -), each having, at both ends thereof, curved recessed portions corresponding to the curved surface of the rolling member (**33**, - - -), are disposed between the rolling members for the screw shaft in a manner separated from each other; and

[0014] a holding member (**17**) extending along both side edges of the loaded rolling member rolling portion (**19**) is mounted to the movable member (**8**) for preventing the rolling member (**28**, - - -) held by the belt-shaped members (**31**, **31**) and the spacers (**30**, - - -) from coming off at a time when the movable member (**8**) is removed from the track member (**7**).

[0015] According to the present invention, a plurality of spacers, having curved recessed portions corresponding to the curved surfaces of the rolling members, are disposed between the rolling members of the guide portion and the screw portion, so that the mutual contact between the respective metal rolling members can be prevented. Furthermore, since the plural spacers arranged in the guide portion, in which two-dimensional motion is carried out, are connected to each other in series by the belt-shaped members, the rolling members circulate in the constant track, and unnecessary contacting of the rolling members and their surrounding circulation passage can be prevented. In the screw portion, on the other hand, the twisting motion around the advancing direction is required as well as the two-dimensional and three-dimensional direction changing motions, so that unnecessary contacting of the rolling members and their surrounding circulation passage can be prevented by separating the spacers without connecting the spacers by the belt-shaped members. Thus, since the mutual contact of the rolling members and the unnecessary contacting of the rolling members and their surrounding circulation passage can be prevented, low generation of dust or like and low generation of noise can be realized.

[0016] Still furthermore, by arranging the spacers, each having curved recesses at its both end portions corresponding to the curved surface of the rolling member, the distance between the adjacent balls can be shortened in comparison with the case of using the spacer balls, for example. Accordingly, there is provided a linear actuator having a large axial load to be applied.

[0017] The invention of claim **2** is characterized, in the linear actuator of claim **1**, in that the rolling member rolling passage composed of the loaded rolling member rolling passage (**19**, A), the rolling member return passage (C) and the direction changing passage (B) is provided with a guide portion (**16**a, **26**) for guiding the belt-shaped member (**31**, **31**).

[0018] According to this invention, since the belt-shaped member is guided by the guide portions provided for the rolling member circulation passage, the belt-shaped member circulates in the more constant track, and hence, the plural spacers connected by the belt-shaped member and the rolling members disposed between the spacers can be also circulated in the more constant track.

[0019] Still furthermore, according to the invention of claim **3**, in the linear actuator of claim **1** or **2**, it is characterized in that the return passage constituting member (**16**) constituting the return passage (C), the direction changing inner periphery side constituting member (**25**) constituting the inner periphery side of the direction changing member (B), the direction changing outer periphery side constituting member (**18**) constituting the outer periphery side of the direction changing member (B), and the holding member (**17**) are formed from resin material independent from a body portion of the movable member (**8**).

[0020] According to this invention, in the guide portion, the metallic contact is only made between the rolling member and the rolling member rolling portion of the track and between the rolling member and the loaded rolling member rolling portion, so that the generation of dust and noise can be suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] In the accompanying drawings:

[0022] **FIG. 1** is a perspective view, partially cutaway, showing an essential portion of a linear actuator according to one embodiment of the present invention.

[0023] **FIG. 2** is a developed perspective view of the linear actuator.

[0024] **FIG. 3** is a plan view of the linear actuator.

[0025] **FIG. 4** is a side view, partially in section, of the linear actuator.

[0026] **FIG. 5** is a sectional view taken along the line V-V in **FIG. 4**.

[0027] **FIG. 6** is a plan view of a retainer.

[0028] **FIG. 7** is a side view of the retainer.

[0029] **FIG. 8** is a sectional view taken along the line VIII-VIII in **FIG. 7**.

[0030] **FIG. 9** is a perspective view of balls and spacers to be accommodated in a ball circulation passage of a screw portion.

[0031] **FIG. 10** is a schematic view of the balls and the retainer to be accommodated in a ball circulation passage of a guide portion.

[0032] **FIG. 11** is a perspective view of a linear actuator of conventional structure.

BEST MODE FOR EMBODYING THE INVENTION

[0033] FIGS. **1** to **4** represent a linear actuator according to one embodiment of the present invention, in which **FIG. 1** is a perspective view, partially cutaway, showing an essential portion of a linear actuator, **FIG. 2** is a developed perspective view, **FIG. 3** is a plan view and **FIG. 4** is a side view, partially in section, of the linear actuator.

[0034] The linear actuator is provided with an outer rail **7** as track member having an approximately U-shaped section and an inner block **8** as movable member disposed inside the outer rail and having an integral structure of guide portions disposed on both side surface sides and a central ball screw portion. When a screw shaft **9** screw-engaged with the inner block **8** is rotated by a driving source such as electric motor, not shown, the inner block **8** is linearly moved along the outer rail **7**. In such a linear actuator, since the guide portion and the ball screw portion are integrally composed, functions as actuator having high rigidity and high performance are attained in the minimum space.

[0035] Hereunder, the guide portion of the linear actuator will be first mentioned. The outer rail **7** has an approximately U-shaped structure having a pair of opposing inner wall surfaces **7***a*, **7***a*. The inner wall surfaces **7***a*, **7***a* are formed with recessed grooves **10, 10** so as to extend throughout the full length thereof, and two rows of ball rolling grooves **11, 11** are formed, as rolling member rolling portion, at upper and lower corner portions of each of the recessed grooves **10, 10**, respectively. That is, upper and lower two ball rolling grooves **11, 11** are formed on each of the paired inner wall surfaces **7***a*, **7***a* of the outer rail **7** (totally, four ball rolling grooves). Each of the ball rolling groove **11** is composed of a so-called single circular arc groove having a curvature of its section slightly larger than a radius of a ball. As shown in **FIGS. 3 and 4**, housings **13** and **14** supporting a screw shaft **9** to be rotatable are disposed at longitudinal both end portions of the outer rail **7**. The housings **13, 14** and the outer rail **7** are connected by fastening means such as bolts. A drive source is mounted to the housing **13** and a joint is disposed between the screw shaft and an output shaft of the drive source.

[0036] As shown in **FIGS. 1 and 2**, the inner block **8** is disposed so as to be clamped between the inner wall surfaces **7***a*, **7***a* of the outer rail **7**. The inner block **8** comprises a block body **15**, a resin mold member (including return passage constituting member **16** - - - and holding members **17, 17**) assembled with the block body **15** and end plates **18, 18** mounted to both end surfaces of the block body **15**.

[0037] Loaded ball rolling grooves **19, 19** as upper and lower two rows of loaded rolling member rolling grooves are formed on both the side surfaces of the block body **15** so as to oppose respectively to the ball rolling grooves **11, 11** of the outer rail **7**. That is, two loaded ball rolling groove **19, 19** are formed on each of the side surfaces of the block body **15** (i.e., totally four grooves **19**). Each of these loaded ball rolling grooves is also composed of a so-called single circular arc groove having a curvature of its section slightly larger than the radius of the ball. A loaded ball rolling passage as a portion of ball circulation passage (rolling member circulation passage) in which the balls circulate is formed between each of the ball rolling grooves **11** of the outer rail **7** and each of the loaded ball rolling grooves **19** of the inner block **8**.

[0038] **FIG. 5** shows a section of the linear actuator, and with reference to this **FIG. 5**, contact angle line of ball rows will be explained hereunder. The contact angle line means, herein, a line connecting a contact point of the ball and the ball rolling groove **11** of the outer rail **7** and a contact point of the ball and the loaded ball rolling groove **19** of the inner block **8**. In this linear actuator, four rows of loaded ball rolling passages are formed, and accordingly, four contact angle lines exit. The upper two contact angle lines ① inclines by, for example, 45° from a horizontal line so as to be directed obliquely upward towards the outside from the center of the actuator and the lower two contact angle lines ② inclines by, for example, 45° from a horizontal line so as to be directed obliquely downward towards the outside from the center of the actuator. According to such structure, there is provided a linear actuator capable of bearing loads in four directions including radial direction (lower direction), opposite radial direction (upper direction) and horizontal direction (including lateral both directions).

[0039] As shown in **FIGS. 1 and 2**, in the block body, there are formed two through holes **21, 21** extending in parallel with a predetermined distance from the upper and lower two rows of loaded ball rolling grooves **19, 19**, respectively, formed on both side portions of the block body. Return passage constituting members **16**, - - - formed from a resin material and constituting ball return passages are inserted into these through holes **21**, - - - , respectively. On these return passage constituting members **16**, - - - , there are formed guide grooves **16***a* (guide portions) for guiding a belt-like member of a retainer, mentioned hereinlater, so as to extend in its axial direction (see **FIG. 5**).

[0040] The inner block **8** is formed with a U-shaped direction changing passage for circulating the balls by connecting the loaded ball rolling passage and the ball return passage. A circuit-shaped ball circulation passage is composed by the loaded ball return passage, the direction changing passage and the ball return passage. Four, two in each lateral side, rows of such ball circulation passages are formed. Each ball circulation passage is formed in one plane so that the balls circulate in the ball circulation passage two-dimensionally. To this ball circulation passage, a guide portion for guiding the belt-shaped portion of the retainer is arranged around the entire periphery.

[0041] The outer peripheral side of the direction changing passage is formed on the end plate **18** as an outer peripheral side constituting member of the direction changing passage, and the inner peripheral side of the direction changing passage is formed on the holding member as an inner peripheral side constituting member of the direction changing passage. By combining these end plate **18** and holding member **17**, the guide groove (guide portion) for guiding the belt-like member of the retainer in the direction changing passage is formed.

[0042] FIGS. **6** to **8** represent the holding member. The holding member **17** is provided with holding portions **24** extending along both side edges of the loaded ball rolling groove **19** and preventing the ball held by the retainer from coming off from the outer rail **7** at the time of removal of the inner block **8** from the outer rail **7** and provided with direction changing passage inner peripheral side constituting portions **25**, - - - , constituting the inner peripheral side of the direction changing passage, disposed at longitudinal both end portions of the holding portions **24**. When such holding member **24** is mounted to the block body **15**, it cooperates with the outer side surface of the block body **15** to thereby form the guide portion **26** (guide groove) for guiding the belt-shaped member of the retainer.

[**0043**] The holding portion **24** includes a first holding piece **24***c* for holding the lower side of the retainer mounted to the lower side ball circulation passage, a second holding piece **24***b* for holding the upper side of the retainer mounted to the lower side ball circulation passage and mounted to the upper side ball circulation passage, and a third holding piece **24***a* for supporting the upper side of the retainer mounted to the upper side ball circulation passage. Each of the respective direction changing passage inner periphery constituting members **25** has an approximately semicircular-arc shape.

[**0044**] These holding members **17**, **17**, return passage constituting members **16**, - - - and end plates **18**, **18** are independently formed from resin material, which are then assembled with the block body **15**.

[**0045**] As shown in **FIG. 2, a** number of balls **28**, - - - supported by the retainer **27** to be rotatable and slidable are accommodated in each ball circulation passage. The retainer **27** is provided with a plurality of spacers **30**, - - - each disposed between the balls and belt-shaped members **31**, **31** connecting both side edge portions of the respective spacers **30**, **30** (see **FIG. 10**). The spacers **30**, - - - are formed so as to provide a cylindrical shape having an outer diameter smaller than a diameter of the ball **28**. Each of the spacers **30** is formed, at its axial both ends, with spherical recessed portions **30***a*, **30***a* as curved recesses each having a curvature radius substantially equal to the radius of the ball **28** so as to correspond thereto. In an arrangement that the spacers **30**, - - - are disposed between the balls **28**, - - - , the axes of the spacers **30**, - - - lie on the line connecting the centers of the balls **28**, - - - . The axial length of the spacer **30** is set to be thin so that the interval of the adjacent balls **28**, **28** has necessarily minimum value.

[**0046**] The belt-shaped members **31**, **31** have constant thickness and are connected to both sides of the side surface of the spacer **30**. These belt-shaped members **31**, **31** have flexibility so as to flexibly cooperate with the direction changing passage. In an interfering position of the belt-shaped members **31**, **31** and the balls **28**, - - - , there is formed a cut-in portion having a curvature radius substantially equal to the radius of the ball **28**. The belt-shaped members **31**, **31** project over both the side edge portions of the balls **28**, and the projected portions are guided by the guide portions formed in the ball circulation passages. Furthermore, corner portions of the longitudinal both end portions of belt-shaped members **31**, **31** are formed so as to provide round portions **31***a*, **31***a*. The spacers **30**, - - - and the belt-shaped members **31**, **31** are integrally formed from synthetic resin material through an injection molding process.

[**0047**] Hereunder, the screw portion of the linear actuator will be explained. As shown in **FIG. 1**, the screw shaft **9** penetrates the central portion of the inner block **8**. On the outer peripheral surface of the screw shaft **9**, there is formed a ball rolling groove **9***a* for the screw shaft **9** as rolling member rolling groove for the spiral screw shaft. This ball rolling groove **9***a* for the screw shaft **9** has a cross section formed into a gothic-arch including two circular-arc portions having a curvature radius slightly larger than the radius of a ball **33** for the screw shaft. On the other hand, the through hole formed in the block body **15** is also formed with a loaded ball rolling groove **15***a* for the screw shaft as loaded ball rolling member for the screw shaft so as to correspond to the ball rolling groove **9***a* for the screw shaft. This loaded ball rolling groove **15***a* for the screw shaft **9** also has a cross section formed into a gothic-arch including two circular-arc portions having a curvature radius slightly larger than the radius of the ball **33** for the screw shaft. A loaded rolling passage of the ball circulation passage is composed of the ball rolling groove **9***a* for the screw shaft **9** and the loaded ball rolling groove **15***a* of the block body **15**.

[**0048**] The ball **33** contacts the ball rolling groove **9***a* for the screw shaft **9** at two points, and the ball **33** also contacts the loaded ball rolling groove **15***a* for the screw shaft of the block body **15** at two portions. That is, the ball **33** contacts the ball rolling groove **9***a* and the loaded ball rolling groove **15***a* at four points. Further, in order to apply a preload, there is adopted a so-called over-size system in which a ball having an over-size having a diameter slightly larger than the interval between the screw shaft **9** and the block body **15**.

[**0049**] A return pipe **34** for circulating the ball rolling between the ball rolling groove **9***a* for the screw shaft **9** and the loaded ball rolling groove **15***a* for the block body **15** is provided with the inner block **8**. This return pipe **34** constitutes a ball return passage for the screw shaft (rolling member return passage for screw shaft) communicating one and the other ends of the loaded rolling passage.

[**0050**] The return pipe **34** has a circular cross section and is bent by about 90 degrees at both end portions with respect to its body portion so as to provide an approximately gate shape. The leg portions thereof are not parallel to each other and their extending directions are twisted respectively in accordance with lead angles. Both the end portions of the return pipe **34** are formed with cutouts for scooping up the balls rolling in the loaded rolling passage. Both side portions of the return pipe **34** are fitted into the loaded rolling passage with several pitches of interval. Furthermore, this return pipe **34** is inserted from the lower surface side of the inner block **8**, i.e. on a side opposing to the upper surface of the outer rail **7**, and fixed to the inner block **8** by means of pipe holder. By disposing the return pipe **34** to the lower surface side of the inner block **8**, a portion on the upper surface side of the inner block **8** can be freely utilized, thus making easy the assembling working of a table or like.

[**0051**] A number of balls **33**, - - - for screw shaft are arranged in the loaded rolling passage. A number of spacers **35**, - - - are also arranged each between the balls **33**. The spacers **35** are formed so as to provide a cylindrical shape having an outer diameter smaller than a diameter of the ball **33**. Each of the spacers **30** is formed, at its axial both ends, with spherical recessed portions as curved recesses each having a curvature radius substantially equal to the radius of the ball **33** so as to correspond thereto. In an arrangement that the spacers **35**, - - - are disposed between the balls **33**, - - - , the axes of the spacers **35** lie on the line connecting the centers of the balls **23**, - - - . The axial length of the spacer **35** is set to be thin so that the interval of the adjacent balls **33**, **33** has necessarily minimum value.

[**0052**] When the screw shaft **9** is rotated, the balls **33**, - - - rolling in the circumferential direction in the loaded rolling passage under the loaded state are scooped up by one front end of both end portions of the return pipe **34**. The scooped-up balls **33** pass through the inside of the return pipe **34** and return again to the loaded rolling passage from the other one front end of both the end portions of the return pipe part from the one end by several pitches. The balls **33** circulate in a manner reverse to that mentioned above by reversing the rotating direction of the screw shaft **9**.

[0053] **FIG. 9** shows a perspective view of the balls **33**, - - - and spacers **35**, - - - which are arranged in the ball circulation passage of the screw portion and **FIG. 10** shows the balls **28**, - - - and retainer **27** which are arranged in the ball circulation passage of the guide portion. The arrangement of the spacers **35**, - - - and **30**, - - - having recessed portions corresponding to the curved surfaces of the balls **33**, - - - and **28**, - - - between these balls **33**, - - - and **28**, - - - permits to prevent the metal balls from being contacted to each other and realize a low dust and low noise generation structure.

[0054] As shown in **FIG. 10**, the balls **28** move two-dimensionally on a plane in the ball circulation passage of the guide portion. That is, the balls **28** circulate in the order of the linear loaded rolling passage A→the U-shaped direction changing passage B→the linear return passage C→the U-shaped direction changing passage B. In the direction changing passage B, the belt-shaped member **31** of the retainer is freely bent. Since a number of spacers **30** disposed in the guide portion are connected in series to each other by the belt-shaped members, the balls **28** can circulate in the predetermined track and, hence, unnecessary contacting of the balls **28** to the surrounding circulation passage can be prevented. Furthermore, since the belt-shaped members **31** are guided by the guide portions formed to the ball circulation passage, the belt-shaped members **31** can circulate in the more constant track, and hence, the spacers **30**, - - - connected in series by the belt-shaped members **31** and the balls **28** disposed between these spacers **30** can also circulate in the more constant track.

[0055] Particularly, in the case where the return passage constituting members **16**, the holding members **17** and the end plates **18** are molded independently with resin material different from the metal block body, only the loaded rolling passage and the balls are metal-to-metal contacted. Thus, the generation of dust or like can be preferably suppressed.

[0056] On the other hand, with reference to **FIG. 9**, the loaded rolling passage D in the screw portion is formed into spiral shape and the ball return passage E (return pipe) is circumferentially twisted in the advancing direction of the balls **33** as mentioned before. That is, in the screw portion, the rolling directions of the balls **33** and spacers **35** are three-dimensionally changed and moved in the complicated manner. The unnecessary contacting of the balls **33** to the surrounding circulation passage can be prevented by separating the spacers **35** without connecting them with the belt-shaped member. In addition, the spacers **35**, each having curved recesses at its both end portions corresponding to the curved surface of the ball **33**, are arranged in the screw portion without using conventional spacer balls, so that the distance between the adjacent balls can be shortened in comparison with the case of using the spacer balls. Accordingly, the number of balls **33** which can receive the load is not reduced.

[0057] The linear actuator of the characters mentioned above will be assembled in the following manner with reference to **FIG. 2**.

[0058] First, the screw shaft **9** is inserted into the block body **15** and balls **33**, - - - and spacers **35** - - - are then alternatively accommodated and arranged in the space between the screw shaft **9** and the block body **15**. The balls **33** and spacers **35** are also accommodated and arranged in the return pipe **34**. The return pipe **34** is then mounted to the block body **15**. In thus manner, the assembling of the block body **15** and the screw shaft **9** is completed.

[0059] Next, the return passage constituting members **16**, - - - are inserted into the through holes **21** of the block body **15**, and the holding members **17**, **17** are assembled to both the side surfaces of the block body **15**. Then, the end plate **18** is mounted to one end surface of the block body **15**. In the next step, the balls **28**, - - - arranged and held by the retainer **27** is inserted in the ball circulation passage of the guide portion from the side opposing to the mounting side of the above-mentioned one end plate **18**, and the other end plate **18** is thereafter mounted to the other one end surface of the block body **15**. Finally, the inner block **8** is forcibly fitted into the outer rail **7** and the housings **13** and **14** supporting both the ends of the screw shaft are fastened to both ends of the outer rail **7**.

[0060] Further, it is to be noted that tubular rollers may be used as rolling members in substitution for the balls.

[0061] As mentioned hereinbefore, according to the present invention, a plurality of spacers, each formed at its both ends, with curved recessed portions corresponding to the curved surface of the rolling member, are disposed between the rolling members of the guide portion, and these plural spacers are connected in series by the belt-shaped members having flexibility. On the other hand, a plurality of spacers, each formed at its both ends, with curved recessed portions corresponding to the curved surface of the rolling member, are disposed between the rolling members for the screw shaft of the screw portion in a manner separated from each other. The mutual contact between the respective metal rolling members can be prevented by disposing the spacers, having recessed portions corresponding to the curved surfaces corresponding to the rolling members, arranged in the guide portion and the screw portion. Furthermore, since the plural spacers arranged in the guide portion, in which two-dimensional motion is carried out, are connected to each other in series by the belt-shaped members, the rolling members circulate in the constant track, and unnecessary contacting of the rolling members and their surrounding circulation passage can be prevented. In the screw portion, the twisting motion around the advancing direction is required as well as the two-dimensional and three-dimensional direction changing motions, so that unnecessary contacting of the rolling members and their surrounding circulation passage can be prevented by separating the spacers without connecting the spacers by the belt-shaped members. Thus, since the mutual contact of the rolling members and the unnecessary contacting of the rolling members and their surrounding circulation passage can be prevented, low generation of dust or like and low generation of noise can be realized.

1. A linear actuator comprising a track member, having U-shape in section, provided with inner wall surfaces oppos-

ing to each other, a movable member disposed between the inner wall surfaces and a screw shaft penetrating the movable member, in which rolling member rolling portions are formed on the inner wall surfaces of the track member; loaded rolling member rolling portions are formed on both side surfaces of the movable member so as to correspond to the rolling member rolling portions; rolling member return passages extending in parallel to each other with a predetermined distance from the loaded rolling member rolling portions and direction changing passages each connecting the loaded rolling member rolling portions and the rolling member return passages are formed in the movable member so as to circulate the rolling members rolling between the rolling member rolling portions and the loaded rolling member rolling portions; a rolling member rolling portion for the screw shaft in form of spiral is formed to an outer peripheral surface of the screw shaft; a loaded rolling member rolling passage for the screw shaft is formed on the through hole formed in the movable member so as to correspond to the rolling member rolling portion of the screw shaft; and a rolling member return passage for circulating the rolling member for the screw shaft rolling between the rolling member rolling portion for the screw shaft and the loaded rolling member rolling portion for the screw shaft is formed in the movable member,

wherein a plurality of spacers, each having, at both ends thereof, curved recessed portions corresponding to curved surface of the rolling member are arranged between the rolling members, the plural spacers being connected in series by belt-shaped members having flexibility;

a plurality of spacers, each having, at both ends thereof, curved recessed portions corresponding to the curved surface of the rolling member, are disposed between the rolling members for the screw shaft in a manner separated from each other; and

a holding member extending along both side edges of the loaded rolling member rolling portion is mounted to the movable member for preventing the rolling member held by the belt-shaped members and the spacers from coming off at a time when the movable member is removed from the track member.

2. The linear actuator according to claim 1, wherein the rolling member rolling passage composed of the loaded rolling member rolling passage, the rolling member return passage and the direction changing passage is provided with a guide portion for guiding the belt-shaped member.

3. The linear actuator according to claim 1 or **2**, wherein the return passage constituting member constituting the return passage, the direction changing inner periphery side constituting member constituting the inner periphery side of the direction changing member, the direction changing outer periphery side constituting member constituting the outer periphery side of the direction changing member, and the holding member are formed from resin material independent from a body portion of the movable member.

* * * * *

US 20040057640A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2004/0057640 A1

Michioka et al. (43) Pub. Date: Mar. 25, 2004

(54) METHOD OF MANUFACTURING ROLLING ELEMENT STRING

(75) Inventors: **Hidekazu Michioka**, Tokyo (JP); **Yasuhiro Matsumoto**, Tokyo (JP); **Hiroshi Nakabayashi**, Yamanashi-ken (JP); **Katsuya Iida**, Yamanashi-ken (JP); **Daisuke Yatsushiro**, Yamanashi-ken (JP)

Correspondence Address:
ARENT FOX KINTNER PLOTKIN & KAHN
1050 CONNECTICUT AVENUE, N.W.
SUITE 400
WASHINGTON, DC 20036 (US)

(73) Assignee: **THK CO., LTD**

(21) Appl. No.: **10/645,583**

(22) Filed: **Aug. 22, 2003**

Related U.S. Application Data

(62) Division of application No. 09/656,413, filed on Sep. 6, 2000, now abandoned.

(30) **Foreign Application Priority Data**

Sep. 7, 1999 (JP) 252572/1999

Publication Classification

(51) **Int. Cl.**[7] **F16C 29/06**; F16C 19/00

(52) **U.S. Cl.** **384/43**; 384/51

(57) **ABSTRACT**

An object of the invention is to provide a method of manufacturing a rolling element string wherein a smaller rolling element string can be manufactured easily at low cost, and a rolling element string being superior in the tensile strength and the flexural strength even after downsizing can be manufactured. The present invention to achieve the object is a method of manufacturing a rolling element string having a number of rolling elements aligned and rollably retained at prescribed intervals, comprising a first step of forming a flat band shaped belt member with a synthetic resin, a second step of forming retaining holes aligned on said belt member in a row for receiving the rolling elements loosely, and a third step of aligning the rolling elements within said retaining holes and forming the spacer portions between the respective adjacent retaining holes by injection molding for retaining said rolling element with said rolling elements used as cores, so that said rolling elements are trapped within said retaining holes.

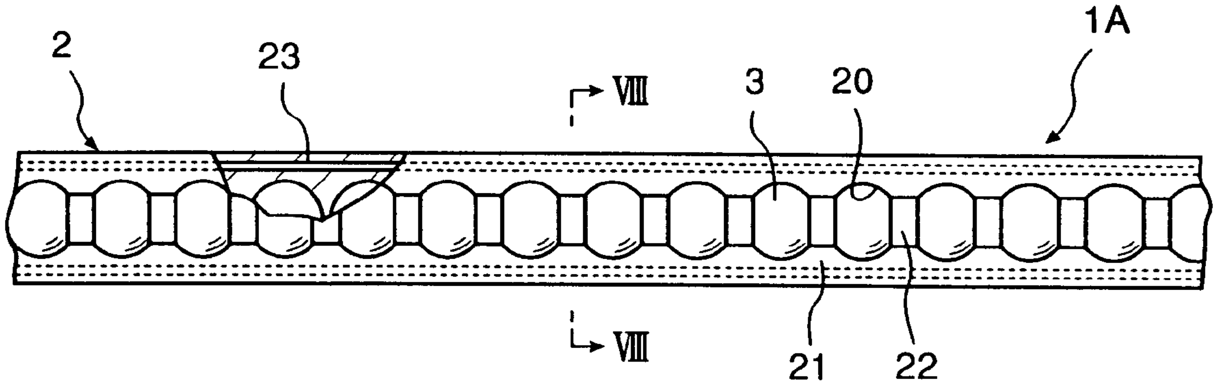


Fig. 1

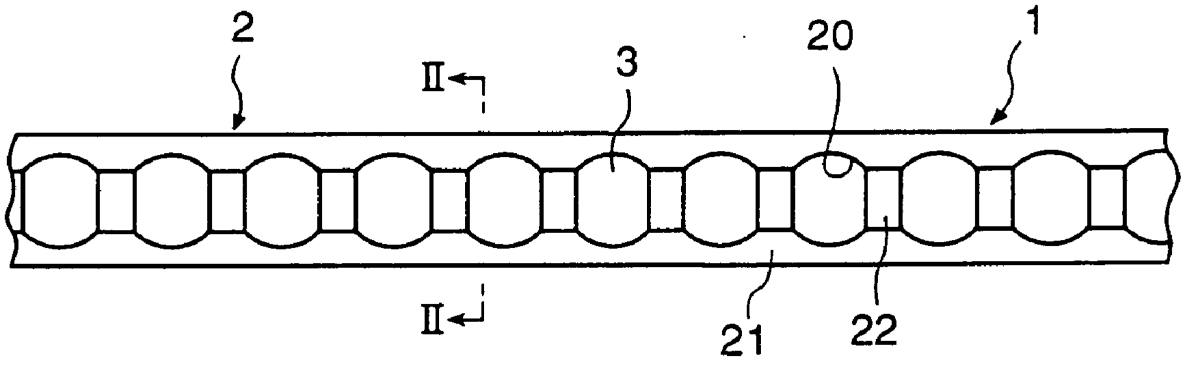


Fig. 2

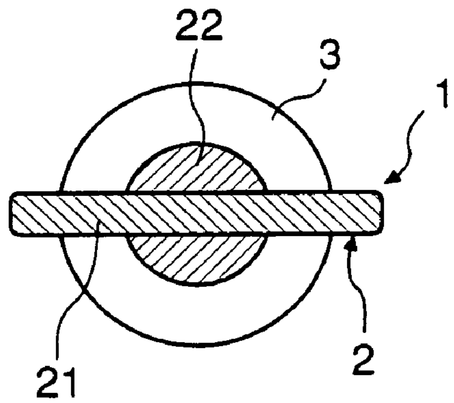


Fig. 3

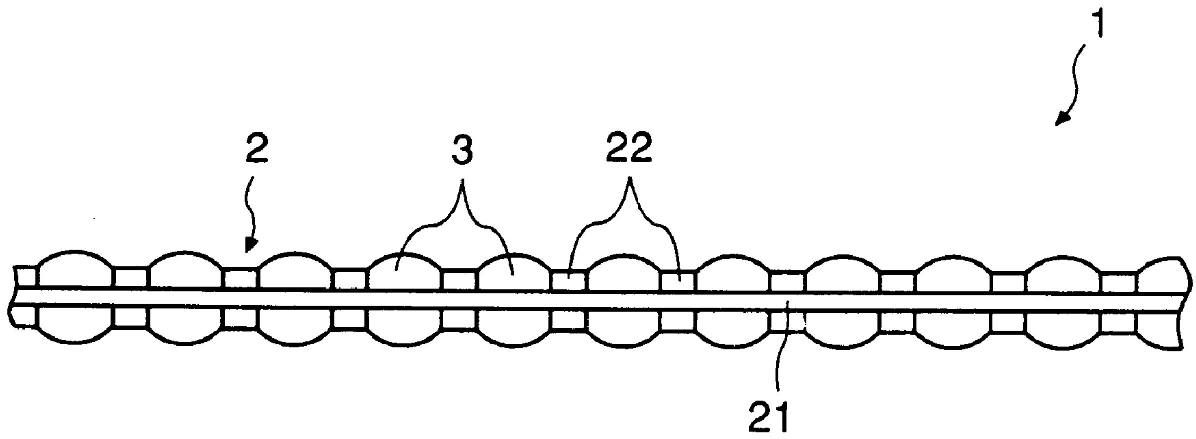


Fig. 4

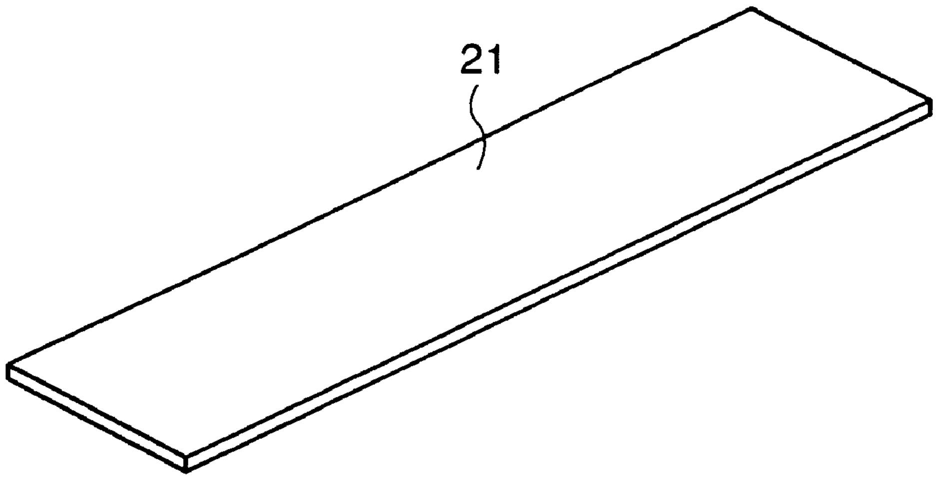


Fig. 5

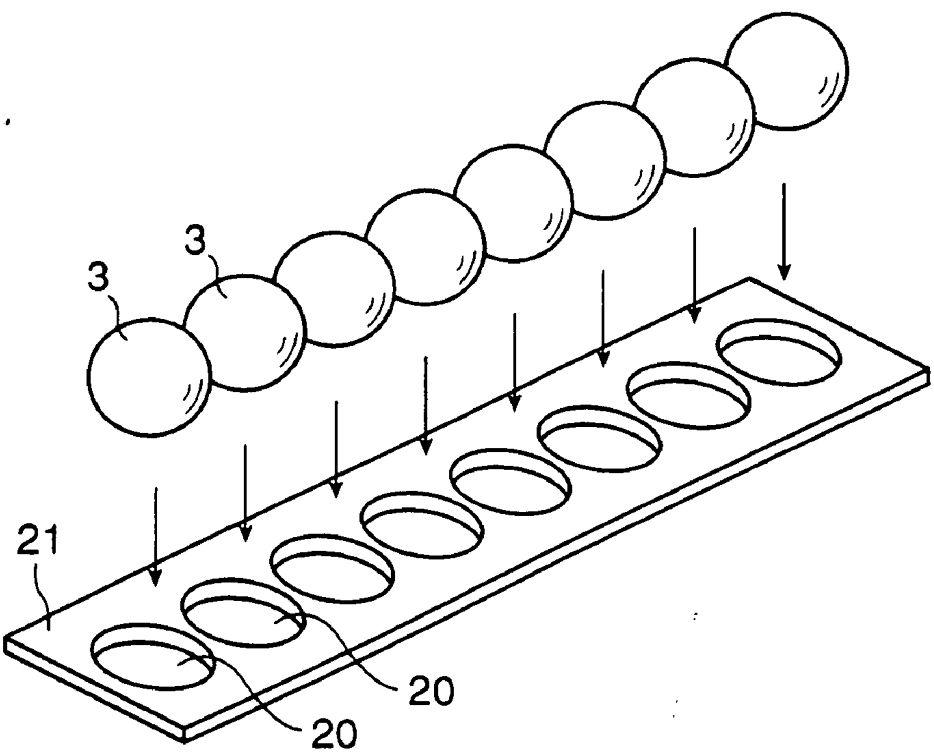
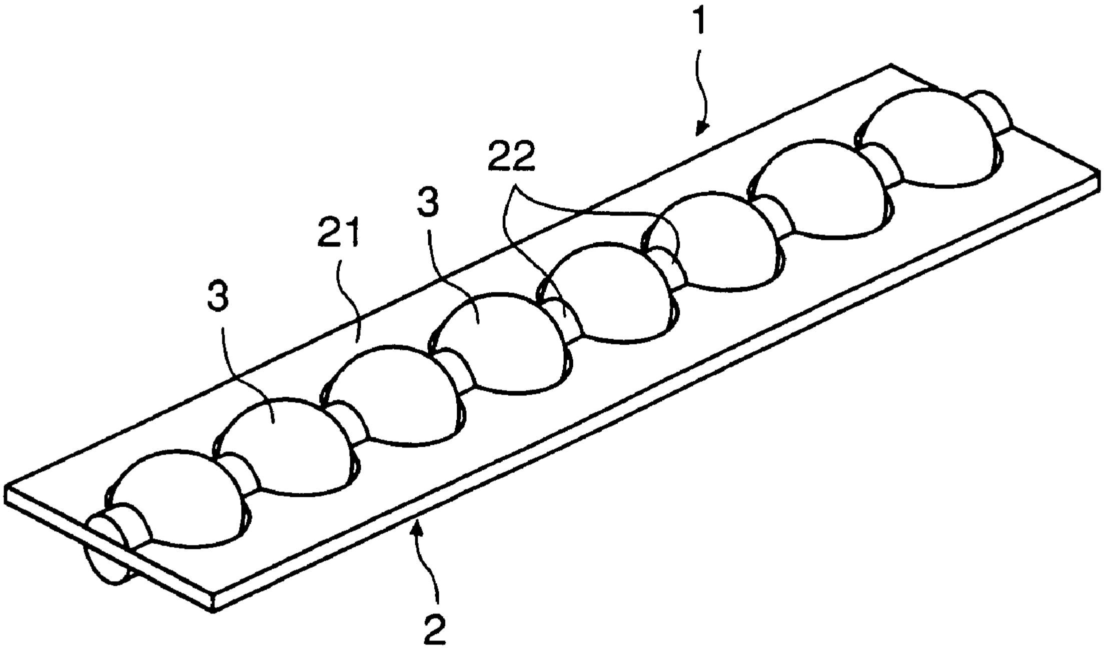


Fig. 6



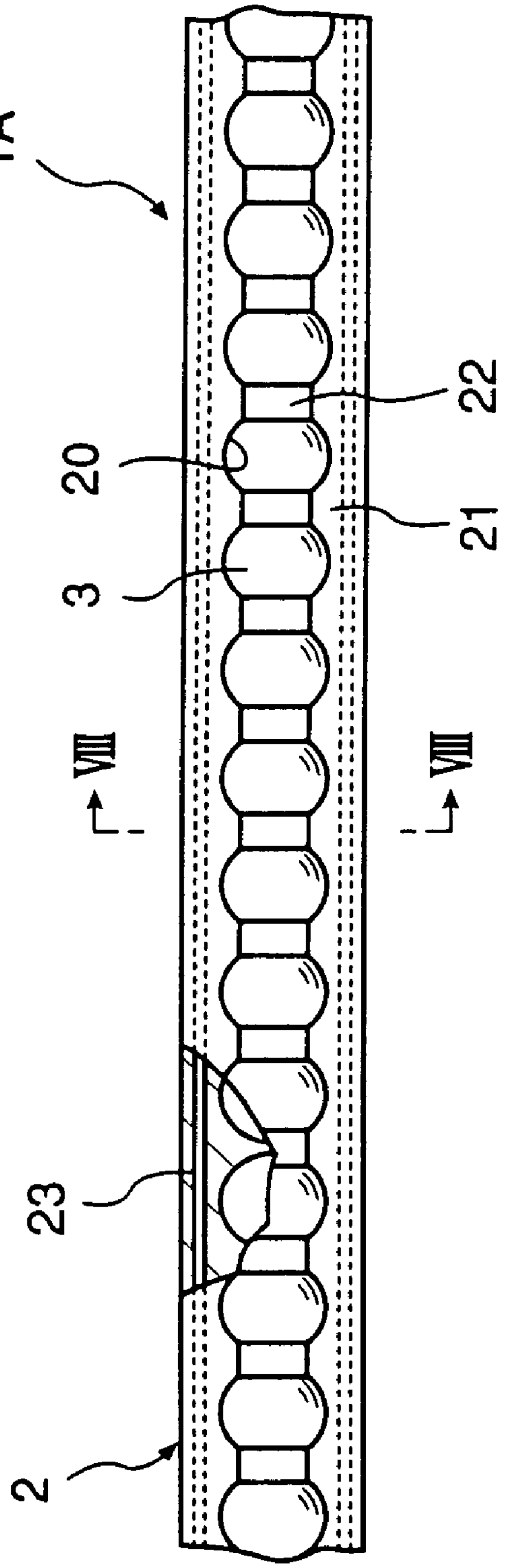


Fig. 7

Fig. 8

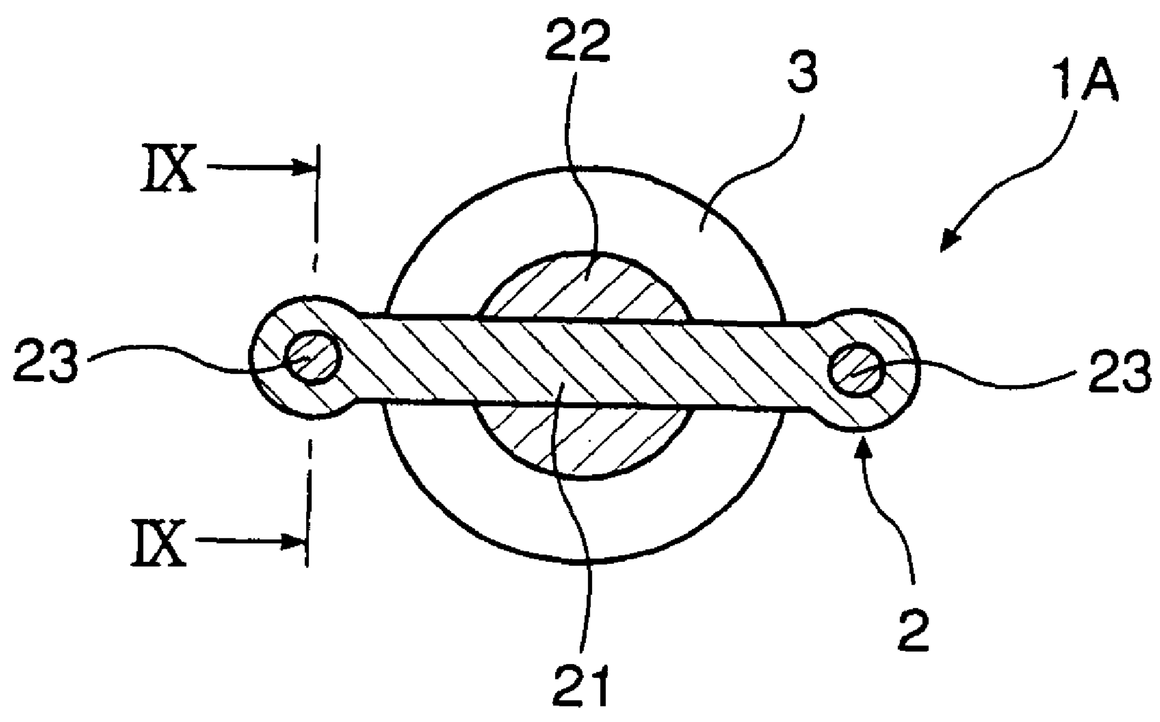


Fig. 9

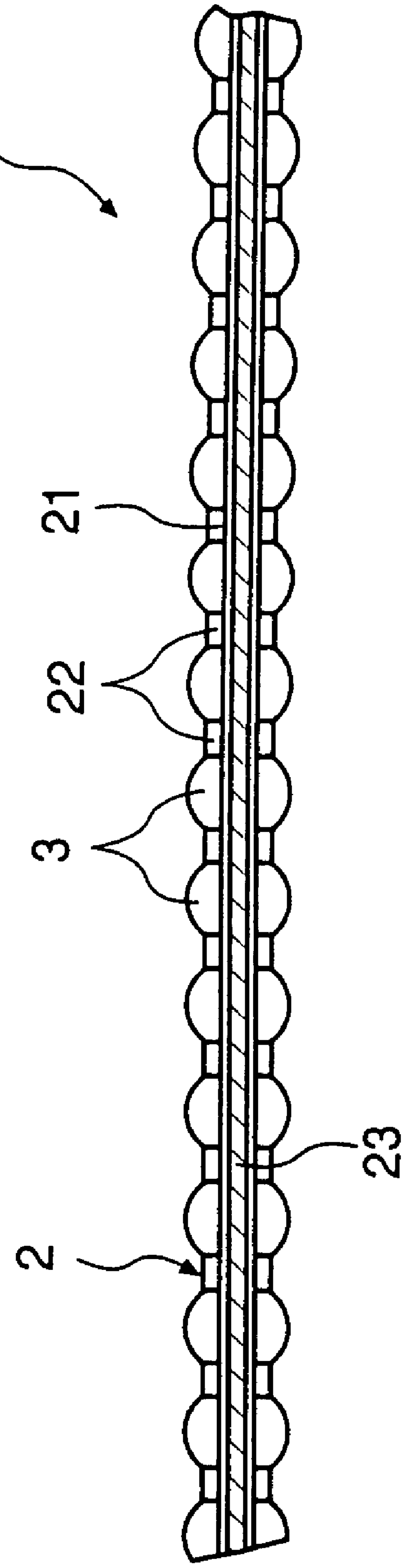


Fig. 10

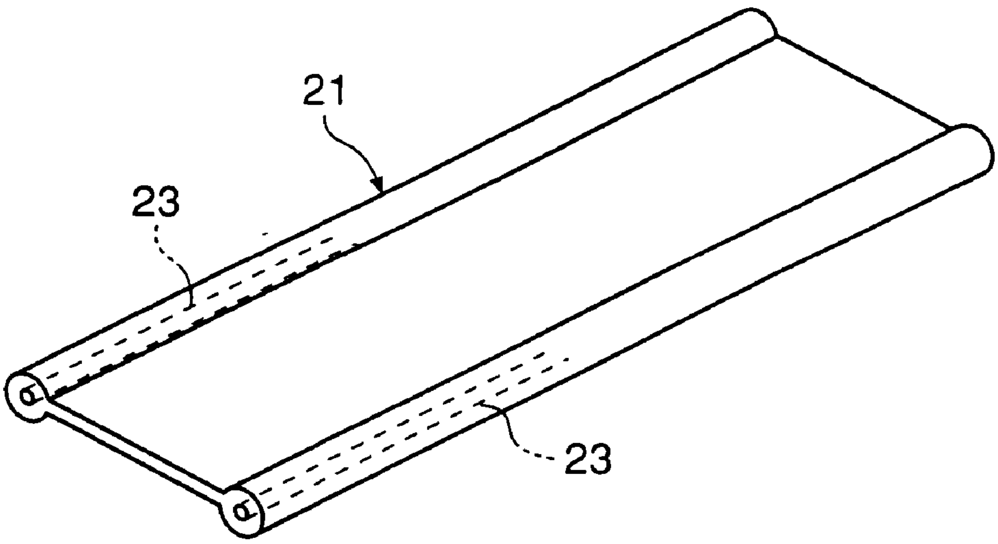


Fig. 11

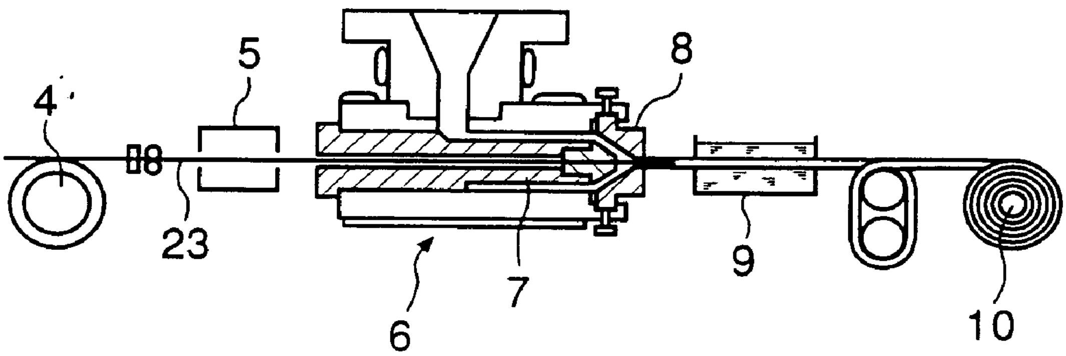


Fig. 12

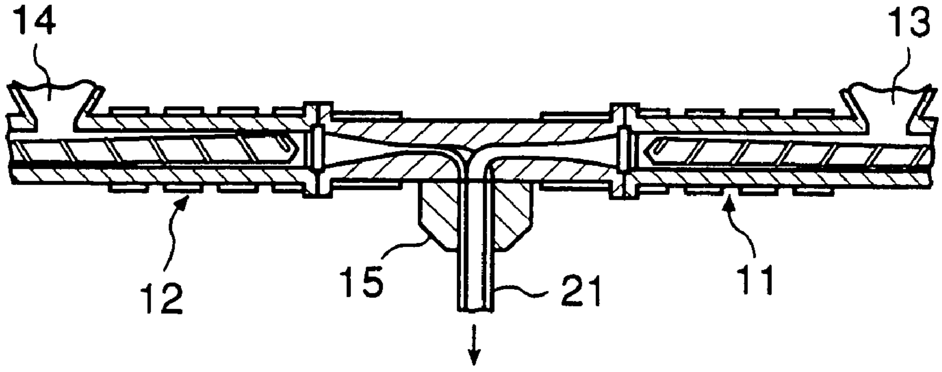


Fig. 13

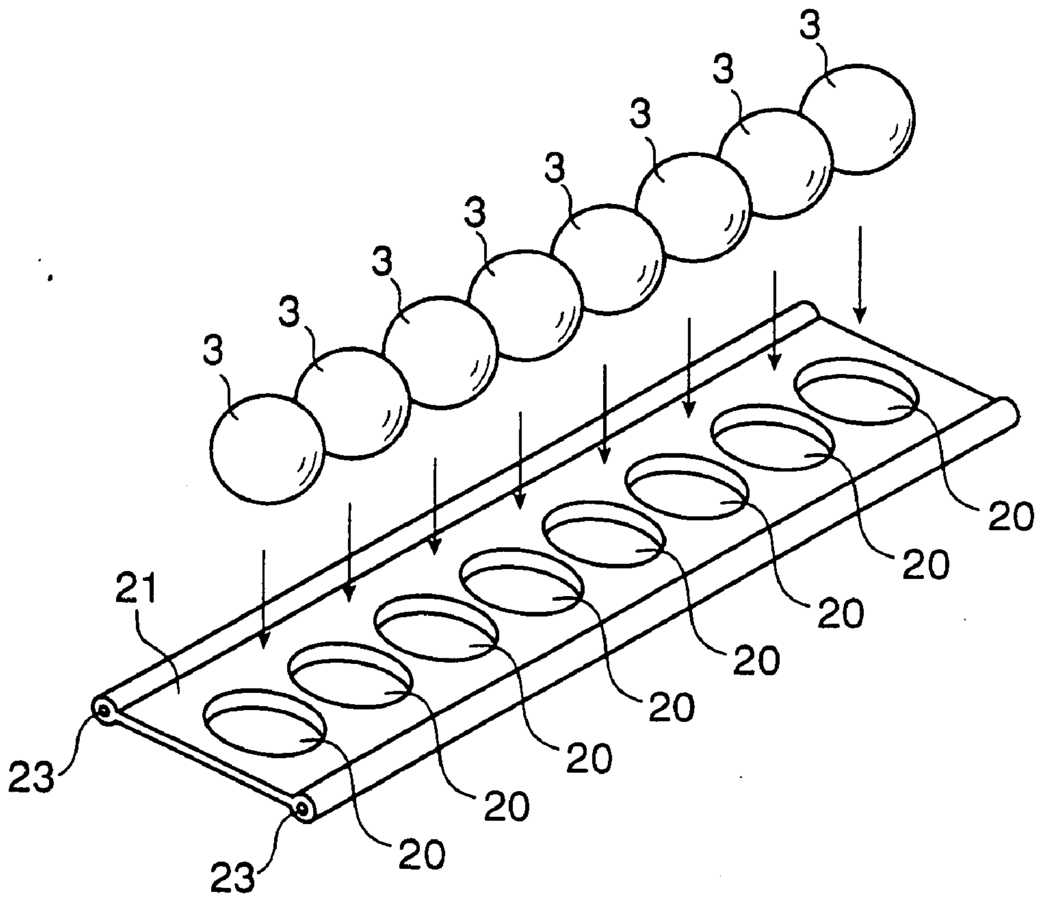


Fig. 14

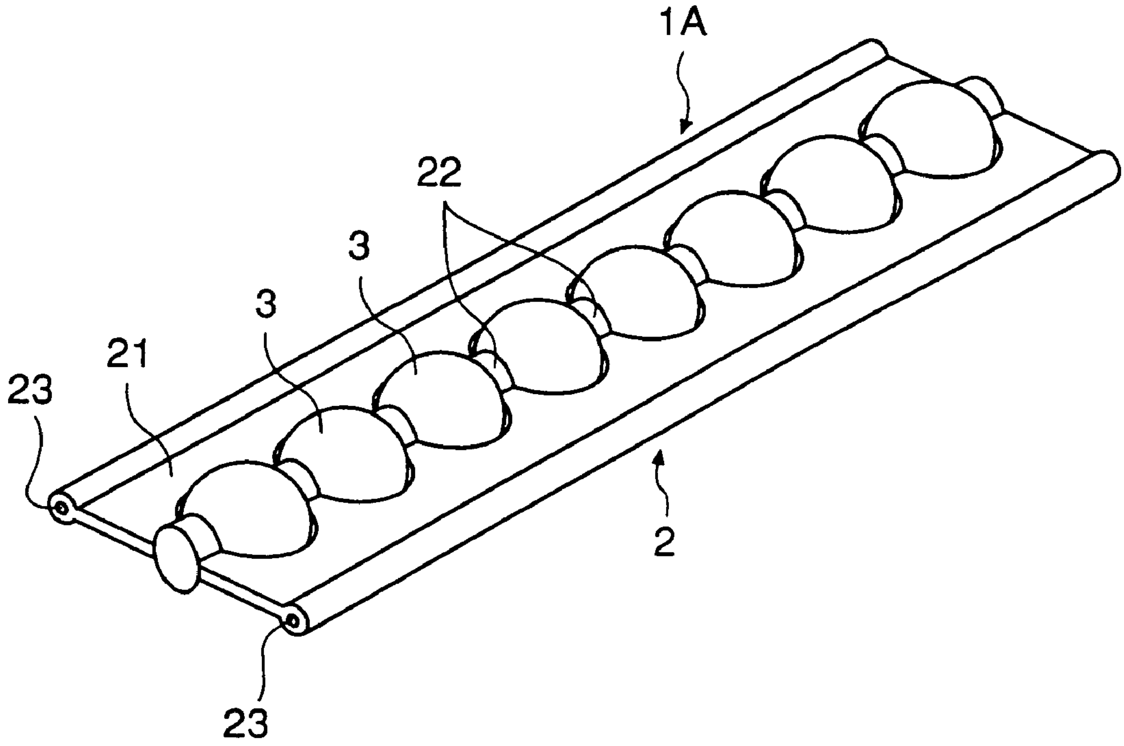


Fig. 15

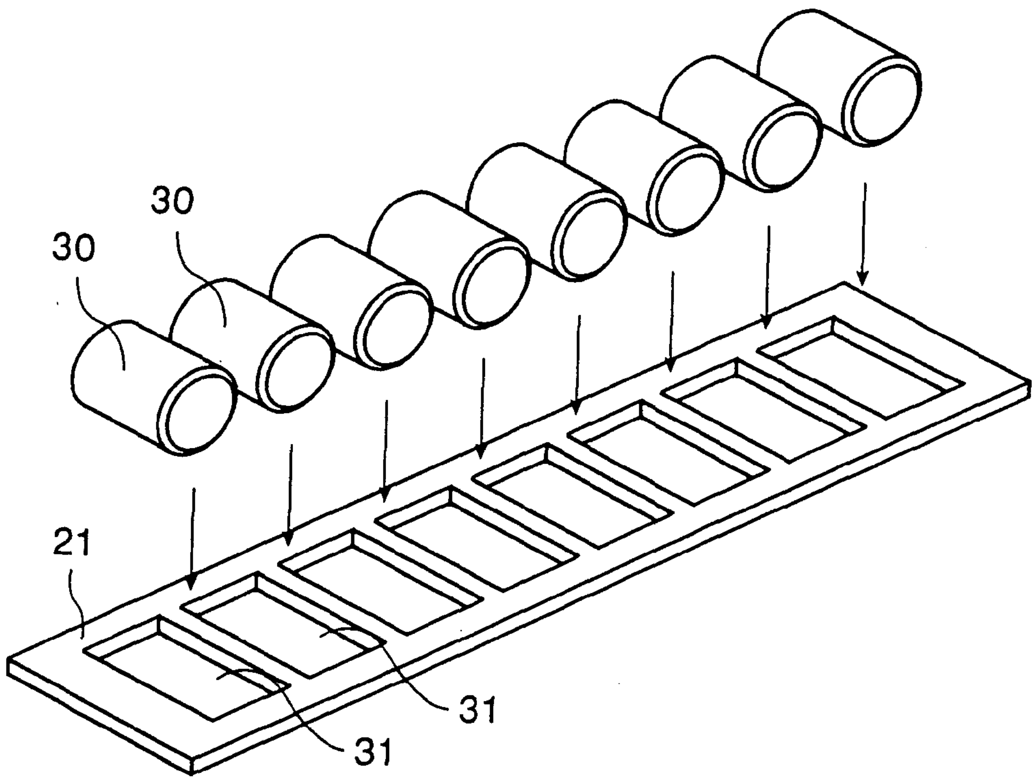


Fig. 16

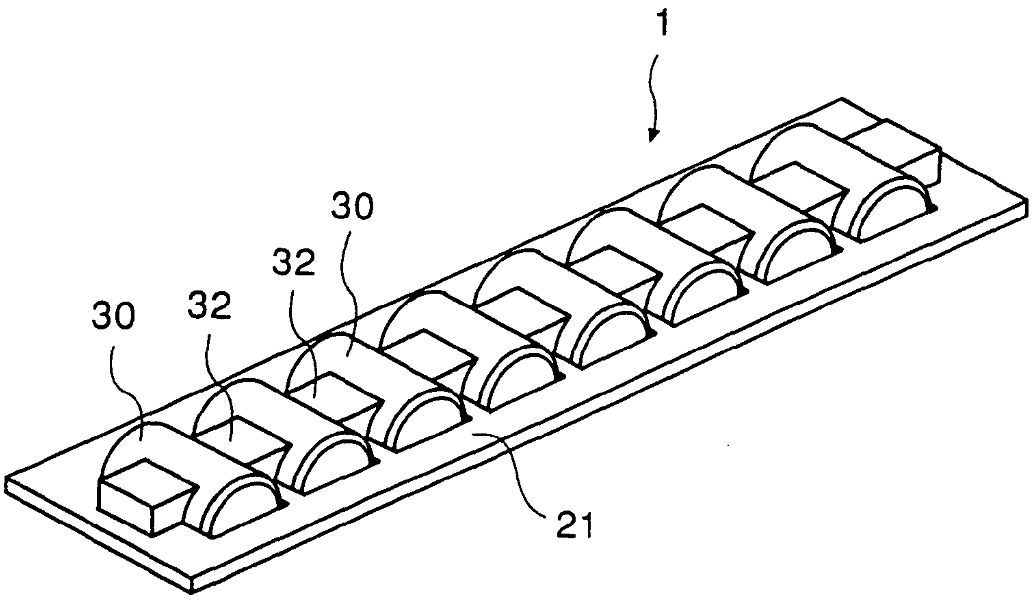


Fig. 17

(RELATED ART)

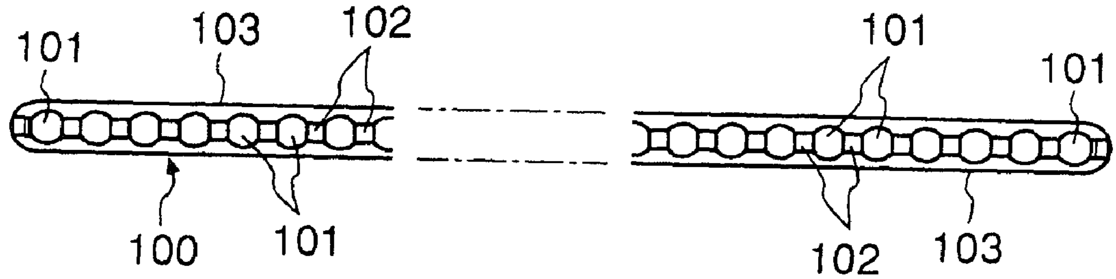


Fig. 18

(RELATED ART)

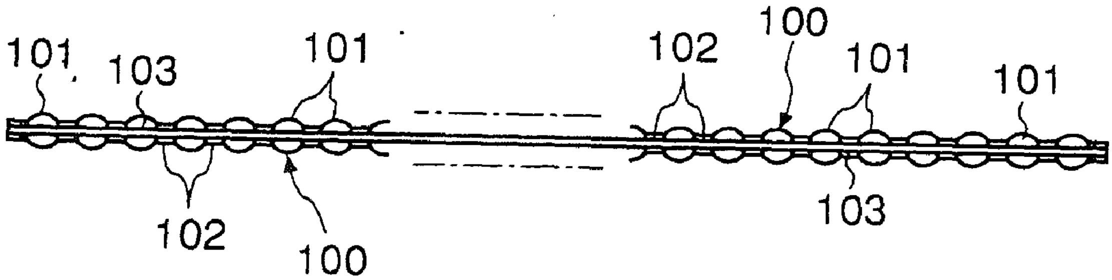
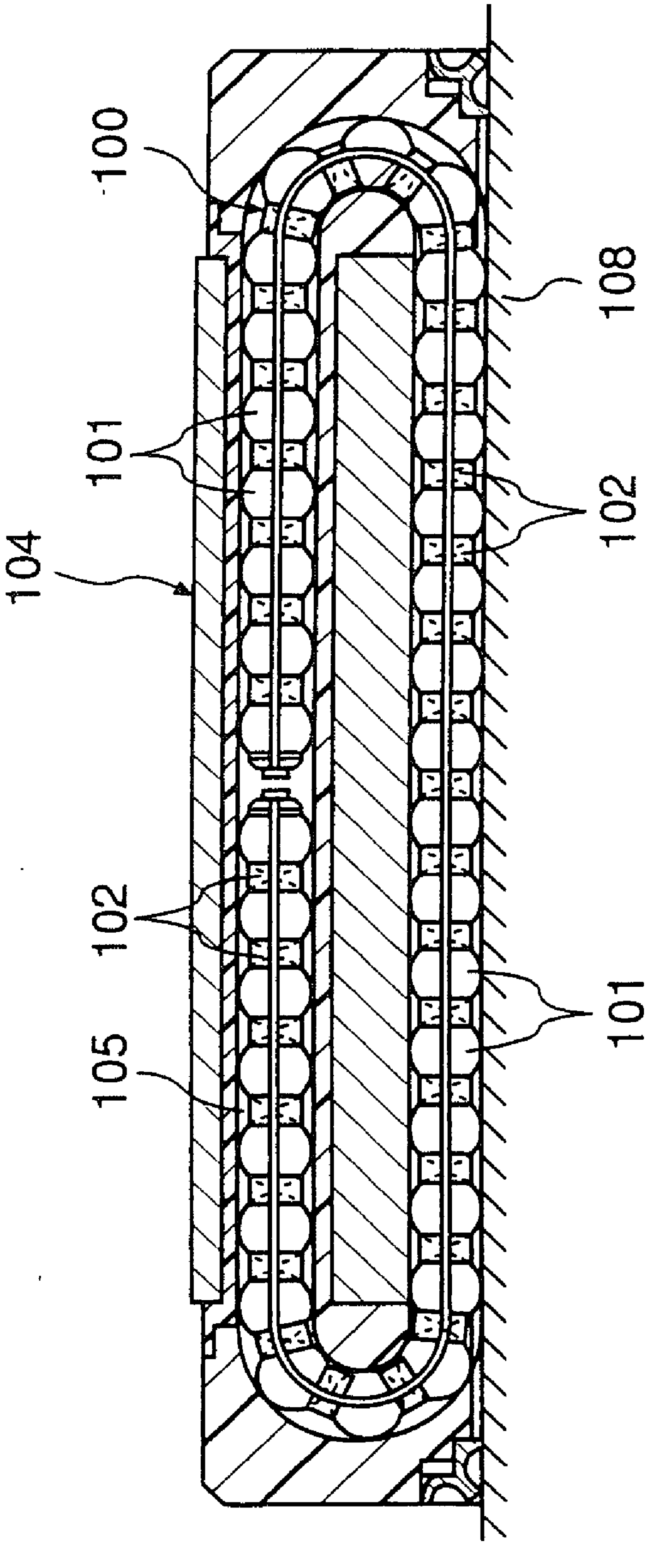


Fig. 19
(RELATED ART)



METHOD OF MANUFACTURING ROLLING ELEMENT STRING

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a method of manufacturing a rolling element string in which a number of rolling elements are aligned and rollably held in a row at prescribed intervals, and which is used by integrating, for example, in a linear guide device for endless sliding. More specifically, the invention relates to an improved rolling element string the tensile strength and the flexural strength of which are enhanced.

[0003] 2. Description of the Related Art

[0004] Conventionally, the known linear guide device for guiding a movable body such as a table along the fixed portion such as a bed is of the type that comprises a rollway having a ball rolling groove, a slider having a loaded rolling groove opposed to the ball rolling groove and a no-load rollway in which the ball is circulated from one end to the other end of the loaded rolling groove and moving along the rollway, and a number of balls rolling between the slider and the rollway under loaded conditions and circulating along the endless raceway composed of a loaded rolling groove and a no-load rollway of the slide.

[0005] In the conventional linear guide device in this arrangement, since the endless raceway of the slider is filled with balls, when the slider moves along the rollway, the adjacent balls tend to collide with or rub against each other as they circulate along the endless raceway, which results in earlier abrasion of balls and shorter operational life of the device.

[0006] Therefore, in order to solve the problem described above, a linear guide device incorporating a rolling element string having a plurality of balls aligned in a row into the endless raceway has been proposed (Japanese Patent Laid-Open No. 5-52217). As shown in **FIG. 17** and **FIG. 18**, the rolling element string **100** comprises ball retaining members **102** interposed between the respective adjacent balls **101** and is constructed in such a manner that the balls are linked consecutively by linking the respective ball retaining members **102** with a pair of belt members **103** disposed in the direction of alignment of the balls **101**, and is manufactured by injection molding of a flexible resin with the balls **101** disposed in a mold as cores.

[0007] In the conventional rolling element string **100** arranged in such a manner being incorporated into the endless raceway **105** and circulating along the endless raceway as shown in **FIG. 19**, since the ball retaining members **102** are interposed between the respective adjacent balls **101**, friction or collision between balls are prevented from being occurred and abrasion of the balls **101** could be avoided as much as possible.

[0008] However, in the conventional method, since an elongated rolling element string of the length corresponding to an orbit of the endless raceway is manufactured by injection molding, there has been a problem in that a number of gates for injecting molten resin into a cavity in the mold must be provided to make the belt member **103** for linking the respective ball retaining members **102** form in a uniform thickness, whereby the mold becomes complex and the cost increases.

[0009] There has been another problem in that considering further downsizing of the linear guide device requires the thinner belt member for the rolling element string to be incorporated in the endless raceway, and decrease in the tensile strength and the flexural strength of the belt member associated with thinning thereof may cause breakage of the rolling element string in the endless raceway, thereby impairing the ball retaining capability of the rolling element string.

[0010] There has been still another problem in that when contemplating further thinning of the belt member, the molten resin injected from the gate may not reach the deepest portion of the cavity in the mold, thereby resulting in a number of defective moldings and thus reducing yields.

SUMMARY OF THE INVENTION

[0011] The present invention is directed toward the problems described above, and accordingly, it is an object of the present invention to provide a method of manufacturing a rolling element string in which further downsized rolling element string may be manufactured easily at low cost, and in which the rolling element string having superior tensile strength and flexural strength may be manufactured even after downsizing.

[0012] In other words, the present invention is a method of manufacturing a rolling element string having a number of rolling elements aligned and rollably held in a row at prescribed intervals comprising a first step of forming a flat band shaped belt member with a synthetic resin, a second step of forming retaining holes aligned in a row on the belt member for receiving rolling elements loosely, and a third step of placing the rolling elements in the respective retaining holes, forming spacer portions between the respective adjacent retaining holes for retaining the rolling elements therein by injection molding with these rolling elements used as cores, and trapping the rolling elements within the retaining holes.

[0013] According to the method of the present invention, since the spacer portions are formed after the flat band shaped belt member is molded in the first step, and then the rolling elements are trapped within the retaining holes formed on the belt member, the belt member may be formed consecutively in a long strip for example by extrusion molding of a synthetic resin, not by injection molding. Therefore, even when the thickness of the belt member is reduced in association with downsizing of the rolling element string, the belt member of uniform thickness may be formed stably.

[0014] In addition, since the belt member and the spacer portions are formed separately, the belt member can be formed of a synthetic resin material that is completely different from a molding material used for the spacer portions. Therefore, by forming the belt member with a synthetic resin the tensile strength or flexural strength of which has been improved by adding, for example, carbon filler, the rolling element string of high tensile strength may be manufactured even if the thickness of the belt portion is reduced. On the other hand, since the spacer portions are to be kept in slide-contact with the rolling elements, the material for the spacer portions may be selected to have a low friction coefficient such as oleoresin, thereby ensuring smooth rotation of the rolling elements.

[0015] It is also possible to integrate a reinforcing material such as a carbon fiber or a glass fiber along the length of the belt member as the belt member is formed by extrusion molding, whereby the tensile strength of the belt member can be increased even when the tensile strength or flexural strength of the synthetic resin constituting the belt member is low.

[0016] As is described thus far, according to the method of manufacturing the rolling element string of the present invention, since the spacer portions for retaining the rolling element within the belt member are formed by injection molding after the belt member for aligning the rolling elements is molded, the belt can be consecutively formed in a long strip by extrusion molding, but not by injection molding, whereby the belt member of a uniform thickness may be formed easily at low cost even when the thickness of the belt member is reduced in association with downsizing of the rolling element string.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] **FIG. 1** is a plan view showing the first embodiment of the rolling element string manufactured according to the method of the present invention;

[0018] **FIG. 2** is a cross sectional view showing the rolling element string of **FIG. 1** taken along the line II-II;

[0019] **FIG. 3** is a front view showing the rolling element string according to the first embodiment;

[0020] **FIG. 4** is a perspective view showing the belt member of the first embodiment formed in the first step of the method of the present invention;

[0021] **FIG. 5** is a perspective view showing how the ball retaining holes are formed on the belt of the first embodiment and how the balls are aligned in the ball retaining holes;

[0022] **FIG. 6** is a perspective view showing the state that the spacer portions are formed by injection molding on the belt member of the first embodiment having balls aligned therein;

[0023] **FIG. 7** is a plan view showing the second embodiment of the rolling element string manufactured according to the method of the present invention;

[0024] **FIG. 8** is a cross sectional view of the rolling element string of **FIG. 7** taken along the line VIII-VIII;

[0025] **FIG. 9** is a cross sectional view of the rolling element string of **FIG. 8** taken along the line IX-IX;

[0026] **FIG. 10** is a perspective view of the second embodiment formed in the first step of the method according to the present invention;

[0027] **FIG. 11** is a drawing illustrating a step of forming the belt member of the second embodiment having reinforcing material incorporated therein by extrusion molding of a synthetic resin.

[0028] **FIG. 12** is a drawing illustrating a step of forming the belt member of the second embodiment by extrusion molding with two types of synthetic resin the physical properties of which are different from each other;

[0029] **FIG. 13** is a perspective view showing how the ball retaining holes are formed on the belt of the second embodiment and how the balls are aligned in the ball retaining holes;

[0030] **FIG. 14** is a perspective view showing the state where the spacer portions are formed by injection molding on the belt member of the second embodiment having balls aligned therein;

[0031] **FIG. 15** is a perspective view showing how the roller retaining holes are formed on the belt and how the rollers are aligned in the roller retaining holes;

[0032] **FIG. 16** is a perspective view showing the state where the spacers are formed by injection molding on the belt member having rollers aligned therein;

[0033] **FIG. 17** is a plan view showing the conventional rolling element string;

[0034] **FIG. 18** is a front view showing the conventional rolling element string; and

[0035] **FIG. 19** is a cross sectional view showing the state where the rolling element string is incorporated in the endless raceway of the linear guide device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0036] Referring now to the drawings, the present invention will be described.

[0037] FIGS. **1** to **3** show the first embodiment of the rolling element string manufactured according to the method of the present invention. The rolling element string **1** comprises a string belt **2** formed of a synthetic resin and balls **3** as rolling elements aligned in a row at prescribed intervals, and these balls **3** are rollable in the state of being retained in the string belt **2**.

[0038] The string belt **2** comprises a belt member **21** formed in the flat band shape and having retaining holes **20** for retaining balls **3** at prescribed intervals, and spacer portions **22** projecting from both surfaces of the belt member **21** between the respective adjacent retaining holes **20**, wherein balls **3** are rollably trapped within the retaining holes **20** of the belt member **21** by the respective spacer portions **22**.

[0039] The method of manufacturing the rolling element string **1** will now be described step-by-step.

[0040] **FIG. 4** shows a belt member **21** formed in the first step of the present invention. The belt member **21** is manufactured by extrusion molding of a synthetic resin. The belt member **21** consecutively extruded from the molding die is cooled down in a water tank, and then wound by a reel. In the subsequent step, the belt member **21** wound on the reel is cut into a prescribed length and used.

[0041] Since the belt member **21** before the spacer portions **22** are built up thereon has an uniform cross section along its length, the belt member **21** of a uniform thickness can be formed by extrusion molding easily at low cost even when the belt member **21** is thin.

[0042] The belt member **21** formed in such a manner is cut into a length corresponding to one orbit of the endless raceway of the linear guide device, and then formed with retaining holes **20** for retaining balls **3** along its length at prescribed intervals. The retaining hole **20** is formed in such a manner that the inner diameter thereof is somewhat larger than the diameter of the ball **3**, so that the ball **3** can be put in and taken out without any friction. Injection molding of the spacer portions **22** is carried out with the balls **3** aligned within these retaining holes **20**.

[0043] Injection molding is carried out in the state where the belt member **21** cut into a prescribed length is set in the mold at a prescribed position and the balls **3** are placed in the respective retaining holes **20** formed on the belt member **21**, with such belt member **21** and balls **3** used as cores. The spacer portions **22** are built up between the respective adjacent retaining holes **20** on the belt member **21** so as to cover a part of the surfaces of the balls **3**, and the balls **3** partly covered are trapped within the retaining holes **20** of the belt member **21**. Accordingly, as shown in **FIG. 6, a** string belt **2** having balls **3** aligned and retained at prescribed intervals on the belt member **21** is completed. In injection molding of the spacer portions **22**, a synthetic resin such as polyamide elastomer or polyester elastomer is used as in the case of molding the belt member **21**. By forming the spacer portions **22** by injection molding using the identical synthetic resin as the belt member **21**, the spacer portions **22** are welded to the belt member **21** when being molded, and as a consequent, the spacer portion **22** and the belt member **21** are securely integrated.

[0044] When the spacer portions **22** are formed by injection molding with the balls **3** as cores, the spacer portions **22** come into intimate contact with the surfaces of the balls **3**, thereby preventing smooth rolling of the ball. Therefore, upon completion of such injection molding, the belt member **21** is soaked into oil for a certain period of time. Since the string belt **2** formed of a synthetic resin takes up oil and thus swells, small gaps are formed between the spacer portions **22** and the balls **3** after a prescribed period of time has elapsed, thereby permitting free rolling of the balls **3** without falling off the retaining holes **20**. The rolling element string **1** is thus completed.

[0045] On the other hand, it is also possible to mold the spacer portions **22** by aligning ball models (rolling element model), which is slightly larger than the ball **3** in diameter, in the retaining holes **20** of the belt member **21** and molding with the ball models and the belt member **21** used as cores. When the balls **3** are used as cores, the step of forming gaps between respective balls **3** and spacers **22** is required after the completion of molding of the spacer portions **22**, as described above. On the other hand, in case where the ball models are used as cores, since the ball models are slightly larger than the balls **3**, the spacer portions **22** become smaller correspondingly. Therefore, by forcing the ball models out the string belt **2** and then fitting balls **3** instead when molding of the spacer portions **22** is finished, the balls **3** can roll within the retaining holes **20** freely without a time consuming step of soaking the string belt **2** into oil for a prescribed period of time.

[0046] According to the method of manufacturing the rolling element string **1** as described above, formation of an elongated rolling element string in a mold by injection molding as in the conventional manner is not necessary any more, and the rolling element string **1** comprising a thin belt member **21** can be manufactured simply at low cost and stably.

[0047] According to the method of manufacturing the rolling element string **1** as described thus far, the same material as the spacer portion **22** is used for the belt member **21**, and a reinforcing material **23** is integrated within the belt member **21** in order to enhance the tensile strength and the flexural strength of the belt member **21**. However, it is also possible to enhance the tensile strength and the flexural strength of the belt member **21** by adding carbon filler or the like to the material for the belt member **21** itself to compensate deterioration of the tensile strength and the flexural strength of the belt member **21** associated with the reduction of the thickness thereof.

[0048] FIGS. **7** to **9** show the second embodiment of the rolling element string manufactured according to the method of the present invention.

[0049] The rolling element string **1A** has almost the same structure as the rolling element string **1** of the first embodiment. However, as shown in cross sectional views of **FIG. 8** and **FIG. 9**, the belt member **21** includes a reinforcing material such as a glass fiber, a carbon fiber, or a ceramics fiber integrated in both edge portions along its length. Therefore, when the tensile force is applied along the length of the string belt **2**, the tensile force is loaded onto the reinforcing material **23**, whereby breakage of the string belt **2** can be prevented more effectively than in the first embodiment. The same reference numerals are designated to the components identical to the first embodiment, and detailed description will be omitted.

[0050] The method of manufacturing the rolling element string **1A** will now be described step-by-step.

[0051] **FIG. 10** shows a belt member **21** formed in the first step of the present invention. The belt member **21** is manufactured by extrusion molding of a synthetic resin, and a reinforcing material **23** described above is integrated therein during extrusion molding.

[0052] **FIG. 11** is a schematic illustration showing the step of carrying out extrusion molding of the belt member **21** while integrating a reinforcing material. The reinforcing material **23** is wound on a large diameter reel **4**. The reinforcing material **23** unwound from the reel **4** is preheated by the pre-heater **5**, then passed through the mandrel **7** of the cross head die **6** and pulled out of the molding die **8**. A molten synthetic resin such as polyamide elastomer or polyester elastomer is forced into the cross head die **6** by a screw, not shown, and built up around the reinforcing material **23** as the reinforcing material **23** is extruded from the molding die **8**, whereby an elongated belt member **21** is consecutively extruded from the cross head die **6**. The extruded belt member **21** is cooled down in the water tank **9** and then wound by the reel **10**, which is cut into a prescribed length and used in the subsequent step.

[0053] The reinforcing material **23** may not be necessarily a glass fiber itself, but may be a synthetic resin the tensile strength or the flexural strength of which has been improved by adding carbon filler or the like. In such a case, double-layer extrusion molding may be employed to form the belt member **21** of the shape shown in **FIG. 10**. As shown in **FIG. 12**, two extruders **11**, **12** are used in this double-layer extrusion. After setting a synthetic resin for forming a reinforcing material in the hopper **13** of one extruder **11** and a synthetic resin for covering the reinforcing material in the hopper **14** of the other extruder **12**, these synthetic resins are extruded from the common die **15**. Then, as in **FIG. 11**, the extruded belt member **21** is cooled down in the water tank and wound by the reel, and an elongated belt member **21** including a synthetic resin of high tensile strength and flexural strength as a reinforcing material **23** covered with another type of synthetic resin can be obtained.

[0054] In this manner, even when a reinforcing material **23** is integrated within the belt member **21**, the belt member **21** before the spacer portion **22** is built up thereon has a uniform cross section along its length, whereby the belt member **21** of a uniform thickness may be formed simply at low cost as in the case of the first embodiment.

[0055] Subsequently, molding of the spacer portion **22** is carried out in the same manner as the rolling element string **1** of the first embodiment that does not comprise a reinforcing material **23**. In other words, the belt member **21** cut into the length corresponding to one orbit of the endless raceway of the linear guide device is formed with retaining holes **20** for retaining the balls **3** along its length at prescribed intervals as shown in **FIG. 13**, and injection molding of the spacer portions **22** is carried out with the balls **3** aligned in these retaining holes **20**. The string belt **2** after molding of the spacer portion **22** has finished is soaked in oil for a certain period of time, thereby gaps for allowing the balls **3** to roll are formed between the spacers **22** and the balls **3**. As a consequent, as shown in **FIG. 14**, the rolling body string **1A** of the second embodiment having a reinforcing material **23** integrated therein is completed.

[0056] In the embodiments as is described thus far, balls are employed as rolling elements to be aligned in the belt member. However, this invention may be applied to the case where rollers are employed as rolling elements. More specifically, as shown in **FIG. 15**, after forming retaining holes **31** for rollers **30** on the belt member **21** along its length at prescribed intervals, injection molding is carried out with the rollers **30** aligned in these retaining holes **31** as shown in **FIG. 16**. As a consequent, the rollers **30** are trapped within the retaining holes **31** of the belt member **21**, and as is in the case where the balls **3** are employed as rolling elements, the string belt **2** having the rollers **30** aligned and retained in the belt member **21** at prescribed intervals may be completed.

What is claimed is:

1. A rolling element string comprising a number of rolling elements for rolling between a slider and a rollway of a linear guide device under loaded conditions and circulating along an endless raceway of the slider, and a string belt by which these rolling elements aligned in a row at prescribed intervals and each rolling elements rollably retained, the string belt comprising:

a belt member formed in the flat band shape and having retaining holes with a central portion in width direction of it for retaining these rolling elements;

spacer portions projecting from both surfaces of the belt member between the respective adjacent retaining holes for trapping the rolling element within the retaining holes of the belt member;

a pair of reinforcing material included the belt member integrated in both edge portions along its length;

wherein a thickness of the central portion of the belt member is thinner than the both edge portions of the belt member.

* * * * *

US 20040000208A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2004/0000208 A1

Michioka et al. (43) Pub. Date: Jan. 1, 2004

(54) CIRCULATION MEMBER, MOTION GUIDE DEVICE PROVIDED WITH CIRCULATION MEMBER AND BALL SCREW PROVIDED WITH CIRCULATION MEMBER

(75) Inventors: **Hidekazu Michioka**, Tokyo-to (JP); **Yasuyuki Abe**, Tokyo-to (JP)

Correspondence Address:
ARMSTRONG, KRATZ, QUINTOS, HANSON & BROOKS, LLP
1725 K STREET, NW
SUITE 1000
WASHINGTON, DC 20006 (US)

(73) Assignee: **THK CO., LTD.**, Tokyo-to (JP)

(21) Appl. No.: **10/600,453**

(22) Filed: **Jun. 23, 2003**

(30) **Foreign Application Priority Data**

Jun. 25, 2002 (JP) P2002-184540

Publication Classification

(51) **Int. Cl.**[7] **F16H 25/22**

(52) **U.S. Cl.** **74/424.86**; 74/424.88

(57) **ABSTRACT**

A ball screw comprises a screw shaft, a nut assembled with the screw shaft, a number of balls disposed in the ball rolling passage formed by a ball rolling groove formed to the screw shaft and a loaded ball rolling groove formed to the nut, a number of spacers disposed between the balls in the ball rolling passage, and a circulation member for circulating the balls and spacers in accordance with a relative motion of the nut with respect to the screw shaft. The circulation member is provided with a scoop-up groove for scooping the balls, when contacting the ball rolling in the ball rolling passage, at both side edge portions of the scoop-up groove and is also provided with a spacer scoop-up portion which contacts and scoops the spacer moving in the ball rolling passage without contacting the balls. Such circulation member will be preferably utilized for a motion guide device such as linear motion guide or spline shaft.

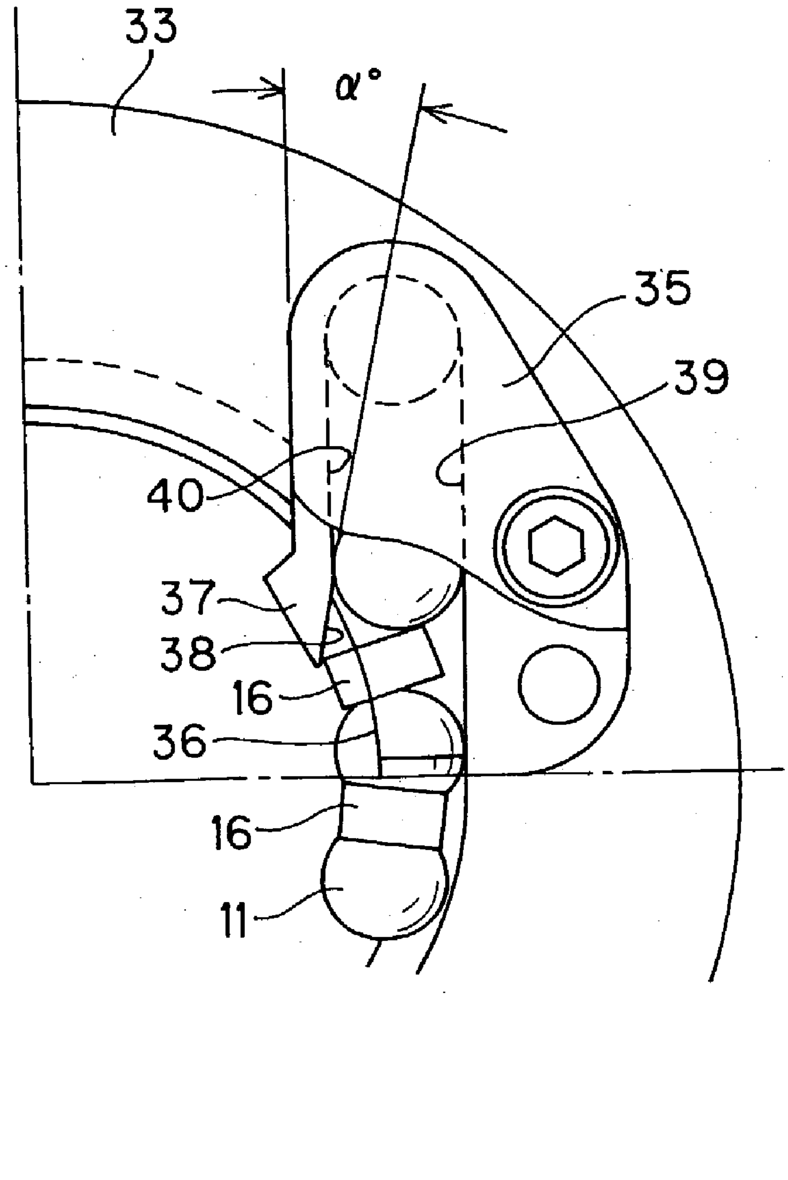


FIG. 1

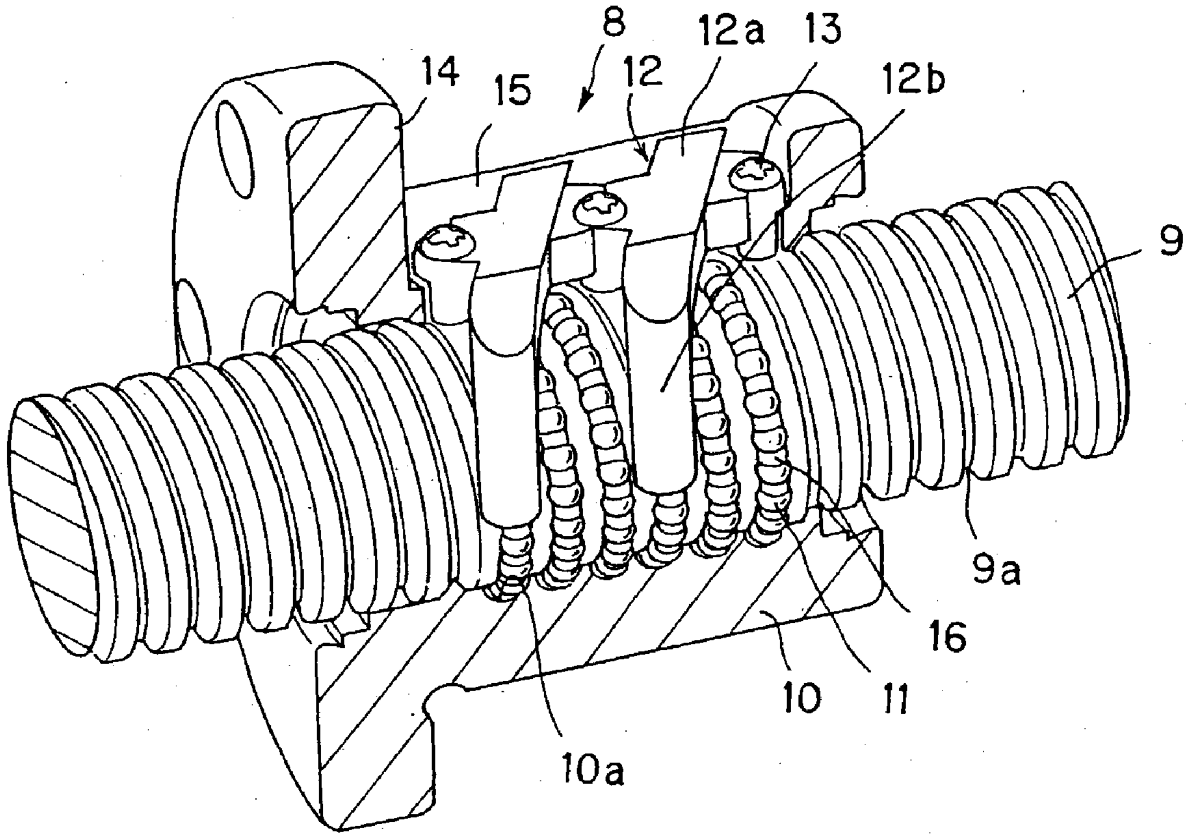


FIG. 2A

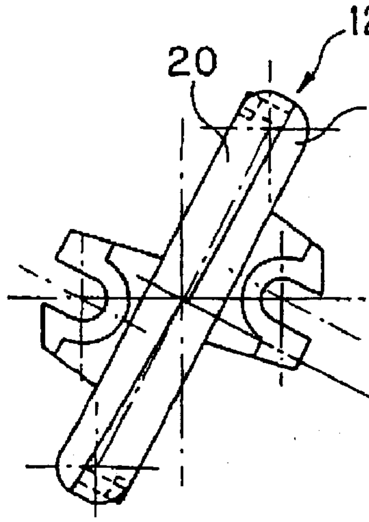


FIG. 2B

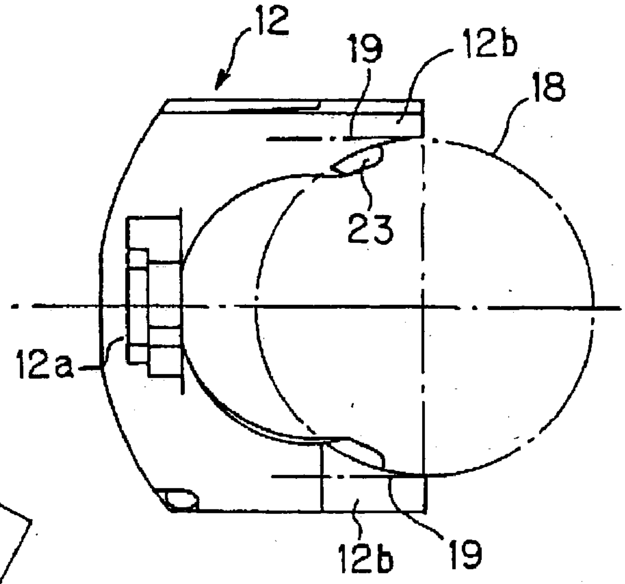


FIG. 2C

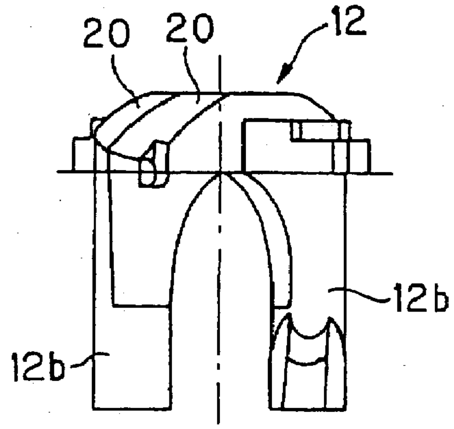


FIG. 2D

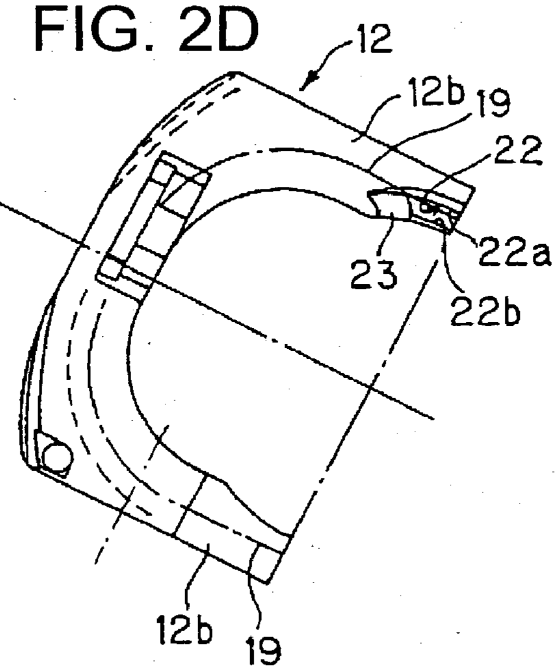


FIG. 3A

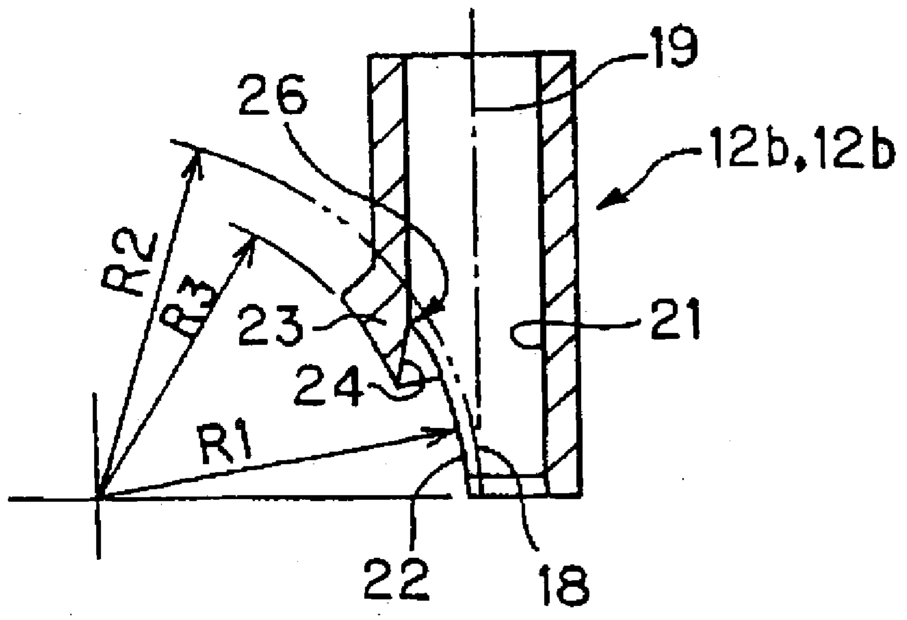


FIG. 3B

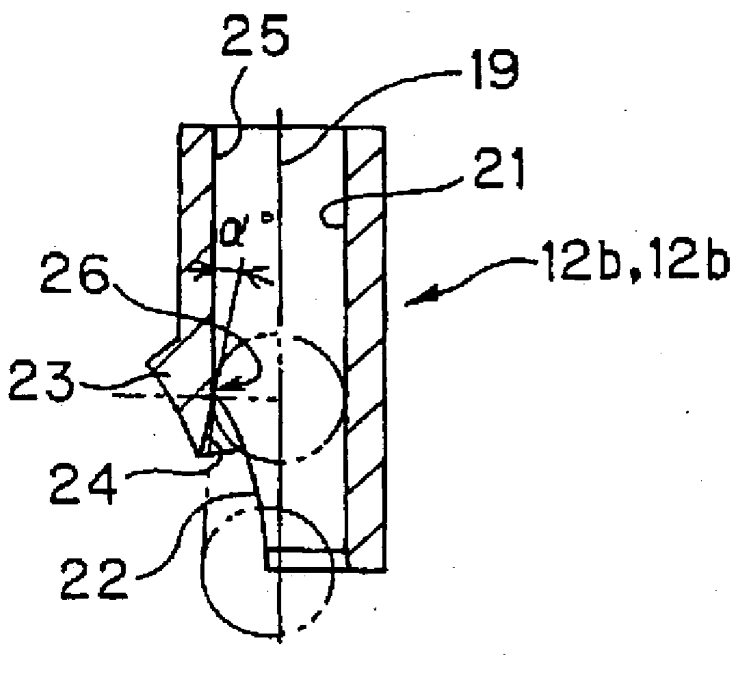


FIG.4

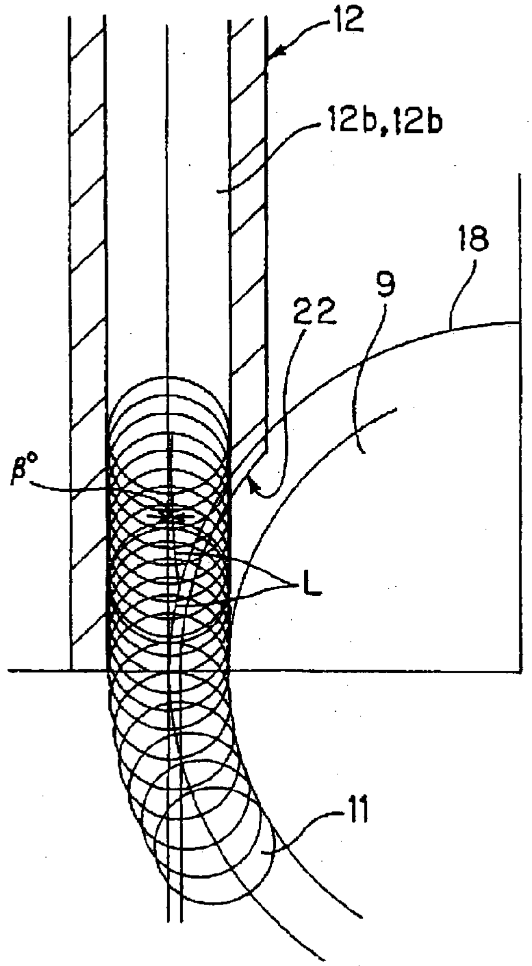


FIG. 5

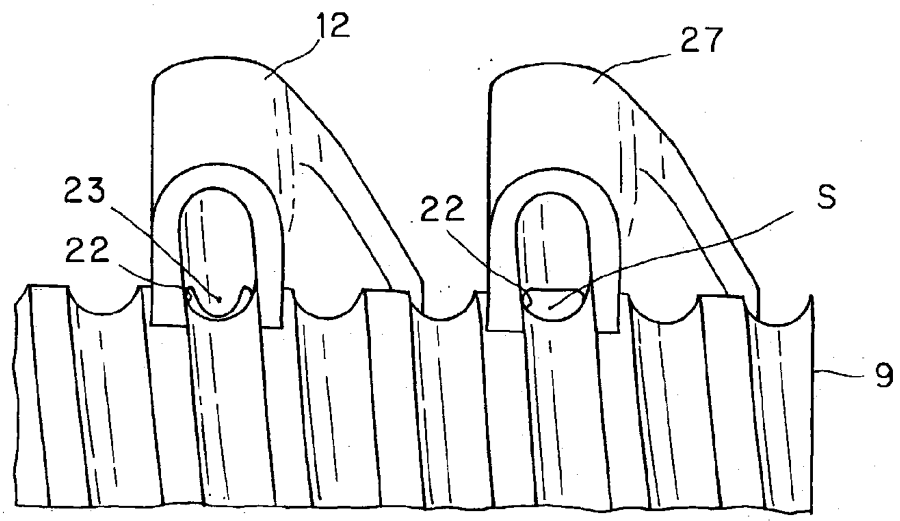


FIG. 6

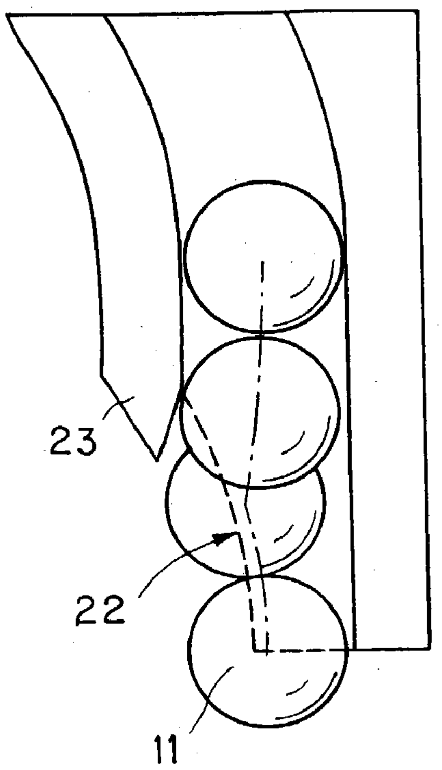


FIG. 7

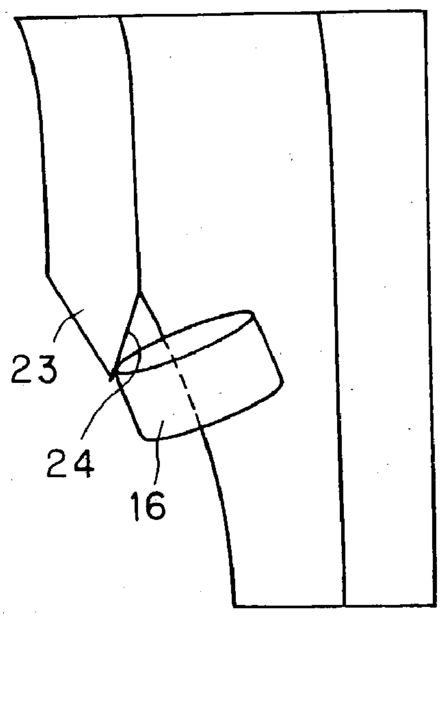


FIG. 8

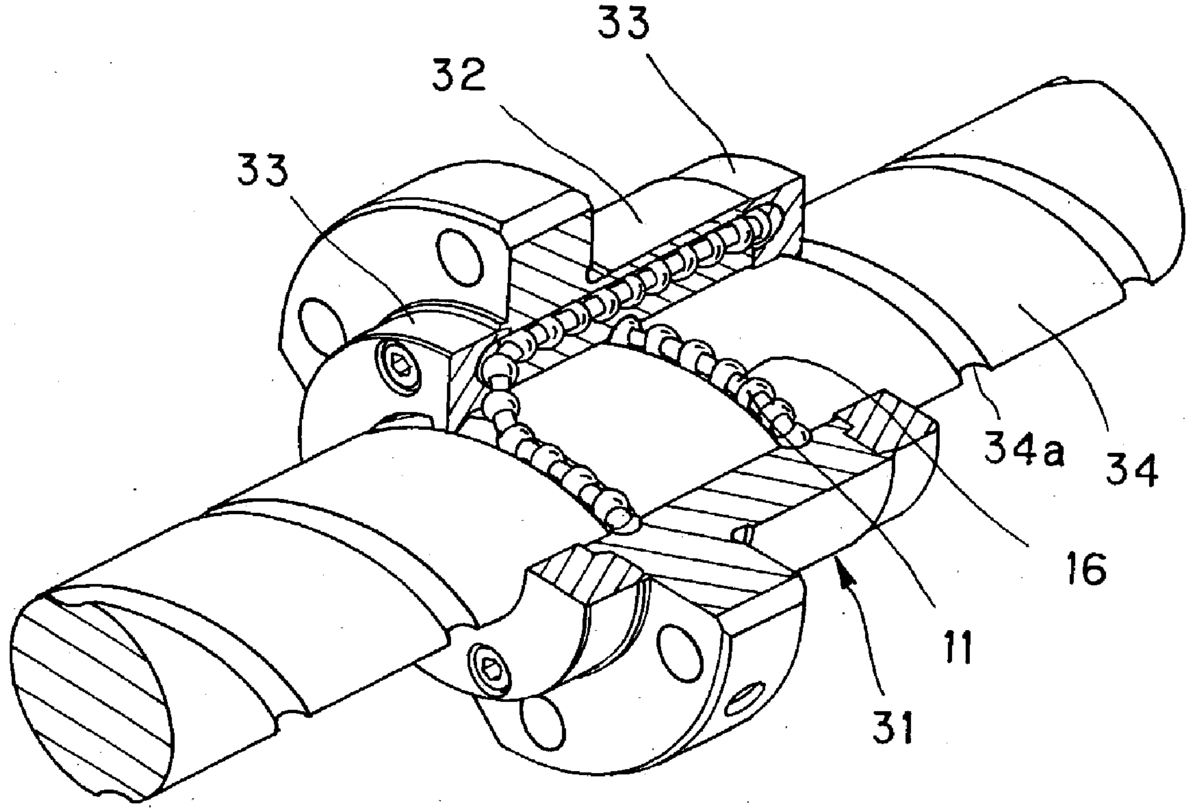


FIG. 9A

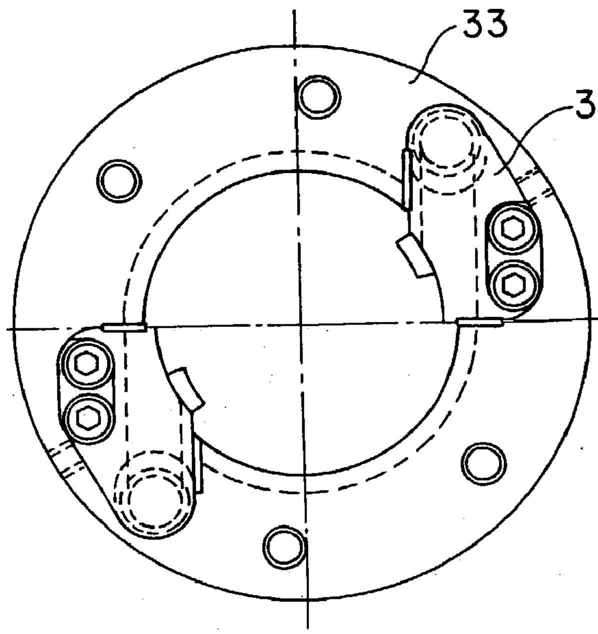


FIG. 9B

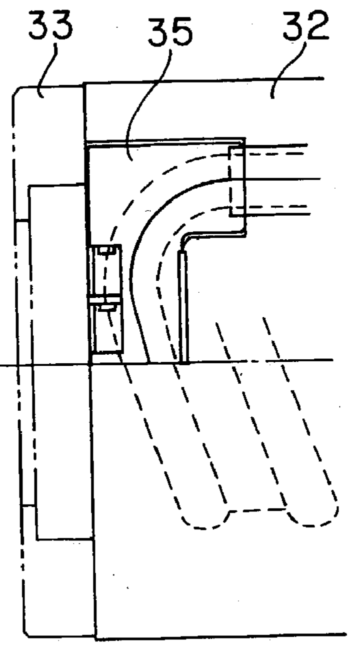


FIG. 10

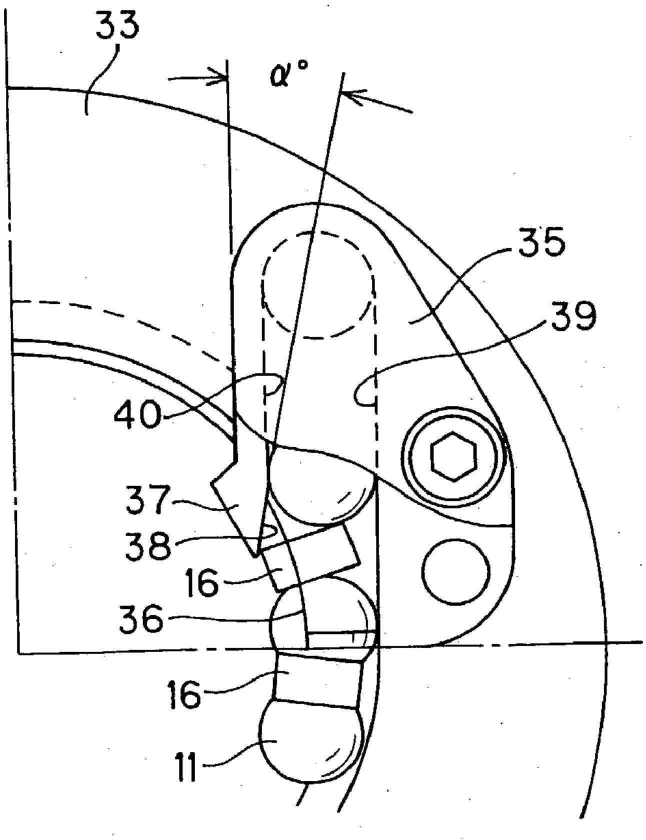


FIG. 11

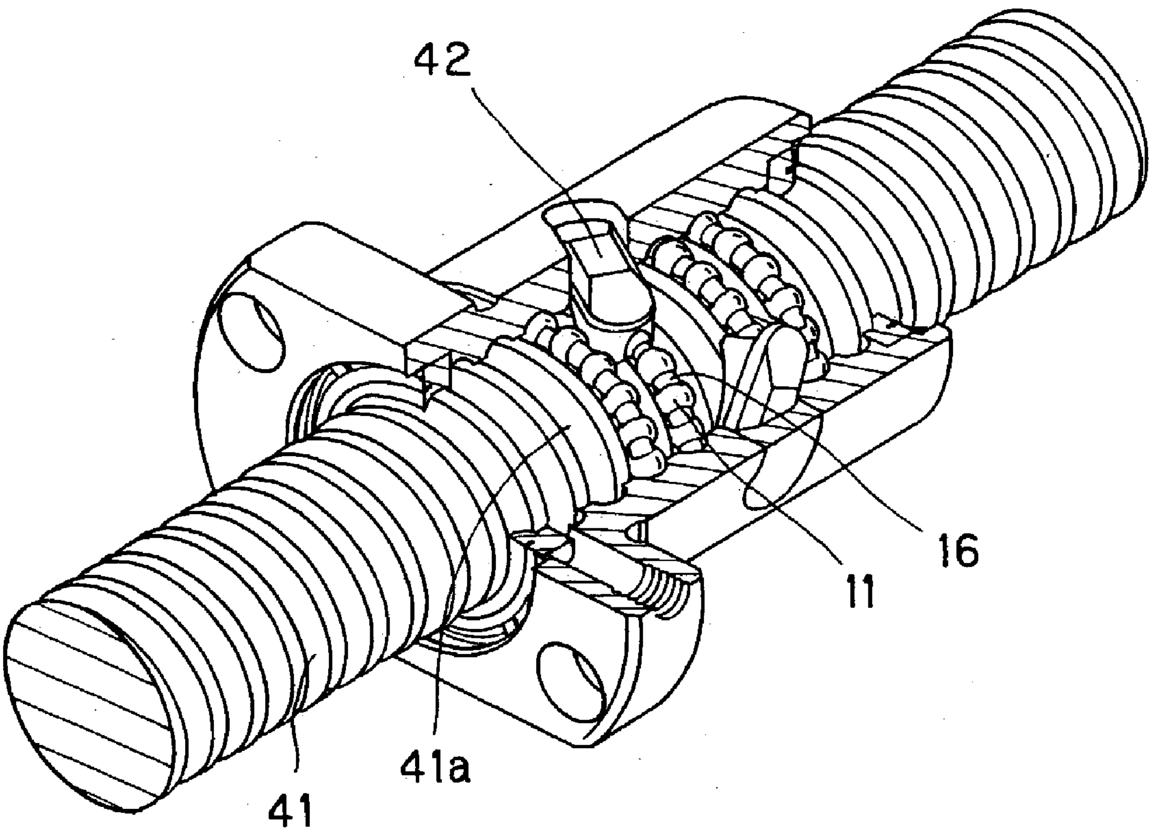


FIG. 12

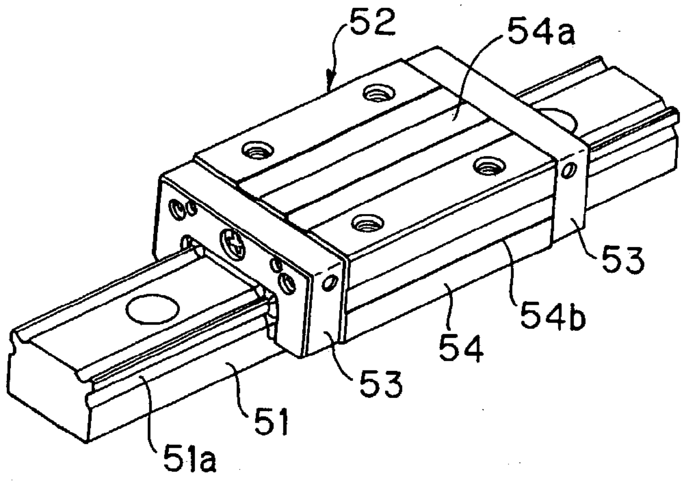


FIG. 13

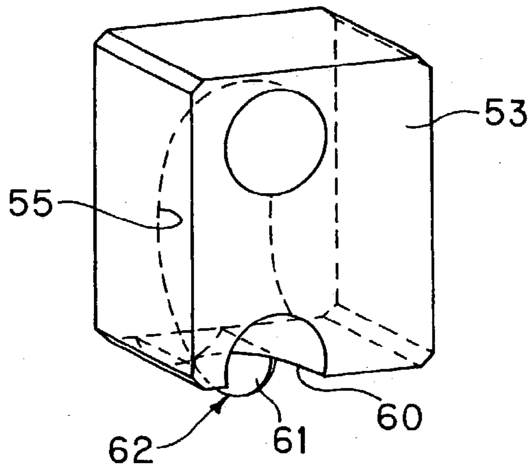


FIG. 14

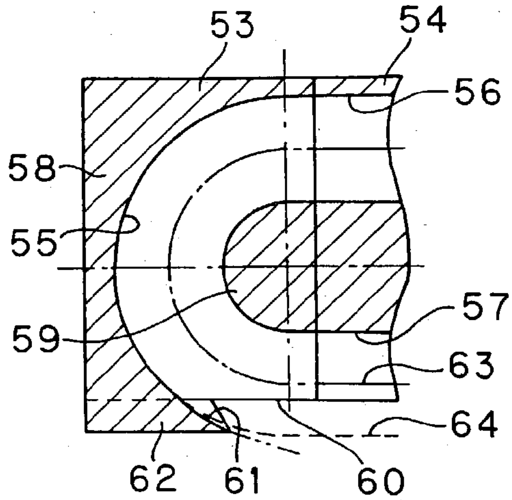


FIG. 15

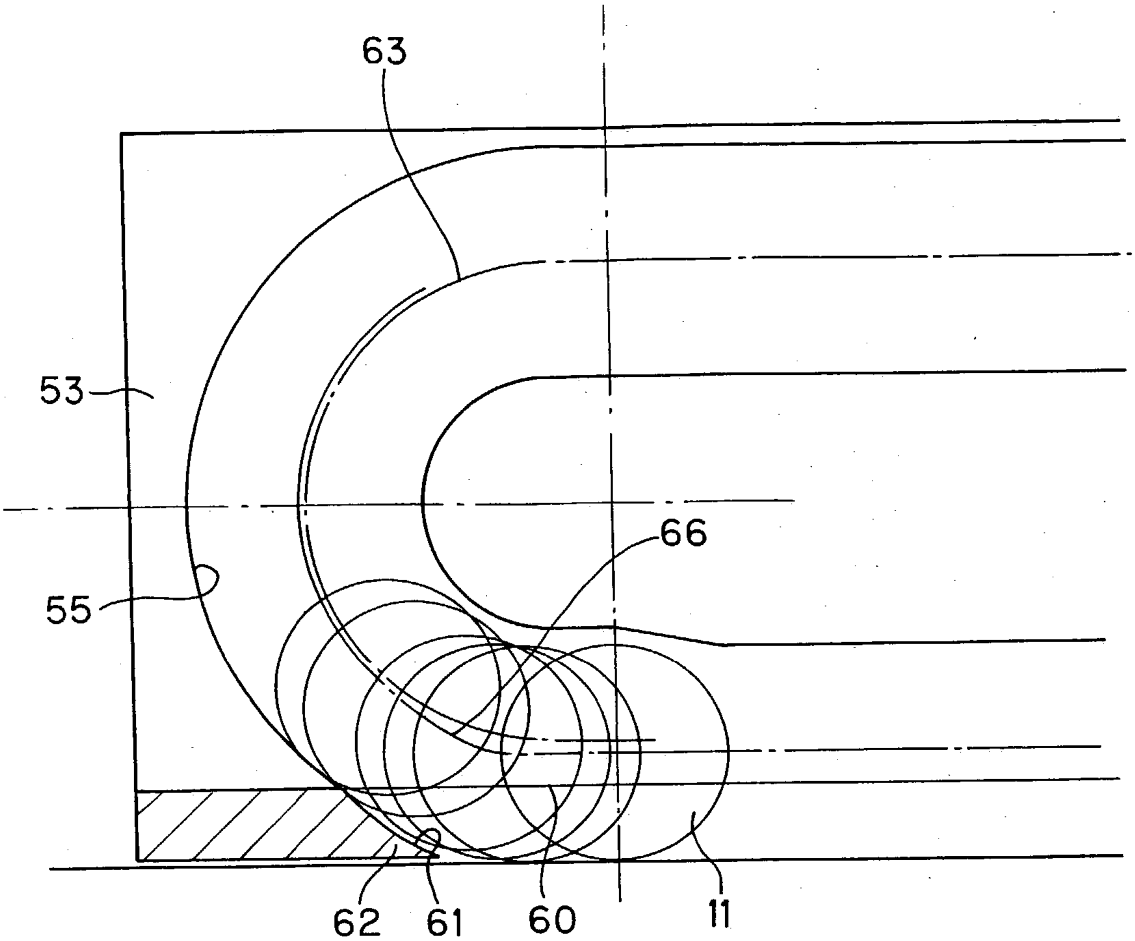


FIG. 16

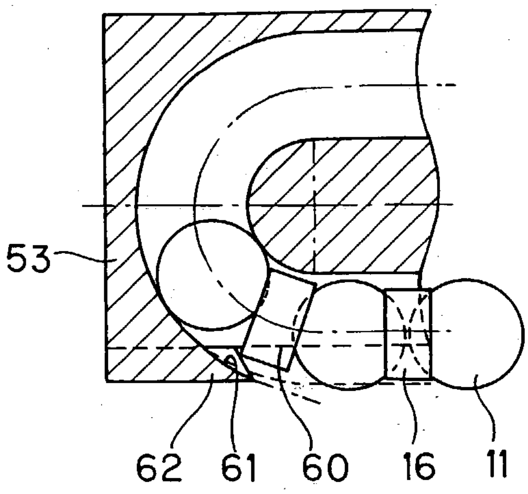


FIG. 17

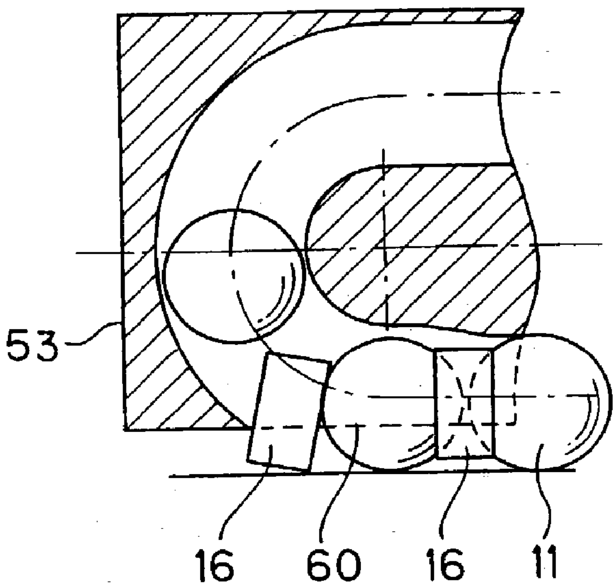


FIG. 18

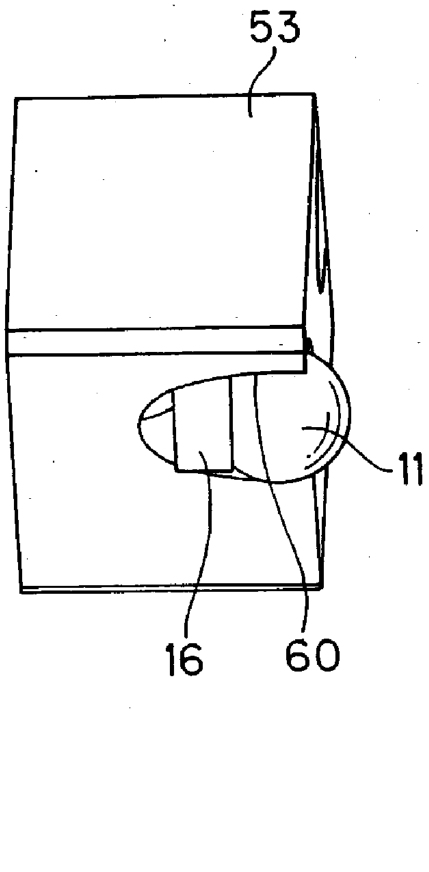


FIG. 19

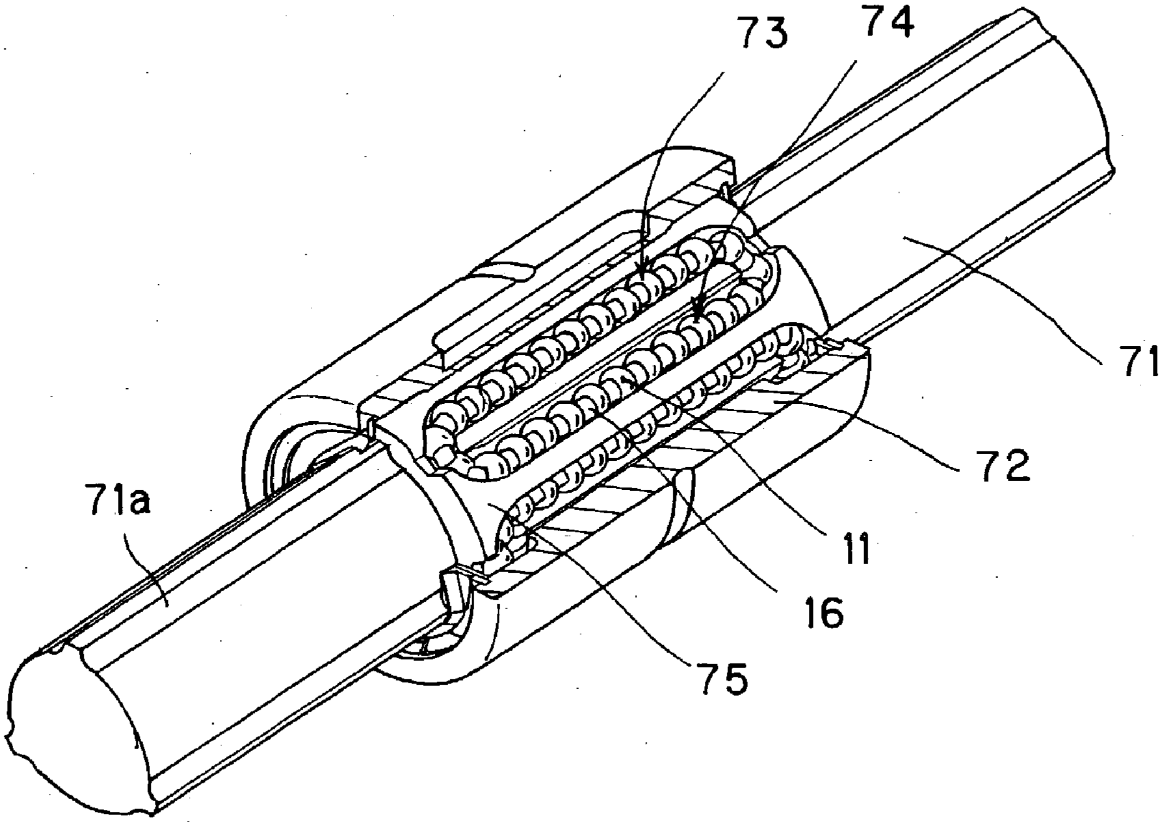


FIG. 20
PRIOR ART

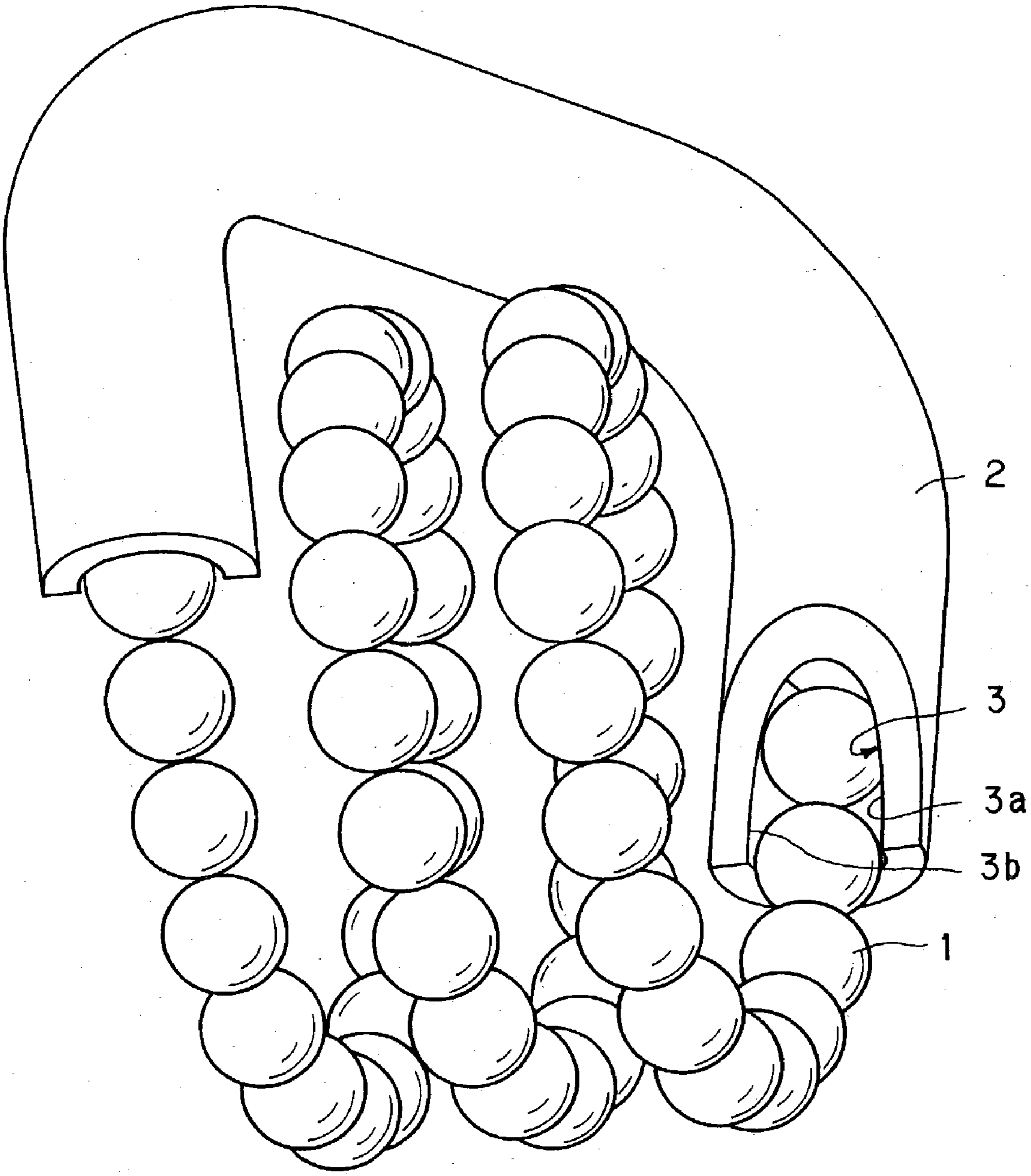


FIG. 21
PRIOR ART

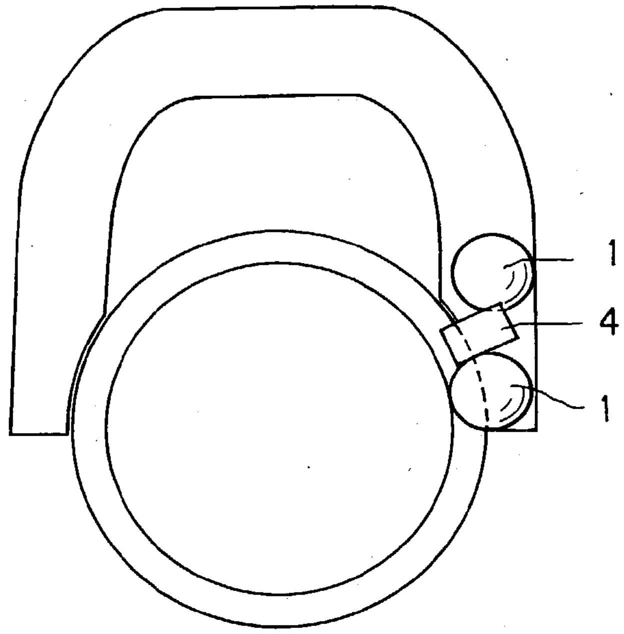
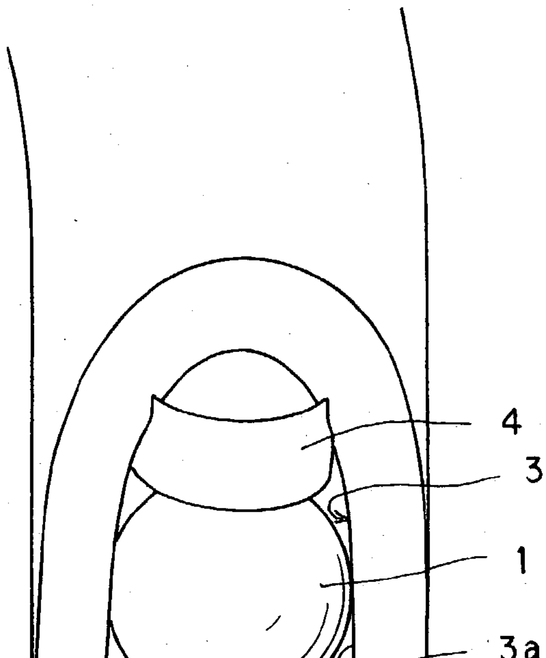


FIG. 22
PRIOR ART



CIRCULATION MEMBER, MOTION GUIDE DEVICE PROVIDED WITH CIRCULATION MEMBER AND BALL SCREW PROVIDED WITH CIRCULATION MEMBER

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a circulation member for circulating a number of balls and spacers disposed in a ball rolling passage formed between a track member and a movable member in conformity with a relative motion of the movable member with respect to the track member, and also relates to motion guide device and ball screw provided with such circulation member.

[0003] 2. Related Art

[0004] The applicant of the subject application provided a circulation member such as shown in **FIG. 20** applied to a ball screw, which is disclosed in Japanese Patent Application No. HEI 10-180767.

[0005] With reference to **FIG. 20, a** ball screw is formed with a ball rolling groove, and balls **1** rolling along the ball rolling groove contact both edge portions **3***a*, **3***b* of a scoop-up groove **3** formed in a circulation member **2** and are then scooped from the ball rolling groove **3** in an embraced fashion. In the case where scoop-up groove **3** is formed in the circulation member **2**, an impact force is substantially not applied to the circulation member **2**, and therefore, it becomes possible to rotate a screw shaft at high speed to thereby move the balls **1** also at high speed.

[0006] Such circulation member **2** may be functionally sufficient to act only to circulate the balls **1**. However, there are many cases where spacers are disposed between the balls **1** for preventing friction or like. Such a spacer has substantially cylindrical shape having a diameter smaller than that of the ball **1** and is provided, at its both end portions in the ball advancing direction, with recesses in conformity with the spherical shape of the ball.

[0007] When scooping the ball **1** and the spacer by using the circulation member of the conventional structure mentioned above, for example, because the ball **1** has a spherical surface, the ball **1** is embraced and scooped by both side edge portions **3***a*, **3***a* of the scoop-up groove **3**. In a case where there exists a small gap between the adjacent balls **1**, **1**, the spacer put between the balls **1**, **1** may be also scooped together with the balls. However, as shown in **FIGS. 21 and 22**, in a case where the spacer **4** freely moves between the adjacent balls **1**, **1**, there is a fear that the spacer **4** engages with the side edge portions **3***a*, **3***b* of the scoop-up groove **3** because the spacer **4** has nearly flat end portions in the advancing direction, thus being inconvenient.

SUMMARY OF THE INVENTION

[0008] An object of the present invention is therefore to substantially eliminate defects or inconveniences encountered in the prior art and to provide a circulation member capable of surely scooping a spacer as well as a ball even in an arrangement that a gap exist between balls, for example, of a ball screw.

[0009] Another object of the present invention is to provide a ball screw and a motion guide device provided with an improved circulation member mentioned above.

[0010] These and other objects can be achieved according to the present invention by providing, in a general aspect, a circulation member formed with a scoop-up groove for scooping the ball and a spacer scoop-up portion by contacting the spacer without contacting the ball.

[0011] That is, in one main aspect, the circulation member for achieving the above objects is a circulation member for circulating a number of balls and a number of spacers, each spacer being disposed between the balls, which are arranged in a ball rolling groove formed between a track member and a movable member, in accordance with a relative motion of the movable member with respect to the track member, wherein the circulation member is provided with a scoop-up groove for scooping the balls by contacting the ball rolling in the ball rolling passage at both side edge portions of the scoop-up groove and is also provided with a spacer scoop-up portion which contacts and scoops the spacer moving in the ball rolling passage without contacting the balls.

[0012] According to this aspect, the ball rolling on the ball rolling passage is embraced by both side edge portions of the scoop-up groove formed in the circulation member and is then scooped. In such operation, even if the gap between the balls is widened and the spacer tends to come off from a track of the ball, the spacer can be scooped by the spacer scoop-up portion. Also, since the spacer scoop-up portion does not contact the balls being scooped by the scoop-up groove, the spacer scoop-up portion will not be damaged.

[0013] In a preferred embodiment of this aspect, the spacer scoop-up portion is formed with an escape surface which is apart from a track of the ball scooped by the scoop-up groove and contacts the spacer, thus contacting only the spacer without contacting the ball.

[0014] In another aspect of the present invention, there is provided a ball screw comprising:

[0015] a screw shaft formed, on an outer periphery thereof, with a spiral ball rolling groove;

[0016] a nut assembled with the screw shaft and formed, on an inner periphery thereof, with a spiral loaded ball rolling groove so as to oppose to the ball rolling groove formed on the screw shaft to thereby form a ball rolling passage;

[0017] a number of balls disposed in the ball rolling passage;

[0018] a number of spacers disposed between the balls in the ball rolling passage; and

[0019] a circulation member for circulating a number of balls and spacers, each spacer being disposed between the balls in accordance with a relative motion of the nut with respect to the screw shaft, wherein the circulation member is provided with a scoop-up groove for scooping the balls by contacting the ball rolling in the ball rolling passage at both side edge portions of the scoop-up groove and is also provided with a spacer scoop-up portion which contacts and scoops the spacer moving in the ball rolling passage without contacting the balls.

[0020] In preferred embodiments of this aspect, the spacer scoop-up portion is also formed with an escape surface which is apart from a track of the ball scooped by the scoop-up groove and contacts the spacer.

[0021] The circulation member has a linear passage having a circular section for linearly moving the ball scooped by the scoop-up groove, and the spacer scoop-up portion is formed at a bottom portion of the scoop-up groove and is formed with an escape surface which is inclined by a predetermined angle with respect to an inner peripheral surface of the linear passage in a sectional area including a center line of the linear passage.

[0022] In a further aspect of the present invention, there is also provided a motion guide device comprising:

[0023] a track rail formed with a ball rolling groove;

[0024] a slide member mounted to the track member to be relatively movable with respect thereto and is formed with a loaded ball rolling groove so as to oppose to the ball rolling groove of the track member to thereby form a ball rolling passage;

[0025] a number of balls disposed in the ball rolling passage;

[0026] a number of spacers disposed between the balls in the ball rolling passage; and

[0027] a circulation member for circulating a number of balls and spacers, each spacer being disposed between the balls in accordance with a relative motion of the slide member with respect to the track member, wherein the circulation member is provided with a scoop-up groove for scooping the balls by contacting the ball rolling in the ball rolling passage at both side edge portions of the scoop-up groove and is also provided with a spacer scoop-up portion which contacts and scoops the spacer moving in the ball rolling passage without contacting the balls.

[0028] According to the ball screw and the motion guide device, the circulation member has an improved structure of spacer scoop-up portion, so that the ball and the spacer can be surely scooped without damaging the constitutional elements.

[0029] The nature and further characteristic features will be made more clear from the following descriptions made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] In the accompanying drawings:

[0031] **FIG. 1** is a perspective view, partially in section, of a ball screw provided with a circulation member according to a first embodiment of the present invention;

[0032] **FIG. 2** shows the circulation member and includes **FIG. 2A** being a plan view of the circulation member, **FIG. 2B** being a side view thereof as viewed from an axial direction of a screw shaft of the ball screw, **FIG. 2C** being a side view thereof as viewed from a direction perpendicular to the axis of the screw shaft and **FIG. 2D** being a front view thereof;

[0033] **FIG. 3** shows a leg portion of the circulation member and includes **FIG. 3A** being a sectional view thereof indicating a radius of curvature of a scoop-up groove and **FIG. 3B** showing a sectional view thereof indicating an inclination (inclining angle) of an escape surface;

[0034] **FIG. 4** is an illustration showing a ball scooping state by the scoop-up groove;

[0035] **FIG. 5** is an illustration, in an enlarged scale, showing a comparison of gaps between the scoop-up groove and the screw shaft in a case of a circulation member provided with a scoop-up portion and in a case of a circulation member provided with no scoop-up portion;

[0036] **FIG. 6** is an illustration showing a ball scooping state by the scoop-up portion;

[0037] **FIG. 7** is an illustration showing a spacer scooping state by a spacer scooping portion;

[0038] **FIG. 8** is a perspective view, partially in section, showing an end-cap type ball screw provided with a circulation member according to a second embodiment of the present invention;

[0039] **FIG. 9** shows a combination of a side lid and the circulation member of the second embodiment and includes **FIG. 9A** showing a state viewed from the axial direction of the screw shaft and **FIG. 9B** showing a state viewed from the side of the screw shaft;

[0040] **FIG. 10** is an illustration showing the circulation member of the second embodiment;

[0041] **FIG. 11** is a perspective view showing one example of a deflector type ball screw provided with the circulation member of the present invention;

[0042] **FIG. 12** is a perspective view of a linear motion guide device provided with a circulation member according to a third embedment of the present invention;

[0043] **FIG. 13** is a perspective view showing the circulation member;

[0044] **FIG. 14** is a sectional view of the circulation member;

[0045] **FIG. 15** is an illustration showing a track of the ball scooped by the scoop-up groove;

[0046] **FIG. 16** is an illustration showing a ball scooping state by the scoop-up groove and a spacer scooping state by the spacer scoop-up portion;

[0047] **FIG. 17** is an illustration comparative with **FIG. 16**, provided with no spacer scooping portion;

[0048] **FIG. 18** is a perspective view, comparative with **FIG. 16**, provided with no spacer scooping portion;

[0049] **FIG. 19** is a perspective view of a ball spline provided with the circulation member of the present invention;

[0050] **FIG. 20** is a perspective view of a ball screw provided with a circulation member of conventional structure;

[0051] **FIG. 21** is an illustration, viewed from the axial direction of a screw shaft, showing a state that a ball is engaged with the scoop-up groove; and

[0052] **FIG. 22** is an illustration, viewed from the front side of the scoop-up groove, showing a state that a gap grows between adjacent balls.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0053] Preferred embodiments of the present invention will be described hereunder in detail in conjunction with the accompanying drawings.

[0054] **FIG. 1** shows a ball screw provided with a circulation member according to the first embodiment of the present invention.

[0055] With reference to **FIG. 1, a** ball screw **8** is composed of a screw shaft **9** formed with a spiral ball rolling groove **9***a* formed on an outer peripheral surface thereof and a nut **10** mounted to the screw shaft **9**. The spiral ball rolling groove **9***a* is formed by a grinding or rolling working so as to have a constant lead and approximately semi-circular section.

[0056] On the other hand, the nut **10** is formed, on its inner peripheral surface, with a spiral loaded ball rolling groove **10***a* corresponding to the ball rolling groove **9***a* of the screw shaft **9**. The nut **10** generally has a cylindrical shape and the nut **10** is provided, at its one end, with a flanged potion **14** for mounting the ball screw **8** to a machine or like. The spiral loaded ball rolling groove **10***a* of the nut **10** is formed so as to have an approximately semi-circular section of the shape corresponding to the ball rolling groove **9***a* of the screw shaft **9**.

[0057] The nut **10** is formed with insertion holes, at plural portions, for inserting leg portions **12***b*, **12***b* of a circulation member **12**.

[0058] The ball rolling groove **9***a* of the screw shaft **9** and the loaded ball rolling groove **10***a* formed on the nut **10** constitute, in their combination, a ball rolling passage in which a number of balls **11, 11**, - - - are accommodated and spacers **16, 16**, - - - are also accommodated to prevent the balls **11** from contacting each other.

[0059] In this first embodiment, the nut **10** is mounted with, for example, two circulation members **12, 12**, which are called "return pipes". The circulation member **12** constitutes a non-loaded return passage communicating one end of the ball rolling passage with the other one end thereof so that a number of balls **11, 11**, - - - and spacers **16, 16**, - - - circulate in accordance with the relative motion of the nut **10** with respect to the screw shaft **9**.

[0060] The circulation member **12** has a gate shape having a central portion **12***a* and a pair of leg portions **12***b*, **12***b* extending from both side end portions of the central portion **12***a*. These leg portions **12***b*, **12***b* are inserted into the ball rolling passage with an interval of several pitches, and the circulation member **12** is fastened to the nut **10** by means of bolts **13** or like.

[0061] With reference to **FIG. 2 (FIGS. 2A** to 2D), the circulation member **12** is disposed so that center lines **19, 19** of the inner peripheries of the paired leg portions **12***b*, **12***b* are positioned to the tangential direction of the center line **18** of the spiral ball track as shown in **FIG. 2**B, and the leg portions **12***b*, **12***b* are inclined in directions different from each other in conformity with lead angles of the center line **18**.

[0062] According to such arrangement of the center lines of the leg portions **12***b*, **12***b*, the ball **11** can be scooped in the tangential direction and lead angle direction of the track center line **18**. That is, the ball **11** can be scooped up along its rolling (advancing) direction. Therefore, no forcible force is not applied to the leg portions **12***b*, **12***b* at the time of scooping the ball **11**.

[0063] The circulation member **12** is divided into two sections or parts along its axial direction as a pair of divided bodies **20, 20**, which are then jointed by means of heat calking, fusing, bonding or like process or by using fastening means, adhesive sheet, clip or like.

[0064] Next, with reference to **FIG. 3**, each of the leg portions **12***b* has a linear passage **21**, having a circular section, for substantially linearly moving the ball **11**. As mentioned above, the center line **19** of the inner periphery of this linear passage **21** is arranged in the tangential direction of the ball track center line **18** as shown in **FIG. 2**. The leg portion **12***b* has a front end extending to the position at which the ball track center line **18** and the center line **19** of the linear passage **21** contact each other, and at a portion near the front end of the leg portion **12** is formed with a scoop-up groove **22** for scooping the ball **11**.

[0065] Referring to **FIG. 3**A, the radius R1 of curvature of the scoop-up groove **22** viewed from the axial direction of the screw shaft **9** is designed to be slightly smaller than the radius R2 of curvature of the track center line **18** of the ball **11** and slightly larger than the outer diameter R3 of the screw shaft **9**. Further, the scoop-up groove **22** has a lateral width gradually reduced towards the deep direction of the circulation member **12**.

[0066] A spacer scoop-up portion **23** is formed at the bottom portion of the scoop-up groove **22**. The spacer scoop-up portion **23** is formed with an escape surface **24** so as to be apart from the track of the ball **22** scooped by the scoop-up groove **22** and to contact the spacer **16**.

[0067] With reference to **FIG. 3**B, in the sectional area including the center line **19** of the linear passage **21**, the escape surface **24** of the spacer scoop-up portion **23** is inclined by a predetermined angle a with respect to the inner peripheral surface **25** of the linear passage **21**. According to such design, a boundary portion **26** is formed between the inner peripheral surface **25** of the linear passage **21** and the escape surface **24** of the spacer scoop-up portion **23**. This escape surface **24** can contact the spacer **16** without contacting the ball **11** and scoop the spacer **16** moving in the ball rolling passage.

[0068] In the structure of this first embodiment, the ball scoop-up groove **22** has a width gradually reduced towards inward the circulation member **12**, and the ball **11** can be scooped by the contact of both the side edges of the scoop-up groove **22** to the ball **11**. Furthermore, in this embodiment, the spacer scoop-up portion **23** is formed at the bottom of the scoop-up groove **22** so as to guide the spacers **16, 16**, - - - disposed between the balls **11, 11**, - - - into the circulation member **12**.

[0069] Although it was difficult to manufacture, through machine working, these scoop-up groove **22** and the spacer scoop-up portion **23** because of complicated structures thereof, it becomes possible to manufacture the scoop-up groove **22** and the spacer scoop-up portion **23** having complicated structures by molding the circulation member from resin or metal material. When the circulation member is formed as metal product, it is molded by thermally treating metal powder. On the other hand, a resin product will be molded through an injection molding process. However, it is still difficult to mold the complicated scoop-up groove **22** and spacer scoop-up portion **23** only by using a lateral pair of mold halves. In this embodiment, therefore, the scoop-up groove **22** and spacer scoop-up portion **23** are molded by using a slide mold capable of being slid in the axial direction of the leg portions **12***b*, **12***b*.

[0070] More specifically, at the molding operation, the slide mold is inserted into a lateral pair of mold halves. Next, under the slide mold inserted state, the scoop-up grooves **22** and the spacer scoop-up portions **23** are formed to the leg portions **12***b*, **12***b*. On the other hand, at the mold releasing operation, the slide mold is slid in the opposing direction. As mentioned, by using the slide mold, the scoop-up grooves **22** and the spacer scoop-up portions having complicated structures can be manufactured, as well as the inner peripheral surfaces of the leg portions **12***b*, **12***b*.

[0071] The ball scoop-up state by the scoop-up groove **22** is shown in **FIG. 4**, in which the spacers **16** and the scoop-up portions **23** are removed for the sake of easy understanding of the description for scooping the ball **11** by the scoop-up groove **22**.

[0072] When the ball **11** rolling along the peripheral direction on the ball rolling groove **9***a* of the screw shaft **9** rolls in the circulation member **12**, both the edge portions **22***a*, **22***b* of the scoop-up groove **22** contact the bal **11**. At this time, since the width of the scoop-up groove **22** is reduced gradually towards the ball rolling direction (from the lower side towards the upper side as viewed in **FIG. 4**), the ball **11** can be scooped, as if it is embraced, from the ball rolling groove into the circulation member **12**.

[0073] The circulation member **12** has an inner diameter, which is slightly larger than an outer diameter of the ball **11** so that the ball **11** can pass the circulation member **12** even in a case where lubricant or like adheres to the ball **11** or the circulation member **12** is slightly displaced. In more strictly, the ball **11** is scooped at after the shifting by an angle β in the screw shaft side and not in the tangential direction of the track center line **18** of the ball **11**.

[0074] In **FIG. 4**, the line L denotes the track of the center of the ball **11**. As mentioned above, according to this embodiment, the ball **11** can be scooped by both the edge portions of the scoop-up groove **22**, a load caused at the time when the ball **11** contacts the scoop-up groove **22** can be significantly reduced.

[0075] On the other hand, in a conventional structure of the ball screw having a return pipe type circulation member, it is general that the ball is scooped by a tongue portion formed to the return pipe. In the use of such conventional ball screw, however, when the screw shaft is rotated at a high speed, the ball moves at a high speed (ball movement becomes faster), there is a fear of damaging the tongue portion through the collision of the ball with the tongue portion. In order to obviate such defect, it was necessary to determine the upper limit of the revolution number of the screw shaft, thus having been inconvenient.

[0076] Therefore, the present invention has been conceived to overcome such inconvenience and provides a screw shaft capable of being rotated at a high speed by forming the scoop-up groove **22** to the circulation member **12**. According to the present invention, as mentioned before, since the ball can be scooped by both the edge portions of the scoop-up groove **22**, there is no need for forming the tongue portion as in the conventional structure.

[0077] The spacer scoop-up portion **23** acts to scoop up only the spacer **16** and has an outer shape similar to a shape of the tongue portion, which scoops the ball in the return pipe, in the conventional structure. However, the most essential difference of the present invention from the conventional structure resides in the presence of the escape surface **24**.

[0078] That is, in general, the tongue portion of the conventional return pipe is formed by cutting or grinding, for example, metal tube or grinding stone. Hence, an escape surface (such as escape surface **24** in this embodiment) having a predetermined inclination a with respect to the linear passage is never formed in the return pipe. Since the escape surface **24** is inclined by the predetermined angle of a, a projecting amount from the bottom of the scoop-up groove **22** is made smaller than that of the tongue portion.

[0079] **FIG. 5** shows a comparison of gaps between the scoop-up groove **22** and the screw shaft **9** in the case of the circulation member **12** provided with the scoop-up portion **23** and in the case of a circulation member **27** provided with no scoop-up portion. Further, it is to be noted that, in order to observe the gaps, in this **FIG. 5**, wall sections of the circulation members **12** and **27** on the side opposing to the scoop-up grooves **22** are eliminated in the illustration.

[0080] With reference to **FIG. 5**, the balls **11** are scooped by the scoop-up grooves **22** positioned on the sides opposing to the illustrated state. In the case of the circulation member **27** provided with no spacer scoop-up portion **23**, a relatively large gap S appears between the scoop-up groove **22** and the screw shaft **9**, and there is a fear that the spacer **16** dropping off from the ball **11** is adversely engaged with this space S. However, in the embodiment in which the spacer scoop-up portion **23** is formed, such space S can be clogged by the spacer scoop-up portion **23**.

[0081] Next, with reference to **FIGS. 6 and 7**, the ball **11** is scooped up in the manner of being embraced with both the edge portions of the scoop-up groove **22** (FIG. **6**). Furthermore, the spacer **16** can be surely scooped up by the escape surface **24** formed to the spacer scoop-up portion **23** contacting the spacer **16** even if the distance between the adjacent balls **11** is widened and the spacer **16** comes off from the moving passage. The spacer **16** does not always contact the spacer scoop-up portion **23**, and only in the case that the distance between the balls **11** is widened and the spacer **16** tends to come off from its track, the spacer **16** contacts the spacer scoop-up portion **23**. In the other cases, the spacers **16** are moved together with the balls **11**. Further, the spacer scoop-up portion **23** does not contact the ball **11** at the time when the ball **11** is scooped up, thus being not damaged or broken.

[0082] **FIG. 8** represents a ball screw of end-cap structure provided with a circulation member according to the second embodiment of the present invention.

[0083] The ball screw of this embodiment comprises a screw shaft **34** formed with a ball rolling groove **34***a* and a nut **31** composed of a nut body **32** formed with a ball rolling groove and side lids as end caps **33, 33** mounted to both ends of the nut body **32**. The nut body **32** is formed with the ball rolling groove and a ball return passage, and the side lids **33, 33** are formed with communication passages each communicating the ball rolling groove and the return passage. The circulation member is mounted to each of the side lids **33, 33** so as to act to scoop the balls **11, 11**, - - - and the spacers **16, 16**, - - - disposed between the balls.

[**0084**] **FIG. 9** shows the assembled state of the side lid **33** and the circulation member **35**. The circulation member **35** is mounted inside the side lid **33** and fixed to the nut body **32** by means of bolt or like. The circulation member **35** may have a various outer appearances in accordance with a mounting condition to the side lid **33**.

[**0085**] With reference to **FIG. 10** showing the mounting condition of the circulation member **35**, the circulation member **35** is provided with a ball scoop-up groove **36** which contacts and then scoops the ball **11** rolling in the ball rolling passage at its both side edge portions. The ball scoop-up groove **36** is formed, at its bottom portion, with a spacer scoop-up portion **37** for contacting and scooping the spacer **16** in the ball rolling groove without contacting the ball **11**. The spacer scoop-up portion **37** is formed with an escape surface **38** positioned apart from the ball rolling track and contacting the spacer **16**.

[**0086**] The circulation member **35** is formed with a linear passage **39**, having a circular section, for moving substantially linearly the ball **11** scooped by the scoop-up groove **36**. Further, in the sectional area including the center line of the linear passage **39**, the escape surface **38** of the spacer scoop-up portion **37** is inclined by a predetermined angle a with respect to the inner peripheral surface **40** of the linear passage **39**. According to this embodiment, the spacer **16** can be scooped up by the escape surface **38** even in the case where the distance between the adjacent balls **11, 11** is widened and the spacer **16** is come off from the moving track.

[**0087**] **FIG. 11** also represents a ball screw **41** provided with a circulation member of deflector structure type according to another embodiment of the present invention.

[**0088**] With reference to this embodiment of **FIG. 11**, the balls **11, 11**, - - - and the spacers **16, 16**, - - - traveling on the ball rolling groove **41***a* of the ball screw **41** once separated therefrom by the circulation member **42** having deflector structure and returned, by one lead, to a portion of the ball rolling groove **41***a* by jumping over the outer diameter portion of the screw shaft **41**. This circulation member **42** is formed with a ball return groove having approximately S-shape. The ball return groove has a most recessed portion at the central portion of the circulation member **42** so that the ball **11** and the spacer **16** advancing in the ball return groove can jump over the outer peripheral portion of the screw shaft **41**.

[**0089**] The circulation member **42**, i.e., deflector, acts to forcibly push the ball rolling on the ball rolling groove **41***a* from its lateral side so as to jump the ball over the outer periphery of the screw shaft **41**. Further, a spacer scoop-up portion for scooping only the spacer **16** by contacting it without contacting the ball **11** is formed to the circulation member **42**. In this deflector type circulation member **42**, the escape surface formed to the scoop-up portion has a three-dimensional shape apart from the three-dimensional ball track.

[**0090**] The present invention further provides a linear motion guide provided with a circulation member according to the third embodiment with reference to **FIG. 12**.

[**0091**] The linear motion guide of this embodiment is, for example, a device for guiding a movable member or body such as table on a stationary member such as bed or saddle.

[**0092**] The linear motion guide comprises a track rail **51** disposed on a stationary member and having a longitudinal extension, and a slide member assembled with the track rail **5l** to be relatively movable. The track rail **51** is formed with a ball rolling groove **51***a* formed along the longitudinal direction thereof and the slide member is also formed with a loaded ball rolling groove so as to correspond to the ball rolling groove **51***a* formed to track rail **51**.

[**0093**] The linear motion guide further comprises a number of balls disposed in a ball rolling passage formed by, in combination, the ball rolling groove **51***a* of the track rail **51** and the loaded ball rolling groove formed to the slide member **52**, a number of spacers disposed between the balls, and circulation members **53, 53**, provided for the slide member **52**, for circulating the balls and the spacers in conformity with the relative motion of the slide member **52** with respect to the track rail **51**.

[**0094**] The track rail **51** has an elongated scale so as to provide, for example, a rectangular shape in section. The ball rolling groove **51***a* constitutes a track for ball rolling, and a plurality of rows of ball rolling grooves **51***a* may be formed in accordance with the object on use of the linear motion guide. In the illustrated embodiment, the track rail **51** has a linear structure, but it may have a curved rail structure. The track rail **51** has screw holes to which screws are fastened so as to secure the track rail **51** to the stationary member.

[**0095**] The slide member **52** comprises a block body **54** and end plates as the circulation members **53, 53** disposed both end portions of the block body **54**. The circulation members **53, 53** are formed with U-shaped direction changing passage for changing the rolling direction of the ball.

[**0096**] The block body **54** of the slide member **52** is a ⊐-shaped member having a flat horizontal portion **54***a* opposing to the upper surface of the track rail **51**, when assembled, and a pair of support leg (skirt) portions **54***b*,**54***b* opposing to the bilateral side surfaces of the track rail **51**. Loaded ball rolling grooves are formed to the inside surfaces of the block body **54** so as to oppose to the ball rolling grooves **51***a*, **51***a* formed to the outside surface of the track rail **51**. Ball return passages are also formed to the block body **54**, as bores, in parallel to the ball rolling grooves **51***a*. The ball rolling passage and the ball return passage are communicated by means of the direction changing passage formed to the circulation member **53**. A plurality of fastening holes are formed to the upper surface of the block body **54** for fastening and securing an object to be guided to the block body **54** by means of screws or bolts.

[**0097**] The circulation member **53** will be further described hereunder with reference to **FIGS. 13 and 14**, in which **FIG. 13** is a perspective view of a portion of the circulation member **53** and **FIG. 14** is a sectional view showing the direction changing passage **55** formed to the circulation member **53**.

[0098] The circulation member **53** is formed with, as shown, the ball rolling direction changing passage **55** communicating the ball return passage **56** and the ball rolling passage **57**. More specifically, the circulation member is formed with an outer periphery guide portion **58** constituting the outer periphery of the direction changing passage **55** and, on the other hand, the block body **54** is formed with an arch-shaped inner periphery guide portion **59** constituting the inner periphery of the direction changing passage **55**.

[0099] As shown in **FIG. 13, a** ball scoop-up groove **60** is formed to the lower portion of the direction changing passage **55** of the circulation member **53** for contacting and then scooping the ball in the ball rolling passage **57** by both side edge portions of the groove **60**. The scoop-up groove **60** is formed on one flat surface, in parallel to the track rail **51**, on the side of the track rail **51** more than the center line **63** of the direction changing passage **55**. The scoop-up groove **60** has a horizontal width gradually reduced towards the ball advancing direction. The ball scooping manner of this scoop-up groove **60** is substantially the same as that of the former embodiment.

[0100] As shown in **FIGS. 13 and 14**, in this embodiment, there is formed, at the bottom portion of the scoop-up groove **60**, a spacer scoop-up portion **62** for contacting and then scooping the spacer without contacting the ball in the ball rolling passage **57**. The spacer scoop-up portion **62** has an escape surface **61** apart from the track **64** of the ball scooped by the scoop-up groove **60** but contacting the spacer.

[0101] **FIG. 15** shows the track of the ball **11** scooped by the scoop-up groove **60**. In this embodiment, different from the embodiment of the ball screw, the direction changing passage **55** of the circulation member **53** is bent in a circular-arc shape. Further, since the small gap exists between the ball **11** and the direction changing passage **55**, the track **66** of the center of the ball **11** passes slightly outside the center line **63** of the direction changing passage. Therefore, the escape surface **61** of the spacer scoop-up portion **62** is formed in consideration of this track of the ball **11** so as not to contact the ball. This escape surface **61** may have a curved shape as shown in **FIG. 15** as well as linear shape.

[0102] **FIG. 16** shows the scooping state of the ball **11** by the scoop-up groove and the scooping state of the spacer **16** by the spacer scoop-up portion **62**. As shown, the ball **11** is first embraced and then scooped by both the edge portions of the scoop-up groove **60**. Even if the distance between the balls **11** and the spacer **16** tends to come off from the track, the spacer scoop-up portion **62** contacting the ball **11** can scoop the ball **11**.

[0103] An example provided with no spacer scoop-up portion is shown in **FIGS. 17 and 18** for comparison.

[0104] In this comparative example, the ball **11** having a spherical outer surface is scooped by both the edge portions of the scoop-up groove **60** in the embraced manner. On the other hand, the spacer **16** has a flat end shape, and in the case when the distance between the balls **11, 11** is widened and the spacer **16** tends to come off from the track, there may cause a fear that the flat end portion of the spacer **16** adversely engages with the scoop-up groove **60**, thus being inconvenient.

[0105] **FIG. 19** also shows an example of a ball spline provided with the circulation member according to the present invention.

[0106] The ball spline is composed of a spline shaft **71** as track rail and an outer sleeve **72** as a slide member mounted to the spline shaft **71** through a number of balls **11, 11** - - - disposed therebetween.

[0107] The spline shaft **71** has a columnar structure having true circularity and has an outer surface formed as a ball track on which a ball rolling groove **71***a* so as to extend its axial direction.

[0108] The outer sleeve **72** mounted to the spline shaft **71** is formed with a loaded ball rolling groove corresponding to the ball rolling groove **71***a* so as to constitute a ball rolling passage as a ball circulation passage in form of circuit. In this ball circulation passage, a number of balls **11, 11**, - - - and spacers **16, 16**, - - - are accommodated so as to circulate therein in accordance with the relative linear motion of the outer sleeve **72** with respect to the spline shaft **71**. That is, the ball rolling passage **73** is formed by the ball rolling groove **71***a* of the spline shaft **71** and the loaded ball rolling groove of the outer sleeve **72**. A non-loaded return passage **74**, in which the balls **11, 11**, - - - released from the load, is formed adjacent to the ball rolling passage **73**. On the other hand, the outer sleeve **72** is mounted with a circulation member **75** as a retainer for arranging and retaining the balls **11, 11**, - - - in the axial direction of the spline shaft **71**.

[0109] The circulation member **75** as a retainer is integrally mounted to the outer sleeve **72** and has an inner hollow cylindrical structure into which the spline shaft **71** is disposed in a penetrating manner. The circulation member **75** has an outer surface to which the circuit-formed ball circulation passage is formed. According to this circulation member **75**, the balls **11, 11**, - - - rolling on the ball rolling passage **73** are held from both sides between the outer sleeve **72** and the spline shaft **71** and the balls **11, 11**, - - - rolling on the loaded return passage **74** are held between the outer sleeve **72** and the passage **74** to thereby prevent the balls **11, 11**, - - - from coming off at the time when the outer sleeve **72** is withdrawn from the spline shaft **71**.

[0110] A ball scoop-up groove for scooping the balls **11, 11**, - - - rolling on the ball rolling passage **73** is formed to the circulation member **75**, which may also be formed with a spacer scoop-up portion for scooping us the spacers **16**.

[0111] It is to be noted that the present invention is not limited to the described embodiments and many other changes and modifications may be made without departing from the scopes of the appended claims.

[0112] For example, a number of spacers arranged independently between the adjacent balls may be connected in series by using a band or belt member. Furthermore, the track rail of the motion guide device may be formed to provide a curved structure in place of the linear structure.

[0113] The present application claims priority under 35 U.S.C §119 to Japanese Patent Application No.2002-184540 filed Jun. 25, 2002 entitled "CIRCULATION MEMBER, MOTION GUIDE DEIVCE PROVIDED WITH CIRCULATION MEMBER AND BALL SCREW PROVIDED WITH CIRCULATION MEMBER". The contents of that application are incorporated herein by reference in their entirety.

What is claimed is:

1. A circulation member for circulating a number of balls and a number of spacers, each spacer being disposed between the balls, which are arranged in a ball rolling groove formed between a track member and a movable member, in accordance with a relative motion of the movable member with respect to the track member,

wherein the circulation member is provided with a scoop-up groove for scooping the balls by contacting the ball rolling in the ball rolling passage at both side edge portions of the scoop-up groove and is provided with a spacer scoop-up portion which contacts and scoops the spacer moving in the ball rolling passage without contacting the balls.

2. The circulation member according to claim 1, wherein said spacer scoop-up portion is formed with an escape surface which is apart from a track of the ball scooped by the scoop-up groove and contacts the spacer.

3. A ball screw comprising:

a screw shaft formed, on an outer periphery thereof, with a spiral ball rolling groove;

a nut assembled with the screw shaft and formed, on an inner periphery thereof, with a spiral loaded ball rolling groove so as to oppose to the ball rolling groove formed on the screw shaft to thereby form a ball rolling passage;

a number of balls disposed in the ball rolling passage;

a number of spacers disposed between the balls in the ball rolling passage; and

a circulation member for circulating a number of balls and spacers, each spacer being disposed between the balls in accordance with a relative motion of the nut with respect to the screw shaft, wherein the circulation member is provided with a scoop-up groove for scooping the balls by contacting the ball rolling in the ball rolling passage at both side edge portions of the scoop-up groove and is provided with a spacer scoop-up portion which contacts and scoops the spacer moving in the ball rolling passage without contacting the balls.

4. The ball screw according to claim 3, wherein said spacer scoop-up portion is formed with an escape surface which is apart from a track of the ball scooped by the scoop-up groove and contacts the spacer.

5. The ball screw according to claim 4, wherein said circulation member has a linear passage having a circular section for linearly moving the ball scooped up by the scoop-up groove, and said spacer scoop-up portion is formed at a bottom portion of the scoop-up groove and is formed with an escape surface which is inclined by a predetermined angle with respect to an inner peripheral surface of the linear passage in a sectional area including a center line of the linear passage.

6. A motion guide device comprising:

a track rail formed with a ball rolling groove;

a slide member mounted to the track member to be relatively movable with respect thereto and is formed with a loaded ball rolling groove so as to oppose to the ball rolling groove of the track member to thereby form a ball rolling passage;

a number of balls disposed in the ball rolling passage;

a number of spacers disposed between the balls in the ball rolling passage; and

a circulation member for circulating a number of balls and spacers, each spacer being disposed between the balls in accordance with a relative motion of the slide member with respect to the track member, wherein the circulation member is provided with a scoop-up groove for scooping the balls by contacting the ball rolling in the ball rolling passage at both side edge portions of the scoop-up groove and is provided with a spacer scoop-up portion which contacts and scoops the spacer moving in the ball rolling passage without contacting the balls.

7. The motion guide device according to claim 6, wherein said spacer scoop-up portion is formed with an escape surface which is apart from a track of the ball scooped by the scoop-up groove and contacts the spacer.

* * * * *

US 20030194161A1

(19) United States
(12) Patent Application Publication (10) Pub. No.: US 2003/0194161 A1
Murata (43) Pub. Date: Oct. 16, 2003

(54) ROLLER RETAINER, DIRECT-ACTING GUIDE DEVICE AND ROLLER SCREW USING THE ROLLER RETAINER

(75) Inventor: **Tomozumi Murata**, Tokyo (JP)

Correspondence Address:
MORGAN LEWIS & BOCKIUS LLP
1111 PENNSYLVANIA AVENUE NW
WASHINGTON, DC 20004 (US)

(73) Assignee: **THK Co., Ltd.**

(21) Appl. No.: **10/448,223**

(22) Filed: **May 30, 2003**

Related U.S. Application Data

(63) Continuation of application No. 09/809,285, filed on Mar. 16, 2001.

(30) **Foreign Application Priority Data**

Mar. 21, 2000 (JP) P.2000-083253

Publication Classification

(51) **Int. Cl.**^{7} **F16C 29/06**
(52) **U.S. Cl.** **384/43**

(57) **ABSTRACT**

In a roller retainer assembly, a roller retainer **15** is thinned to retain individual one of plural rollers **7** circulating in a roller circulation path inclusive of linear and curved races and to hold opposite side surfaces of the roller **7** and front and rear surfaces thereof in the roller moving direction. A combination of linear and curve guide portions **16***a* and **16***b* different in inclination angle and a combination of linear and curve guide portion **17***a* and **17***b* different in inclination angle are formed respectively in opposite end surfaces of the roller retainer **15** in a retainer moving direction. In a linear race, the linear guide portions **16***a* and **17***a* come into contact with adjacent roller retainers **15** respectively. In a curved race, the curve guide portions **16***b* and **17***b* come into contact with adjacent roller retainers **15** respectively.

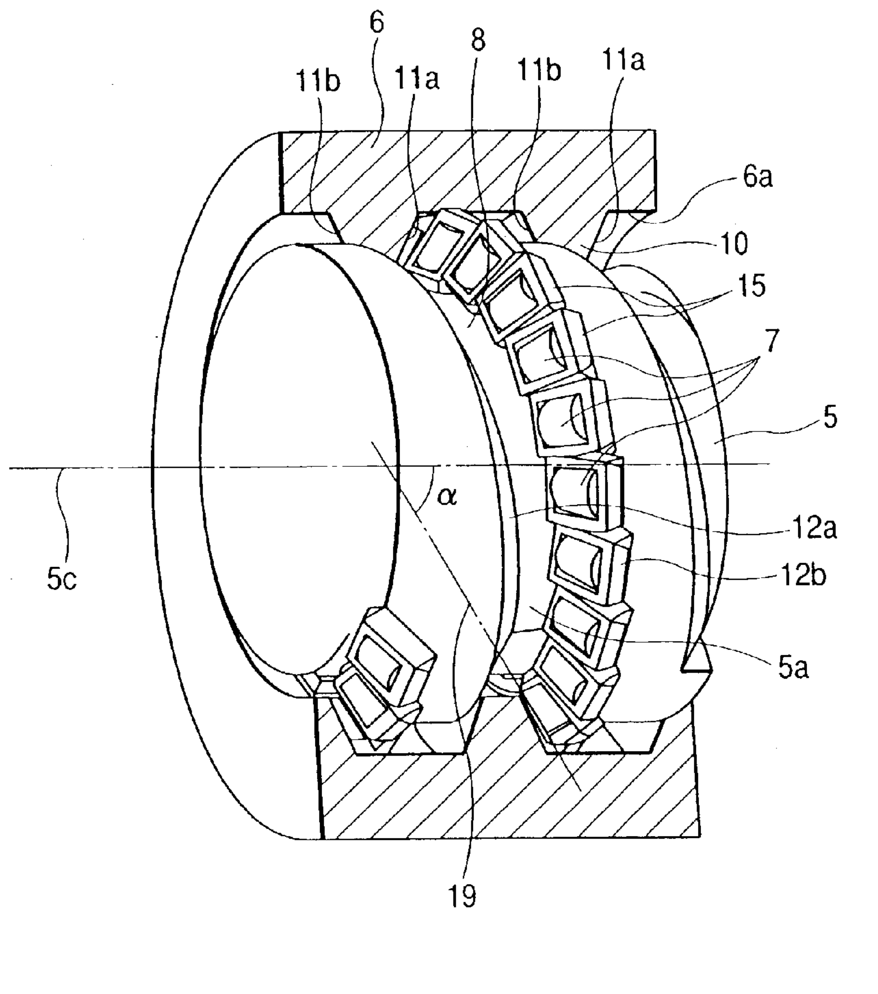


FIG. 1

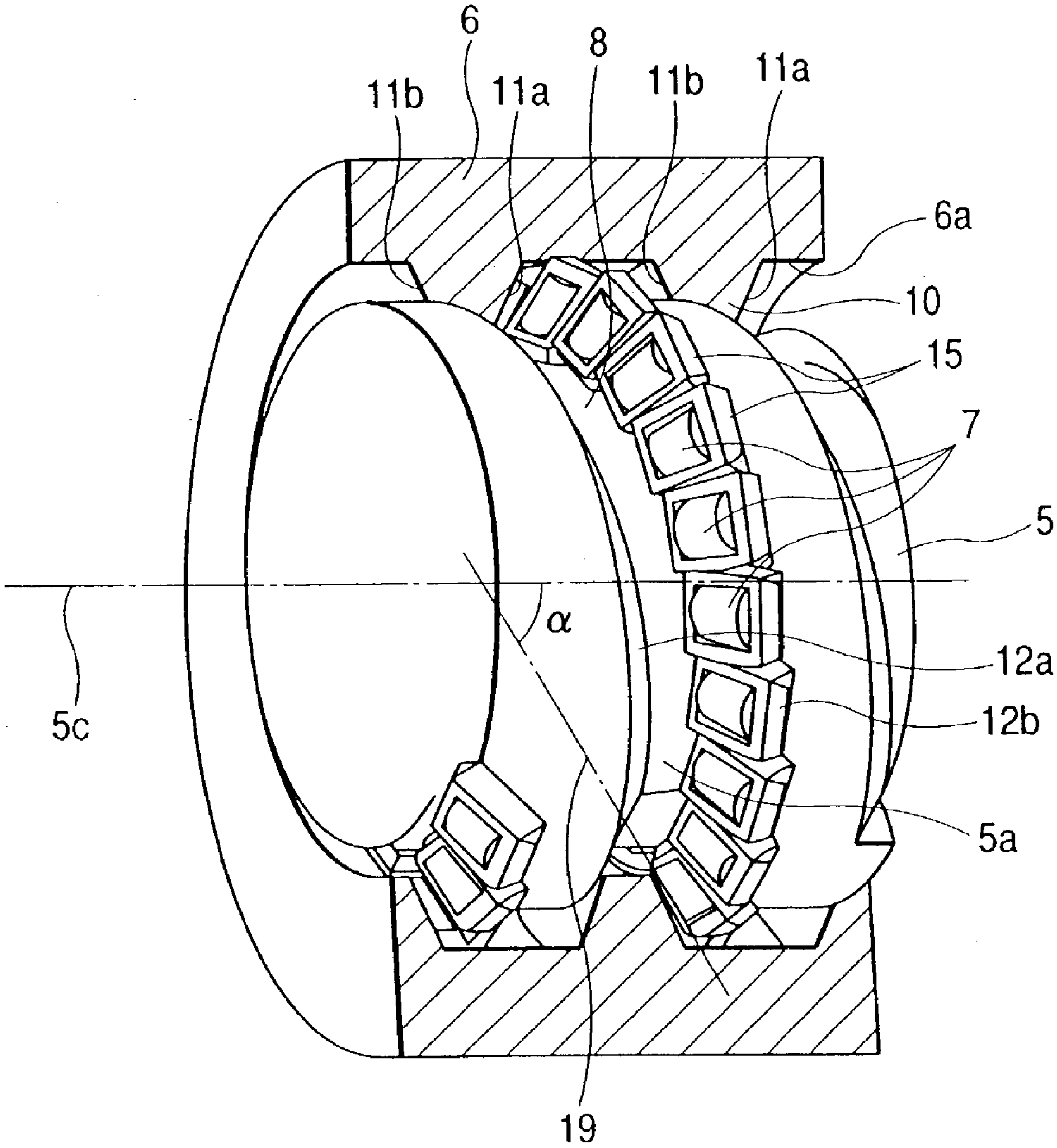


FIG. 2

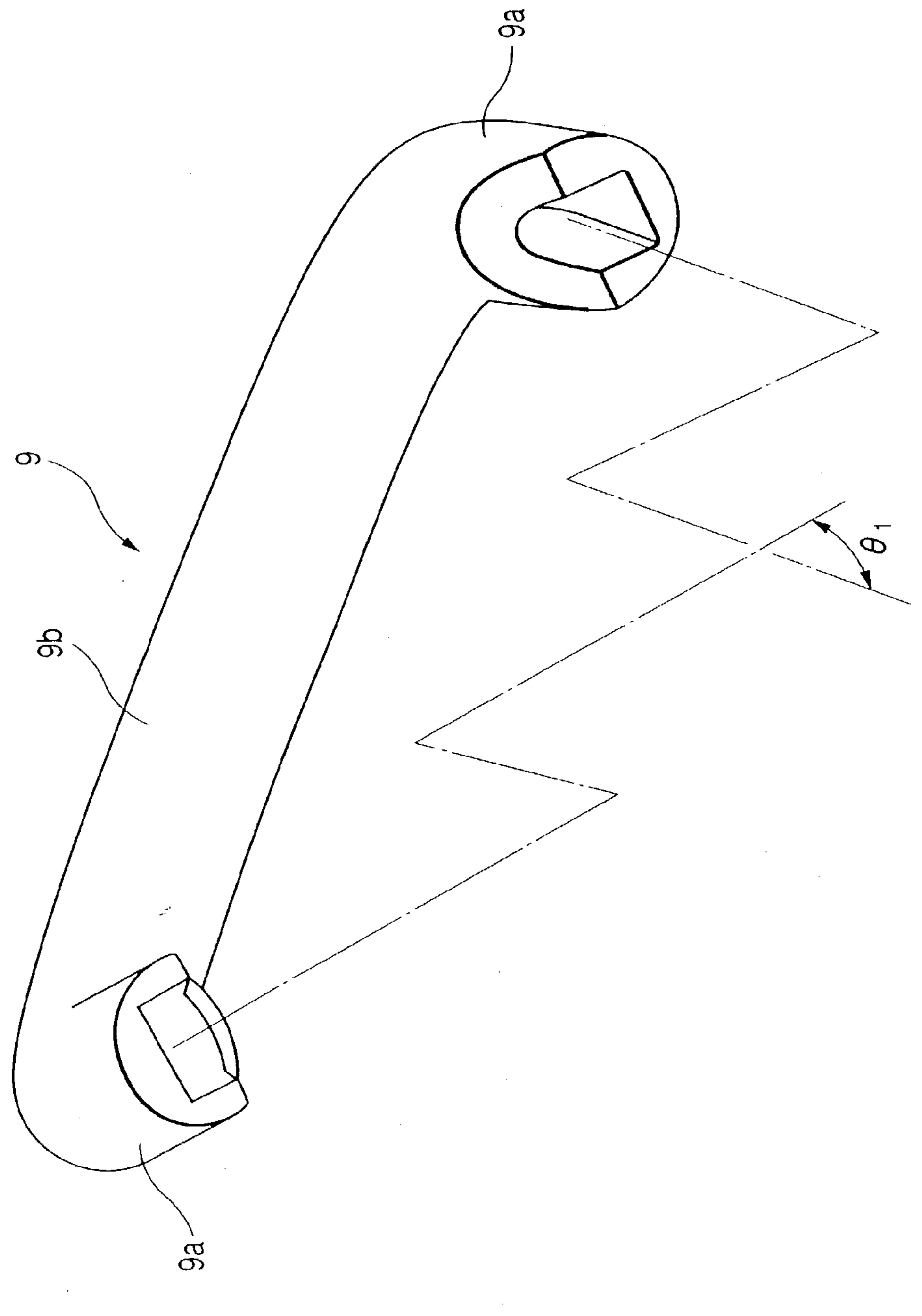


FIG. 3

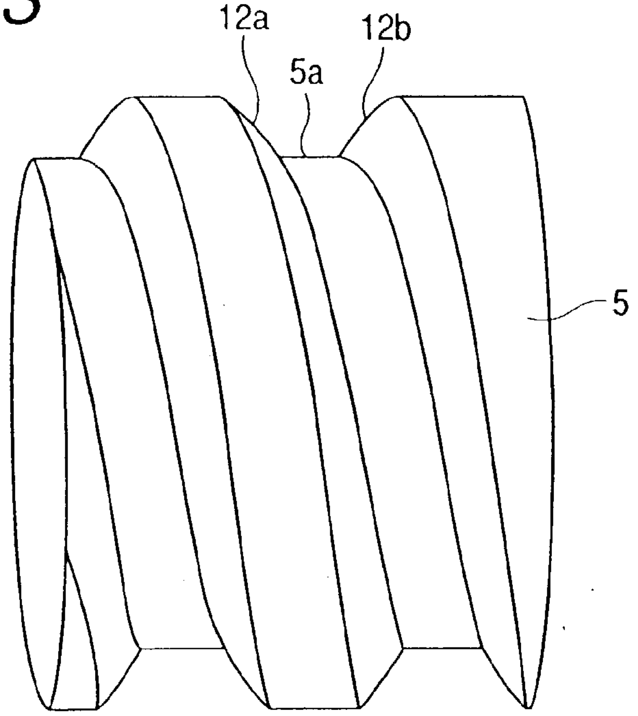


FIG. 4

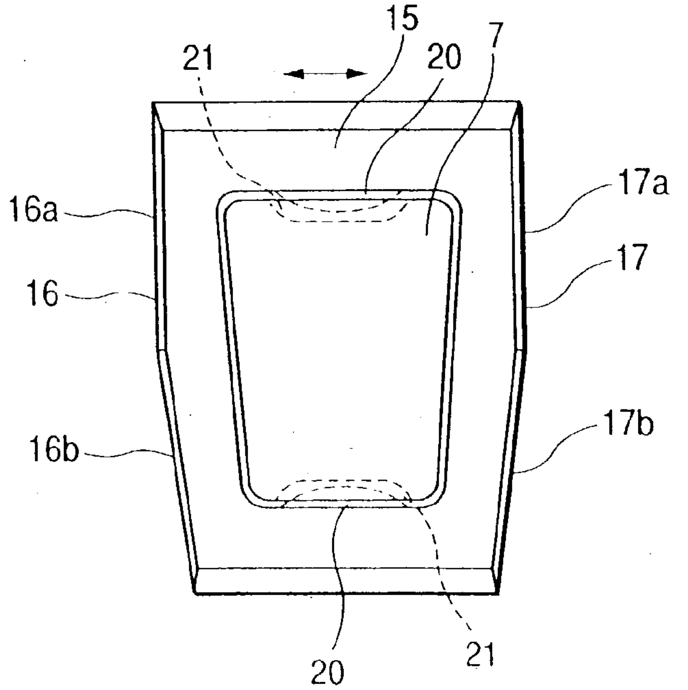


FIG. 5

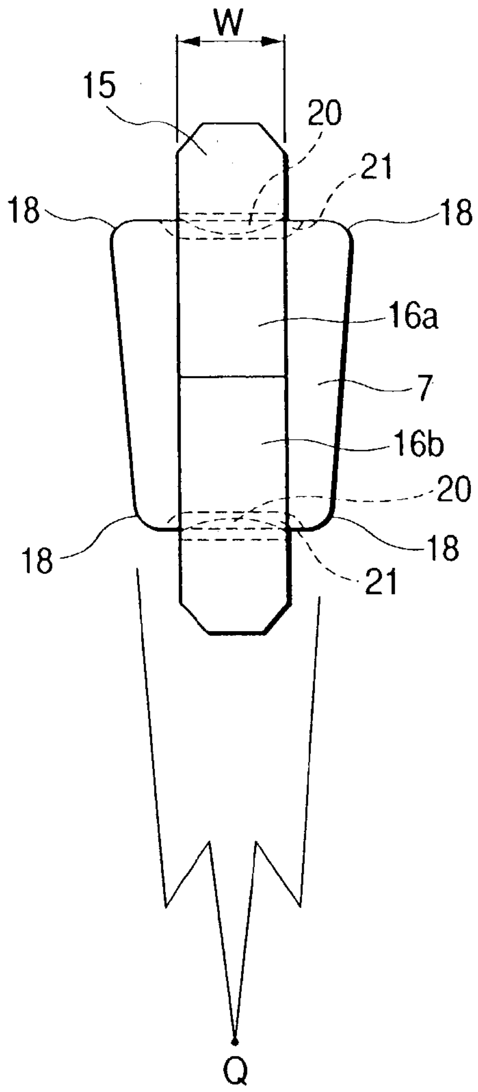


FIG. 6

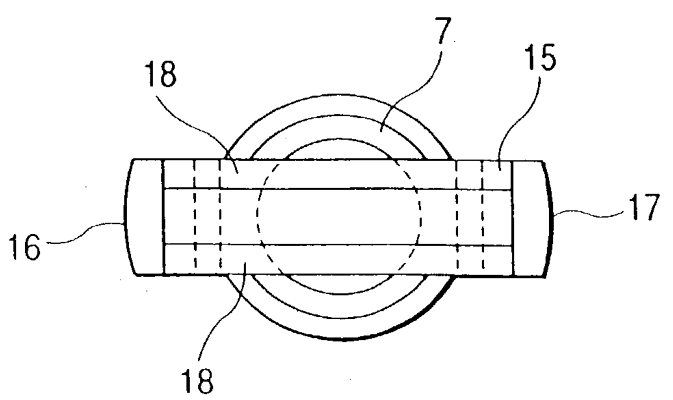
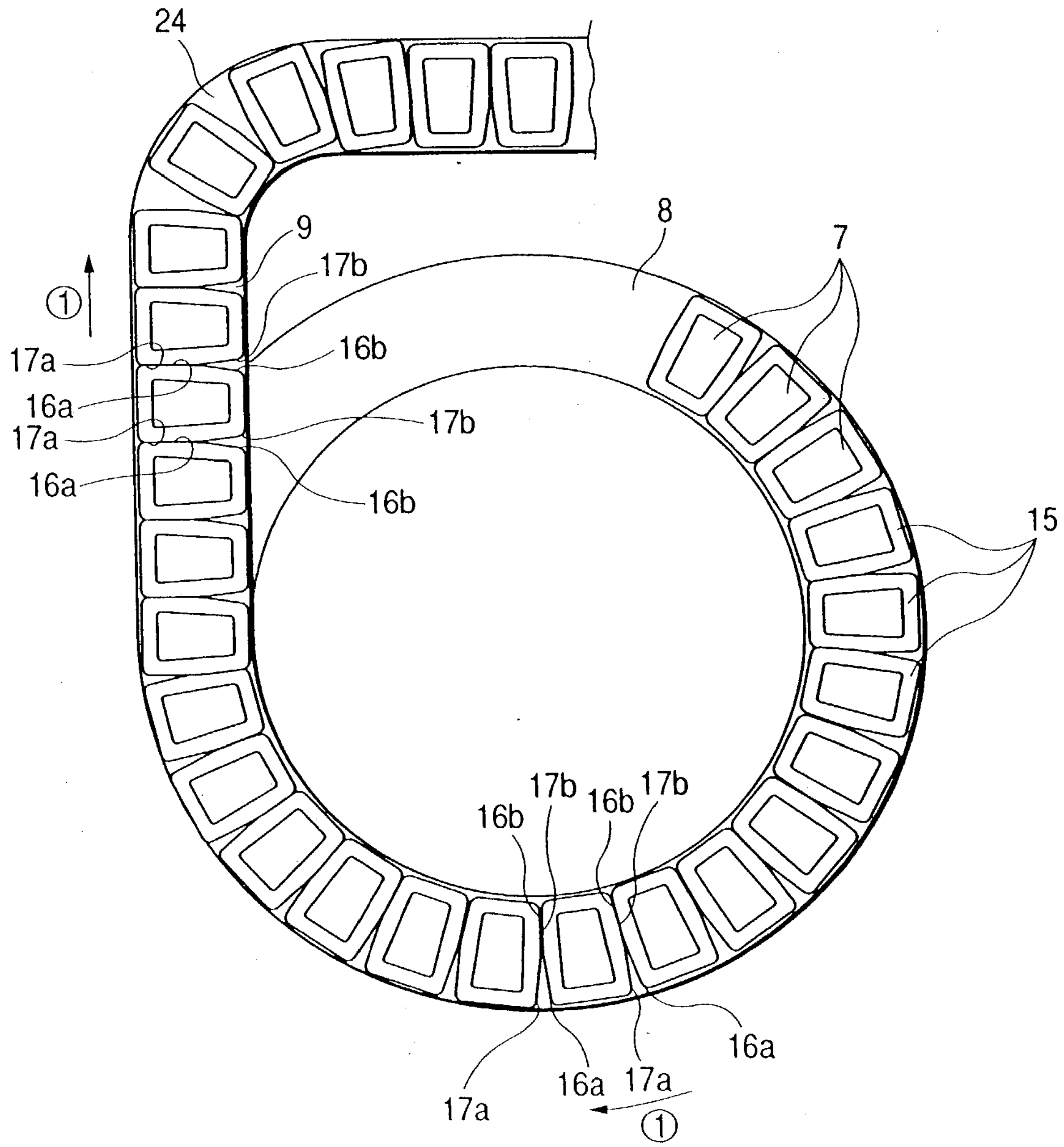


FIG. 7


24
9
8
7
17b
16b
17a
16a
17a
17b
16a
16b
15
①
17b
16b
16b
17b
17a
16a
17a
16a
①

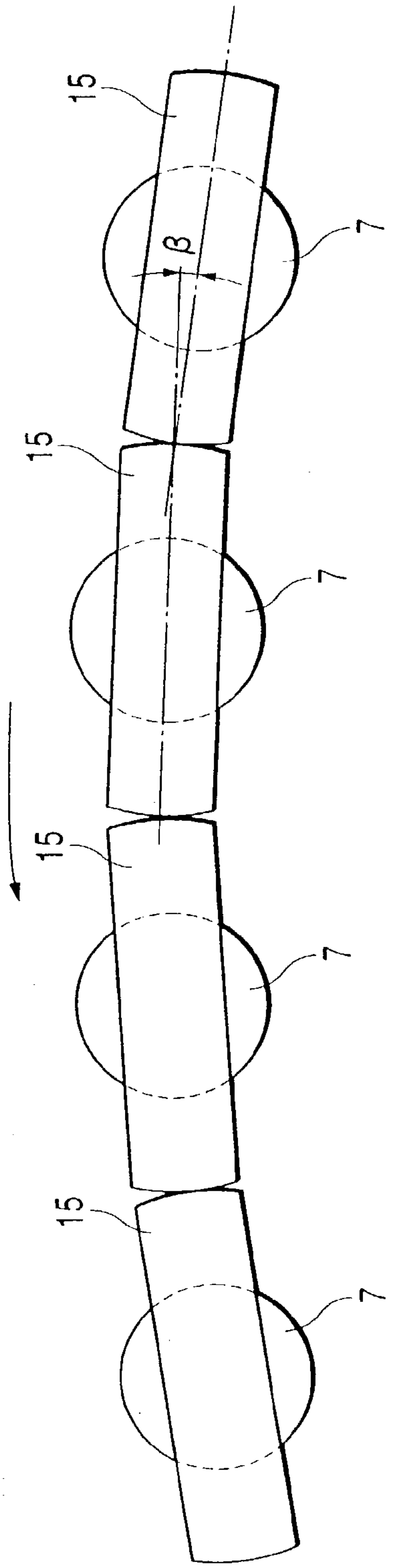


FIG. 8

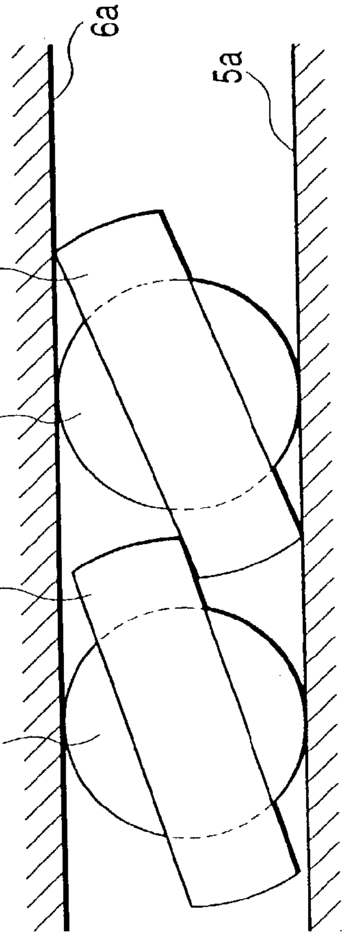


FIG. 9

FIG. 10

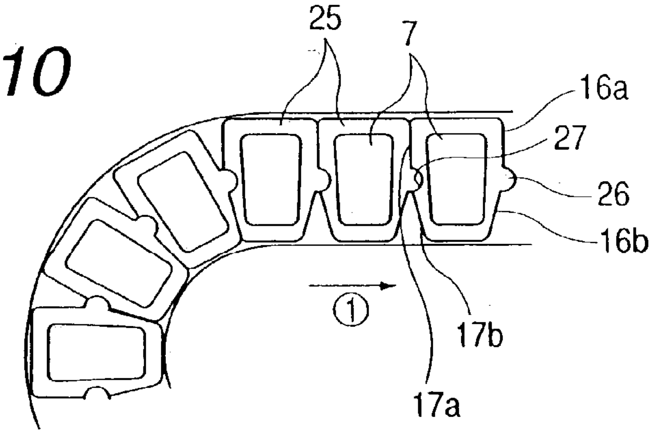


FIG. 11

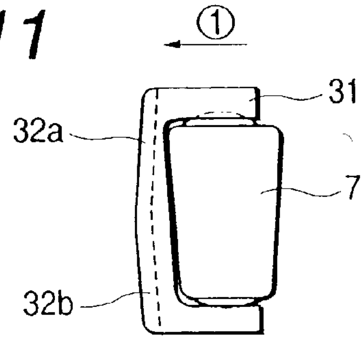


FIG. 12

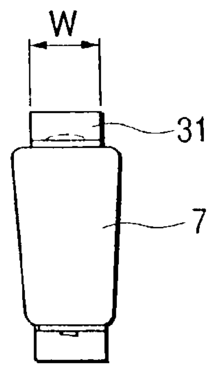


FIG. 13

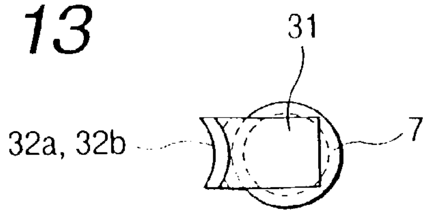


FIG. 14A

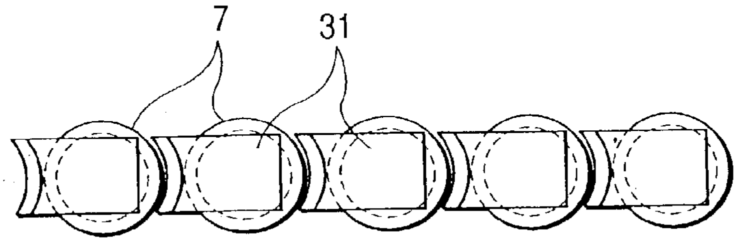


FIG. 14B

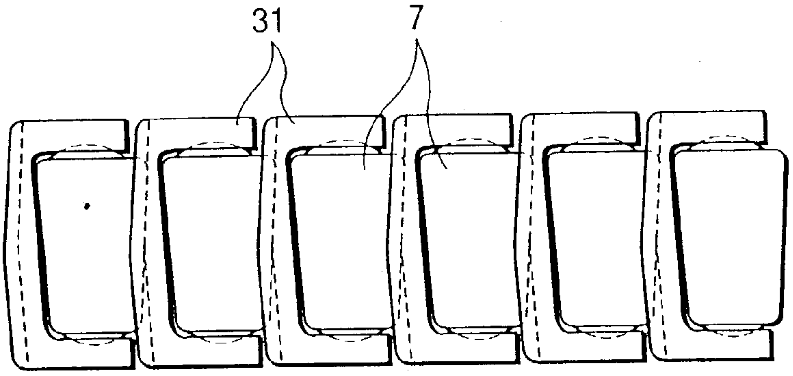


FIG. 14C

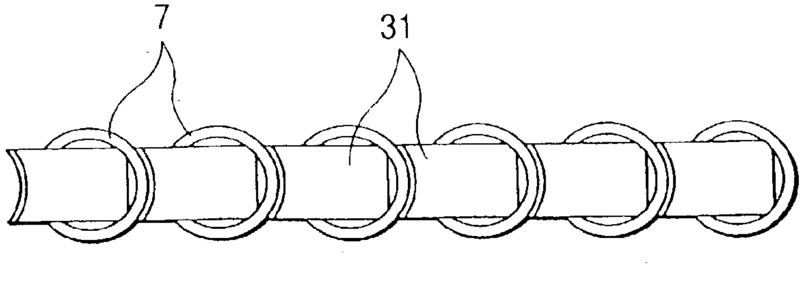


FIG. 15

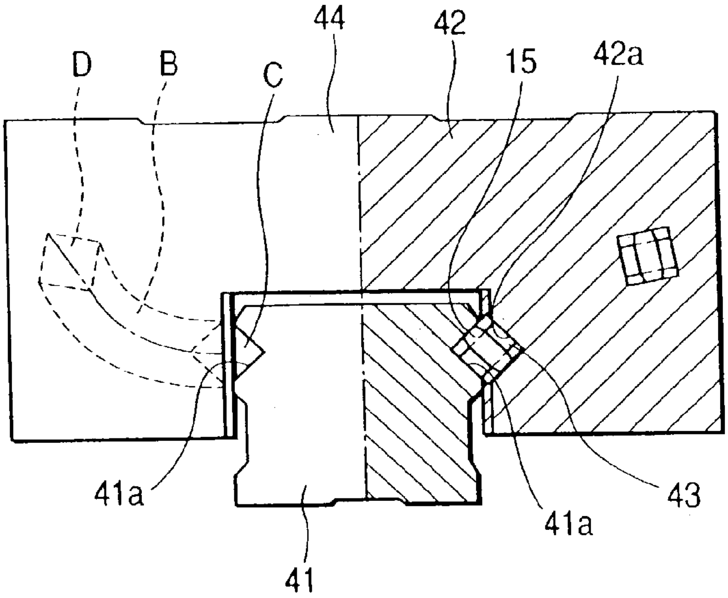


FIG. 16

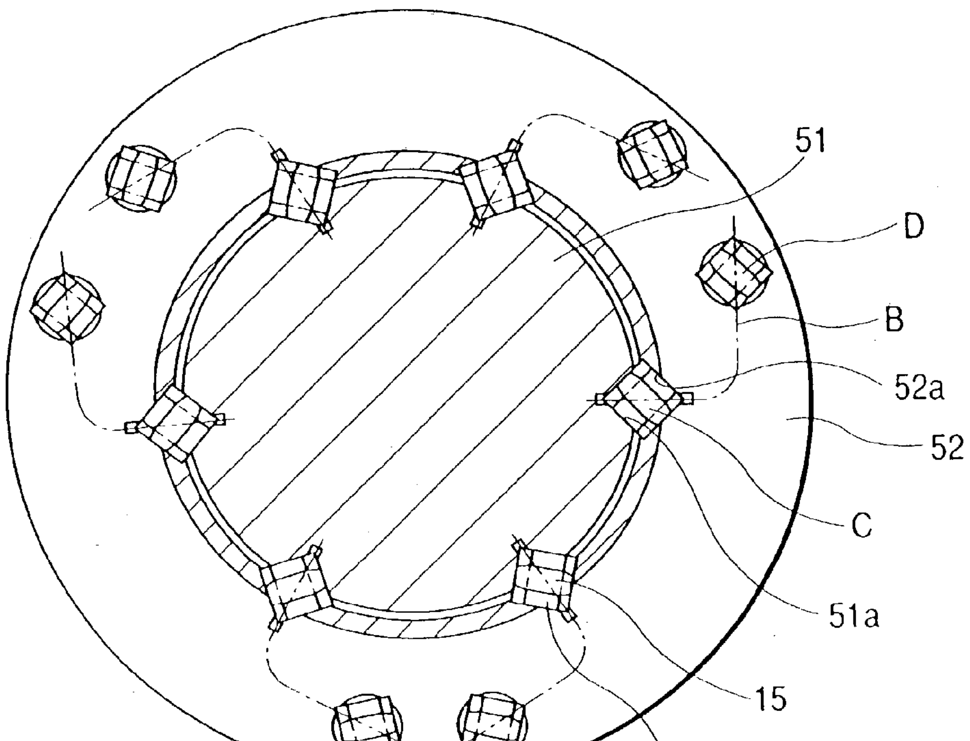


FIG. 17

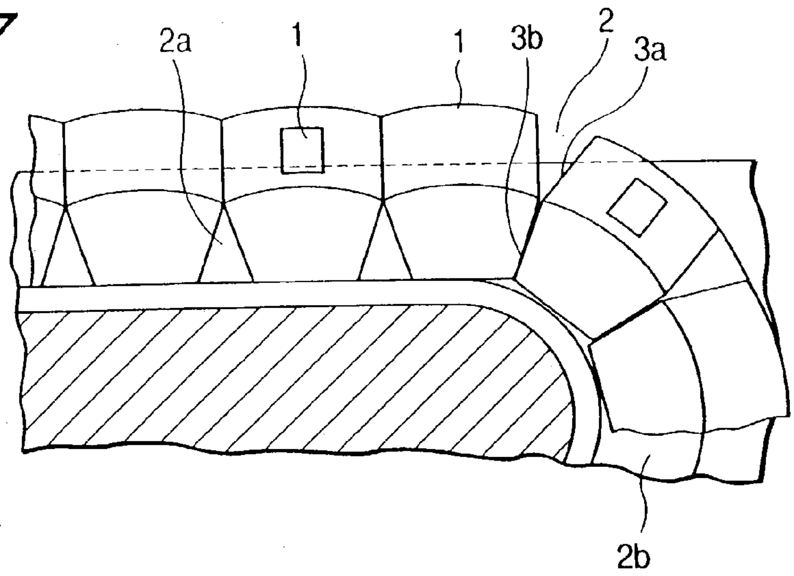


FIG. 18

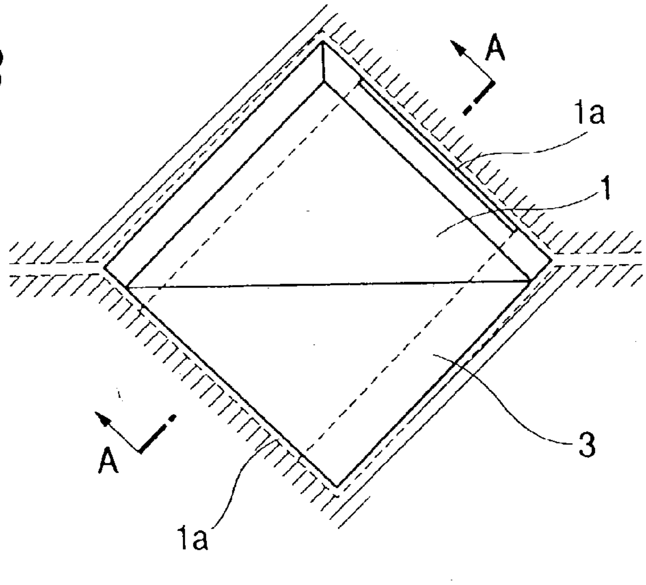
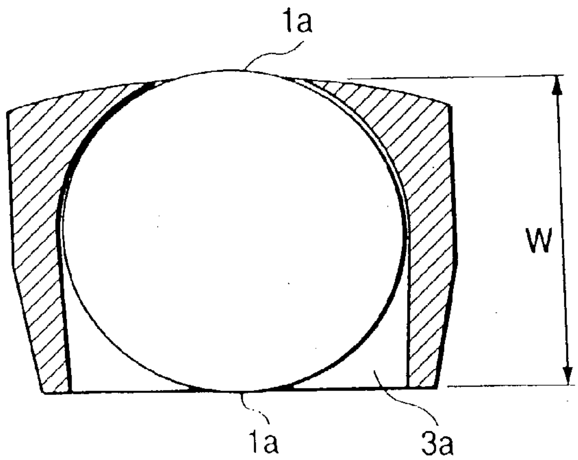


FIG. 19

SECION A-A



ROLLER RETAINER, DIRECT-ACTING GUIDE DEVICE AND ROLLER SCREW USING THE ROLLER RETAINER

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a roller retainer which is used in a direct-acting guide device, a roller screw, or the like, and in which a roller rolling in a circulation path is held so as to be rotatable/slidable.

[0003] 2. Description of the Related Art

[0004] A roller screw having rollers interposed between a screw shaft and a nut member is known. When the screw shaft is rotated relative to the nut member, the nut member makes reciprocating motion in a direction of the axis of the screw shaft. The rollers make rolling motion so as to go around the outer circumference of a screw groove between the screw shaft and the nut member. Thus, the rollers circulate in a roller circulation path. A helical roller rolling groove is formed in the screw shaft. The roller circulation path containing a helical load rolling groove corresponding to the roller rolling groove is formed in the nut member. In the roller screw, the plurality of rollers may be arranged in the roller circulation path so as to be parallel to one another to keep the axes of adjacent rollers approximately parallel to each other, or the plurality of rollers may be arranged in the roller circulation path so as to cross one another to intersect the axes of adjacent rollers.

[0005] Generally, in the case of a full-roller type roller screw in which only rollers are arranged in the roller circulation path, the respective rollers make no consistent motion so that each of the rollers falls down in a plane containing the axis of the roller and the direction of the movement of the roller to cause skew. Hence, the rollers are prevented from circulating while arranged in the roller circulation path. Though not relating to the roller screw, a belt-like ball retainer for rotatably/slidably holding a plurality of balls of a ball screw to make arranged circulation of the balls is known (for example, see JP-A-11-223258). The ball retainer holds the balls in the form of a linear chain so that front-side and rear-side adjacent balls can circulate smoothly.

[0006] On the other hand, a cage for holding corresponding one of rollers arranged and received in a circulation path of a direct-acting guide device is known (see JP-A-60-205013). **FIG. 17** shows such cages circulating in the roller circulation path of the direct-acting guide device. A plurality of rollers **1** are cross-arranged in the roller circulation path **2** so that the axes of adjacent rollers **1** cross each other. The direction of the roller **1** is changed two-dimensionally in between a linear load passage **2***a* and a U-shaped changing-direction passage **2***b*. **FIG. 18** is a front view of a cage **3** with a roller **1** when viewed in the direction of the movement thereof. **FIG. 19** is a sectional view taken along the line A-A in **FIG. 18**. Because of the cross arrangement of the rollers **1**, the roller circulation path **2** is shaped substantially like a square in section. The cages **3** rotatably/slidably hold the rollers **1** in container holes **3***a* of the cages **3** individually and correspondingly while the outer circumferences **1***a* of the rollers **1** are exposed partially slightly. The thickness of the cage **3** (the radial thickness of the roller) is set to be approximately equal to that of the roller **1**. As shown in the drawings, the shape of the cage **3** viewed from the front side in the direction of the movement forms a square approximately equal to the sectional shape of the roller circulation path **2** so that the roller **1** can be guided by the cage **3**. As shown in **FIG. 17**, two end surfaces **3***a* and **3***b* which form an angle of not smaller than 90° are formed at two ends of the adjacent cages **3** in the direction of the movement thereof. When the cage **3** is located on the linear load passage **2***a*, one end surface **3***a* is positioned so as to be approximately perpendicular to the load passage **2***a*. When the cage **3** is located on the U-shaped changing-direction passage **2***b*, the other end surface **3***b* is directed to the direction of the radius of the changing-direction passage **2***b*. Thus, the cages **3** with the rollers **1** circulate in the roller circulation path **2** while the end surfaces **3***a* and **3***b* of adjacent cages **3** press each other.

[0007] In the background-art ball retainer holding balls in the form of a straight chain, however, the circulation path of the ball screw draws a spiral. Hence, the ball retainer is twisted so spirally that load is applied on the ball retainer. There is a risk that the ball retainer may be broken by the load.

[0008] On the other hand, the cages **3** by which the rollers **1** arranged and received in the roller circulation path **2** of the direct-acting guide device are held individually are adapted to the case where the linear load passage and the U-shaped changing-direction passage are positioned on one plane so that the direction of the rollers **1** is changed two-dimensionally. For example, in a circulation path of a roller screw, however, not two-dimensional direction changing but three-dimensional direction changing and, accordingly, twisting motion around the direction of the movement, may be required. In the aforementioned cages **3**, the circulating cages **3** are not allowed to rotate slightly around the axes of the rollers **1** respectively so that the cages **3** can hardly make such complex motion. This is because the shape of each cage **3** is formed to be approximately equal to the sectional shape of the roller circulation path **2** and because adjacent cages **3** are in surface contact with each other at large-area flat end surfaces **3***a* and **3***b*. Moreover, a lubricant can hardly enter in between the cage **3** and a corresponding roller **1** because the circumference of the roller **1** except part of the outer circumference **1***a* is covered with the cage **3**. Hence, the roller **1** cannot be lubricated sufficiently. Moreover, the approximately whole section of the roller circulation path **2** is covered with the cage **3**. There is a problem that a support member for supporting the cage **3** to prevent the cage **3** from dropping down from the slide member when the slide member is removed from the race rail is hardly provided in the circulation path.

SUMMARY OF THE INVENTION

[0009] An object of the present invention has been made to solve the above object, and therefore an object of the invention is to provide a roller retainer which can circulate smoothly even in a complex kinetic condition such as a three-dimensional changing-direction passage and in which lubricating oil can be supplied sufficiently to rollers, and to provide a direct-acting guide device and a roller screw using such roller retainers.

[0010] The present invention will be described below. Although the reference numerals in the accompanying drawings are put in parentheses to make understanding of the present invention easy, the present invention is not limited to the embodiments based on the accompanying drawings.

[0011] To solve the problem, the inventor of the present invention provides a system in which rollers circulating in a circulating path are not held in the form of a straight chain but are held in roller retainers individually so that the rollers circulate in a circulation path while the rear-side roller retainer presses the front-side roller retainer. Further, because linear portions and curved portions mainly exit in the circulation path, the inventor considers the shape of each end of the roller retainer in a direction of the movement thereof so that pressing force is transmitted smoothly either in the linear portions or in the curved portions. Further, the inventor provides a system in which roller retainers can circulate while allowed to rotate slightly around the axes of the rollers respectively when the roller retainers circulate while pressing each other. Accordingly, the roller retainers can be adapted to a three-dimensionally complex circulation path on the assumption that the rollers are arranged in the circulation path and the axes of adjacent rollers are substantially kept parallel to each other.

[0012] Specifically, according to a first aspect of the present invention, there is provided a roller retainer assembly having roller retainers (**15**) for individually and correspondingly retaining a plurality of rollers (**7**) circulating in a roller circulation path inclusive of linear and curved races, wherein: each of the roller retainers (**15**) is made thin to hold opposite side surfaces of the roller (**7**) and front and rear surfaces of the roller (**7**) in a direction of movement of the roller (**7**); a linear guide portion (**16***a*, **17***a*) and a curve guide portion (**16***b*, **17***b*) which are different in inclination angle from each other are formed in opposite end surfaces of the roller retainer (**15**) in a direction of movement of the roller retainer (**15**); and the linear guide portion (**16***a*, **17***a*) of the roller retainer (**15**) comes into contact with an adjacent roller retainer (**15**) in the linear race and the curve guide portion (**16***b*, **17***b*) of the roller retainer (**15**) comes into contact with an adjacent roller retainer (**15**) in the curved race. By the provision of the roller retainer assembly, the above-mentioned problem is therefore solved. The thickness of the roller retainer (**15**) is selected to be not larger than 90%, preferably not larger than 60% of the roller diameter.

[0013] According to this invention, in either of linear races and curved races constituting a circulation race, adjacent roller retainers can press each other without spoiling the posture of a roller located in the front side in the direction of the movement of the roller. Hence, rollers can be aligned so that smooth circulation can be obtained. Further, because the roller retainer is made thin, the following effects are obtained.

[0014] (1) Adjacent roller retainers can press each other while they are allowed to rotate slightly around the axes of corresponding rollers respectively. As a result, the roller retainer can be obtained as a roller retainer adapted to a complex circulation path such as a three-dimensional changing-direction passage or a helical load rolling passage shaped like a screw.

[0015] (2) A large space can be secured for reserving lubricating oil in the circulation path. Hence, the rollers can be lubricated sufficiently.

[0016] (3) A drop-down prevention member for supporting the roller retainer can be provided in the circulation path so that the roller retainer is prevented from dropping down from the nut member, or the like.

[0017] According to a second aspect of the invention, there is provided a roller retainer assembly having roller retainers (**31**) for individually and correspondingly retaining a plurality of rollers (**7**) circulating in a roller circulation path inclusive of linear and curved races, wherein: each of the roller retainers (**31**) is made thin to hold the opposite side surfaces of the roller (**7**) and either one of front and rear surfaces of the roller (**7**) in a direction of movement of the roller (**7**); a linear guide portion (**32***a*) and a curve guide portion (**32***b*) which are different in inclination angle are formed in one end surface of the roller retainer (**31**) in a direction of movement of the roller retainer (**31**); and the linear guide portion (**32***a*) of the roller retainer (**31**) comes into contact with an adjacent roller (**7**) in the linear race and the curve guide portion (**32***b*) of the roller retainer (**31**) comes into contact with an adjacent roller (**7**) in the curved race. By the provision of the roller retainer assembly, the above-mentioned problem is therefore solved.

[0018] According to this invention, in addition to the same operation and effect as those of the aforementioned invention, the roller retainer holds either of front and rear surfaces of a corresponding roller in the direction of the movement of the roller. Hence, the space occupied by one roller retainer in the circulation path is reduced so that the number of rollers can be increased Hence, the load capacity of a direct-acting guide device or roller screw using such roller retainers can be increased.

[0019] According to a third aspect of the invention, in the first aspect of the invention, each of the linear guide portion (**16***a*, **17***a*) and the curve guide portion (**16***b*, **17***b*) of the roller retainer (**15**) is formed to be a curved surface shaped like a circular arc in section so as to come into linear contact with the adjacent roller retainer (**15**).

[0020] According to this invention, adjacent roller retainers can press each other while they are securely allowed to rotate slightly around the axes of corresponding rollers respectively.

[0021] According to a fourth aspect of the invention, in the second aspect of the invention, each of the linear guide portion (**32***a*) and the curve guide portion (**32***b*) of the roller retainer (**31**) is formed to be a curved surface in accordance with an outer circumference of the roller (**7**).

[0022] According to this invention, a roller and a roller retainer which are adjacent to each other can press each other while the roller retainer is securely allowed to rotate slightly around the axis of a corresponding roller. Moreover, because the roller retainer comes into surface contact with a roller located in the front side or rear side in the direction of the movement of the roller retainer, contact surface pressure can be reduced.

[0023] According to a fifth aspect of the invention, in the roller retainer assembly as stated in the first or third aspect, a hinge protrusion (**26**) is provided at a point of intersection between the linear guide portion (**16***a*) and the curve guide portion (**16***b*) in one end surface of the roller retainer (**25**); and a hinge recess (**27**) is provided at a point of intersection between the linear guide portion (**17***a*) and the curve guide portion (**17***b*) in the other end surface of the roller retainer

(**25**) so that the hinge recess (**27**) engages with the hinge protrusion (**27**) of an adjacent roller retainer.

[**0024**] According to this invention, the roller retainer is only allowed to swing around a hinge constituted by a combination of the hinge protrusion and the hinge recess in a plane containing the axis of a corresponding roller and the direction of the movement of the roller. Hence, the roller can be prevented from falling down even in a boundary shifting from a linear race to a curved race. Hence, smooth circulation of the roller can be ensured.

[**0025**] According to a sixth aspect of the invention, in any one of the first to fifth aspects, drop-down prevention protrusions (**20**) are formed on either one of the roller retainer (**15**) and the opposite side surfaces of the roller (**7**); and drop-down prevention recesses (**21**) are formed in the other one of the roller retainer and the opposite side surfaces of the roller so that the drop-down prevention protrusions are fitted into the drop-down prevention recesses.

[**0026**] According to this invention, the roller can be prevented from dropping out from the roller retainer. For example, even in the case where a slide member such as a nut member is removed from the race rail, the roller retainer can prevent the roller from dropping down from the slide member so that the roller can be prevented from dropping down from the slide member.

[**0027**] According to a seventh aspect of the invention, in any one of first to sixth aspects, a thickness of the roller retainer (**15**) is selected to be not smaller than 50% of a diameter of the roller. When a tapered roller is used as each of the rollers, the terminology "roller diameter" used herein means the smallest roller diameter.

[**0028**] If the thickness of each of the roller retainers is smaller than 50% of the roller diameter, the front end of the succeeding roller retainer in the circulation path enters the gap between the front-side roller retainer and the roller rolling groove so that adjacent roller retainers overlap each other. As a result, there is a risk that the circulation of rollers may stop. When the thickness of each of the roller retainers is not smaller than 50% of the roller diameter, such adjacent roller retainers can be prevented from overlapping each other.

[**0029**] Further, according to the invention, there is also provided a direct-acting guide device comprising: a race shaft (**41, 51**) containing a roller rolling surface (**41***a*, **51***a*); a slide member (**42, 52**) including a roller circulation path containing a load rolling surface (**42***a*, **52***a*) corresponding to the roller rolling surface (**41***a*, **51***a*), the slide member (**42, 52**) being fitted to the race shaft (**41, 51**) so as to be freely movable relative to the race shaft (**41, 51**); a plurality of rollers (**43, 53**) arranged and received in the roller circulation path so as to circulate in accordance with movement of the slide member (**42, 52**) relative to the race shaft (**41, 51**); and a plurality of roller retainers (**15**) for holding the plurality of rollers (**43, 53**) individually and correspondingly so that the plurality of rollers (**43, 53**) are rotatable/slidable, wherein: the plurality of rollers (**43, 53**) are arranged and received so that the axes of adjacent rollers (**43, 53**) are kept approximately parallel to each other; each of the roller retainers (**15**) is made thin to hold opposite side surfaces of corresponding one of the rollers (**7**) and front and rear surfaces of the roller (**7**) in a direction of movement of the roller (**7**); a linear guide portion (**16***a*, **17***a*) and a curve guide portion (**16***b*, **17***b*) which are different in inclination angle from each other are formed in each of opposite end surfaces of the roller retainer (**15**) in a direction of movement of the roller retainer (**15**); and the linear guide portion (**16***a*, **17***a*) of the roller retainer (**15**) comes into contact with an adjacent roller retainer (**15**) in a linear race and the curve guide portion (**16***b*, **17***b*) of the roller retainer (**15**) comes into contact with an adjacent roller retainer (**15**) in a curved race.

[**0030**] Further, according to the invention, there is also provided a direct-acting guide device comprising: a race shaft (**41, 51**) containing a roller rolling surface (**41***a*, **51***a*); a slide member (**42, 52**) including a roller circulation path containing a load rolling surface (**42***a*, **52***a*) corresponding to the roller rolling surface (**41***a*, **51***a*), the slide member (**42, 52**) being fitted to the race shaft (**41, 51**) so as to be freely movable relative to the race shaft (**41, 51**); a plurality of rollers (**43, 53**) arranged and received in the roller circulation path so as to circulate in accordance with movement of the slide member (**42, 52**) relative to the race shaft (**41, 51**); and a plurality of roller retainers (**15**) for holding the plurality of rollers (**43, 53**) individually and correspondingly so that the plurality of rollers (**43, 53**) are rotatable/slidable, wherein: the plurality of rollers (**43, 53**) are arranged and received so that the axes of adjacent rollers (**43, 53**) are kept approximately parallel to each other; each of the roller retainers (**31**) is made thin to hold opposite side surfaces of corresponding one of the rollers (**7**) and either one of front and rear surfaces of the roller (**7**) in a direction of movement of the roller (**7**); a linear guide portion (**32***a*) and a curve guide portion (**32***b*) which are different in inclination angle are formed in one end surface of the roller retainer (**31**) in a direction of movement of the roller retainer (**31**); and the linear guide portion (**32***a*) of the roller retainer (**31**) comes into contact with an adjacent roller (**7**) in a linear race and the curve guide portion (**32***b*) of the roller retainer (**31**) comes into contact with an adjacent roller (**7**) in a curved race.

[**0031**] Further, according to the invention, there is also provided a roller screw comprising: a race shaft (**5**) containing a helical roller rolling surface (**5***a*); a slide member (**6**) including a roller circulation path (**8**) containing a helical load rolling surface (**6***a*) corresponding to the roller rolling surface (**5***a*), the slide member (**6**) being fitted to the race shaft (**5**) so as to be freely movable relative to the race shaft (**5**); a plurality of rollers (**7**) arranged and received in the roller circulation path (**8**) so as to circulate in accordance with movement of the slide member (**6**) relative to the race shaft (**5**); and a plurality of roller retainers (**15**) for holding the plurality of rollers (**7**) individually and correspondingly so that the plurality of rollers (**7**) are rotatable/slidable, wherein: the plurality of rollers (**7**) are arranged and received so that axes of adjacent rollers (**7**) are kept approximately parallel to each other; each of the roller retainers (**15**) is made thin to hold opposite side surfaces of corresponding one of the rollers (**7**) and front and rear surfaces of the roller (**7**) in a direction of movement of the roller (**7**); a linear guide portion (**16***a*, **17***a*) and a curve guide portion (**16***b*, **17***b*) which are different in inclination angle from each other are formed in each of opposite end surfaces of the roller retainer (**15**) in a direction of movement of the roller retainer (**15**); and the linear guide portion (**16***a*, **17***a*) of the roller retainer (**15**) comes into contact with an adjacent roller retainer (**15**) in a linear race and the curve guide portion (**16***b*, **17***b*) of the roller retainer (**15**) comes into contact with an adjacent roller retainer (**15**) in a curved race.

[0032] Further, according to the invention, there is also provided a roller screw comprising: a race shaft (**5**) containing a helical roller rolling surface (**5***a*); a slide member (**6**) including a roller circulation path (**8**) containing a helical load rolling surface (**6***a*) corresponding to the roller rolling surface (**5***a*), the slide member (**6**) being fitted to the race shaft (**5**) so as to be freely movable relative to the race shaft (**5**); a plurality of rollers (**7**) arranged and received in the roller circulation path (**8**) so as to circulate in accordance with movement of the slide member (**6**) relative to the race shaft (**5**); and a plurality of roller retainers (**15**) for holding the plurality of rollers (**7**) individually and correspondingly so that the plurality of rollers (**7**) are rotatable/slidable, wherein: the plurality of rollers (**7**) are arranged and received so that axes of adjacent rollers (**7**) are kept approximately parallel to each other; each of the roller retainers (**31**) is made thin to hold opposite side surfaces of corresponding one of the rollers (**7**) and either one of front and rear surfaces of the roller (**7**) in a direction of movement of the roller (**7**); a linear guide portion (**32***a*) and a curve guide portion (**32***b*) which are different in inclination angle are formed in one end surface of the roller retainer (**31**) in a direction of movement of the roller retainer (**31**); and the linear guide portion (**32***a*) of the roller retainer (**31**) comes into contact with an adjacent roller (**7**) in a linear race and the curve guide portion (**32***b*) of the roller retainer (**31**) comes into contact with an adjacent roller (**7**) in a curved race.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] **FIG. 1** is a perspective view showing a roller screw in which roller retainers according to a first embodiment of the present invention are incorporated;

[0034] **FIG. 2** is a perspective view showing a return pipe which is incorporated in the roller screw;

[0035] **FIG. 3** is a perspective view showing a screw shaft in the roller screw;

[0036] **FIG. 4** is a front view showing a combination of a roller retainer and a roller in the first embodiment of the present invention;

[0037] **FIG. 5** is a side view showing a combination of a roller retainer and a roller in the first embodiment of the present invention;

[0038] **FIG. 6** is a bottom view showing a combination of a roller retainer and a roller in the first embodiment of the present invention;

[0039] **FIG. 7** is a view showing roller retainers and rollers which circulate in a roller screw circulation path;

[0040] **FIG. 8** is a view showing rollers and roller retainers which circulate in a helical load rolling passage;

[0041] **FIG. 9** is a view showing an example where adjacent roller retainers overlap each other;

[0042] **FIG. 10** is a view showing roller retainers arranged in a circulation path according to a second embodiment of the present invention;

[0043] **FIG. 11** is a front view showing a combination of a roller retainer and a roller in a third embodiment of the present invention;

[0044] **FIG. 12** is a side view showing a combination of a roller retainer and a roller in the third embodiment of the present invention;

[0045] **FIG. 13** is a bottom view showing a combination of a roller retainer and a roller in the third embodiment of the present invention;

[0046] **FIG. 14A** is a plan view showing an example where roller retainers and rollers in the third embodiment of the present invention are aligned in a line;

[0047] **FIG. 14B** is a side view showing an example where roller retainers and rollers in the third embodiment of the present invention are aligned in a line;

[0048] **FIG. 14C** is a bottom view showing an example where roller retainers and rollers in the third embodiment of the present invention are aligned in a line;

[0049] **FIG. 15** is a view showing a linear guide in which roller retainers according to the first embodiment of the present invention are incorporated (partly including a section taken in a direction perpendicular to a guide rail);

[0050] **FIG. 16** is a view showing a spline in which roller retainers according to the first embodiment of the present invention are incorporated;

[0051] **FIG. 17** is a view showing cages which circulate in a roller circulation path of a background-art direct-acting guide device;

[0052] **FIG. 18** is a view showing a background-art combination of a cage and a roller; and

[0053] **FIG. 19** is a sectional view taken along the line A-A in **FIG. 18**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0054] Now, a description will be given in more detail of preferred embodiments of the invention with reference to the accompanying drawings.

[0055] **FIG. 1** shows a roller screw in which roller retainers according to a first embodiment of the present invention are incorporated. The roller screw comprises a screw shaft **5** (race shaft), a nut member **6** (slide member), and a plurality of rollers **7**. The screw shaft **5** has a helical roller rolling groove **5***a* in its outer circumferential surface so that the helical roller rolling groove **5***a* serves as a roller rolling surface. The nut member **6** has a roller circulation path formed in its inner cirumferential surface. The roller circulation path includes a helical load rolling groove **6***a* so that the helical load rolling groove **6***a* serves as a load rolling surface corresponding to the roller rolling groove **5***a*. The nut member **6** is fitted to the screw shaft **5** so as to be relatively movable. The plurality of rollers **7** are arranged and received in the roller circulation path and circulate in accordance with the relative movement of the nut member **6** to the screw shaft **5**. The plurality of rollers **7** are arranged and received in the roller circulation path so that axes of adjacent rollers **7** are kept substantially parallel to each other. In the roller circulation path, a load rolling passage **8** is formed between the roller rolling groove **5***a* of the screw shaft **5** and the load rolling groove **6***a* of the nut member **6**. The nut member **6** has a return pipe. The return pipe forms a no-load return passage by which one end of the load rolling passage **8** communicates with the other end of the load rolling passage **8**.

[0056] **FIG. 2** shows the return pipe **9**. The return pipe **9** has a body portion **9***b*, and opposite end portion **9***a* bent with respect to the body portion **9***b*. The opposite end portions **9***a* are fitted into the load rolling passage so that a distance of several pitches is left between the opposite end portions **9***a*. Incidentally, the return pipe **9** is fixed to the nut member **6** by a pipe pressing.

[0057] **FIG. 3** shows the screw shaft **5**. The helical roller rolling groove **5***a* having a predetermined lead is formed in the outer circumferential surface of the screw shaft **5**. The roller rolling groove **5***a* is shaped like a trapezoid in section. Each of the rollers **7** rolls on a wall surface **12***a* or **12***b* of the roller rolling groove **5***a*.

[0058] As shown in **FIG. 1**, the nut member **6** is substantially shaped like a cylinder. The helical load rolling groove **6***a* having a lead equal to the lead of the screw shaft **5** is formed in the inner circumferential surface of the nut member **6**. The load rolling groove **6***a* is also shaped like a trapezoid in section. A protrusion **10** for forming the load rolling groove **6***a* of the nut member **6** is fitted into the roller rolling groove **5***a* so that the inner diameter of the nut member **6** is made smaller than the outer diameter of the screw shaft **5**. Each of the rollers **7** rolls on a wall surface **11***a* or **11***b* of the load rolling groove **6***a*. The load rolling groove **6***a* of the nut member **6** may be shifted in the middle way. Hence, up to the shift position, a space for arranging the rollers **7** is formed between the wall surface **12***b* of the roller rolling groove **5***a* and the wall surface **11***b* of the load rolling groove **6***a* and, after the shift position, a space for arranging the rollers **7** is formed between the wall surface **12***a* of the roller rolling groove **5***a* and the wall surface **11***a* of the load rolling groove **6***a*. Return pipe fitting holes are formed in the nut member **6** so that the opposite sides of the return pipe **9** are inserted in the holes respectively. The return pipe fitting holes extend into the load rolling groove **6***a*.

[0059] As is obvious from **FIG. 2**, the return pipe **9** has opposite end portions **9***a* bent by about 90° with respect to the body portion **9***b*. That is, the return pipe **9** is substantially formed of a double housing type. A section of the no-load return passage of the return pipe **9** is determined in accordance with the shape of each roller **7**. As shown in **FIG. 2**, the opposite end portions **9***a* are not parallel to each other so that the respective directions of the opposite end portions **9***a* make a torsional angle $\theta 1$ (which changes in accordance with the lead angle).

[0060] FIGS. **4** to **6** show roller retainers **15** and rollers **7** which are incorporated in the roller screw. **FIG. 4** is a view (front view) in a direction perpendicular to the direction of the axis of each roller **7** and perpendicular to the direction of the movement of each roller **7**. **FIG. 5** is a view (side view) from the direction of the movement of each roller **7**. **FIG. 6** is a view (bottom view) from the direction of the axis of each roller **7**. Roller retainers **15** of the same number as that of the rollers **7** are provided to retain the rollers **7** individually. Each of the roller retainers **15** is made thin to hold front and rear surfaces of a corresponding roller **7** in the direction of the movement of the roller **7**. The frontal shape of the roller retainer **15** (viewed from the direction perpendicular to the axis of the roller and perpendicular to the direction of the movement of the roller) is formed like a frame. The thickness W of each side surface of the roller retainer **15** is set to be in a range of from 50% to 90% , preferably in a range of from 50% to 60% of the diameter of the roller. Incidentally, when a tapered roller is used as the roller **7**, the diameter of the roller is minimized.

[0061] A linear guide portion **16***a* and a curve guide portion **16***b* different in inclination angle from each other are formed in an end surface **16** of a roller retainer **15** in the direction of the movement of the roller retainer **15**. A linear guide portion **17***a* and a curve guide portion **17***b* different in inclination angle from each other are formed in the other end surface **17** of the roller retainer **15** in the direction of the movement of the roller retainer **15**. The linear guide portions **16***a* and **17***a* are formed so as to be substantially parallel to the axis of each roller **7**. The curve guide portions **16***b* and **17***b* are formed so that the curve guide portions **16***b* and **17***b* face radial directions respectively when roller retainers are arranged in a curved race. That is, in a curved race, the curve guide portions **16***b* and **17***b* of the roller retainer **15** come into contact with adjacent roller retainers **15** and, in a linear race, the linear guide portions **16***a* and **17***a* of the roller retainer **15** come into contact with adjacent roller retainers **15**. The linear guide portions **16***a* and **17***a* and the curve guide portions **16***b* and **17***b* of the roller retainer **15** are formed to be sectionally circular arc-shaped curved surfaces so as to come into linear contact with adjacent roller retainers **15** (see **FIG. 6**). As shown in **FIG. 5**, four corners of side surfaces of the roller retainer **15** are cut to be chamfered portions **18**. Hence, the roller retainer **15** can be prevented from interfering with the screw shaft **5** even in the case where the axis **19** of the roller **7** is arranged not to be perpendicular to the center line **5***c* of the screw shaft **5** but to be inclined at an angle α as shown in **FIG. 1**. As shown in **FIG. 4, a** pair of drop-down prevention protrusions **20, 20** are formed on the upper and lower portions, on the roller **7** side, of the roller retainer **15**. Further, a pair of recesses **21, 21** are formed on the side surface of the roller **7** so that the recesses **21** are fitted to the protrusions **20, 20**. Hence, the roller retainer **15** holds the roller **7** so that the roller **7** can rotate around its axis **19**. Incidentally, the drop-down prevention protrusions **20** may be provided on the roller **7** side while the drop-down prevention recesses **21** may be provided on the roller retainer **15** side. The roller retainer **15** is made from a synthetic resin or the like, as a raw material, by injection molding, or the like.

[0062] A tapered roller can be used as the roller **7**. The apex Q of the cone of the tapered roller is located on the center line **5***c* of the screw shaft **5**. Hence, the tapered roller rolls without slipping between the load rolling groove **6***a* and the roller rolling groove **5***a*. Incidentally, the sectional shape of the roller rolling groove **5***a*, the sectional shape of the load rolling groove **6***a* and the side shape of the roller can be set freely in accordance with load, accuracy, etc. required of the roller screw.

[0063] As shown in **FIG. 1**, when the screw shaft **5** is rotated, rollers **7** and roller retainers **15** rolling in the load rolling passage **8** in the direction of the circumference of the screw shaft **5** while suffering load are scooped by the return pipe **9**. The scooped rollers **7** and roller retainers **15** pass through the return pipe **9**. Then, the rollers **7** and roller retainers **15** are returned to the load rolling passage **8** after the distance of several pitches. When the direction of the rotation of the screw shaft **5** is inverted, the respective rollers **7** circulate in the reverse course. Incidentally, the nut member **6** may be rotated in the condition that the screw shaft **5** is provided as a stationary side. Also in this case, the rollers **7** can circulate in the aforementioned manner.

[0064] **FIG. 7** shows rollers **7** and roller retainers **15** circulating in the return pipe **9** and the load rolling passage **8**. As shown in **FIG. 7**, in a linear race (in a return pipe **9**) constituting a circulation path, a linear guide portion **16***a* of a roller retainer **15** located in the rear side in the direction **(1)** of the movement of the roller **7** presses a linear guide portion **17***a* of another roller retainer **15** located in the front side. In a curved race (in a load rolling passage **8**), the curve guide portion **16***b* of the rear-side roller retainer **15** presses the curve guide portion **17***b* of the front-side roller retainer **15**. Either in the linear race or in the curved race, the rear-side roller retainer **15** can press the front-side roller retainer **15** without spoiling the posture of the roller **7** located in the rear side in the direction of the movement of the rollers **7**. When a tapered roller is used as each of the rollers **7**, particularly in a linear race, the roller **7** tries to fall down in a plane containing the axis and the direction of the movement of the roller. In the linear race, linear guide portions **16***a* and **17***a* of adjacent roller retainers **15** come into close contact with each other, while, in the curved race, curve guide portions **16***b* and **17***b* of adjacent roller retainers **15** come into close contact with each other. As a result, the rollers **7** are aligned so that smooth circulation can be obtained. In most cases, the return pipe **9** in a no-load region has a linear race, a circular-arc race, a linear race, and a circular-arc race. When the curvature of a circular arc **24** of the return pipe **9** is made coincide with the curvature of the load rolling passage **8**, rollers **7** can be aligned so that smooth circulation can be obtained. This is because the curve guide portions **16***b* and **17***b* of adjacent roller retainers **15** come into close contact with each other even in the circular arc portion of the return pipe **9**. When the curvature of the circular arc **24** of the return pipe **9** does not coincide with the curvature of the load rolling passage **8**, the curve guide portions **16***b* and **17***b* may be further separated into two portions different in inclination angle. That is, guide portions may be separated into three stages, for example, a linear guide portion, a curve guide portion for load rolling passage and a curve guide portion for return pipe, may be formed.

[0065] As described above, the load rolling passage **8** of the roller screw is formed helically. As described above with reference to **FIG. 2**, the return pipe for changing the direction of the scooped roller **7** has a torsion (torsional angle θ1) around the direction of the movement of the roller. That is, in the roller screw, the rollers **7** and roller retainers **15** change their directions three-dimensionally and make complex motion. The aforementioned roller retainers **15** are adapted to such a complex motion. As shown in **FIG. 5**, the thickness W of each side of each roller retainer **15** is made small. Furthermore, the linear guide portions **16***a* and **17***a* (to be in close-contact) and curve guide portions **16***b* and **17***b* (to be in close-contact) of adjacent roller retainers **15** are shaped like circular arcs in section so as to come into linear contact with each other. Hence, such adjacent roller retainers **15** press each other while they are allowed to rotate slightly around the axes of corresponding rollers **7** respectively. As a result, the roller retainers **15** freely change their direction three-dimensionally with corresponding rollers **7** respectively, so that complex motion required of the roller screw in this embodiment can be made. Particularly when the axis **19** of each roller **7** is not perpendicular to the center line **5***c* of the screw shaft **5** but inclined at a predetermined angle as shown in **FIG. 1**, the roller **7** circulates in an umbrella-like curved race. Therefore, adjacent roller retainers **15** need to come into close contact with each other while a crossing angle β between the adjacent roller retainers **15** is kept constant as shown in **FIG. 8**. According to the present invention, adjacent roller retainers **15** press each other while they are allowed to rotate slightly around the axes of corresponding rollers **7** respectively. Accordingly, roller retainers **15** sufficiently adapted to such circulation form can be obtained.

[0066] Because each of the roller retainers **15** is made thin, a large space can be ensured for reserving lubricating oil in the circulation path. Hence, the rollers **7** can be lubricated sufficiently. Furthermore, because each of the roller retainers **15** is made thin, a large gap can be taken between the roller retainers **15** and the load rolling groove **6***a*. Hence, a support member for supporting the roller retainers **15** can be provided in the circulation path to prevent the roller retainers **15** from dropping down from the nut member **6**, or the like.

[0067] **FIG. 9** shows the case where the thickness of each roller retainer **15** is selected to be smaller than 50% of the roller diameter. If the thickness of the roller retainer **15** is made smaller than 50% of the roller diameter, the front end of the succeeding roller retainer **15** enters the gap between the front-side roller retainer **15** and the roller rolling groove **5***a* so that adjacent roller retainers **15** may overlap each other. As a result, there is a risk that the circulation of the rollers **7** may stop. When the thickness of the roller retainer **15** is selected to be not smaller than 50% of the roller diameter, adjacent roller retainers **15** can be prevented from overlapping each other as described above.

[0068] **FIG. 10** shows a second embodiment of the present invention concerning rollers and roller retainers incorporated in the roller screw. Each of the roller retainers **25** has substantially the same configuration as that of the roller retainer **15** according to the first embodiment. The roller retainer **25** further has a hinge protrusion **26**, and a hinge recess **27** fitted to the hinge protrusion **26** of the adjacent roller retainer **25**. The hinge protrusion **26** is provided at a point of intersection between the linear guide portion **16***a* and the curve guide portion **16***b* on one end surface of the roller retainer **25** in the direction of the movement of the roller **7**. The hinge recess **27** is provided at a point of intersection between the linear guide portion **17***a* and the curve guide portion **17***b* on the other end surface of the roller retainer **25**. Because the hinge protrusion **26** and the hinge recess **27***a* reprovided in the aforementioned manner, the roller retainer **25** is only allowed to swing around a hinge constituted by a combination of the hinge protrusion **26** and the hinge recess **27** in a plane containing the axis of a corresponding roller **7** and the direction **(1)** of the movement of the roller **7**. Hence, the roller **7** can be prevented from falling down even in the boundary in which the roller is moving from the linear race to the curved race. Hence, smooth circulation of the roller **7** can be ensured.

[0069] FIGS. **11** to **13** and **FIGS. 14A** to **14C** show a third embodiment of the present invention concerning roller retainers incorporated in the roller screw. **FIG. 11** is a view (front view) from a direction perpendicular to the axis of each roller **7** and perpendicular to the direction (**1**) of the movement of the roller **7**. **FIG. 12** is a view (side view) from the rear side in the direction of the movement of the roller **7**. **FIG. 13** is a view (bottom view) from the direction of the axis of the roller **7**. **FIGS. 14A** to **14**C are views showing the case where roller retainers with rollers **7** are aligned in a line. In this embodiment, each of the roller retainers **31** is made thin to hold only the opposite side surfaces of a corresponding roller **7** and the front surface of the same roller **7** in the direction of the movement of the roller **7**. Each of the roller retainers **31** is shaped like a U figure in front view. The thickness W of each side of the roller retainer **31** is selected to be in a range of from 50% to 90% , preferably in a range of from 50% to 60% of the roller diameter.

[**0070**] A linear guide portion **32***a* and a curve guide portion **32***b* which are different in inclination angle from each other are formed in one end surface of the roller retainer **31** in the direction of the movement thereof. The linear guide portion **32***a* is inclined at a predetermined angle with respect to the axis of the roller **7** so that the axes of adjacent rollers **7** are kept parallel to each other. The curve guide portion **32***b* is inclined so that the roller retainers **31** face radial directions when the roller retainers **31** are arranged in a curved race. That is, in a curved race, the curve guide portion **32***b* comes into contact with an adjacent roller **7** and, in a linear race, the linear guide portion **32***a* comes into contact with the adjacent roller **7**. The linear guide portion **32***a* and the curve guide portion **32***b* are formed as a curved surface corresponding to the outer circumference of the roller **7**.

[**0071**] According to this roller retainer **31**, the roller retainer **31** and a roller **7** adjacent to the roller retainer **31** can press each other while the roller retainer **31** is allowed to rotate slightly around the axis of a corresponding roller **7** in the same manner as that in the roller retainer **15** in the first embodiment. Hence, the roller retainer **31** can fulfil the same operation and effect as those of the roller retainer **15** obtained in the first embodiment. Furthermore, because the roller retainer **31** comes into surface contact with a roller **7** located in the front side or rear side in the direction of the movement of the roller, contact surface pressure can be also reduced.

[**0072**] In the example of this roller screw, rollers **7** rolling in the roller rolling groove **5***a* of the screw shaft **5** are scooped by the return pipe **9** and returned by several pitches. Alternatively, a deflector for scooping rollers **7** may be provided in the nut member **6**. That is, one of rollers **7** rolling on the roller rolling groove **5***a* of the screw shaft **5** may be picked out from the roller rolling groove **5***a* by the deflector so that the roller **7** skips over the outer diameter portion of the screw shaft **5** and returns to the roller rolling groove **5***a* before one lead. Though not shown, a so-called side cover type roller screw may be used. That is, the nut member **6** is constituted by a nut body having a load rolling groove formed therein and side covers attached to opposite ends of the nut body. A roller return passage is formed in the nut body. A communication passage by which the load rolling groove and the return passage communicate with each other is formed in each of the side covers.

[**0073**] The roller retainer according to the present invention is not limited only to the roller screw, but can be applied to a direct-acting guide device such as a linear guide or a spline. Particularly the roller retainer according to the present invention can be adapted to a direct-acting guide device except the case where each roller circulates two-dimensionally in a plane perpendicular to the axis of the roller. That is, the roller retainer according to the present invention can be adapted to a direct-acting guide device having a circulation path which is so complex that the path is bent while the roller is twisted.

[**0074**] **FIG. 15** shows a linear guide in which roller retainers **15** according to the first embodiment of the present invention are incorporated. The linear guide is a well known device for guiding a movable body such as a table on a stationary portion such as a bed or a saddle. The linear guide has a guide rail **41** (race shaft), a moving block (slide member) **42**, and a plurality of rollers **43**. The guide rail **41** is disposed on the stationary portion and has a roller rolling groove **41***a* which is formed along the direction of the length thereof so that the roller rolling groove **41***a* serves as a roller rolling surface. The moving block **42** is fitted to the guide rail **41** so as to be relatively movable. A roller circulation path containing a load rolling groove **42***a* corresponding to the roller rolling grove **41***a* of the guide rail **41** is formed in the moving block **42** so that the load rolling groove **42***a* serves as a load rolling surface. The plurality of rollers **43** are arranged and received in the roller circulation path and circulate in the roller circulation path in accordance with the relative movement of the moving block **42** to the guide rail **41**. The plurality of rollers **43** are held in the roller retainers **15** individually and correspondingly. The rollers **43** are arranged and received in the roller circulation path so that the axes of the rollers **43** are substantially kept parallel to one another. With the endless circulation of the rollers **43**, the moving block **42** supporting the rollers makes linear motion along the guide rail **41**.

[**0075**] The guide rail **41** is slenderly elongated to form a quadrilateral in section. A roller rolling groove **41***a*, which serves as a race when a roller **43** rolls, is formed in each of left and right side surfaces of the guide rail **41** so as to extend over the whole length of the guide rail. Although **FIG. 15** shows the case where the race rail is linear, the invention may be applied also to the case where the rail is curved. Although **FIG. 15** shows the case where two roller rolling grooves **41***a* are provided in left and right, the invention may be applied also to the case where the number of roller rolling grooves is changed variously in accordance with the purpose of use of the linear guide, or the like.

[**0076**] The moving block **42** is roughly constituted by a combination of a moving body **44** and a pair of side covers (not shown) disposed at opposite ends of the moving body **44**. Two load rolling grooves **42***a* corresponding to the roller rolling grooves **41***a* are provided in the moving body **44**. The combination of the load rolling grooves **42***a* and the roller rolling grooves **41***a* forms two load rolling passages C between the guide rail **41** and the moving block **42**.

[**0077**] Two return passages D extending in parallel to the load rolling passages C respectively and changing-direction passages B for connecting the load rolling passages C to the return passages respectively are further provided in the moving body **44**. The combination of the load rolling passages C, the return passages D and the pair of changing-direction passages for connecting the load rolling passages C to the return passages D respectively forms one roller circulation path. Each of the changing-direction passages B has a three-dimensionally complex race.

[0078] As the moving block **42** moves along the guide rail **41**, the roller **43** rolls in the load rolling passage C from one end to the other end while the roller **43** suffers load from the moving block **42**. Then, each of the rollers **43** is scooped by one changing-direction passage B and led to the return passage D. The roller **43** is further returned to one end of the load rolling passage C through the opposite changing-direction passage B. On this occasion, in the load rolling passages C and return passages D constituting a linear race, the linear guide portion of the rear-side roller retainer **15** presses the linear guide portion of the front-side roller retainer **15**. In the changing-direction passages B constituting a curved race, the curve guide portion of the rear-side roller retainer **15** presses the curve guide portion of the front-side roller retainer **15**. Either in the linear race or in the curved race, the rear-side roller retainer **15** can press the front-side roller retainer **15** without spoiling the posture of the roller **7** located in the front side in the direction of the movement of the rollers.

[0079] As described above, each side surface of the roller retainer **15** is made thin, and the linear guide portion and curve guide portion for making adjacent roller retainers in close contact with each other are shaped like circular arcs in section so that they come into linear contact with adjacent roller retainers. Hence, adjacent roller retainers press each other while they are allowed to rotate slightly around the axes of corresponding rollers respectively. In such a manner, the roller retainers **15** with the rollers **43** can change their direction three-dimensionally freely. Hence, the roller retainers **15** can make such complex motion as that required of the changing-direction passages B of the linear guide in this embodiment.

[0080] Although this embodiment has shown the case where the relative movement of the moving block **42** to the guide rail **41** is made linearly, the present invention may be preferably applied also to a guide device which is configured so that the relative motion is curved.

[0081] **FIG. 16** shows a spline in which roller retainers according to the first embodiment of the present invention are incorporated. The spline has a spline shaft **51**, and an outer cylinder **52**. The spline shaft **51** serves as a race member whereas the outer cylinder **52** serves as a slide member. The outer cylinder **52** is mounted on the spline shaft **51** so as to be movable through a plurality of rollers **53**. The plurality of rollers **53** are held in roller retainers **15**, individually, obtained in the first embodiment. Further, the axes of adjacent rollers are substantially kept parallel to each other.

[0082] The spline shaft **51** is shaped like a column of a true circle. A plurality of roller rolling grooves **51***a*, which act as roller races and serve as roller rolling surfaces extending in the axial direction of the spline shaft **51**, are formed in a surface of the spline shaft **51**. For example, six roller rolling grooves **51***a* are formed.

[0083] The outer cylinder **52** mounted on the spline shaft **51** has load rolling grooves **52***a* corresponding to the roller rolling grooves **51***a*. The load rolling grooves **52***a* serve as load rolling surfaces. A plurality of rollers **53** are arranged in the roller circulation path so that the rollers **53** circulate in addition to the linear movement of the outer cylinder **52** relative to the spline shaft **51**. A load rolling passage C is formed between each load rolling groove **52***a* formed in the outer cylinder **52** and a corresponding roller rolling groove **51***a* formed in the spline shaft **51**. Ano-load return passage D is formed adjacently to each load rolling passage C. In the no-load return passage D, rollers **53**, which is released from load, roll. A changing-direction passage B for connecting each load rolling passage C to a corresponding no-load return passage D is further formed in the outer cylinder **52**. The changing-direction passage B has a three-dimensionally complex race like that of the linear guide.

[0084] When the outer cylinder **52** is moved relatively to the spline shaft **51**, the roller **53** rolls in the no-load rolling passage C while it suffers load. Hence the roller **53** changes its direction in the changing-direction passage B and moves to the no-load return passage D. In the no-load return passage D, the roller **53** moves in the reverse direction against the load rolling passage C. The rollers **53** moving in the no-load return passage D change its direction again in the other changing-direction passage B and return to the no-load return passage C again. On this occasion, in the load rolling passages C and no-load return passages D constituting linear races, the linear guide portion of the rear-side roller retainer **15** presses the linear guide portion of the front-side roller retainer **15**. In the changing-direction passage B constituting curved race, the curve guide portion of the rear-side roller retainer **15** presses the curve guide portion of the front-side roller retainer **15**. Either in the linear race or in the curved race, the rear-side roller retainer **15** can press the front-side roller retainer **15** without spoiling the posture of the roller **53** located in the front side in the direction of the movement of the roller.

[0085] Further, each side surface of the roller retainer **15** is made thin, and the linear guide portion and curve guide portion for making adjacent roller retainers **15** in close contact with each other are shaped like circular arcs in section so that they come into linear contact with adjacent roller retainers. Hence, adjacent roller retainers **15** press each other while they are allowed to rotate slightly around the axes of corresponding rollers respectively. In such a manner, the roller retainers **15** with the rollers **53** can change their direction three-dimensionally freely. Hence, the roller retainers **15** can make such complex motion as that required of the changing-direction passages B of the spline in this embodiment.

[0086] As described above, according to the present invention, a roller retainer is made thin to hold opposite side surfaces of a corresponding roller and front and rear surfaces of the roller in the direction of the movement of the roller. A linear guide portion and a curve guide portion different in inclination angle from each other are formed in each end surface of the roller retainer in the direction of the movement of the roller retainer. Hence, in the curved race, the curve guide portion comes into contact with an adjacent roller retainer. In the linear race, the linear guide portion comes into contact with an adjacent roller retainer. Hence, in either of the linear race and curved race constituting a circulation race, the rear-side roller retainer can press the front-side roller retainer without spoiling the posture of the roller located in the front side in the direction of the movement of the roller. Hence, rollers can be aligned so that smooth circulation can be obtained. Further, because the roller retainer is made thin, the following effects are obtained.

[0087] (1) Adjacent roller retainers can press each other while they are allowed to rotate slightly around the axes of corresponding rollers respectively. As a result, the roller retainer can be obtained as a roller retainer adapted to a complex circulation path such as a three-dimensional changing-direction passage or a helical load rolling passage shaped like a screw.

[0088] (2) A large space can be secured for reserving lubricating oil in the circulation path. Hence, the rollers can be lubricated sufficiently.

[0089] (3) A drop-down prevention member for supporting the roller retainer can be provided in the circulation path so that the roller retainer is prevented from dropping down from the nut member, or the like.

What is claimed is:

1. A roller retainer assembly, comprising:

a plurality of roller retainers for individually correspondingly retaining a plurality of rollers circulating in a roller circulation path inclusive of linear and curved races;

wherein each of said roller retainers are made thin to hold opposite side surfaces of said roller and front and rear surfaces of said roller in a direction of movement of said roller;

wherein a linear guide portion and a curve guide portion which are different in inclination angle from each other are formed in opposite end surfaces of said roller retainer in a direction of movement of said roller retainer; and

wherein said linear guide portion of said roller retainer comes into contact with an adjacent roller retainer in said linear race and said curve guide portion of said roller retainer comes into contact with said adjacent roller retainer in said curved race.

2. A roller retainer assembly, comprising:

a plurality of roller retainers for individually correspondingly retaining a plurality of rollers circulating in a roller circulation path inclusive of linear and curved races;

wherein each of said roller retainers is made thin to hold said opposite side surfaces of said roller and either one of front and rear surfaces of said roller in a direction of movement of said roller;

wherein a linear guide portion and a curve guide portion which are different in inclination angle from each other are formed in one end surface of said roller retainer in a direction of movement of said roller retainer; and

wherein said linear guide portion of said roller retainer comes into contact with an adjacent roller in said linear race and said curve guide portion of said roller retainer comes into contact with said adjacent roller in said curved race.

3. A roller retainer assembly according to claim 1, wherein each of said linear guide portion and said curve guide portion of said roller retainer is formed to be a curved surface shaped like a circular arc in section so as to come into linear contact with said adjacent roller retainer.

4. A roller retainer assembly according to claim 2, wherein each of said linear guide portion and said curve guide portion of said roller retainer is formed to be a curved surface in accordance with an outer circumference of said roller.

5. A roller retainer assembly according to claim 1 or 3, wherein a hinge protrusion is provided at a point of intersection between said linear guide portion and said curve guide portion in one end surface of said roller retainer in the direction of movement of said roller retainer; and

wherein a hinge recess is provided at a point of intersection between said linear guide portion and said curve guide portion in the other end surface of said roller retainer in the direction of movement of said roller retainer so that said hinge recess engages with said hinge protrusion of an adjacent roller retainer.

6. A roller retainer assembly according to claim 1, wherein drop-down prevention protrusions are formed one either one of said roller retainer and said opposite side surfaces of said roller; and

wherein drop-down prevention recesses are formed in the other one of said roller retainer and said opposite side surfaces of said roller so that said drop-down prevention protrusions are fitted into said drop-down prevention recesses.

7. A roller retainer assembly according to claim 1, wherein a thickness of said roller retainer is selected to be not smaller than 50% of a diameter of said roller.

8. A direct-acting guide device comprising:

a race shaft containing a roller rolling surface;

a slide member including a roller circulation path containing a load rolling surface corresponding to said roller rolling surface, said slide member being fitted to said race shaft so as to be freely movable relative to said race shaft;

a plurality of rollers arranged and received in said roller circulation path so as to circulate in accordance with movement of said slide member relative to said race shaft; and

a plurality of roller retainers for holding said plurality of rollers individually and correspondingly so that said plurality of rollers are rotatable/slidable;

wherein said plurality of rollers are arranged and received so that axes of adjacent rollers are kept approximately parallel to each other;

wherein each of said roller retainers is made thin to hold opposite side surfaces of corresponding one of said rollers and front and rear surfaces of said roller in a direction of movement of said roller;

wherein a linear guide portion and a curve guide portion which are different in inclination angle from each other are formed in each of opposite end surfaces of said roller retainer in a direction of movement of said roller retainer; and

wherein said linear guide portion of said roller retainer comes into contact with an adjacent roller retainer in a linear race and said curve guide portion of said roller retainer comes into contact with said adjacent roller retainer in a curved race.

9. A direct-acting guide device comprising:

a race shaft containing a roller rolling surface;

a slide member including a roller circulation path containing a load rolling surface corresponding to said roller rolling surface, said slide member being fitted to said race shaft so as to be freely movable relative to said race shaft;

a plurality of rollers arranged and received in said roller circulation path so as to circulate in accordance with movement of said slide member relative to said race shaft; and

a plurality of roller retainers for holding said plurality of rollers individually and correspondingly so that said plurality of rollers are rotatable/slidable;

wherein said plurality of rollers are arranged and received so that axes of adjacent rollers are kept approximately parallel to each other;

wherein each of said roller retainers is made thin to hold opposite side surfaces of corresponding one of said rollers and either one of front and rear surfaces of said roller in a direction of movement of said roller;

wherein a linear guide portion and a curve guide portion which are different in inclination angle from each other are formed in one end surface of said roller retainer in a direction of movement of said roller retainer; and

wherein said linear guide portion of said roller retainer comes into contact with an adjacent roller in a linear race and said curve guide portion of said roller retainer comes into contact with said adjacent roller in a curved race.

10. A roller screw comprising:

a race shaft containing a helical roller rolling surface;

a slide member including a roller circulation path containing a helical load rolling surface corresponding to said roller rolling surface, said slide member being fitted to said race shaft so as to be freely movable relative to said race shaft;

a plurality of rollers arranged and received in said roller circulation path so as to circulate in accordance with movement of said slide member relative to said race shaft; and

a plurality of roller retainers for holding said plurality of rollers individually and correspondingly so that said plurality of rollers are rotatable/slidable;

wherein said plurality of rollers are arranged and received so that axes of adjacent rollers are kept approximately parallel to each other;

wherein each of said roller retainers is made thin to hold opposite side surfaces of corresponding one of said rollers and front and rear surfaces of said roller in a direction of movement of said roller;

wherein a linear guide portion and a curve guide portion which are different in inclination angle from each other are formed in each of opposite end surfaces of said roller retainer in a direction of movement of said roller retainer; and

wherein said linear guide portion of said roller retainer comes into contact with an adjacent roller retainer in a linear race and said curve guide portion of said roller retainer comes into contact with said adjacent roller retainer in a curved race.

11. A roller screw comprising:

a race shaft containing a helical roller rolling surface;

a slide member including a roller circulation path containing a helical load rolling surface corresponding to said roller rolling surface, said slide member being fitted to said race shaft so as to be freely movable relative to said race shaft;

a plurality of rollers arranged and received in said roller circulation path so as to circulate in accordance with movement of said slide member relative to said race shaft; and

a plurality of roller retainers for holding said plurality of rollers individually and correspondingly so that said plurality of rollers are rotatable/slidable;

wherein said plurality of rollers are arranged and received so that axes of adjacent rollers are kept approximately parallel to each other;

wherein each of said roller retainers is made thin to hold opposite side surfaces of corresponding one of said rollers and either one of front and rear surfaces of said roller in a direction of movement of said roller;

wherein a linear guide portion and a curve guide portion which are different in inclination angle from each other are formed in one end surface of said roller retainer in a direction of movement of said roller retainer; and

wherein said linear guide portion of said roller retainer comes into contact with an adjacent roller in a linear race and said curve guide portion of said roller retainer comes into contact with said adjacent roller in a curved race.

* * * * *

US 20030108255A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2003/0108255 A1**

Teramach et al. (43) **Pub. Date: Jun. 12, 2003**

(54) **ROLLING GUIDE DEVICE AND DRIVE SYSTEM USING ROLLING GUIDE DEVICE**

(75) Inventors: **Akihiro Teramach**, Tokyo-to (JP); **Takeki Shirai**, Tokyo-to (JP); **Kaoru Hoshide**, Tokyo-to (JP)

Correspondence Address:
ARMSTRONG,WESTERMAN & HATTORI, LLP
1725 K STREET, NW
SUITE 1000
WASHINGTON, DC 20006 (US)

(73) Assignee: **THK CO., LTD**, Tokyo-to (JP)

(21) Appl. No.: **10/340,714**

(22) Filed: **Jan. 13, 2003**

Related U.S. Application Data

(63) Continuation of application No. 09/804,222, filed on Mar. 13, 2001.

(30) **Foreign Application Priority Data**

Mar. 13, 2000	(JP)	P2000-073932
Dec. 1, 2000	(JP)	P2000-367605
Feb. 14, 2001	(JP)	P2001-037486

Publication Classification

(51) **Int. Cl.**^{7} **F16C 29/06**

(52) **U.S. Cl.** **384/45**

(57) **ABSTRACT**

A rolling guide device comprises: a track rail formed with a rolling member rolling surface extending along a longitudinal direction thereof; a movable rail formed with a loaded rolling member rolling surface extending along a longitudinal direction thereof so as to oppose to the rolling member rolling surface of the track rail; a track rail side rolling member circulation passage formed to the track rail so as to circulate the rolling members rolling between the track rail and the movable rail; a movable rail side rolling member circulation passage formed to the movable rail so as to circulate the rolling members rolling between the track rail and the movable rail; and a number of rolling members disposed and arranged in the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage. A drive system comprises such rolling guide device and linear motors having a primary side mounted to either one of the track rail and the movable rail and a secondary side mounted to another one of the track rail and the movable rail.

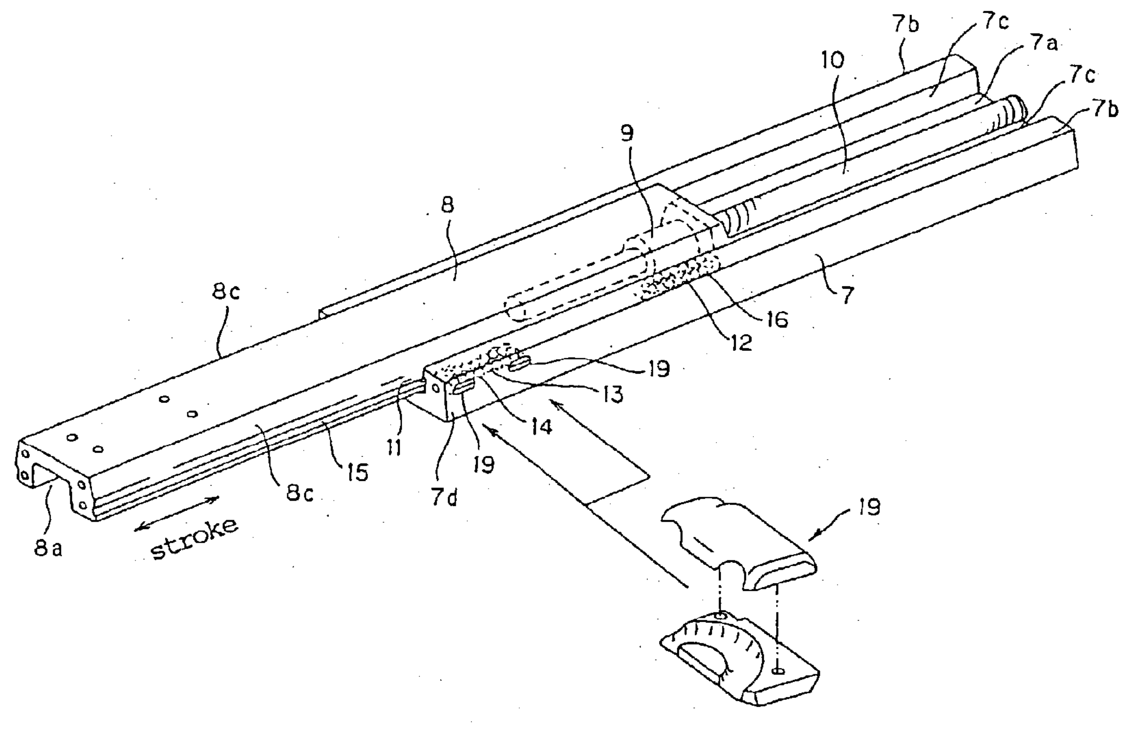


FIG. 1

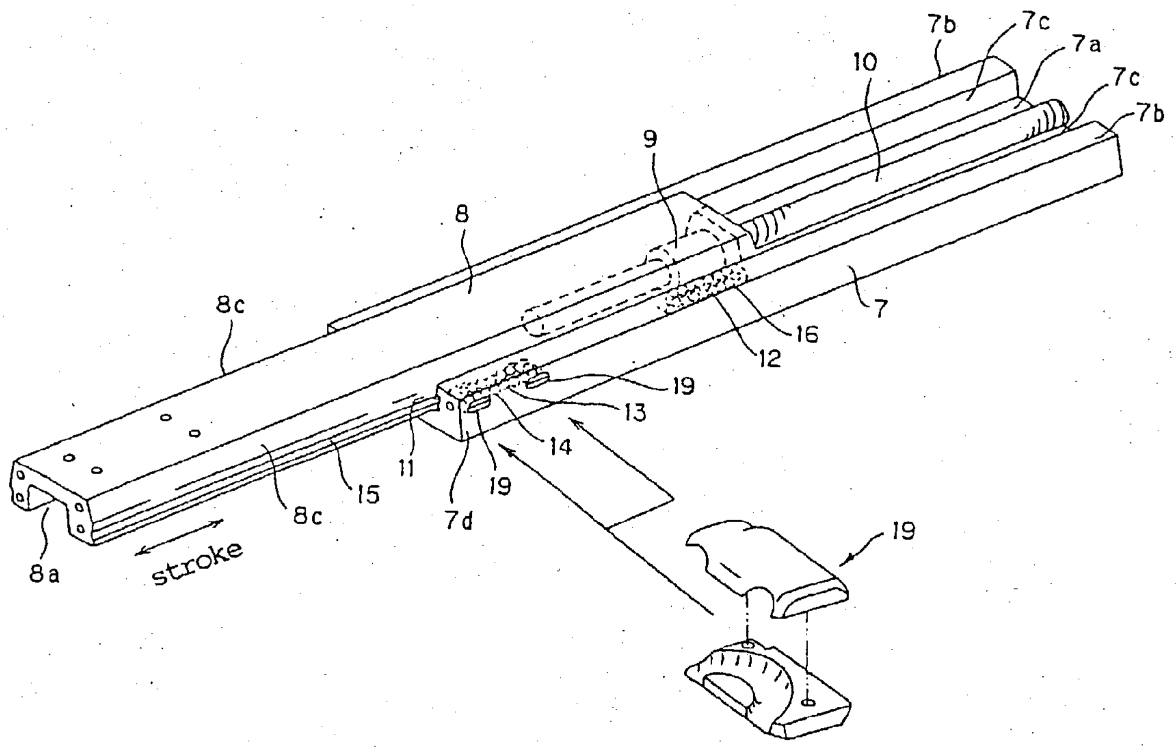


FIG. 2

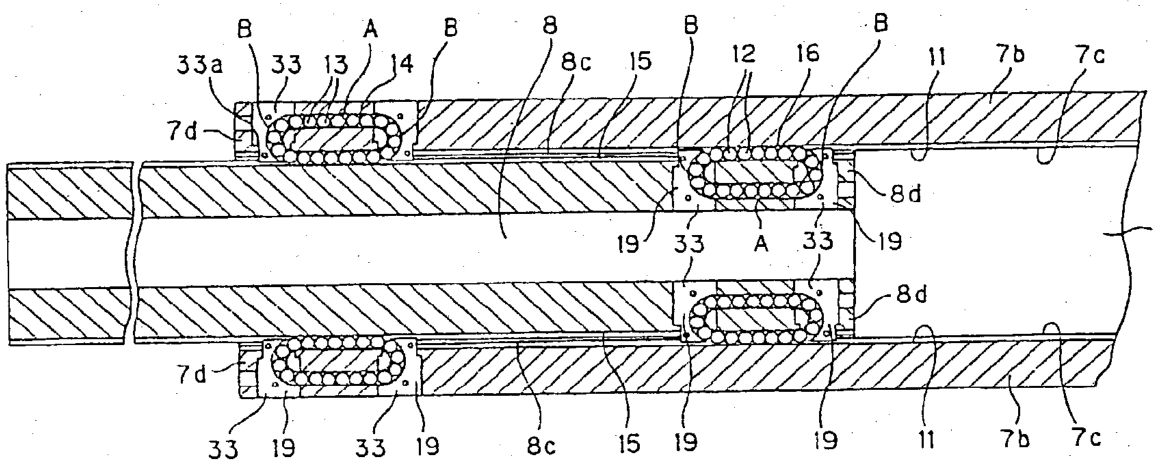

B
A
B
8
B
B
33a
33
13
14
8c
15
12
16
11
7b
7c
7d
8d
19
33
A
33
19
7
8d
7d
33
19
33
19
8c
15
19
19
11
7b
7c

FIG. 3

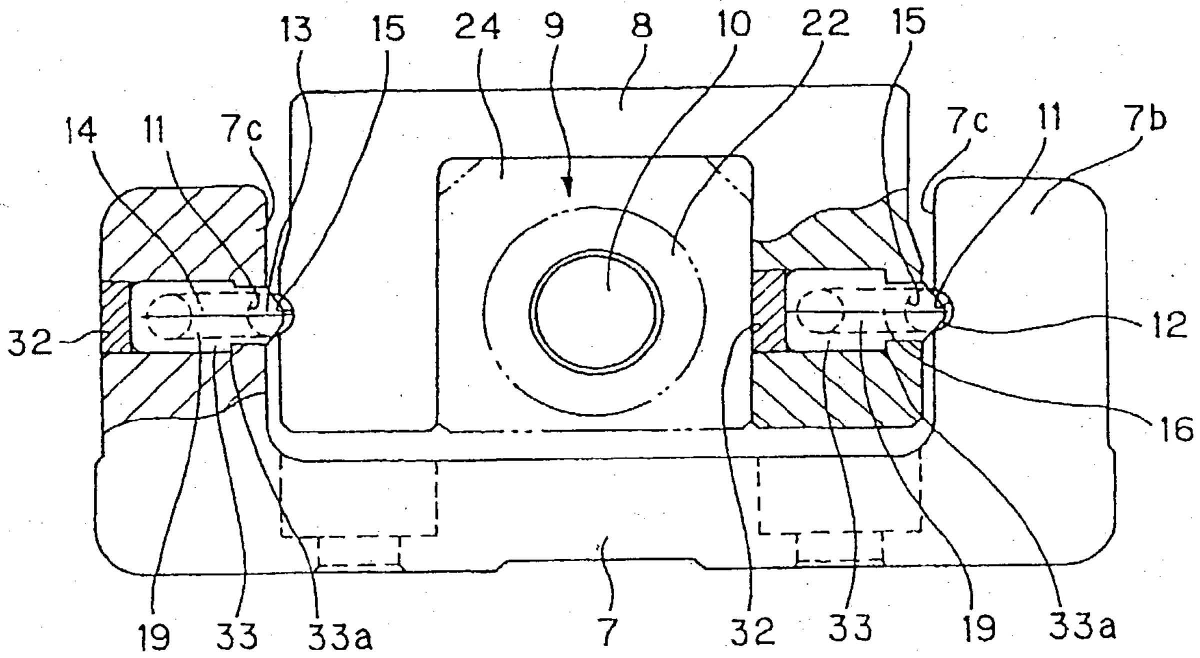


FIG. 4

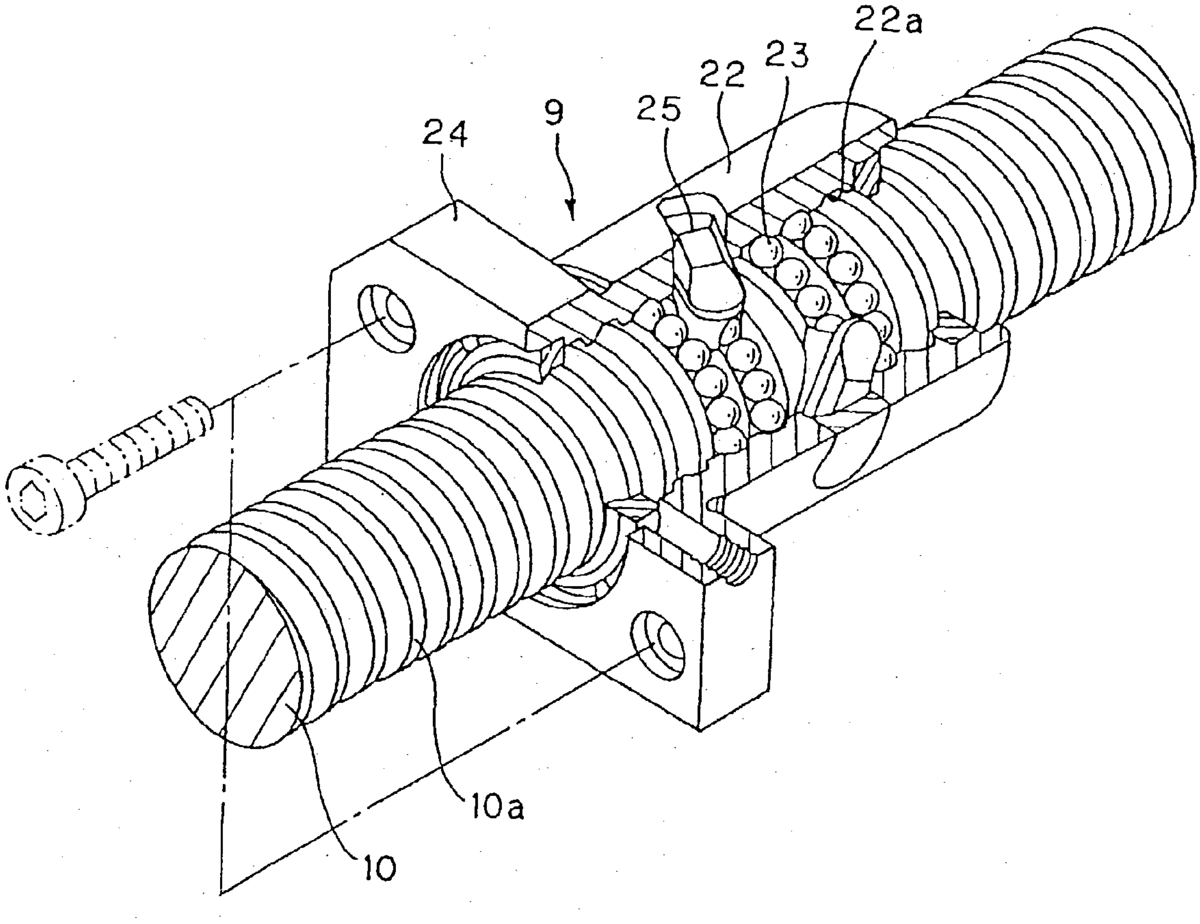


FIG. 5

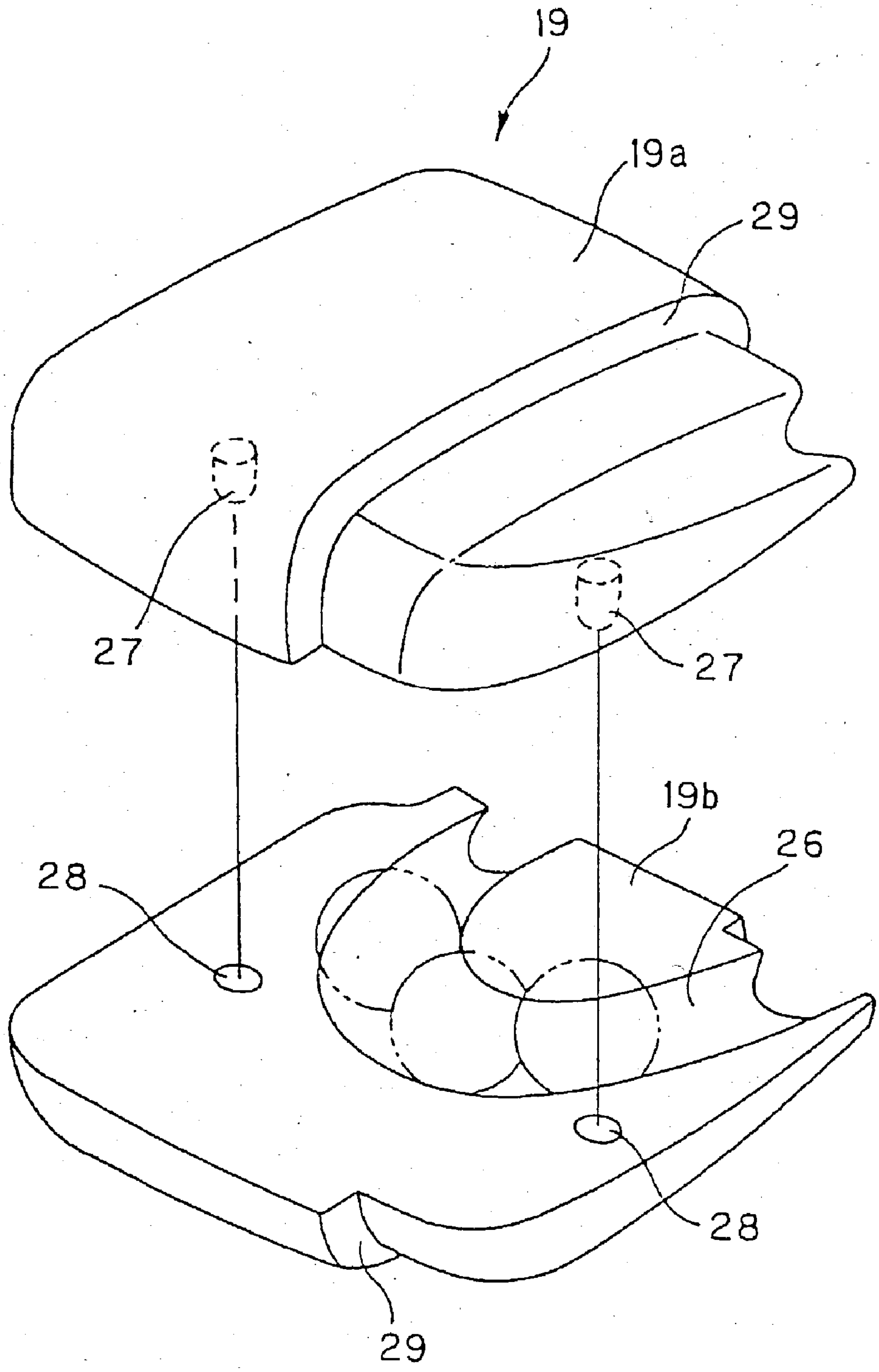


FIG. 6

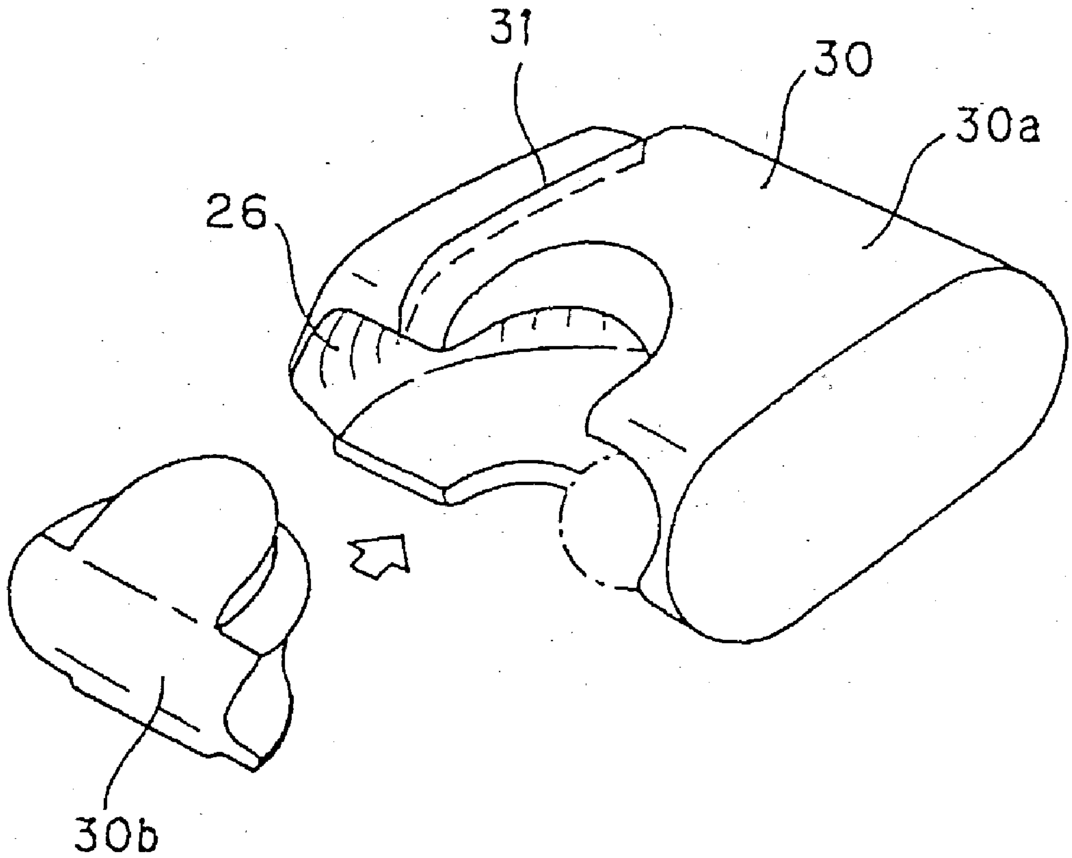


FIG. 7

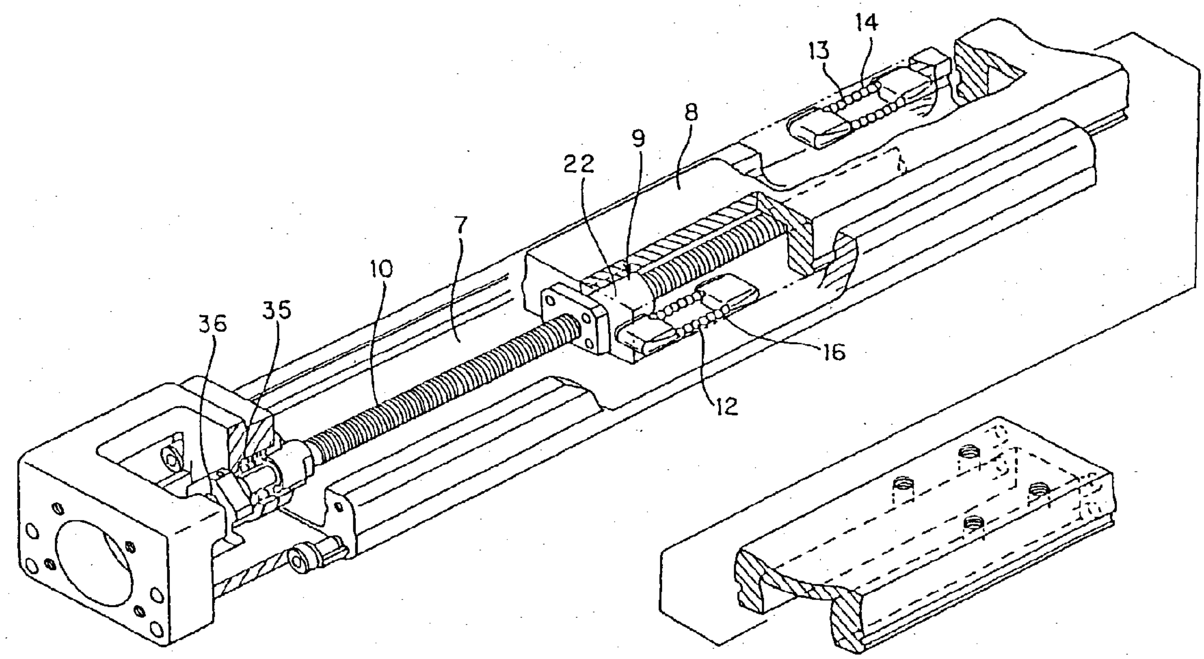


FIG. 8

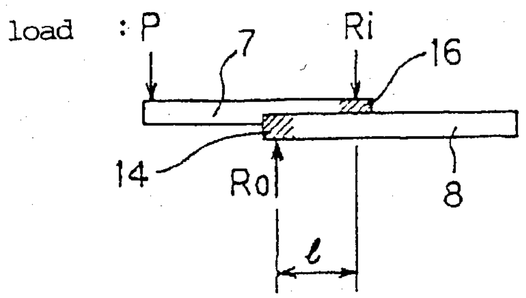


FIG. 9A

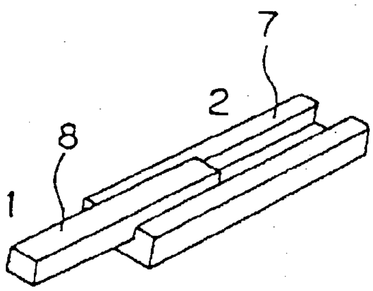


FIG. 9B

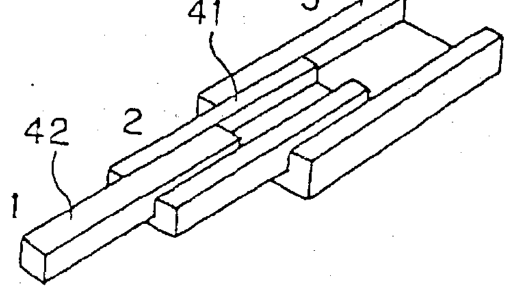
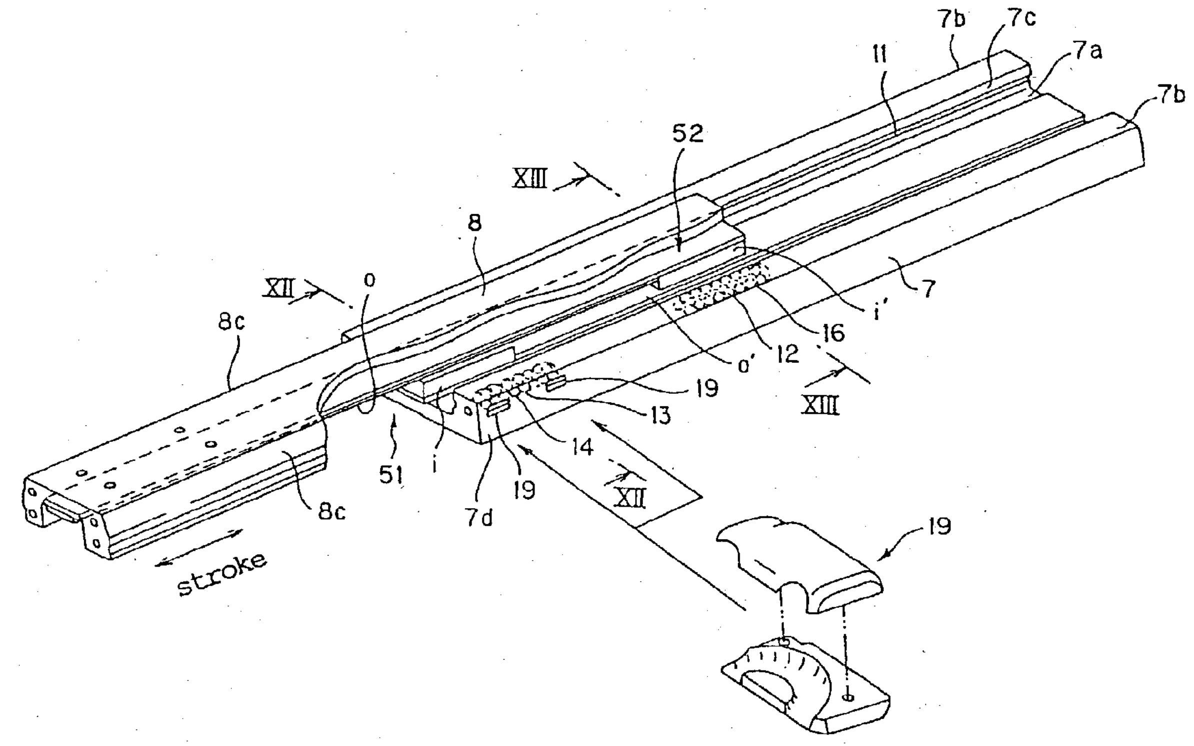


FIG. 10



7b
7c
7a
7b
11
52
XIII
8
XII
o
i'
7
8c
16
12
o'
19
XIII
13
14
51
i
19
XII
7d
8c
19
stroke

FIG.11

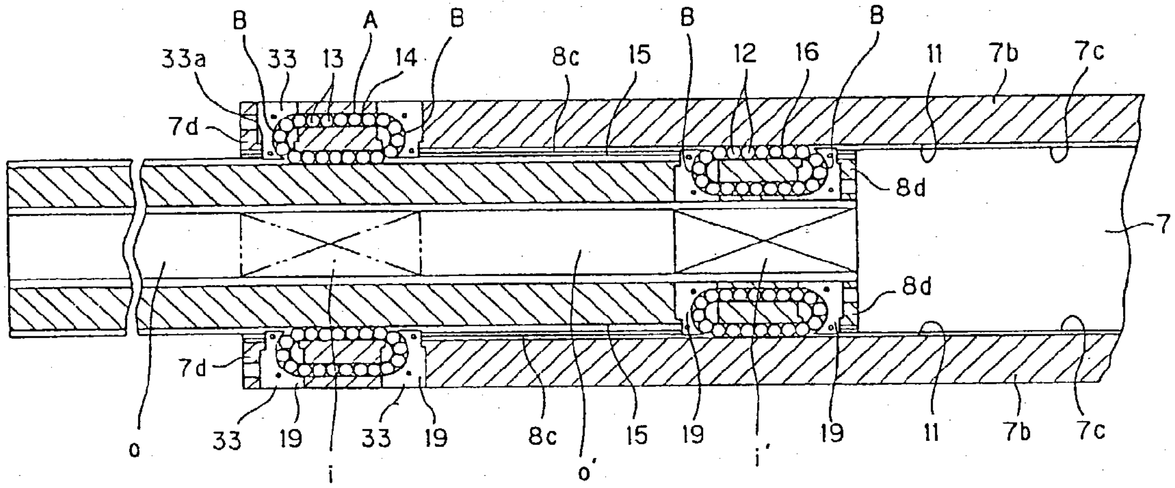

B
A
B
B
B
33a
33
13
14
8c
15
12
16
11
7b
7c
7d
8d
7
8d
7d
o
33
19
i
33
19
8c
15
o'
19
i'
19
11
7b
7c

FIG. 12

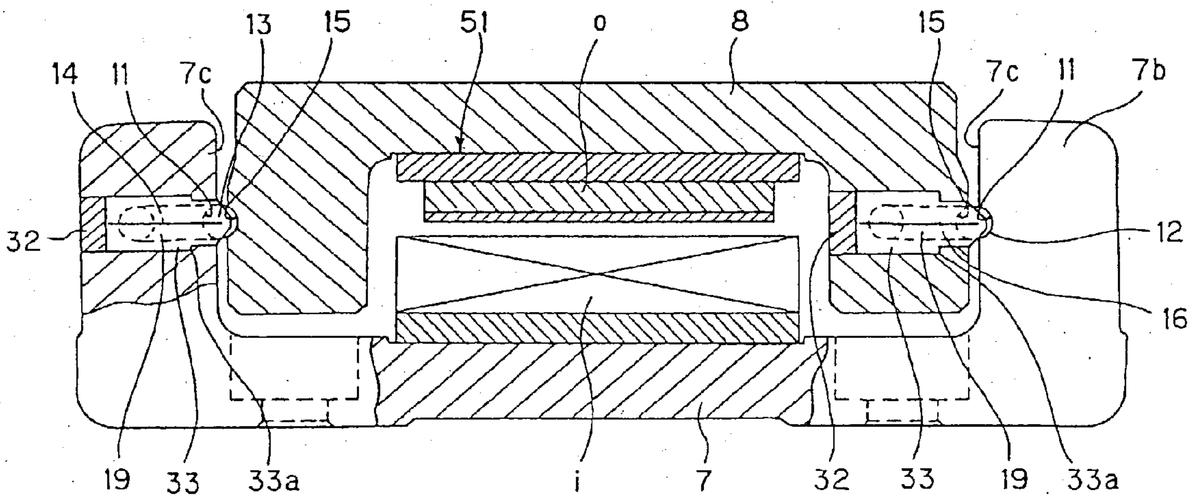


FIG. 13

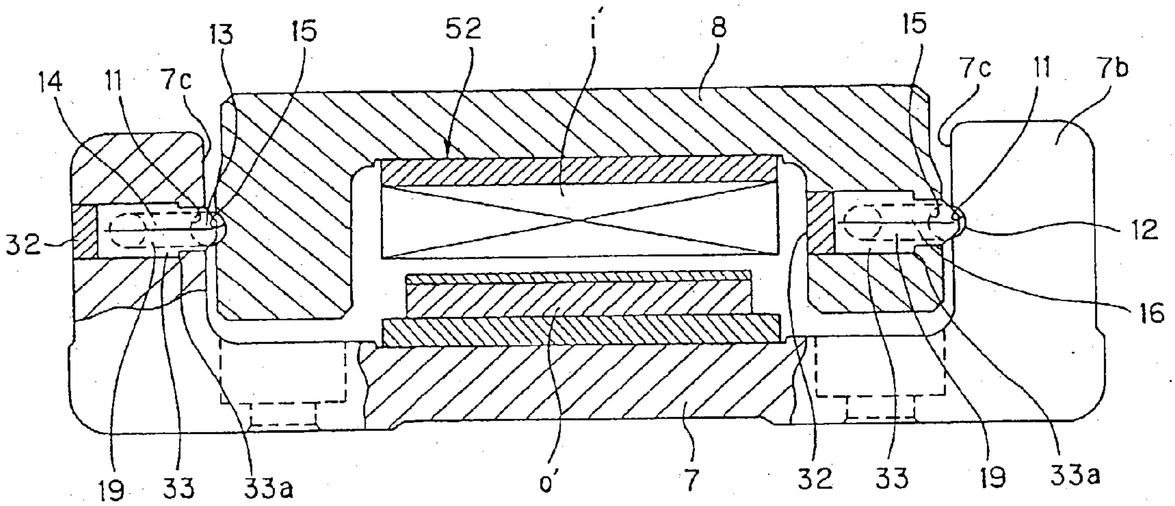


FIG. 14

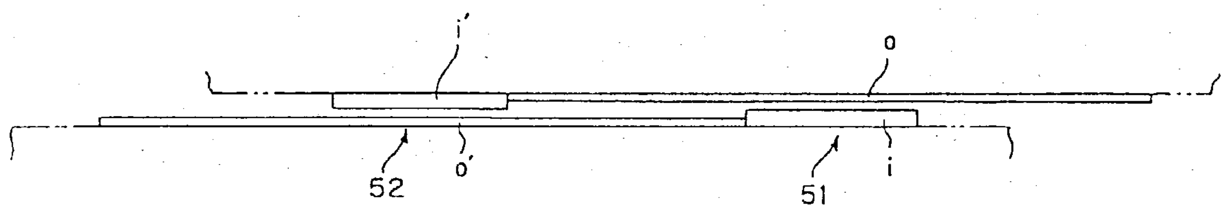


FIG. 15

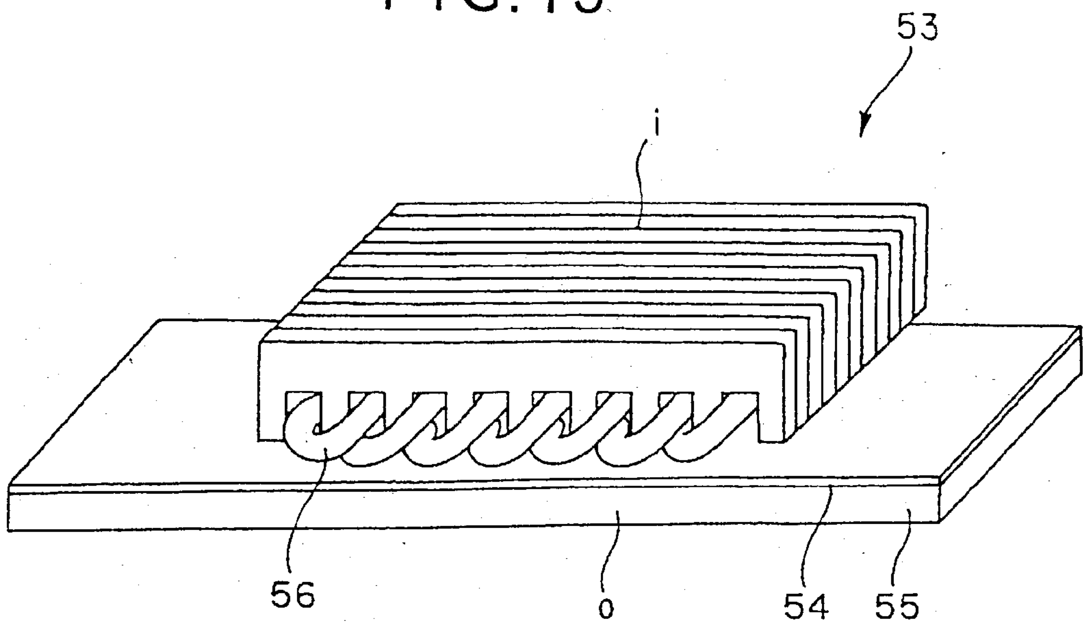

53
i
56
o
54
55

FIG. 16

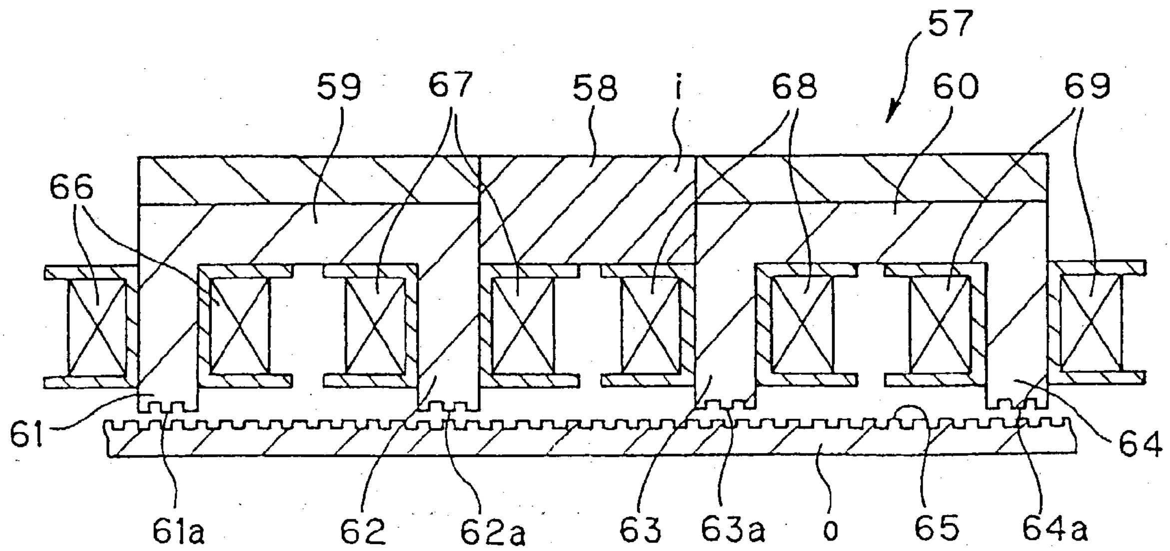

57
59
67
58
i
68
60
69
66
61
64
61a
62
62a
63
63a
o
65
64a

FIG.17A

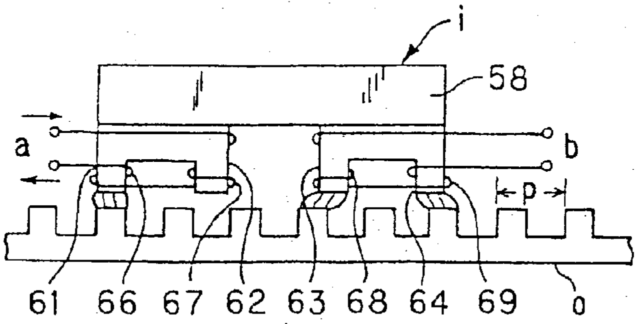


FIG.17B

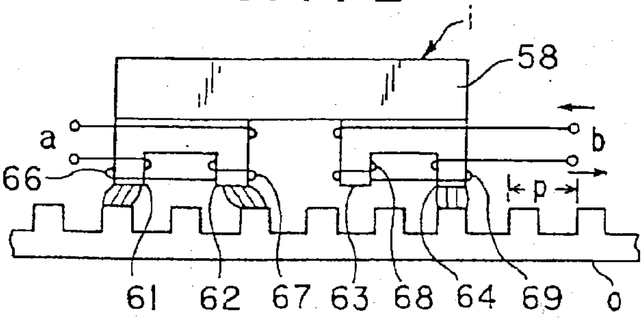


FIG.17C

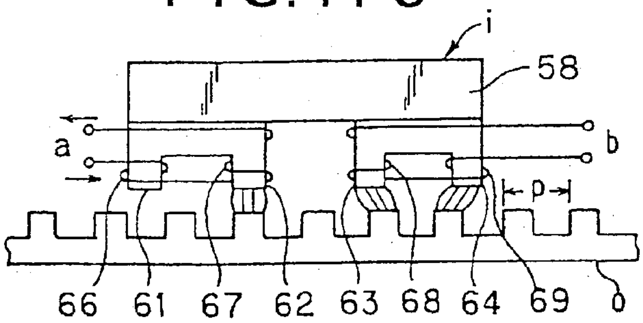


FIG.17D

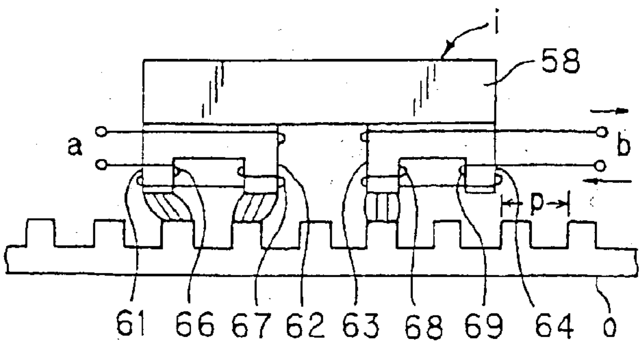


FIG. 18

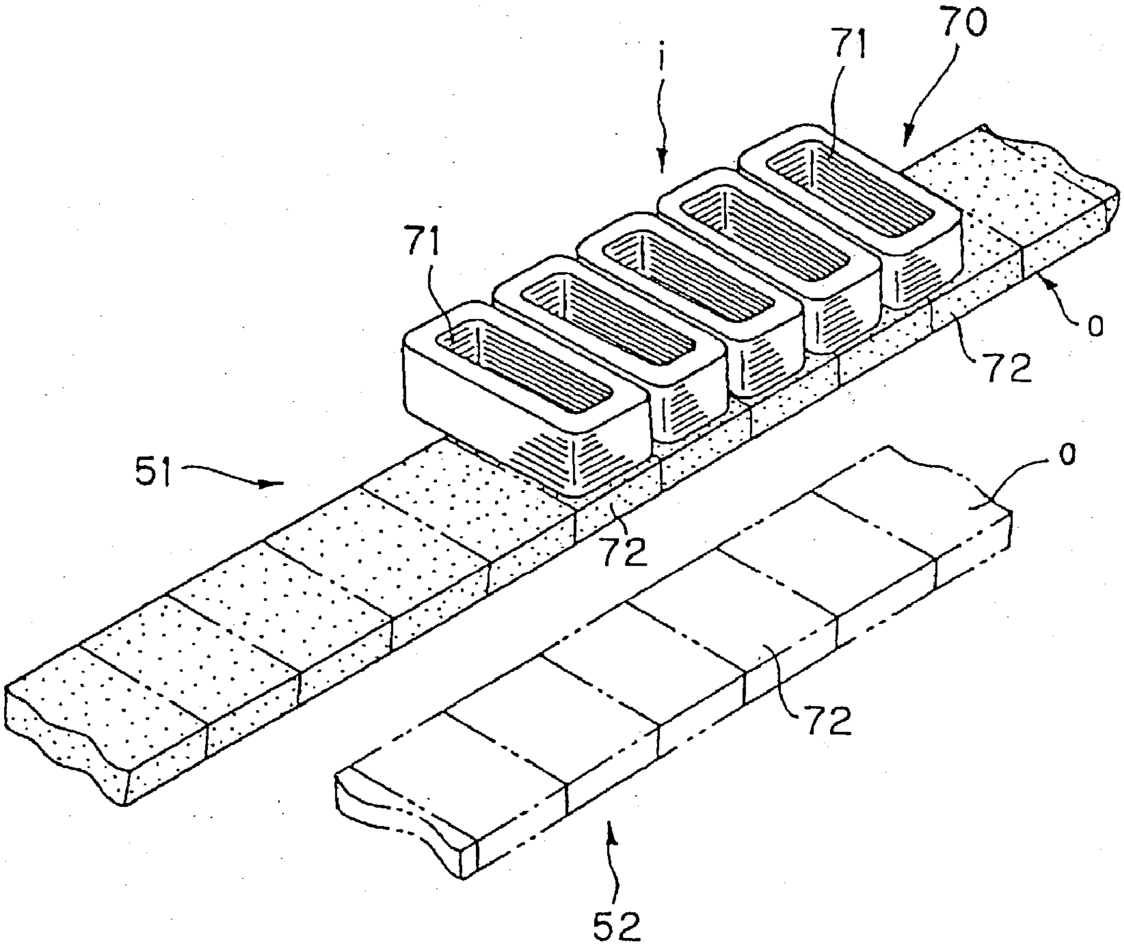


FIG. 19

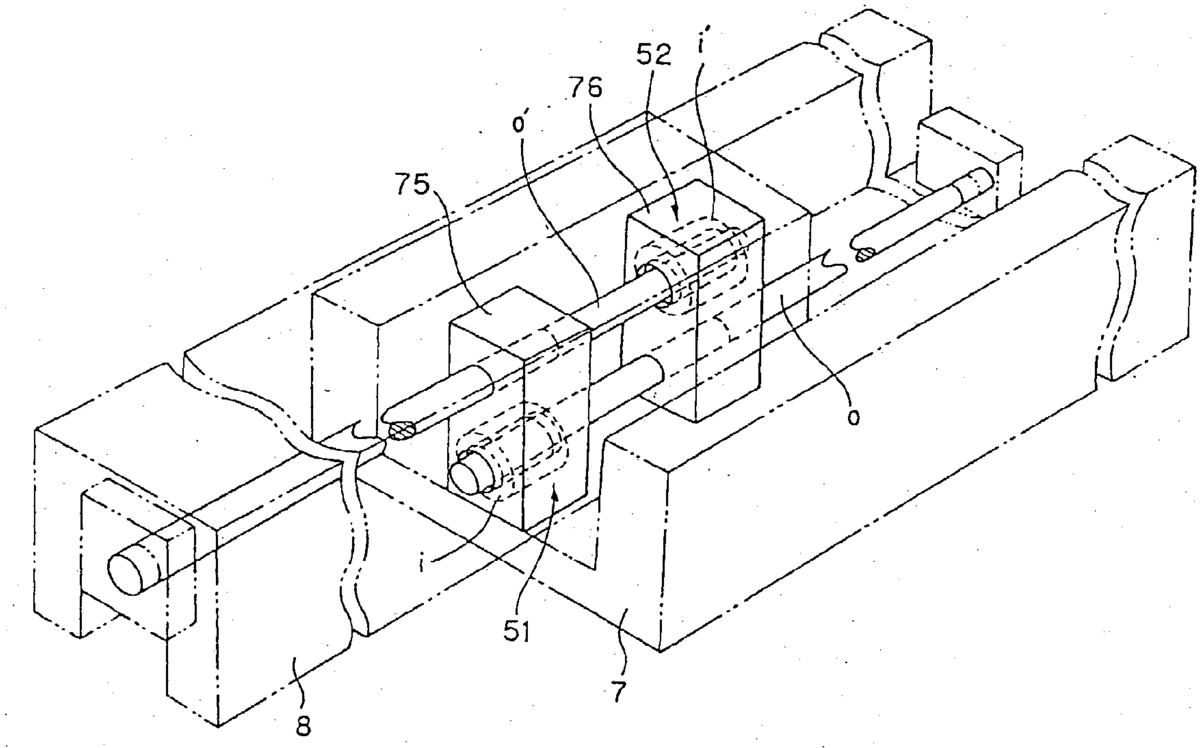


FIG. 20

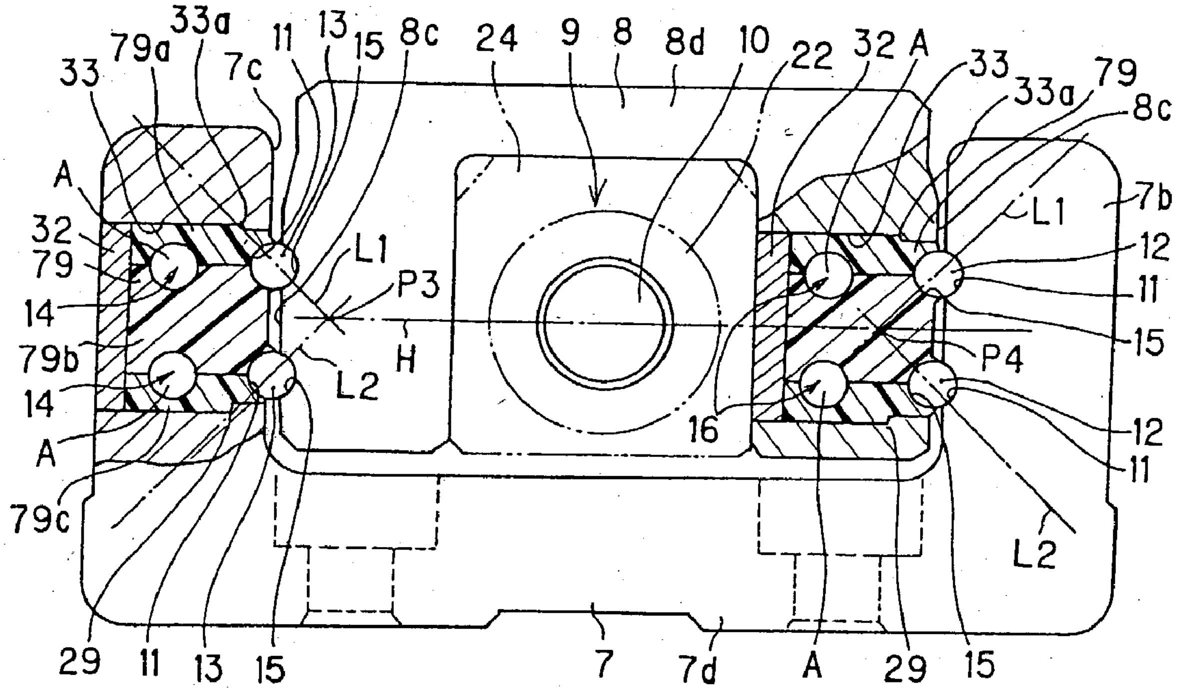

33
79a
33a
7c
11
13
15
8c
24
9
8
8d
10
22
32
A
33
33a
79
8c
A
32
79
14
79b
14
A
79c
L1
P3
H
L2
L1
7b
12
11
15
P4
16
12
11
L2
29
11
13
15
7
7d
A
29
15

FIG. 21

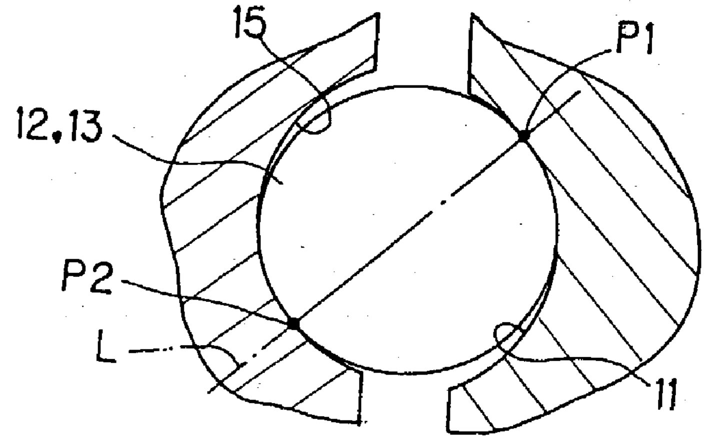


FIG. 22

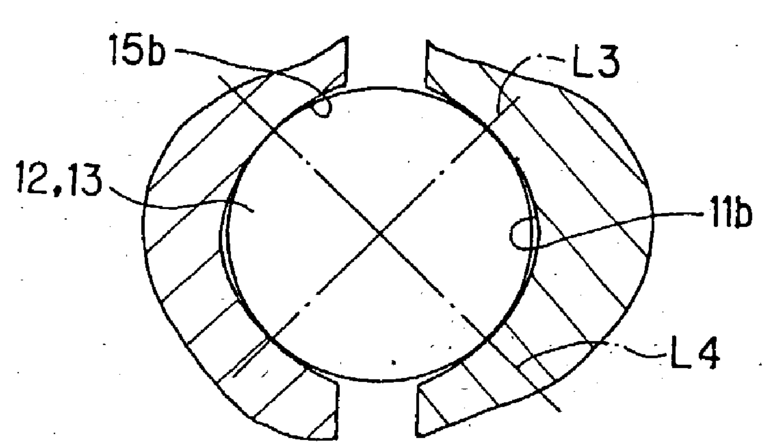


FIG. 23

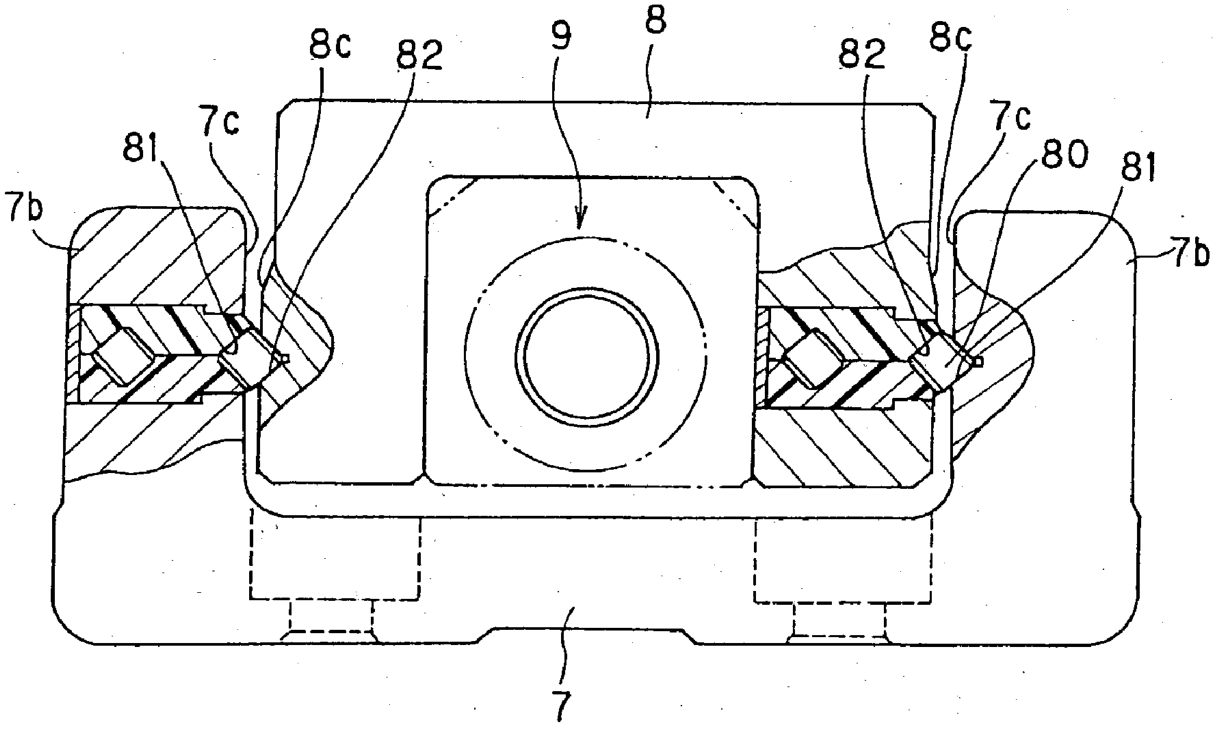


FIG. 24

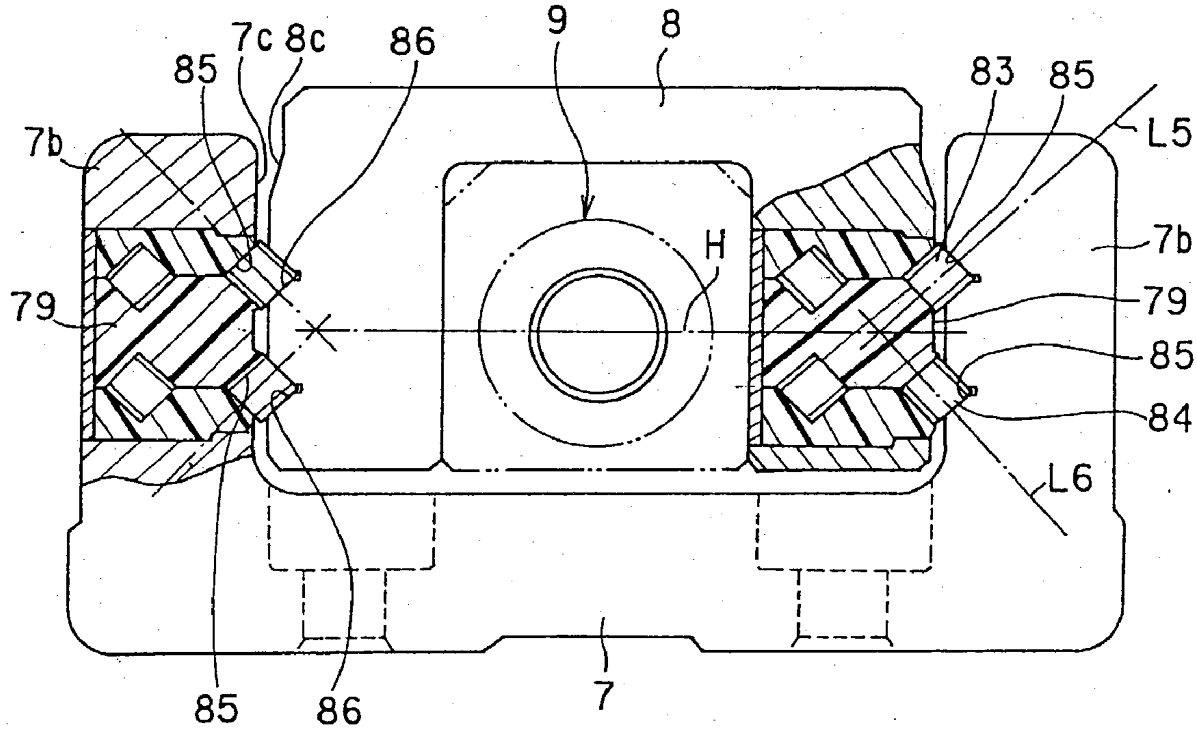
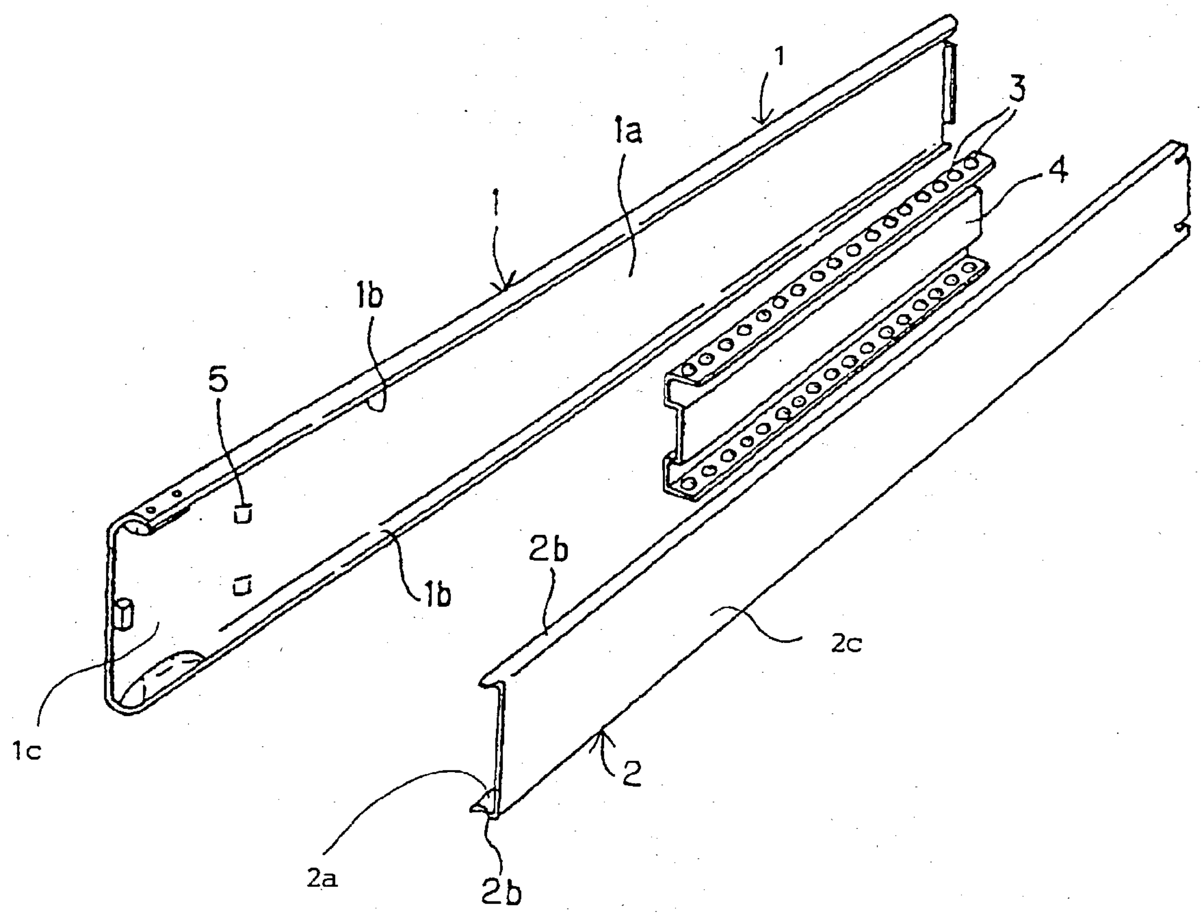


FIG. 25

PRIOR ART



ROLLING GUIDE DEVICE AND DRIVE SYSTEM USING ROLLING GUIDE DEVICE

[0001] The present application claims priority under 35 U.S.C §119 to Japanese Patent Application No.2000-073932 filed Mar. 13, 2000 entitled "ROLLING GUIDE DEVICE ", No.2000-367605 filed Dec. 1, 2000 entitled "ROLLING GUIDE DEVICE AND DRIVE SYSTEM USING ROLLING GUIDE DEVICE", and No.2001-037486 filed Feb. 14, 2001 entitled "ROLLING GUIDE DEVICE AND DRIVE SYSTEM USING ROLLING GUIDE DEVICE". The contents of that application are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to a rolling guide device in which a movable rail is made slidable with respect to a track rail and also relates to a drive system using such rolling guide device.

[0003] As a rolling guide device in which a movable rail is made slidable with respect to a track rail, there has been known a slide rail such as shown in **FIG. 25** (see Japanese Utility Model Publication No. SHO 62-8765). Such slide rail comprises a track rail member **1** having an opened recess **1***a* (i.e. having substantially ⊐-shaped (box-shaped) cross section) formed by both inner side surfaces **1***b*, **1***b* and a bottom surface **1***c* and a movable rail member **2** which is supported between both the inner side surfaces **1***b*, **1***b* of the track rail member **1** to be movable in the longitudinal direction thereof. The movable rail member **2** also has an opened recess **2***a* (i.e. having substantially ⊐-shaped (box-shaped) cross section).

[0004] The track rail member **1** and the movable rail member **2** have substantially the same longitudinal length. The inner side surfaces **1***b* of the track rail member **1** are formed with ball rolling grooves, respectively, along which balls roll in the longitudinal direction thereof, and outer side surfaces **2***b* of the movable rail member **2** are also formed with loaded ball rolling grooves, respectively, so as to extend in the longitudinal direction thereof and oppose to the ball rolling grooves formed to the track rail member **1**.

[0005] A number of balls **3** are arranged and housed between these ball rolling grooves and loaded ball rolling grooves, and these balls **3** are held by a cage **4** to be rotatable and slidable. When the movable rail member **2** is slid with respect to the track rail member **1** in the longitudinal direction thereof, these balls **3** roll and, hence, the slide rail becomes smoothly expandable or contractive.

[0006] Further, though not shown, there is also known a cam-follower type drawer device of a structure that movable and track rails are both provided with wheels so that the movable rail is drawn with respect to the track rail, as a rolling guide device in which a movable rail is slidable with respect to a track rail.

[0007] However, in the conventional slide rail such as mentioned above, a number of balls **3** disposed and arranged between the track rail member **1** and the movable rail member **2** do not completely perform the rolling motion and will roll with a slight sliding motion. In the conventional slide rail, since the balls **3** do not circulate and only reciprocally move along the loaded rolling passage between the ball rolling grooves and the loaded ball rolling grooves, if the balls **3** are slid, the cage **4** supporting (bearing) the balls **3** would be displaced from the initial position. As a result, in spite of the fact that an effective stroke of the movable rail member **2** is not achieved, the cage **4** collides with a stopper **5** of the track rail member **1** and, hence, such effective stroke could not be obtained. In this case, when it is required to slide the movable rail member **2** with the cage **4** colliding with the stopper **5**, the movable rail member **2** will be slid with the balls **3** being slipped, and accordingly, a large force is required to move the movable rail member **2**.

[0008] Furthermore, in the conventional structure of the slide rail, in order to obtain a large stroke of the movable rail member **2**, it is necessary for the movable rail member **2** to be once come off from a portion at which the balls **3** exist and then to be engaged with that portion at which the balls **3** exist. That is, in the case where the movable rail member **2** is come off from the portion at which the balls **3** exist, for example, the movable rail member **2** which has been loaded with ten (10) balls **3** is loaded with, for example, six (6) balls **3**, and hence, ability for bearing moment load, radial load and thrust load is deteriorated, thus being inconvenient.

[0009] Moreover, with the cam-follower type drawer device, since the wheels generally have backlash or looseness, the movable rail member **2** is not smoothly slid, and furthermore, since the wheel has a cylindrical structure, a direction along which a load is received is determined, and hence, the thrust load cannot be received.

SUMMARY OF THE INVENTION

[0010] An object of the present invention is to substantially eliminate defects or drawbacks encountered in the prior art mentioned above and to provide a rolling guide device capable of taking a large expansion/contraction stroke and sufficiently bearing moment load, radial load and thrust load at any expanded (contracted) attitude and also provide a drive system incorporated with such rolling guide device.

[0011] This and other objects can be achieved according to the present invention by providing, in one aspect, a rolling guide device comprising:

[0012] a track rail formed with a rolling member rolling surface extending along a longitudinal direction thereof;

[0013] a movable rail formed with a loaded rolling member rolling surface extending along a longitudinal direction thereof so as to oppose to the rolling member rolling surface of the track rail;

[0014] a track rail side rolling member circulation passage formed to the track rail so as to circulate the rolling members rolling between the track rail and the movable rail;

[0015] a movable rail side rolling member circulation passage formed to the movable rail so as to circulate the rolling members rolling between the track rail and the movable rail; and

[0016] a number of rolling members disposed and arranged in the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage.

[0017] According to the invention of this aspect, when the movable rail is slid with respect to the track rail, the rolling members arranged between the track rail and the movable rail endlessly circulate in the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage while rolling therealong. As mentioned, since the rolling members circulate in the endless manner, even if the rolling member slides during the rolling motion, there is no causing of a case that a cage is shifted from the initial position as in the conventional structure, and hence, a large expansion (contraction) stroke is obtainable. Furthermore, in an optional expanded (contracted) attitude, there remains a considerable distance between the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage, so that a rolling guide device, which can bear even the moment load, can be realized.

[0018] Further, when the movable rail is slid and its stroke is made large, the considerable distance corresponding to this stroke is made short and capability of bearing the moment load is reduced. However, according to the present invention, the movable rail is not come off from the balls, so that the capability of bearing the moment load is not extremely reduced. Moreover, since the movable rail is not come off from the balls and the number of the rolling members supported at an optional expansion (contraction) attitude is not changed, different from the conventional slide rail, there can be provided a rolling guide device bearing the constant radial load and thrust load.

[0019] In the above aspect, the following preferred embodiments or examples may be provided with advantageous functions and effects thereof.

[0020] The track rail side rolling member circulation passage is formed to one longitudinal end side of the track rail and the movable rail side rolling member circulation passage is formed to one longitudinal end side, opposing to that one end side of the track rail, of the movable rail.

[0021] Accordingly, the distance between the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage can be made large, so that a rolling guide device bearing the large moment load can be provided.

[0022] Furthermore, the track rail has an opened recess having a ⊐-shaped section and has inside surfaces to which the rolling member rolling surfaces are formed, the movable rail is fitted into the recess of the track rail, and the movable rail has outside surfaces to which the loaded rolling member rolling surfaces are formed so as to oppose to the rolling member rolling surfaces formed to the track rail inside surfaces.

[0023] Thus, various kinds of loads including radial load, thrust load and moment load can be supported in a balanced condition.

[0024] The track rail side rolling member circulation passage is provided with a rolling member return passage substantially parallel to the rolling member rolling surface and a rolling direction changing passage communicating the rolling member rolling surface and the rolling member return passage, the movable rail side rolling member circulation passage is provided with a rolling member return passage substantially parallel to the loaded rolling member rolling surface and a rolling direction changing passage communicating the rolling member rolling surface and the rolling member return passage, the rolling direction changing passages of the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage are formed to a deflector which is formed independently from a track rail body and a movable rail body, and the deflector is fitted to holes formed to the track rail body and movable rail body from the side portions thereof.

[0025] According to this embodiment, the rolling direction changing passages can be easily formed to fine long track rail and movable rail.

[0026] The return passages are drilled to the track rail body and the movable rail body from the longitudinal end portions thereof.

[0027] According to this embodiment, the return passages can be easily formed to fine long track rail and movable rail.

[0028] The deflector is composed of a plurality of sections splittable along the rolling direction changing passages.

[0029] Accordingly, the rolling direction changing passages having complicated structure may be easily formed to the deflector.

[0030] The deflector is made of a synthetic resin.

[0031] Accordingly, the rolling direction changing passages having complicated structure may be easily formed to the deflector, and moreover, noise which may be generated when the rolling members roll in the rolling direction changing passages will be suppressed.

[0032] The above mentioned object of the present invention can be also achieved by providing, in another aspect, a drive system comprising:

[0033] a track rail formed with a rolling member rolling surface extending along a longitudinal direction thereof;

[0034] a movable rail formed with a loaded rolling member rolling surface extending along a longitudinal direction thereof so as to oppose to the rolling member rolling surface of the track rail;

[0035] a track rail side rolling member circulation passage formed to the track rail so as to circulate the rolling members rolling between the track rail and the movable rail;

[0036] a movable rail side rolling member circulation passage formed to the movable rail so as to circulate the rolling members rolling between the track rail and the movable rail;

[0037] a number of rolling members disposed and arranged in the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage; and

[0038] a linear motor means having a primary side mounted to either one of the track rail and the movable rail and a secondary side mounted to another one of the track rail and the movable rail.

[0039] According to the present invention of this aspect, the expansion (contraction) stroke can be made large and the moment load, the radial load and the thrust load can be sufficiently supported at an optional attitude of the system. Furthermore, since the linear motors are incorporated between the track rail and the movable rail, the use of the ball screw or like can be eliminated, thus moving the movable rail at high speed with less noise. Moreover, since it is not necessary to provide a space for a rotary motor, the drive system can be made thin and compact.

[0040] According to preferred embodiments or examples of this aspect, the following advantageous functions and effects may be attained.

[0041] The track rail side rolling member circulation passage is formed to one longitudinal end side of the track rail and the movable rail side rolling member circulation passage is formed to one longitudinal end side, opposing to that one end side of the track rail, of the movable rail, and the linear motor means comprises first and second linear motors, the first linear motor having a primary side mounted to a portion near the track rail side rolling member circulation passage of the track rail, the second linear motor having a secondary side mounted to the track rail along the longitudinal direction thereof so as to be continuous to the primary side of the first linear motor, and the second linear motor having a primary side mounted to a portion near the movable rail side rolling member circulation passage of the movable rail, the first linear motor having a secondary side mounted to the movable rail along the longitudinal direction thereof so as to be continuous to the primary side of the second linear motor.

[0042] According to this embodiment, since two sets of linear motors are incorporated in the drive system, the thrust force can be made two times (twice), and the excitation is averaged to thereby make smooth the movement of the movable rail. Furthermore, the first linear motor has a primary side mounted to a portion near the track rail side rolling member circulation passage of the track rail and the second linear motor has a primary side mounted to a portion near the movable rail side rolling member circulation passage of the movable rail, so that the thrust force can be generated at substantially the same positions of the movable side rolling member circulation passage and the track rail side rolling member circulation passage, regardless of the stroke of the movable rail. Therefore, even if pitching or yawing moment is applied to the movable rail, the thrust force can be stably applied to the movable rail.

[0043] The first and second linear motors may be composed of linear induction motors or linear pulse motors such that the secondary sides thereof are opposed to each other.

[0044] For example, in a case where linear D.C. motors are used, two sets of linear motors are disposed in back-to-back arrangement and a distance between the secondary side magnets is short, an alternating magnetic field may be generated between the magnets. However, according to this embodiment of the present invention, since the linear induction motors or linear pulse motors are used without using the magnets, there is no fear of causing any alternating magnetic filed. However, a linear D.C. motor may be utilized as far as a relatively large distance between the secondary sides of the linear D.C. motors can be taken so as not to influence from each other.

[0045] The nature and further characteristic features of the present invention may be made clear from the following descriptions made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0046] In the accompanying drawings:

[0047] **FIG. 1** is a perspective view of a rolling guide device according to one embodiment of the present invention;

[0048] **FIG. 2** is a transverse sectional view of the rolling guide device of **FIG. 1**, partially cut away, in the longitudinal direction thereof;

[0049] **FIG. 3** is a sectional view in a direction normal to the axis of the rolling guide device;

[0050] **FIG. 4** is a perspective view showing a ball screw to be incorporated in the rolling guide device of **FIG. 1**;

[0051] **FIG. 5** is a perspective view showing one example of a deflector to be assembled with the rolling guide device;

[0052] **FIG. 6** is a perspective view showing another example of the deflector;

[0053] **FIG. 7** is a perspective view of a drive system using the rolling guide device of **FIG. 1**;

[0054] **FIG. 8** is an illustration showing a state that a load is applied to a front end portion of the rolling guide device of **FIG. 1**;

[0055] **FIG. 9** is an illustration of a further embodiment of the rolling guide device and includes **FIG. 9A** showing a two-stage type rolling guide device and **FIG. 9B** showing a three-stage type rolling guide device;

[0056] **FIG. 10** is a perspective view of a drive system, according to another embodiment of the present invention, incorporated with a liner motor;

[0057] **FIG. 11** is a transverse sectional view of the drive system of **FIG. 10**, partially cut away, in the longitudinal direction thereof;

[0058] **FIG. 12** is a sectional view taken along the line XII-XII in **FIG. 10**;

[0059] **FIG. 13** is a sectional view taken along the line XIII-XIII in **FIG. 10**;

[0060] **FIG. 14** is an illustration showing an example in which two set of linear motors are disposed in back-to-back arrangement;

[0061] **FIG. 15** is a perspective view showing a linear induction motor;

[0062] **FIG. 16** is a vertical sectional view of a liner pulse motor in a longitudinal direction thereof;

[0063] **FIGS. 17A** to **17D** show operation principle of the liner pulse motor;

[0064] **FIG. 18** is a perspective view of a linear D.C. motor;

[0065] **FIG. 19** is a perspective view showing a drive system according to a further embodiment of the present invention;

[0066] **FIG. 20** is a sectional view of a rolling guide device formed with lateral two rows of rolling member (ball) rolling grooves;

[0067] **FIG. 21** is a view showing a contacting state of a ball to a ball rolling groove and a loaded ball rolling groove (circular-arc groove);

[0068] **FIG. 22** is a view showing a contacting state of a ball to a ball rolling groove and a loaded ball rolling groove (Gothic-arch groove);

[0069] **FIG. 23** is a sectional view of one example of a rolling guide device using rollers as rolling members;

[0070] **FIG. 24** is a sectional view of another example of a rolling guide device using rollers as rolling members; and

[0071] **FIG. 25** is a perspective view showing a slide rail having a conventional structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0072] FIGS. **1** to **3** represent a first embodiment of a rolling guide device according to the present invention.

[0073] With reference to FIGS. **1** to **3**, a rolling guide device comprises an outer rail **7** as a track rail, an inner rail **8**, as a movable rail, supported by the outer rail **7** to be slidable in the longitudinal direction thereof and a ball screw **9** driving the inner rail **8**. When a screw shaft **10** of the ball screw **9** is rotated, the inner rail **8** is slid with respect to the outer rail **7**. Such rolling guide device will be utilized for a welding servo-gan, fork-lift or like usable in a stockroom, for example. In a case where the rolling guide device is utilized for the welding servo-gan, a welding rod is attached to the inner rail **8** and, then, the inner rail **8** is slid so as to press the welding rod against an object to be welded. On the other hand, in a case where the rolling guide device is utilized for the fork-lift, an inner rail **8** having a front fork member is slid and the fork-lift is then moved while supporting a cargo by the projected fork member. It is of course to be noted that the illustrated rolling guide device is not limited in its use to the welding servo-gan and the fork-lift and can be applied for various usages as far as expansion/contraction stroke is required and a load is supported.

[0074] The outer rail **7** has a recess **7***a* having an upper opening, in an illustrated state, so as to provide substantially a ⊐-shaped (box-shaped) section having an upper opening. That is, the recess **7***a* is defined by a bottom portion and a lateral pair of ridges **7***b*, **7***b* extending in parallel to each other at both longitudinal side portions of the bottom portion. Each of the ridges **7***b* has an inside surface **7***c* to which one row of ball rolling groove **11** is formed as a rolling member rolling surface extending in the longitudinal direction thereof. An outer rail side ball circulation passage **14** for circulating balls **13**, as rolling members, rolling between the inner rail **8** and the outer rail **7** is formed to one longitudinal side end portion of the outer rail **7**.

[0075] The inner rail **8** is fitted to the recess **7***a* of the outer rail **7** and supported thereby through balls **12, 13** so as to be clamped between the ridges **7***b*, **7***b* of the outer rail **7**. The inner rail **8** has a recess **8***a* having a lower opening, in an installed state, so as to provide substantially a ⊐-shape section having a lower opening, thus easily forming a space into which the screw shaft **10** is moved.

[0076] In the fitted state of the inner and outer rails **8** and **7**, the inside surfaces **7***c*, **7***c* of the outer rail **7** face the outside surfaces **8***c*, **8***c* of the inner rail **8**, respectively, so that the ball rolling grooves **11** formed to the inside surfaces **7***c*, **7***c* of the outer rail **7** oppose to the loaded ball rolling grooves **15** formed to the outside surfaces **8***c*, **8***c* of the inner rail **8**. Inner rail side ball circulation passages **16** are formed to one longitudinal end side of the inner rail **8** opposing to the outer rail side ball circulation passages **14** so as to circulate the balls **12** rolling between the outer and inner rails **7** and **8**. That is, in the structure in which the inner rail **8** projects from (extends over) the outer rail **7**, the outer rail side ball circulation passages **14** on the exit side end of the outer rail **7** and the inner rail side ball circulation passages **16** are formed to the rear side end of the inner rail **8**. This will be explained through a manufacturing processes. The outer rail side ball circulation passages **14** are formed to one end side of the outer rail **7** and the inner rail side ball circulation passages **16** are formed to one end side of the inner rail **8**, and thereafter, the inner and outer rails **8** and **7** are assembled (fitted) from the direction in which both the circulation passages **14** and **16** do not interfere.

[0077] As shown in **FIG. 2**, each of the outer rail side ball circulation passages **14** is composed of a portion of the ball rolling groove **11**, a ball return passage A as a rolling member return passage substantially parallel to the ball rolling groove **11** and a pair of rolling member rolling direction changing passages B communicating with the ball rolling groove **11** and the ball return passage A. On the other hand, each of the inner rail side ball circulation passage **16** is also composed of a portion of the loaded ball rolling groove **15**, a ball return passage A as a rolling member return passage substantially parallel to the ball rolling groove **15** and a pair of rolling member rolling direction changing passages B communicating with the loaded ball rolling groove **15** and the ball return passage A. The ball return passage A is formed through a drilling working effected along the longitudinal direction from the end portions of an outer rail body **7***d* and an inner rail body **8***d*. The rolling direction changing passages B formed to the outer and inner ball circulation passages **14** and **16** are formed to deflectors **19** formed independently from the inner and outer rail bodies **8***d* and **7***d*. The details of such deflector **19** will be described hereinlater.

[0078] The ball screw **9** is engaged with the inner rail **8** so that the ball screw **9** is arranged in the recess **8***a* of the inner rail **8**.

[0079] With reference to **FIG. 4** showing the ball screw **9**, the ball screw **9** comprises the screw shaft **10**, a nut member **22** assembled to the screw shaft **10** to be relatively movable and a number of balls **23** disposed in the ball circulation passage. The screw shaft **10** has an outer peripheral surface on which a spiral rolling member rolling groove **10***a* is formed, the nut member **22** has an inner peripheral surface to which is formed a ball circulation passage including a spiral loaded rolling member rolling groove **22***a* opposing to the ball rolling groove, and the number of balls **23** are arranged in the ball circulation passage so as to circulate therein in association with the relative movement of the nut member **22** with respect to the screw shaft **10**. The nut member **22** has a flanged portion **24** formed at its one end side and is secured to the inner rail **8** by means of screws or like. The nut member **22** is also provided with a deflector **25** (direction changing passage forming member) for taking out the ball **23** rolling along the ball rolling groove **10***a* formed to the screw shaft **10** at one portion thereof and returning the ball **23** to the other portion (one-lead on this side from the ball taken out portion) of the ball rolling groove **10***a* over an outer large diameter portion of the screw shaft **10**. The screw shaft **10** is operatively coupled with an output (drive) shaft of a motor, mentioned hereinlater.

[0080] When the screw shaft **10** is rotated, the ball **23** rolling in the circumferential direction of the screw shaft under load is scooped up by the deflector **25** and the scooped ball **23** is then returned to the position, one-lead on this side of the ball rolling groove **10***a*. When the screw shaft **10** is rotated in the reverse direction, the balls **23** are circulated along the route reverse to that mentioned above. Further, in the described embodiment, although the balls **23** are scooped up by using the direction changing passage forming member (deflector) **25** and returned to the position, one-lead on this side of the ball rolling groove **10***a*, a return pipe may be substituted for such deflector **25**. That is, according to the structure using the return pipe, the ball **23** rolling along the ball rolling groove **10***a* of the screw shaft **10** is scooped up by one end of the return pipe and is then returned through the other one end thereof. Furthermore, so-called a side-cover (lid) type ball screw may be adapted, in which the nut member **22** is composed of a nut body formed with a loaded rolling groove and side lids applied to both ends of this nut body, a ball return passage is formed to the nut body, and both the side lids are formed with communication passages communicated with the loaded rolling groove and the return passage, respectively. An arrangement utilizing rollers in place of balls may be also applicable to the present invention.

[0081] **FIG. 5** shows the details of the deflector **19**, which is utilized commonly for the inner rail side ball circulation passage **16** and the outer rail side ball circulation passage **14**. With reference to the deflector **19** of **FIG. 5**, the deflector **19** is formed with rolling direction changing passage **26** in a semi-circular shape, and the deflector is composed of two bodies **19***a* and **19***b* divided along the rolling direction changing passage **26** for the sake of easy formation of this passage **26**. That is, these two body sections **19***a* and **19***b* are divided vertically, as viewed, through a plane including a central line of the rolling direction changing passage **26**. Both the body sections **19***a* and **19***b* are positioned through the engagement of dowels **27** and holes **28** formed to the body sections **19***a* and **19***b*. The deflector **19** is further formed with a stepped abutment portion **29** for the purpose of positioning it to the inner rail side ball circulation passage **16** and the outer rail side ball circulation passage **14**. The deflector **19** of the structure mentioned above will be formed from synthetic resin, for example, through an injection formation process.

[0082] **FIG. 6** shows another example of the deflector **30**. This deflector **30** is also composed of two divided body sections **30***a* and **30***b* separated along the rolling direction changing passage **26** for the easy formation thereof as mentioned before. In this example, however, the rolling direction changing passage **26** is divided into two sections as inner peripheral side section and outer peripheral side section. This deflector **30** is also formed with a stepped abutment portion **31**.

[0083] With reference to **FIGS. 2 and 3**, the outer rail body **7***d* is drilled from the side thereof to form holes **33** by means of end mill, for example, and the deflectors **19** are fitted to these holes **33**. The fitted deflectors **19** is secured to the outer rail body **7***d* by fastening means **32** such as binder members. The holes **33** are formed so as to penetrate the ball return passages A and extend ball rolling grooves **11** or ball rolling grooves **15** and formed inside with stepped portions **33***a* abutting against the abutment portions **29** of the deflectors **19**. When fitting the deflector **19**, the outer periphery of the deflector **19** is fitted to the hole **33** and the abutment portion **29** of the deflector **19** abuts against the stepped portion **33***a* of the hole **33**, thus positioning the deflector **19** with respect to the outer rail body **7***d* or inner rail body **8***d*.

[0084] Through such positioning of the deflector **19**, the balls **12** and **13** can be surely scooped from the ball rolling groove **11** or loaded ball rolling groove **15** and then returned to the ball return passage A.

[0085] On the other hand, other holes **33** are formed to the inner rail body **8***d* from the side thereof by means of end mill, for example, and the deflectors **19** are fitted to these holes **33**. Furthermore, in the described embodiment, although the holes **33** are formed to the outer rail body **7***d* from the outside thereof and formed to the inner rail body **8***d* from the inside thereof, the holes **33** may be formed to the outer rail body **7***d* from the inside thereof and formed to the inner rail body **8***d* from the outside thereof.

[0086] **FIG. 7** shows one preferred example of a drive system according to the present invention, which uses the rolling guide device mentioned above and is assembled with a rotation motor.

[0087] The screw shaft **10** is screwed with the nut member **22** and has one end rotatably supported by a bearing **35** disposed at one end portion of the outer rail **7** and coupled to a motor, not shown, through a joint member **36**. According to this structure, when the motor is driven, the screw shaft **10** is rotated and the rotational motion thereof is transferred to the inner rail **8** through the ball screw to thereby linearly move the inner rail **8** along the outer rail **7**. According to this linear motion of the inner rail **8** along the outer rail **7**, the rolling guide device is expanded or contracted, and the balls **12** and **13** circulate in an endless manner in the inner rail side ball circulation passage **16** and the outer rail side ball circulation passage **14** while rolling therealong. Since the balls **12** and **13** endlessly circulate, even if the balls **12** and **13** be slid during the rolling motion, there is no fear of being shifted from the original position as in a conventional slide rail, and a rolling guide device having a large expansion stroke can be realized, in which the inner rail **8** can be smoothly moved.

[0088] **FIG. 8** is an illustration showing a state that a load P is applied to the front end of the inner rail **8** of the rolling guide device. In an optional expanded or contracted state, since a considerable distance **1** exists between the outer rail side ball circulation passage **14** and the inner rail side ball circulation passage **16**, there can be provided a rolling guide device bearing the moment load. For example, when the load P is applied to the front end portion of the inner rail **8**, a reaction force Ro acts on the outer rail side ball circulation passage **14** and a reaction force Ri acts on the inner rail side ball circulation passage **16**, thus bearing the moment load of (Ri×1). When the inner rail **8** slides and the stroke of the rolling guide device is made large, the above-mentioned distance **1** is gradually reduced and an ability for loading this moment load is also reduced. However, even if the inner rail

8 is slid, the inner rail 8 never come off as in the conventional slide rail from the balls, so that the moment load bearing ability cannot be largely reduced. Furthermore, the movable rail is not come off from the ball as in the conventional slide rail and the number of balls born in the optional expanded or contracted attitude does not change, so that a rolling guide device capable of bearing constant radial load and thrust load can be realized.

[0089] Furthermore, as mentioned above, the outer rail **7** has a recess **7***a* having an upper opened portion has a box-shaped section and the ball rolling grooves **11** are formed to the inside surfaces **7***c*, respectively. The inner rail **8** is fitted into the recess **7***a* of the outer rail **7** and the loaded ball rolling grooves **15** are formed to the outside surfaces **8***c* of the inner rail **8** so as to oppose to the inside surfaces **7***c* of the outer rail **7**. Accordingly, there is provided the rolling guide device capable of bearing the radial load, the thrust load and the moment load in a balanced condition.

[0090] **FIG. 9** includes perspective views of the rolling guide device according to another embodiment of the present invention. Referring to **FIG. 9**A, the device is provided with inner and outer rails **8** and **7**, constituting a single-stroke structure in which only the inner rail **8** is slid. Further, as shown in **FIG. 9**B, the rolling guide device may be composed of three rail sections comprising the outer rail **7**, a first inner rail **41** fitted to the outer rail **7** and a second inner rail **42** fitted to the first inner rail **41**. In this structure, the first inner rail **41** is slid with respect to the outer rail **8** and the second inner rail **42** is slid with respect to the first inner rail **41**. That is, the first inner rail **41** acts like the inner rail **8** of the aforementioned embodiment with respect to the outer rail **7** and also acts like the outer rail **7** of the aforementioned embodiment with respect to the second inner rail **42**. The second inner rail **42** has a structure identical to that of the inner rail **8**. According to this rolling guide device of the embodiment of **FIG. 9**B, since the first inner rail **41** is slid with double strokes, the expansion stroke can be made further long. As mentioned above, when the rolling guide device is composed of a plurality of members (rail members), the expansion stroke composed of a plurality of expansion stages can be realized, thus providing a rolling guide device having a large stroke.

[0091] In the embodiment described above, although the inner rail side ball circulation passage **16** and the outer rail side ball circulation passage **14** are formed to the inner rail **8** and the outer rail **7**, respectively, these passages may be formed as block members independently from the inner and outer rails **8** and **7**. Furthermore, although the inner rail **8** and the outer rail **7** are formed as linear (straight) rail members, a curved rail member may be utilized therefor. The balls may be also substituted with other rolling members such as rollers. Retainers each having a belt shape having flexibility may be arranged for supporting the balls **12** and **13** to be rotatable, and spacers may be also arranged between the balls **12** and **13** for supporting them to be rotatable and slidable.

[0092] **FIGS. 10 and 11** represent a drive system, using a linear motor as drive source, according to one embodiment of the present invention.

[0093] This drive system comprises an outer rail **7** as a track rail, an inner rail **8** as a movable rail supported by the outer rail **8** to be linearly slidable along the longitudinal direction thereof and first and second linear motors **51** and **52** disposed between the inner and outer rails **8** and **7** to be back-to-back arrangement. The outer rail **7** is provided with a primary side movable piece (called merely movable piece i hereinlater) of the first linear motor **51** and a secondary side stationary piece (called merely stationary piece O' hereinlater) of the second linear motor **52**. On the other hand, the inner rail **8** is provided with a secondary side movable piece (called merely movable piece i' hereinlater) of the second linear motor **52** and a primary side stationary piece (called merely stationary piece O hereinlater) of the first linear motor **51**. According to this structure, when energized, suction (attracting) forces are induced between the movable piece i and the stationary piece O and between the movable piece i' and the stationary piece O'.

[0094] As like as the rolling guide device mentioned above, the outer rail **7** is formed with a recess **7***a* having a box-shaped section with an upper opening and also formed with a lateral pair of ridges **7***b*, **7***b* extending on both the sides of the recess **7***a* in parallel to each other along the longitudinal direction of the outer rail **7**. Each of the ridges **7***b*, **7***b* has an inside surfaces **7***c*, to which a single row of ball rolling groove **11** as a rolling member rolling surface is formed so as to extend along the longitudinal direction thereof as shown in **FIG. 11**. An outer rail side ball circulation passage **14** for circulating the balls **13** rolling between the inner and outer rails **8** and **7** is formed to one (front) end side portion of the outer rail **7**.

[0095] The inner rail **8** is fitted to the recess **7***a* of the outer rail **7** and supported thereby so as to be clamped between the ridges **7***b* of the outer rail **7** through the balls **12** and **13**. The inner rail **8** is also formed with a recess **8***a* having an opening opened downward so as to provide a box-shaped section. The inner rail **7** has outside surfaces **8***c* to which loaded ball rolling grooves **15** are formed as loaded rolling member rolling surfaces which face the ball rolling grooves **11** of the outer rail **7**. An inner rail side ball circulation passage **16** for circulating the balls **12** rolling between the inner and outer rails **8** and **7** is formed to one (rear) end side portion of the outer rail **7** in the longitudinal direction thereof.

[0096] As shown in **FIG. 11**, the outer rail side ball circulation passage **14** is composed of a portion of the ball rolling groove **11**, a ball return passage A as a rolling member return passage extending substantially in parallel to the ball rolling groove **11** and a pair of rolling direction changing passages B communicated with the ball rolling groove **11** and the ball return passage A. On the other hand, the inner rail side ball circulation passage **16** is also composed of a portion of the loaded ball rolling groove **15**, a ball return passage A as a rolling member return passage extending substantially in parallel to the loaded ball rolling groove **15** and a pair of rolling direction changing passages B communicated with the loaded ball rolling groove **15** and the ball return passage A. The ball return passages A are formed through drilling working effected from the end portions of the outer rail body **7***d* and the inner rail body **8***d* in their longitudinal directions. The rolling direction changing passages B of the outer rail side ball circulation passage **14** and the inner rail side ball circulation passage **16** are formed to a deflector **19** which is mounted to the inner rail body **8***d* and the outer rail body **7***d* as independent member.

[0097] Holes **33** are formed to the outer rail body **7***d* by means of end mill, for example, from the longitudinal sides thereof, and the deflector **19** is fitted to these holes **33** and then fastened to the outer rail body **7***d*. Holes **33** are also formed to the inner rail body **8***d* by means of end mill, for example, from the longitudinal sides thereof, and the deflector **19** is fitted to these holes **33** and then fastened to the inner rail body **8***d*. Since these deflectors have substantially the same structures as that mentioned herein before with reference to the rolling guide device, the details thereof are omitted herein by adding the same reference numeral of **19**.

[0098] Two linear motors **51** and **52** are interposed between the inner rail **8** and the outer rail **7**, and the linear motors **51** and **52** in this embodiment are linear induction motors and composed of the movable pieces i and i' and the stationary pieces O and O', the induction motors being driven and operated by passing polyphase alternating current to primary windings of the movable pieces i and i'.

[0099] With reference to **FIG. 10**, the movable piece i of the first linear motor **51** is mounted to a portion near one end (front end) in the longitudinal direction of the upper surface of the outer rail **7**, and the stationary piece O' of the second linear motor **52** is also mounted to the upper surface of the outer rail **7** so as to be continuous to the movable piece i of the first linear motor **51** in the longitudinal direction of the outer rail **7**. On the other hand, the movable piece i' of the second linear motor **52** is mounted to a portion near one end (rear end) in the longitudinal direction of the lower surface of the inner rail **8**, and the stationary piece O of the first linear motor **51** is also mounted to the lower surface of the inner rail **8** so as to be continuous to the movable piece i' of the second linear motor **52** in the longitudinal direction of the inner rail **8**. In such arrangement, the movable piece i of the first linear motor **51** and the outer rail side ball circulation passage **14** have substantially the same positions in the longitudinal direction of the outer rail **7**, and on the other hand, the movable piece i' of the second linear motor **52** and the inner rail side ball circulation passage **16** have substantially the same positions in the longitudinal direction of the inner rail **8**. Further, it is to be noted that the terms "upper", "lower" and the like are used herein in the illustrated state in the figures or usable state of the device or system.

[0100] As shown in **FIG. 12**, the movable piece i of the first linear motor **51** is opposed to the stationary piece O of the first linear motor **51**, and as shown in **FIG. 13**, the movable piece i' of the second linear motor **52** is opposed to the stationary piece O' of the second linear motor **52** so that the first and second linear motors **51** and **52** are disposed in the back-to-back arrangement as shown in **FIG. 14**.

[0101] **FIG. 15** shows a linear induction motor **53** constituting one example of the first and second linear motors **51** and **52**. The linear induction motor **53** is provided with the movable piece i and the stationary piece O which is composed of a non-magnetic conductor plate **54** and a magnetic conductor plate **55** by laminating them vertically as viewed. This linear induction motor **53** is driven in a manner basically identical to that of a cage (rotary type) induction motor having an operational function explained by the Lenz's law and the Fleming's left-hand rule.

[0102] When the polyphase alternating current passes the polyphase primary winding **56**, a traveling (progressive) magnetic field moving timely and spacially is generated, and this traveling field induces an eddy current on the non-magnetic conductor plate **54** constituting the secondary side element. The thus generated eddy current constitutes a thrust generation source in cooperation with the traveling field. Further, in the illustrated example of **FIG. 15**, the movable piece i is disposed only to the upper portion of the stationary piece O, but the movable pieces i may be disposed to both the upper and lower portions thereof.

[0103] **FIG. 16** shows a linear pulse motor **57** as another example of the linear motor **51** (**52**).

[0104] With reference to **FIG. 16**, the movable piece i is, for example, composed of a central permanent magnet **58** and two magnetic core members **59** and **60** opposed to each other with the permanent magnet **58** being interposed therebetween. One **59** of the magnetic cores is formed with first and second magnetic poles **61** and **62** magnetized in N-pole by the permanent magnet **58** and, on the contrary, the other one **60** of the magnetic cores is formed with third and fourth magnetic poles **63** and **64** magnetized in S-pole by the permanent magnet **58**.

[0105] On the other hand, the stationary piece O is formed with stationary teeth **65**, each having, a ⊐-shaped section, extending in a direction normal to the longitudinal direction of the stationary piece O equally with the same pitch. The magnetic poles **61** to **64** are formed with magnetic pole teeth **61***a* to **64***a*, respectively, each having the same pitch as that of the stationary piece O.

[0106] A first coil **66** and a second coil **67** are wound up around the first magnetic pole **61** and the second magnetic pole **62** of the N-pole side and connected in series to each other so as to generate magnetic fluxes opposed to each other in directions at a time when current flows. The first coil **66** and the second coil **67** are electrically connected to a pulse generation source, not shown.

[0107] On the other hand, a third coil **68** and a fourth coil **69** are also wound up around the third magnetic pole **63** and the fourth magnetic pole **64** of the S-pole side and connected to a pulse generation source.

[0108] In the described arrangement, the first and second magnetic poles **61** and **62** are arranged so that the magnetic pole teeth **61***a* and **62***a* thereof are shifted from each other by ½ pitch in their phases, and the third and fourth magnetic poles **63** and **64** are also arranged so that the magnetic pole teeth **63***a* and **64***a* thereof are shifted from each other by ½ pitch in their phases. Furthermore, the magnetic pole teeth **63***a* and **64***a* of the third and fourth magnetic poles **63** and **64** of the S-pole side are shifted, by ¼ pitch in phases, from the first and second magnetic pole teeth **61***a* and **62***a* of the first and second magnetic poles **61** and **62** of the N-pole side.

[0109] The linear pulse motor is driven by the following operation theory with reference to **FIGS. 17A** to **17D**.

[0110] Pulses are inputted to the first and second coils **66** and **67** from terminals a, and pulses are also inputted to the third and fourth coils **68** and **69** from terminals b. That is, the pulses are inputted to the terminal a in a direction to energize the first magnetic pole **61** in the state shown in **FIG. 17A**, to the terminal b in a direction to energize the fourth magnetic pole **64** in the state shown in **FIG. 17B**, to the terminal a in a direction to energize the second magnetic pole **62** in the state shown in **FIG. 17C**, and to the terminal b in a direction to energize the third magnetic pole **63** in the state shown in **FIG. 17D**, respectively.

[0111] When the pulse is inputted to the terminal a in a direction to energize the first magnetic pole **61** in the state shown in **FIG. 17**A, the first magnetic pole **61** maintains its stable state under the application of the magnetic fluxes of the permanent magnet **58** and the first coil **66**. Next, in the state shown in **FIG. 17**B, when the pulse is inputted to the terminal b in a direction to energize the fourth magnetic pole **64**, the fourth magnetic pole **64** is moved to a direction so as to maintain its stable state, that is, in the right direction facing the drawing paper by ¼ pitch. As mentioned above, the movable piece is operated continuously as shown in **FIGS. 17C and 17D** by passing alternately the pulse current.

[0112] **FIG. 18** represents a linear D.C. motor **70** as another example of the linear motor.

[0113] With reference to **FIG. 18, a** movable piece of this example is composed of exciting coils **71** and yokes, and a stationary piece O is composed of magnets **72** and yokes. A plurality of exciting coils **71** constituting the movable piece i are arranged along the longitudinal direction thereof, and a plurality of magnets **72** constituting the stationary piece O are arranged along the longitudinal direction so as to provide alternately N- and S-poles.

[0114] The position of the movable piece i is detected by a sensor, and the direction of the current passing the exciting coil **71** at the detected position is changed sequentially reversely. The exciting coil **71** generates a thrust force in accordance with the Fleming's left-hand rule through the relative reaction between the exciting coils **71** and the magnets **72**.

[0115] In the case where such linear D.C. motor is utilized, two sets of linear motors **51** and **52** are disposed in the back-to-back arrangement, and in an arrangement that a distance between the adjacent secondary side magnets **72**, **72** is short, there causes a fear that an alternating magnetic field is caused between the magnets **72** and **72**, which may cause a defective operation. Accordingly, in the case where two sets of the linear motors **51** and **52** are used in the back-to-back arrangement, the linear induction motor **53** and the linear pulse motor **57**, which do not utilize the secondary side magnets **72**, could be effectively utilized. However, in an arrangement in which a relatively large distance could be maintained on the secondary side, no adverse effect is not caused between the magnets **72** and **72**, so that the linear D.C. motor **70** may be utilized.

[0116] The drive system incorporated with the linear motors **51** and **52** of the structures mentioned above will operate in the following manner.

[0117] When the current is applied to the movable pieces i and i' of the first and second linear motors **51** and **52**, suction (attracting) force acts between the movable pieces i and i' and the stationary pieces O and O' to thereby move the inner rail **8** with respect to the outer rail **7** by a predetermined distance in the longitudinal direction thereof. In this case, the movable piece i of the first linear motor **51** moves forward with respect to the stationary piece O. However, with the second linear motor **52**, a current is applied to the movable piece i' in a backward movement direction with respect to the stationary piece O' because of the movement of the stationary piece O', and as a reaction motion thereto, the stationary piece O' is moved forward. Hence, the inner rail **8** is slid with respect to the outer rail **7**, and therefore, the entire structure of the drive system is expanded and contracted.

[0118] In the structure utilizing the linear motors **51** and **52** as driving source, it is not necessary to utilize a ball screw or like, and hence, the inner rail can be moved at high speed with less noise. Furthermore, there is no need for locating a space for a rotary motor or like, thus making the drive system thin and compact in its structure. Still furthermore, since the two sets of linear motors **51** and **52** are arranged between the inner rail **8** and the outer rail **7**, two times of the thrust force is obtainable and the excitation of the linear motors **51** and **52** is averaged, thus making smooth the movement of the inner rail **7**.

[0119] Still furthermore, the movable piece i of the first linear motor **51** is mounted to a portion near the outer rail side rolling member circulation passage **14** and the movable piece i' of the second linear motor **52** is mounted to a portion near the inner rail side rolling member circulation passage **16**, the points on which the thrust force is applied are always positioned at portions near the the outer rail side rolling member circulation passage **14** and the inner rail side rolling member circulation passage **16** irrespective of the stroke of the inner rail **8**. The inner rail **8** is supported by the outer rail **7** at the positions of the inner rail side rolling member circulation passage **16** and the outer rail side rolling member circulation passage **14**. Accordingly, even if a moment causing pitching or yawing acts on the inner rail **8**, the thrust force can be stably generated for the inner rail **8**.

[0120] **FIG. 19** represents a drive system according to a further embodiment of the present invention. The drive system of this embodiment is incorporated with two sets of rod-type linear motors as first and second linear motors **51** and **52**. This drive system is also composed of, like the drive system mentioned hereinbefore, an outer rail **7**, an inner rail **8** supported by the outer rail **7** to be slidable in the longitudinal direction thereof and first and second linear motors **51** and **52** disposed between the outer rail **7** and the inner rail **8** both having box-shaped sections so that the inner rail **8** is fitted into the outer rail **8**. First and second rod-type linear motors are composed of rods O and O' as stationary pieces and cylindrical coils i and i' as movable pieces.

[0121] The cylindrical coil i of the first rod-type linear motor **51** is mounted to the front end portion of the outer rail **7** and, to this front end portion, is also mounted an outer rail side bearer **75** supporting the rod O' of the second rod-type linear motor to be slidable in an axial direction thereof. On the other hand, the cylindrical coil i of the second rod-type linear motor **52** is mounted to the rear end portion of the inner rail **8** and, to this rear end portion, is also mounted an inner rail side bearer **76** supporting the rod O of the first rod-type linear motor to be slidable in an axial direction thereof. The operation theory due to this arrangement is substantially the same as that of the drive system of the embodiment mentioned hereinbefore, and by operating the first and second rod-type linear motors **51** and **52**, the distance between the outer rail side bearer **75** and the inner rail side bearer **76** are expanded or contracted, thus the inner rail **8** being slid with respect to the outer rail **7**. As mentioned above, the rod-type linear motors are also usable as linear motors for the drive system of the present invention.

[0122] Description will be come back to the rolling guide device hereunder.

[0123] **FIG. 20** is a partial sectional view of a drive system using a rolling guide device of a further embodiment of the present invention. The rolling guide device of this embodiment comprises, like the rolling guide device shown in FIGS. **1** to **3**, an outer rail **7** as track rail and an inner rail **8** as movable rail supported to be slidable in the longitudinal direction of the outer rail **7**, and hence, like reference numerals are added to elements or members corresponding to those shown in FIGS. **1** to **3**. The embodiment of **FIG. 20** is provided with a ball screw **9** for driving the inner rail **8**.

[0124] In the rolling guide device of the aforementioned embodiment, although the outer rail **7** and the inner rail **8** are formed with single ball rolling groove to each side portion thereof, in the rolling guide device of this embodiment, the outer rail **7** and the inner rail **8** are formed with two ball rolling grooves **11**, **11** (totally four grooves) to each side portion thereof as shown in **FIG. 20** in section. That is, in the rolling guide device of this embodiment, upper and lower two ball rolling grooves **11**, **11** are formed respectively to each of the inside surfaces of the opposing ridges **7***b*, **7***b* of the outer rail **7**, i.e. four ball rolling grooves **11**, **11** for the outer rail **7**. On the other hand, upper and lower two loaded ball rolling grooves **15**, **15** are formed respectively to each of the outside surfaces of the opposing ridges **8***b*, **8***b* of the inner rail **8**, i.e. four loaded ball rolling grooves **15**, **15** for the inner rail **8** so as to oppose to the ball rolling grooves **11**, **11** of the outer rail **7**, respectively.

[0125] An outer rail side ball circulation passage **14** for circulating the balls rolling between the inner rail **8** and the outer rail **7** is provided to one end side in the longitudinal direction of the outer rail **7** as like as that of the rolling guide device mentioned hereinbefore. This outer rail side ball circulation passage **14** is composed of upper and lower two passages, and more concretely, is composed of portions of the ball rolling grooves **11**, **11**, ball return passages A, A as rolling member return passages substantially parallel to the ball rolling grooves **11**, **11** and a pair of rolling direction changing passages communicated with the ball rolling grooves **11**, **11** and the ball return passages A, A.

[0126] An inner rail side ball circulation passage **16** for circulating the balls rolling between the inner rail **8** and the outer rail **7** is provided to one end side in the longitudinal direction of the outer rail **7** on the side opposing to the outer rail side ball circulation passage **14**. This inner rail side ball circulation passage **16** is composed of upper and lower two passages, and more concretely, is composed of portions of the loaded ball rolling grooves **15**, **15**, ball return passages A, A as rolling member return passages substantially parallel to the loaded ball rolling grooves **15**, **15** and a pair of rolling direction changing passages communicated with the ball rolling grooves **11**, **11** and the ball return passages A, A.

[0127] In the illustration of **FIG. 20**, although it seems that the outer rail side ball circulation passage **14** and the inner rail side ball circulation passage **16** are positioned on the same sectional surface, in an actual arrangement, the outer rail side ball circulation passage **14** and the inner rail side ball circulation passage **16** are shifted in their positions as shown in **FIG. 1**.

[0128] The rolling direction changing passages, each having a semi-circular shape, constituting portions of the outer rail side ball circulation passage **14** and the inner rail side ball circulation passage **16** are formed to deflectors **79** mounted, as independent members, to the inner rail body **8***d* and the outer rail body **7***d*. The deflector **79** is utilized commonly for the outer rail side ball circulation passage **14** and the inner rail side ball circulation passage **16** and is provided with vertical two rolling direction changing passages. The deflector **79** is composed of three sections **79***a*, **79***b* and **79***c* which are splittable vertically along the rolling direction changing passage for easy formation of the vertical two tolling direction changing passages. These three splittable sections **79***a*, **79***b* and **79***c* are divided vertically at planes including central lines of the rolling direction changing passages. These three sections **79***a*, **79***b* and **79***c* are positioned and assembled with each other through fitting of dowels and holes formed to the respective sections. Furthermore, the deflector **79** is formed with a stepped abutment portion **29** to position the deflector **79** at the time when it is mounted to the inner rail side ball circulation passage **16** and the outer rail side ball circulation passage **14**. Holes **33** are formed to the outer rail body **7***d* and the inner rail body **8***d* from the sides thereof, and stepped portions **33***a* are formed to inside surfaces of these holes **33**. Accordingly, the deflector **79** is positioned with respect to the outer rail body **7***d* and the inner rail body **8***d* through the abutment of the stepped abutment portion **29** against the stepped portions **33***a* formed to the holes **33**, i.e. outer rail body **7***d* and the inner rail body **8***d*.

[0129] The ball screw **9** is screw-engaged with the inner rail **8**. This ball screw **9** is composed of a screw shaft **10** having an outer periphery on which a spiral ball rolling groove is formed, a nut (member) **22** having an inner periphery to which a ball circulation passage including a spiral loaded ball rolling groove corresponding to the ball rolling groove formed to the screw shaft **10** and assembled with the screw shaft **10** to be relatively movable thereto, and a number of balls arranged in the ball circulation passage and circulating in accordance with the relative movement of the nut member **22** with respect to the screw shaft **10**.

[0130] **FIG. 21** illustrates a contacting state of the ball rolling groove **11**, the loaded ball rolling groove **15** and the ball **12** or **13**. The ball rolling groove **11** is formed as a single circular groove, so-called, circular arc groove, having a diameter slightly larger than a diameter of the ball so that the ball **12** (**13**) contacts the ball rolling groove **11** at one point P1. On the other hand, the loaded ball rolling groove **15** is formed as a single circular groove, so-called, circular arc groove, having a diameter slightly larger than a diameter of the ball so that the ball **12** (**13**) contacts the loaded ball rolling groove **15** at one point P2. Further, it is to be noted that a line L connecting the contact point P1 at which the ball **12** (**13**) and the ball rolling groove **11** are contacted and the contact point P2 at which the ball **12** (**13**) and the loaded ball rolling groove **11** are contacted is defined herein as contact angle line L. In this meaning, the contact angle lines L1, L2, L3 and L4 will be defined as shown in **FIG. 20**.

[0131] That is, with reference to **FIG. 20**, the mutually opposing two ball rolling grooves **11**, **11** and the two loaded ball rolling grooves **15**, **15** are offset from each other so that the vertical two lines L1 and L2 are inclined towards the horizontal line H passing the center of the screw shaft **10** while reducing a distance therebetween.

[0132] Further, it is desired that a contact angle constituted by the contact angle line L1 (L2) and the horizontal line H is approximately 45o. The center of the screw shaft **10** is positioned on the line passing the intermediate portion between the ball rolling grooves **11**, **11** and on the central line of a span of the loaded ball rolling grooves **15**, **15**. Furthermore, it is desired that the center of the screw shaft **10** (center of the thrust force of the ball screw **9**) is also positioned on a line connecting a point P3 of the left side contact angle lines L1 and L2 and a point P4 of the right side contact angle lines L1 and L2.

[0133] The moment load as shown in **FIG. 8** will be easily loaded on the rolling guide device of the present invention, and accordingly, the vertical load will be also easily born by the balls **12** and **13**. However, the contact angle lines L1 and L2 between the balls **12**, **13** and the ball rolling grooves **11**, **11** and between the balls **12**, **13** and the loaded ball rolling grooves **15**, **15** are inclined with respect to the horizontal line H, thus the vertical load acting on the inner rail **7** being effectively born by the balls **12**, **13**. For this reason, the moment load as shown in **FIG. 8** can be surely loaded. Particularly, by setting the inclination angle to 45o, loads acting on the inner rail **7** from vertical and lateral four directions can be effectively supported by the balls **12** or **13**. Furthermore, the ball screw **9** may be smoothly operated by positioning the center of the thrust force of the ball screw **9** on the line connecting the crossing point P3 of the left side contact angle lines L1 and L2 and the crossing point P4 on the right side contact angle lines L1 and L2.

[0134] **FIG. 22** illustrates a contacting state of a ball rolling groove **11***b*, a loaded ball rolling groove **15***b* and the ball **12** (**13**) in a rolling guide device in which one ball rolling groove **11***b* and one loaded ball rolling groove **15***b* are formed laterally as like as the rolling guide device shown in **FIGS. 1 and 3**. The ball rolling groove **11***b* and the loaded ball rolling groove **15***b* are each formed as a Gothic arch groove. That is, by forming so-called Gothic arch groove in combination of the ball rolling groove **11***b* and the loaded ball rolling groove **15***b* into two circular arcs, two contact angle lines L3 and L4 inclined from the horizontal line H can be obtained to thereby effectively support the vertical load by the ball **12**, **13**.

[0135] **FIG. 23** is an illustration of one embodiment, partially in section, of an essential portion of a drive system utilizing a rolling guide device using rollers **80** as rolling members. In this embodiment, the rollers **80** are utilized in place of the balls **12**, **13** in the former embodiments. In this embodiment of **FIG. 23**, the outer rail **7** is provided with ridges **7***b*, **7***b* as mentioned before having opposing inside surfaces **7***c*, **7***c* to which roller rolling grooves **81**, each having a V-shaped section with opening angle of 90°, are formed, respectively. On the other hand, the inner rail **8** has the opposing outside surfaces **8***c*, **8***c* to which loaded roller rolling grooves **82**, each having a V-shaped section with opening angle of 90°, are formed, respectively. Therefore, a roller rolling passage having substantially square cross section is defined between the roller rolling groove **81** and the loaded roller rolling groove **82**. Within this roller rolling passage, a plurality of rollers **80**, **80**, - - - are arranged in shape of cross (cross arrangement) so that axes of the adjacent two rollers **80** cross each other.

[0136] The structure of this embodiment other than the above mentioned structure is substantially the same as that of the rolling guide device mentioned with reference to FIGS. **1** to **3**, so that the description thereof is omitted herein by adding the same reference numerals to the corresponding portions or elements.

[0137] According to this embodiment, in which the rollers **80**, **80**, - - - are arranged in crossing shape, the rollers **80** can effectively support the vertical load.

[0138] **FIG. 24** is an illustration of another embodiment, partially in section, of an essential portion of a drive system utilizing a rolling guide device using rollers **83**, **84** as rolling members. In this embodiment, the outer rail **7** is provided with ridges **7***b*, **7***b* having opposing inside surfaces **7***c*, **7***c* each to which vertical two roller rolling grooves **81**, **81** each having a V-shaped section with opening angle of 90°, are formed, respectively. On the other hand, the inner rail **8** has the opposing outside surfaces **8***c*, **8***c* each to which two loaded roller rolling grooves **82**, **82** each having a V-shaped section with opening angle of 90°, are formed, respectively. Therefore, vertical two roller rolling passages each having substantially square cross section are defined between the roller rolling grooves **81**, **81** and the loaded roller rolling grooves **82**, **82**. Within these roller rolling passages, a plurality of rollers **83**, **84** are arranged in parallel to each other (parallel arrangement) so that axes of the adjacent two rollers are parallel to each other.

[0139] The rollers **83** disposed in the upper side roller rolling passage are arranged so as to support the load acting in the direction shown by the line L5 (different from the horizontal line H), and on the other hand, the rollers **84** disposed in the lower side roller rolling passage are arranged so as to support the load acting in the direction shown by the line L6 (different from the horizontal line H). Angles constituted by the line L5 and the horizontal line H and by the line L6 and the horizontal line H are defined approximately 45o, respectively. The structure of this embodiment of **FIG. 24** other than the above-mentioned structure is substantially the same as that of the rolling guide device mentioned with reference to **FIG. 20** so that the description thereof is omitted herein by adding the same reference numerals to the corresponding portions or elements.

[0140] According to this embodiment of **FIG. 24**, in which the rollers **83** and **84** are arranged in the vertical two roller rolling passages and the directions along which the rollers **83** and **84** can bear the loads are inclined with respect to the horizontal line H, so that the rollers **83** and **84** can effectively support the vertical loads.

[0141] According to the various preferred embodiments or examples of the present invention mentioned above, the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage, in which the rolling members rolling between the track rail and the movable rail circulate, are formed to the track rail and the movable rail, respectively. Therefore, when the movable rail is slid with respect to the track rail, the rolling members arranged between the track rail and the movable rail endlessly circulate in the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage while rolling therealong. As mentioned, since the rolling members circulate in the endless manner, even if the rolling member be slid during the rolling motion, there is no causing of a case that a cage is shifted from the initial position as in the conventional structure, and hence, a large expansion (contraction) stroke can be realized. Furthermore, in an optional expanded (contracted) attitude, there remains a relatively large distance between the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage, so that a rolling guide device, which can bear even the moment load, can be realized.

[0142] Furthermore, according to the present invention, since the linear motor means is incorporated between the track rail and the movable rail, no specific ball screw or like mechanism is needed, so that the movable rail can be moved at high speed with reduced noise.

[0143] It is further to be noted that the present invention is not limited to the described embodiments and many other changes and modifications may be made without departing from the scopes of the appended claims.

What is claimed is:

1. A rolling guide device comprising:

a track rail formed with a rolling member rolling surface extending along a longitudinal direction thereof;

a movable rail formed with a loaded rolling member rolling surface extending along a longitudinal direction thereof so as to oppose to the rolling member rolling surface of the track rail;

a track rail side rolling member circulation passage formed to the track rail so as to circulate the rolling members rolling between the track rail and the movable rail;

a movable rail side rolling member circulation passage formed to the movable rail so as to circulate the rolling members rolling between the track rail and the movable rail; and

a number of rolling members disposed and arranged in the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage.

2. A rolling guide device according to claim 1, wherein said track rail side rolling member circulation passage is formed to one longitudinal end side of the track rail and said movable rail side rolling member circulation passage is formed to one longitudinal end side, opposing to said one end side of the track rail, of the movable rail.

3. A rolling guide device according to claim 1, wherein said track rail has an opened recess having a ⊐-shaped section and has inside surfaces to which said rolling member rolling surfaces are formed, said movable rail is fitted into the recess of the track rail, and said movable rail has outside surfaces to which the loaded rolling member rolling surfaces are formed so as to oppose to the rolling member rolling surfaces formed to the track rail inside surfaces.

4. A rolling guide device according to claim 3, wherein said track rail side rolling member circulation passage is provided with a rolling member return passage substantially parallel to said rolling member rolling surface and a rolling direction changing passage communicating the rolling member rolling surface and the rolling member return passage, said movable rail side rolling member circulation passage is provided with a rolling member return passage substantially parallel to said loaded rolling member rolling surface and a rolling direction changing passage communicating the rolling member rolling surface and the rolling member return passage, said rolling direction changing passages of the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage are formed to a deflector which is formed independently from a track rail body and a movable rail body, and said deflector is fitted to holes formed to the track rail body and movable rail body from side portions thereof.

5. A rolling guide device according to claim 4, wherein said return passages are drilled to the track rail body and the movable rail body from longitudinal end portions thereof.

6. A rolling guide device according to claim 4, wherein said deflector is composed of a plurality of sections splittable along the rolling direction changing passages.

7. A rolling guide device according to claim 4, wherein said deflector is made of a synthetic resin.

8. A drive system comprising:

a track rail formed with a rolling member rolling surface extending along a longitudinal direction thereof;

a movable rail formed with a loaded rolling member rolling surface extending along a longitudinal direction thereof so as to oppose to the rolling member rolling surface of the track rail;

a track rail side rolling member circulation passage formed to the track rail so as to circulate the rolling members rolling between the track rail and the movable rail;

a movable rail side rolling member circulation passage formed to the movable rail so as to circulate the rolling members rolling between the track rail and the movable rail;

a number of rolling members disposed and arranged in the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage; and

a linear motor means having a primary side mounted to either one of the track rail and the movable rail and a secondary side mounted to another one of the track rail and the movable rail.

9. A drive system according to claim 8, wherein said track rail side rolling member circulation passage is formed to one longitudinal end side of the track rail and said movable rail side rolling member circulation passage is formed to one longitudinal end side, opposing to said one end side of the track rail, of the movable rail, and said linear motor means comprises first and second linear motors, said first linear motor having a primary side mounted to a portion near the track rail side rolling member circulation passage of the track rail, said second linear motor having a secondary side mounted to the track rail along the longitudinal direction thereof so as to be continuous to the primary side of the first linear motor, and said second linear motor having a primary side mounted to a portion near the movable rail side rolling member circulation passage of the movable rail, said first linear motor having a secondary side mounted to the movable rail along the longitudinal direction thereof so as to be continuous to the primary side of the second linear motor.

10. A drive system according to claim 9, wherein said first and second linear motors are linear induction motors having secondary sides being opposed to each other.

11. A drive system according to claim 9, wherein said first and second linear motors are linear pulse motors having secondary sides being opposed to each other.

12. A drive system according to claim 8, wherein said track rail has an opened recess having a ⊐-shaped section and has inside surfaces to which said rolling member rolling surfaces are formed, said movable rail is fitted into the recess of the track rail, and said movable rail has outside surfaces to which the loaded rolling member rolling surfaces are formed so as to oppose to the rolling member rolling surfaces formed to the track rail inside surfaces.

* * * * *

US 20030059135A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2003/0059135 A1**
Shirai et al. (43) **Pub. Date: Mar. 27, 2003**

(54) **TRACK RAIL MOUNTING STRUCTURE OF RECTILINEAR GUIDE APPARATUS**

(76) Inventors: **Takeki Shirai**, Tokyo (JP); **Hidekazu Michioka**, Tokyo (JP); **Genjirou Ise**, Tokyo (JP); **Hiroaki Kishi**, Tokyo (JP)

Correspondence Address:
ARMSTRONG,WESTERMAN & HATTORI, LLP
1725 K STREET, NW.
SUITE 1000
WASHINGTON, DC 20006 (US)

(21) Appl. No.: **10/156,639**

(22) Filed: **May 29, 2002**

(30) **Foreign Application Priority Data**

May 31, 2001 (JP) 2001-164363

Publication Classification

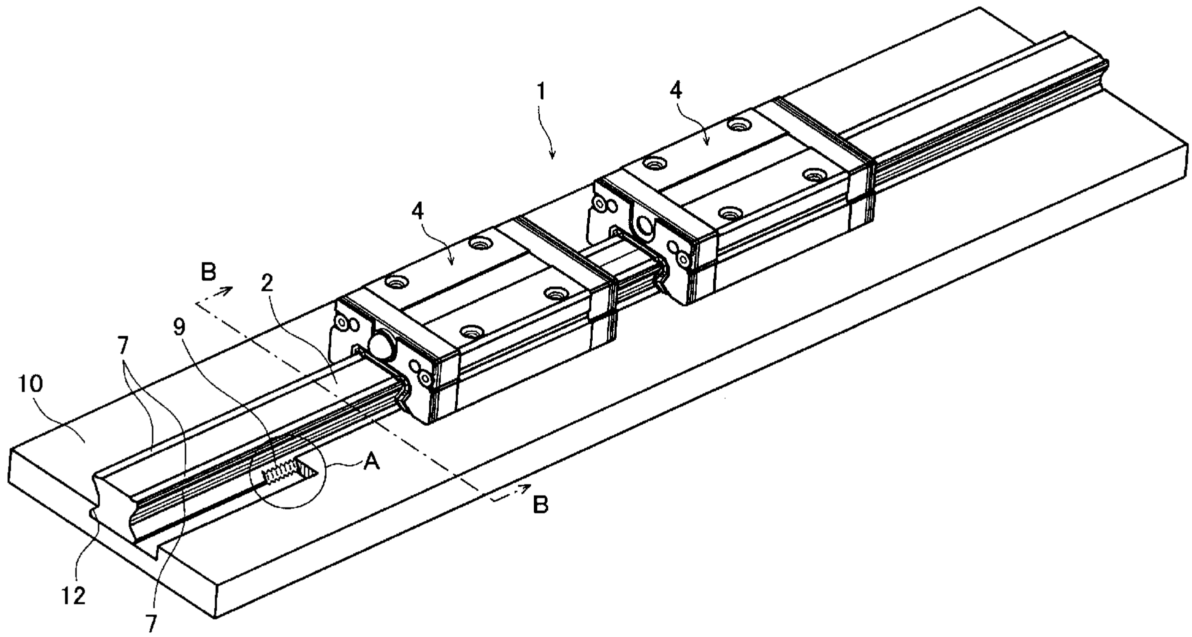
(51) **Int. Cl.**[7] **F16C 29/06**

(52) **U.S. Cl.** **384/45**

(57) **ABSTRACT**

The present invention provides a track rail mounting structure of a rectilinear guide apparatus comprising a track rail having a rotating/running surface where a plenty of rotating/running bodies rotate and run; an endless circulation route for guiding the plenty of rotating/running bodies; and a slider movably arranged with respect to the track rail via the rotating/running bodies; wherein a base where the track rail is mounted has a groove for inserting a bottom portion of the track rail, so that the bottom portion of the track rail is inserted into the groove, and a pressure member is provided for pressing at least one side surface of the track rail toward an inner side surface of the groove.

As has been described above, since the pressure member is provided to press the side surface of the track rail toward the inner side surface of the groove, the side surface of the track rail is pressed by the pressure member so as to press the opposite side of the track rail to the inner side surface of the groove or both side surfaces of the track rail are pressed by the pressure member so as to be fixed to the track rail. Accordingly, even when a thermal expansion difference is caused between the track rail and the base by a temperature change, a contact portion of the pressure member slides along the side surface of the track rail so as to absorb the thermal expansion difference and accordingly, no distortion is caused in the track rail.



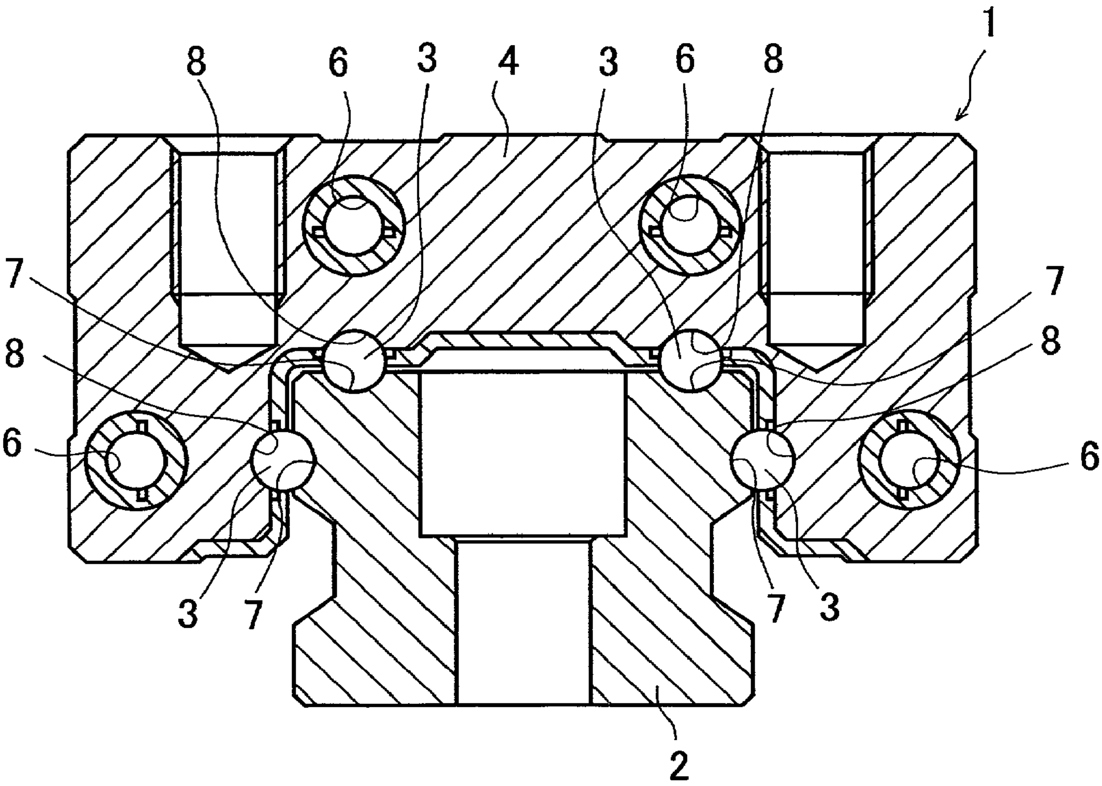


FIG. 1

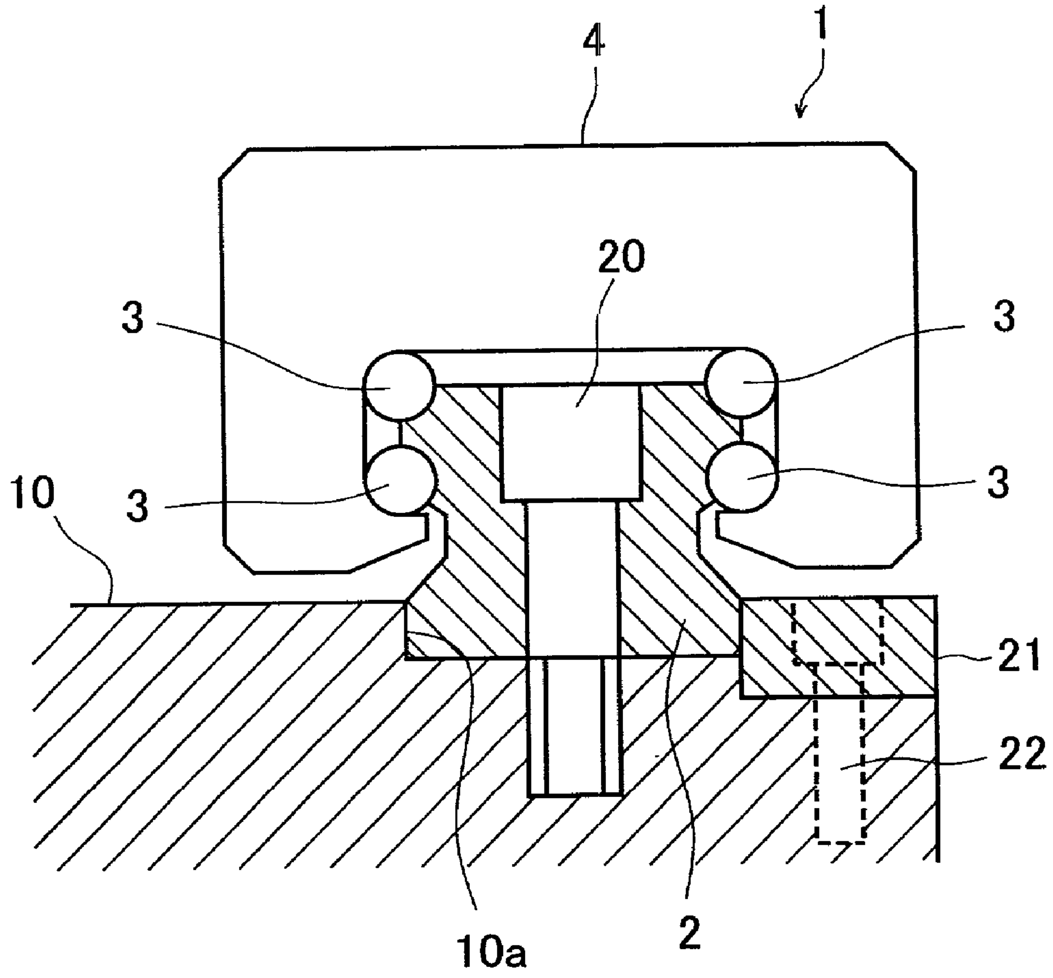


FIG. 2

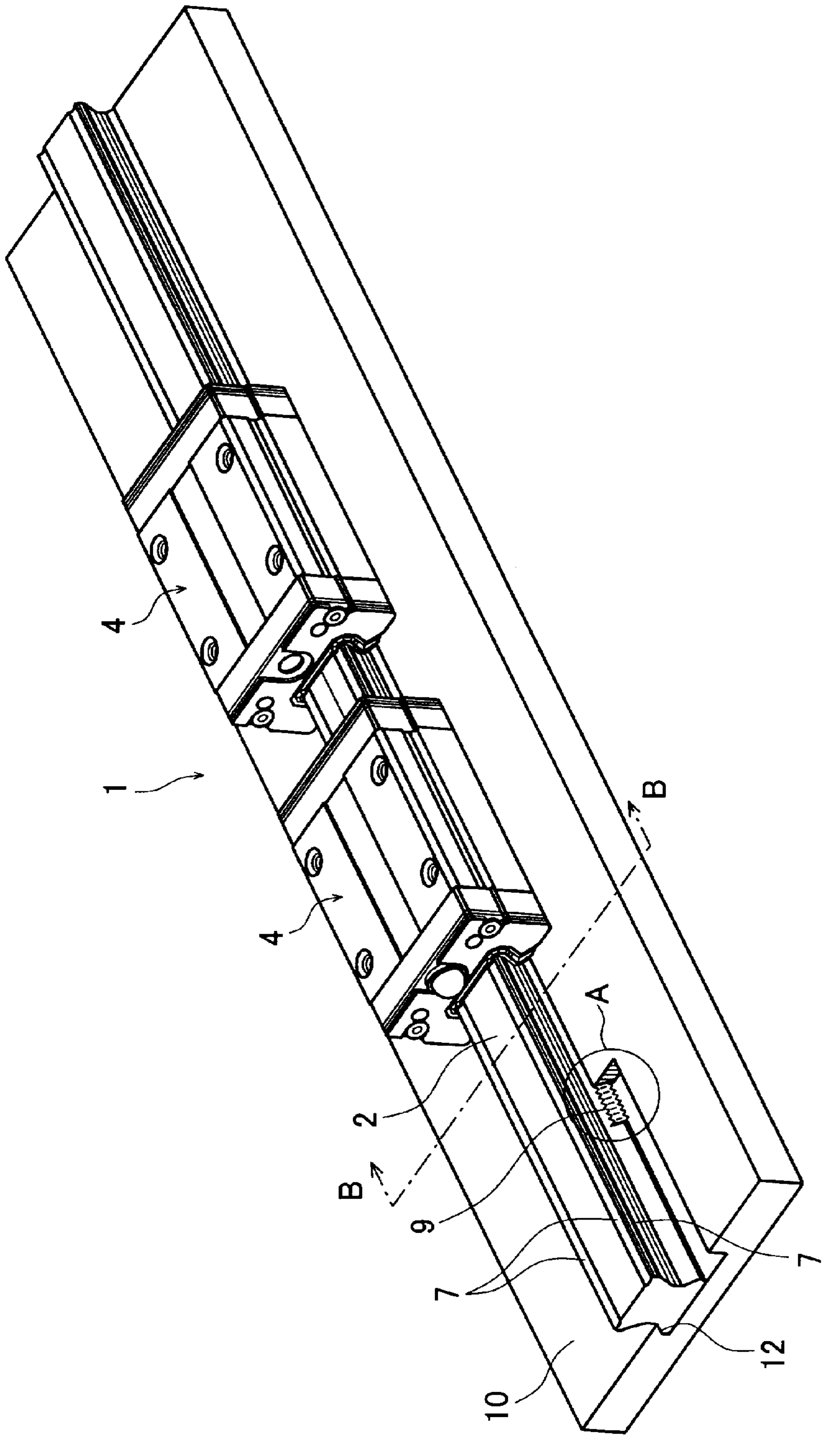


FIG. 3

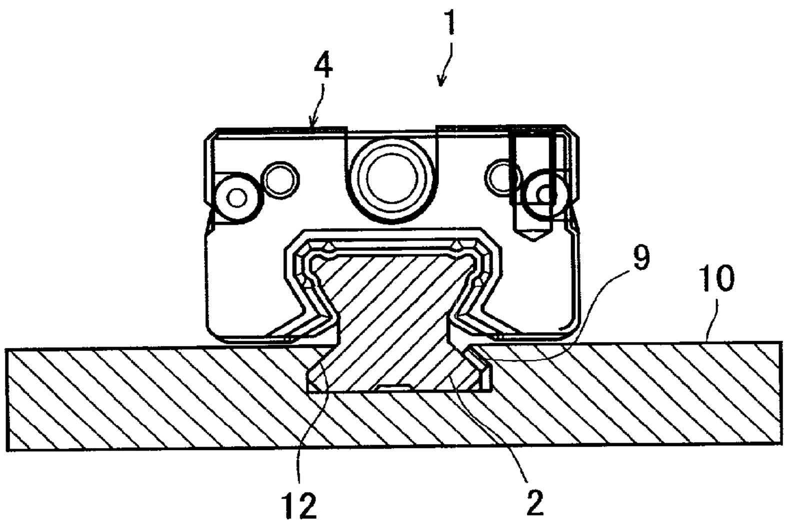


FIG. 4

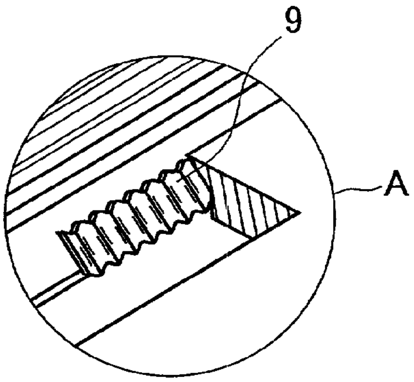


FIG. 5

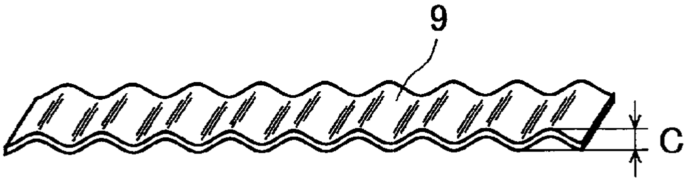


FIG. 6

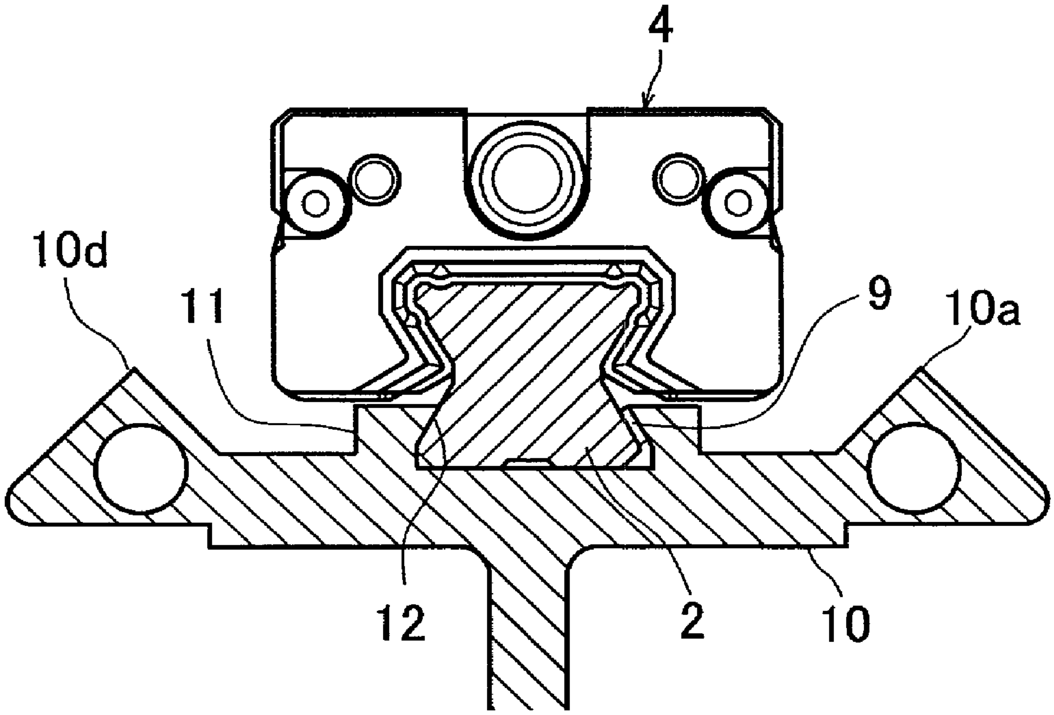


FIG. 7

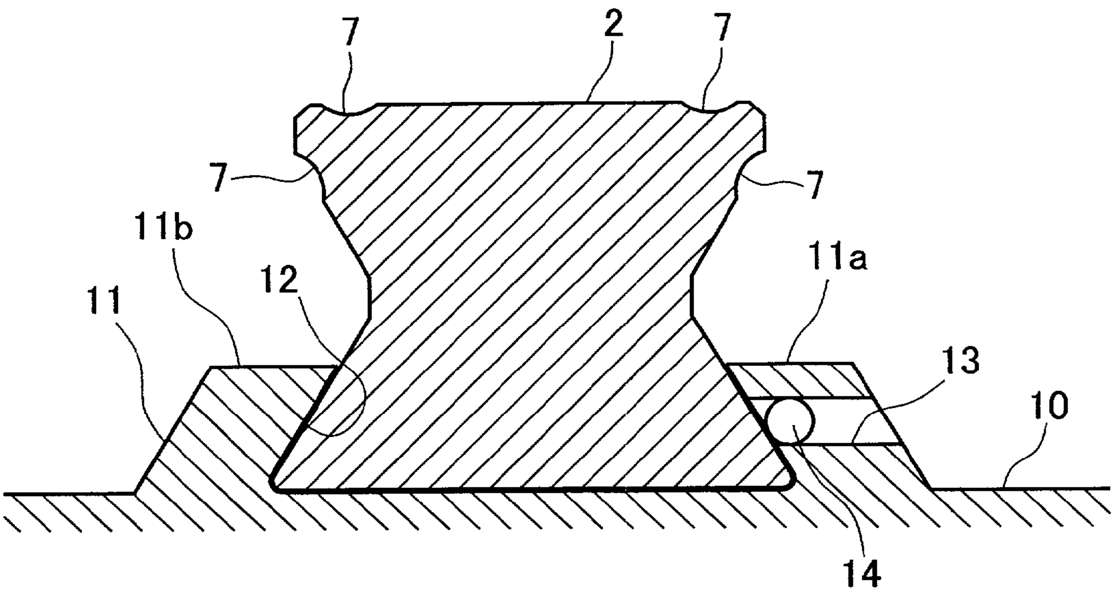


FIG. 8

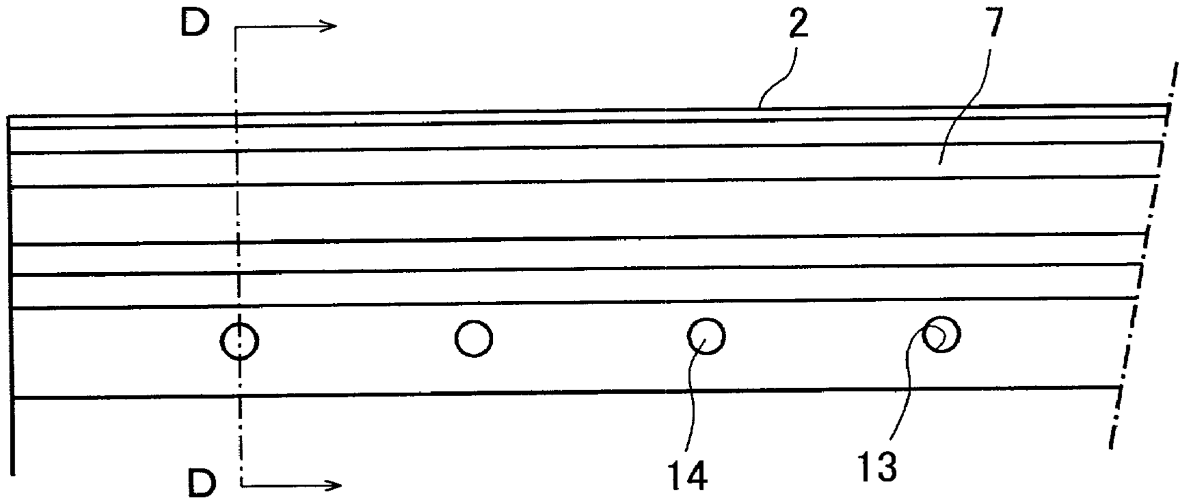


FIG. 9

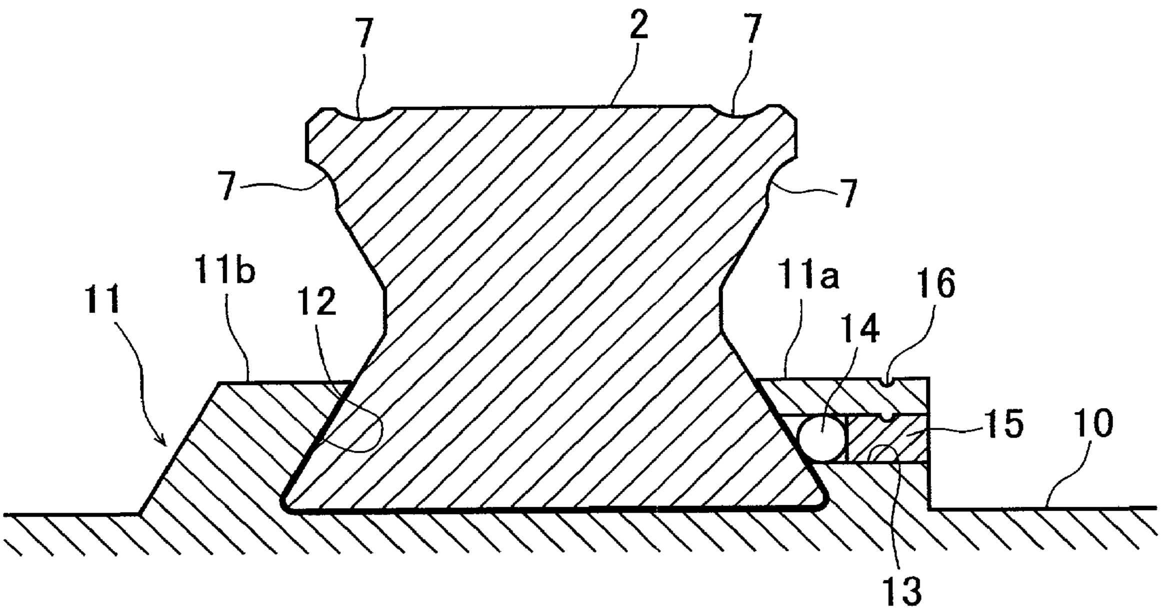


FIG. 10

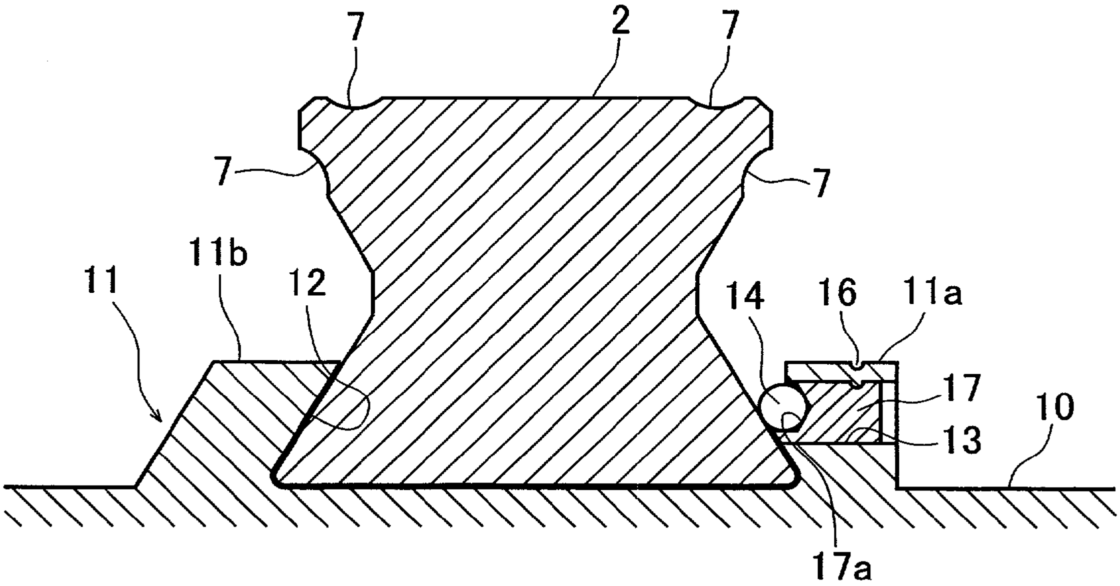


FIG. 11

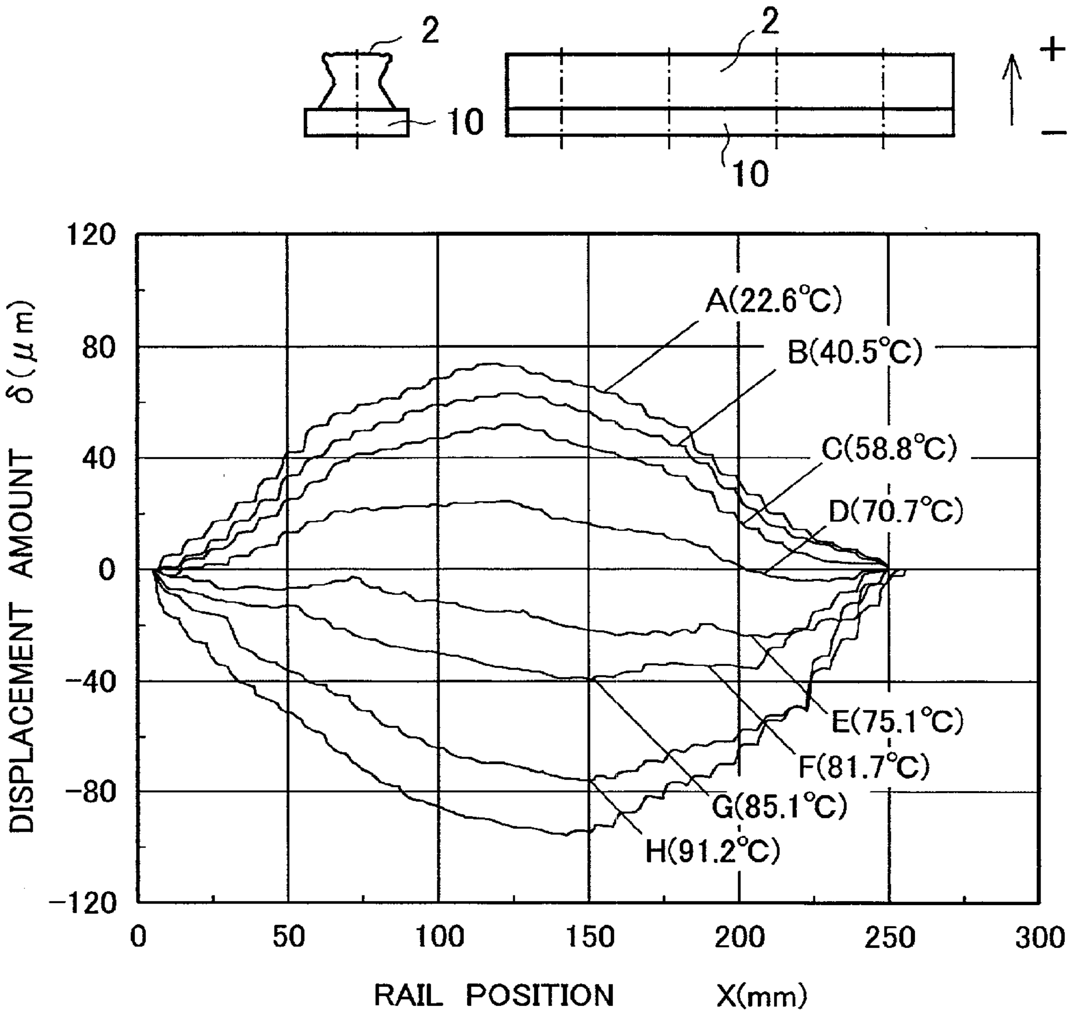

2
10
2
10
+
−
120
80
40
0
-40
-80
−120
DISPLACEMENT AMOUNT δ(μm)
A(22.6°C)
B(40.5°C)
C(58.8°C)
D(70.7°C)
E(75.1°C)
F(81.7°C)
G(85.1°C)
H(91.2°C)
0
50
100
150
200
250
300
RAIL POSITION X(mm)

FIG. 12

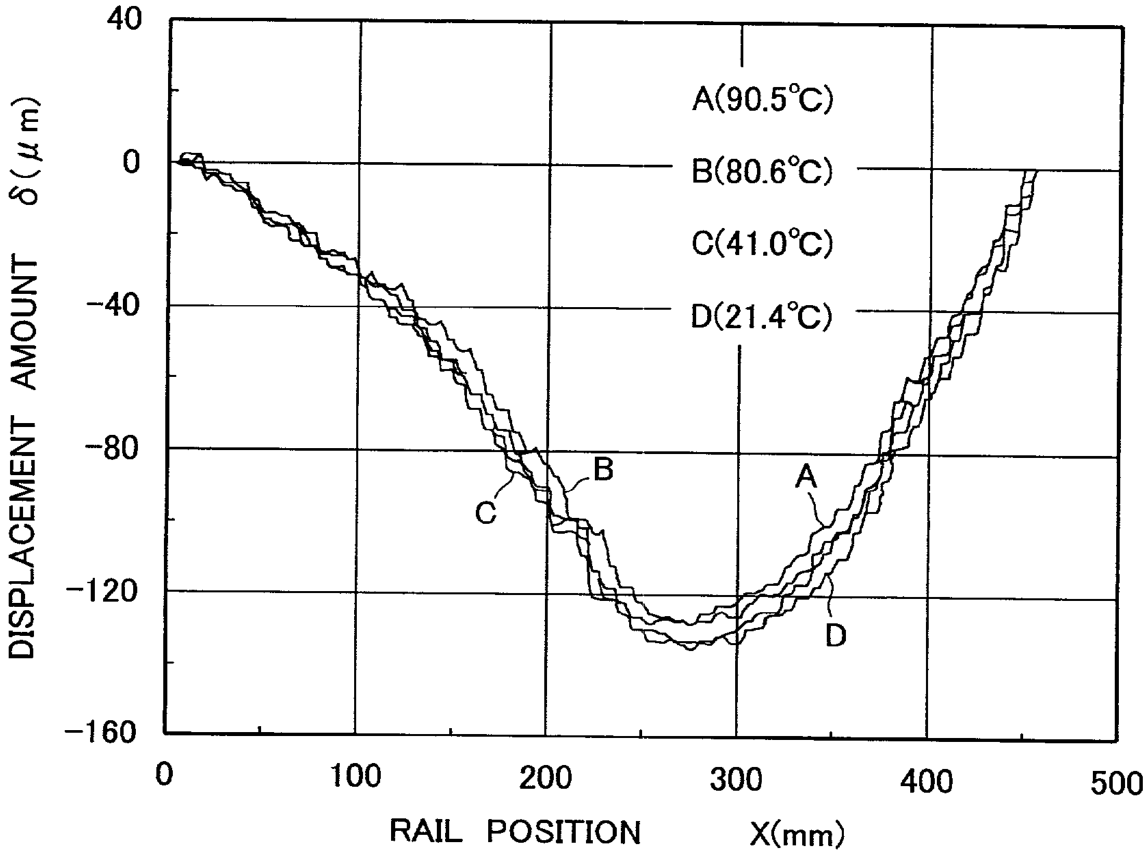

40
0
-40
-80
-120
-160
DISPLACEMENT AMOUNT δ(μm)
A(90.5°C)
B(80.6°C)
C(41.0°C)
D(21.4°C)
A
B
C
D
0
100
200
300
400
500
RAIL POSITION X(mm)

FIG. 13

TRACK RAIL MOUNTING STRUCTURE OF RECTILINEAR GUIDE APPARATUS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a track rail mounting structure of a rectilinear guide apparatus, and more particularly, it relates to a track rail mounting structure of a rectilinear guide apparatus which can preferably be used in the case that a track rail and a base on which the track rail is mounted are made from materials having different thermal expansion coefficients.

[0003] 2. Description of the Prior Art

[0004] **FIG. 1** shows a constitution example of a rectilinear guide apparatus.

[0005] A rectilinear guide apparatus **1** of this type generally comprises a track rail **2** fixed to a fixing portion such as a head of a machining apparatus; and a slider **4** on which a movable member such as a table is mounted and which is engaged with the track rail **2** via a plenty of balls **3** as rotating/running members so as to perform rectilinear motion along the track rail **2**.

[0006] The track rail **2** has a ball rotating/running groove **7** formed as a track where the balls **3** rotate and run, and on the other hand, the slider **4** has a ball rotating/running groove **8** formed as a load track opposing to the ball rotating/running groove **7** of the track rail **2**, so that the balls **3** rotate and run between the ball rotating/running groove **7** and the ball rotating/running groove **8** while being subjected to a load.

[0007] Moreover, the slider **4** has a passage **6** formed for returning balls from one end to the other end of the ball rotating/running groove **8**. This passage **6** and the aforementioned ball rotating/running groove **8** constitute an endless circulation route of the balls **3**. The balls **3** circulate in this endless circulation route following the movement of the slider **4**. Thus, the aforementioned slider **4** smoothly moves along the track rail **2**.

[0008] When fixing to a base the track rail **2** of the rectilinear guide apparatus **1** having the aforementioned constitution, as shown in **FIG. 2, a** reference plane **10***a* is provided on the base **10**, and one side surface of the track rail **2** is brought into abutment with the reference plane **10***a,* which is fixed to the upper surface of the base **10** with a bolt **20**. Moreover, the other side surface of the track rail **2** is brought into abutment with a reinforcing member **21**, which is fixed with a bolt **22**.

[0009] However, as described above, when the track rail **2** is fixed to the base **10** with the bolt **20** (or a fixing member), in case the track rail **2** is made from a material having a thermal expansion coefficient different from that of a material constituting the base **10** (for example, the track rail **2** is made from iron and the base **10** is made from aluminum), a difference is caused in thermal expansion between the track rail **2** and the base **10** by a temperature change, which in turn causes distortion in the track rail **2**.

[0010] Especially when arranging a plurality of rectilinear guide apparatuses **1** in parallel to one another on the base **10** and mounting a common table on their sliders **4**, there is a problem that the table plane is displaced. This problem becomes especially remarkable when the rectilinear guide apparatus is used in an environment of a great temperature change.

SUMMARY OF THE INVENTION

[0011] It is therefore an object of the present invention to provide a track rail mounting structure of a rectilinear guide apparatus capable of absorbing an expansion difference between a track rail and a base caused by thermal expansion, so as not to distort the track rail by a temperature change even when the track rail of the rectilinear guide apparatus is made from a material having a thermal expansion coefficient different from that of a material constituting the base on which the track rail is mounted.

[0012] In order to achieve the aforementioned object, a track rail mounting structure of a rectilinear guide apparatus comprises a track rail having a rotating/running surface where a plenty of rotating/running bodies rotate and run; an endless circulation route for guiding the plenty of rotating/running bodies; and a slider movably arranged with respect to the track rail via the rotating/running bodies; wherein a base where the track rail is mounted has a groove for inserting a bottom portion of the track rail, so that the bottom portion of the track rail is inserted into the groove, and a pressure member is provided for pressing at least one side surface of the track rail toward an inner side surface of the groove.

[0013] As has been described above, since the pressure member is provided to press the side surface of the track rail toward the inner side surface of the groove, the side surface of the track rail is pressed by the pressure member so as to press the opposite side of the track rail to the inner side surface of the groove or both side surfaces of the track rail are pressed by the pressure member so as to be fixed to the track rail. Accordingly, even when a thermal expansion difference is caused between the track rail and the base by a temperature change, a contact portion of the pressure member slides along the side surface of the track rail so as to absorb the thermal expansion difference and accordingly, no distortion is caused in the track rail.

[0014] Moreover, the track rail mounting structure of the rectilinear guide apparatus is characterized in that the pressure member has a convex contact surface which is brought into abutment with the track rail side surface.

[0015] As has been described above, since the contact surface of the pressure member which is brought into abutment with the track rail side surface has a convex shape, the contact between the track rail side surface and the convex surface is a point-to-point contact or a linear contact. Even when a thermal expansion difference is caused between the track rail and the base by a temperature change, the convex contact portion slides along the side surface of the track rail so as to absorb the thermal expansion difference and accordingly, no distortion is caused in the track rail.

[0016] Moreover, the track rail mounting structure of the rectilinear guide apparatus is characterized in that the pressure member is an elastic corrugated spacer inserted between the side surface of the track rail and the inner side surface of the groove.

[0017] As has been described above, since the pressure member is the elastic corrugated spacer inserted between the side surface of the track rail and the inner side surface of the groove, a contact portion between the side surface of the track rail and the corrugated spacer is a linear contact. Even when a thermal expansion difference is caused between the track rail and the base, the contact portion of the corrugated spacer slides along the side surface of the track rail so as to absorb the thermal expansion difference and accordingly, no distortion is caused in the track rail.

[0018] Moreover, the track rail mounting structure of the rectilinear guide apparatus is characterized in that the pressure member is a spherical body which is inserted with pressure into a plurality of holes opened at a predetermined interval on the inner side surface of one side of the groove, so that the spherical body presses the side surface of the track rail.

[0019] As has been described above, the pressure member is a spherical body and a contact between the side surface of one side of the track rail and the spherical body is a point-to-point contact. Even when a thermal expansion difference is caused between the track rail and the base, the contact portion of the spherical body slides along the side surface of one side of the track rail so as to absorb the thermal expansion difference and accordingly, no distortion is caused in the track rail.

[0020] Moreover, the track rail mounting structure of the rectilinear guide apparatus is characterized in that a pressing force of the spherical body is reinforced by a pressing force reinforcing member inserted into the hole where the spherical body is inserted with pressure.

[0021] As has been described above, by inserting the pressing force reinforcing member with pressure into the hole where the spherical body is inserted with pressure, the pressing force of the spherical body is reinforced by the pressure member and the track rail is fixed firmly. Simultaneously with this, even when a thermal expansion difference is caused between the track rail and the base, a contact portion of the spherical body slides along the side surface of one side of the track rail so as to absorb the thermal expansion difference and accordingly, no distortion is caused in the track rail.

[0022] Moreover, the track rail mounting structure of the rectilinear guide apparatus is characterized in that the pressure member is a spherical body which is held by a holding metal member, and the metal member holding the spherical body is inserted with pressure into a plurality of holes opened at a predetermined interval on the inner side surface of the groove, so that the spherical body presses the side surface of the track rail.

[0023] As has been described above, in case the metal member holding the spherical body is inserted with pressure into a plurality of holes opened at a predetermined interval on the inner side surface of one side of the groove, so that the spherical body presses the side surface of one side of the track rail, similarly as the aforementioned, the side surface of one side of the track rail is in contact with the spherical body as a point-to-point contact. Even when a thermal expansion difference is caused between the track rail and the base, the contact portion of the spherical body slides along the side surface of one side of the track rail so as to absorb the thermal expansion difference and accordingly, no distortion is caused in the track rail.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] **FIG. 1** shows a constitution example of a rectilinear guide apparatus.

[0025] **FIG. 2** is a cross sectional view showing an example of a track rail mounting structure of a conventional rectilinear guide apparatus.

[0026] **FIG. 3** shows a constitution example of a rectilinear guide apparatus having a track rail mounting structure according to the present invention.

[0027] **FIG. 4** is a cross sectional view about B-B of **FIG. 3**.

[0028] **FIG. 5** is an enlarged view of a portion A of **FIG. 3**.

[0029] **FIG. 6** shows a corrugated spacer used in the track rail mounting structure according to the present invention.

[0030] **FIG. 7** is a cross sectional view showing a constitution example of the rectilinear guide apparatus having an example of the track rail mounting structure according to the present invention.

[0031] **FIG. 8** is a cross sectional view (about D-D of **FIG. 9**) showing another example of the track rail mounting structure of the rectilinear guide apparatus according to the present invention.

[0032] **FIG. 9** is a side view showing an example of the track rail mounting structure of the rectilinear guide apparatus according to the present invention.

[0033] **FIG. 10** is a cross sectional view showing an example of the track rail mounting structure of the rectilinear guide apparatus according to the present invention.

[0034] **FIG. 11** is a cross sectional view showing an example of the track rail mounting structure of the rectilinear guide apparatus according to the present invention.

[0035] **FIG. 12** shows a displacement amount of a track rail caused by a heated base of a conventional track rail mounting structure of a rectilinear guide apparatus.

[0036] **FIG. 13** shows a displacement amount of a track rail caused by a heated base of the track rail mounting structure of the rectilinear guide apparatus according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0037] Hereinafter, explanation will be given on embodiments of the present invention with reference to the attached drawings. **FIG. 3** to **FIG. 6** show a constitution example of a rectilinear guide apparatus having a track rail mounting structure according to the present invention. **FIG. 3** shows the entire constitution of the rectilinear guide apparatus; **FIG. 4** is a cross sectional view about B-B of **FIG. 3**; **FIG. 5** is an enlarged view of a portion A of **FIG. 3**; and **FIG. 6** shows a corrugated spacer.

[0038] In **FIG. 3** to **FIG. 6**, like reference symbols as in **FIG. 1** and **FIG. 2** denote like or equivalent components. Moreover, this applies to the other drawings. In **FIG. 3** and **FIG. 4, a** reference symbol **10** denotes a base on which a track rail **2** is mounted. The base **10** is made from a material (such as aluminum) having a different thermal expansion coefficient from that of a material (such as iron) constituting the track rail **2**.

[**0039**] The base **10** has at its center portion a belt-shaped groove **12** in which a bottom portion of the track rail **2** is inserted. A corrugated spacer **9** is inserted between the inner side surface of the groove **12** and the side surface of the track rail **2**. As shown in **FIG. 6**, the corrugated spacer **9** is an elastic metal material (such as a steel plate) which is made into a corrugated form.

[**0040**] When inserting the corrugated spacer **9** between the inner surface of the groove **12** and the side surface of the track rail **2**, by pulling the corrugated spacer **9** in its longitudinal direction, the dimension C in the thickness direction is reduced. Accordingly, when the corrugated spacer **9** is in a state pulled in the longitudinal direction, the spacer **9** can easily be inserted between the inner surface of the groove **12** and the side surface of the track rail **2**.

[**0041**] After the corrugated spacer **9** is inserted between the inner surface of the groove **12** and the side surface of the track rail **2**, the pulling is released, so that the track rail **2** is pressed by an elastic force of the corrugated spacer **9** against the inner surface of the other side of the groove **12** and the track rail **2** is fixed in the groove **12**.

[**0042**] By inserting the corrugated spacer **9** between the inner side surface of the groove **12** and the side surface of the track rail **2**, a contact portion of the corrugated spacer **9** with the track rail **2** becomes linear. Even when a thermal expansion difference is caused between the track rail **2** and the base **10**, the contact portion of the corrugated spacer **9** slides along the side surface of the track rail **2** and absorbs the thermal expansion difference. Accordingly, no distortion is caused in the track rail **2**.

[**0043**] It should be noted that in the aforementioned example, explanation has been given on a case that the corrugated spacer **9** is inserted between one side surface of the track rail **2** and one inner side surface of the groove **12**. However, it is also possible to insert the corrugated spacer **9** between both side surfaces of the track rail **2** and both inner side surfaces of the groove **12**.

[**0044**] Moreover, the corrugated spacer **9** may have a length to cover the entire length of the space between the side surface of the track rail **2** and the inner side surface of the groove **12**. Alternatively, it is also possible to arrange at a predetermined interval a plurality of the corrugated spacers **9** cut into a predetermined length.

[**0045**] Moreover, in the aforementioned example, the base **10** has a rectangular cross sectional view and a flat upper surface. However, the cross sectional view of the base **10** is not limited to this and, as shown in **FIG. 7**, may have a mountain-shaped protrusion **10***a* at both sides and a belt-shaped convex base mounting portion at a center portion for mounting the track rail **2**.

[**0046**] Thus, when the protrusion **10***a* is present at both sides of the base **10**, as will be detailed later, the protrusions **10***a* disturb when a hole is formed to open into the inner side surface of the groove **12** and a steel ball is inserted into this hole to press the side surface of the track rail **2**. Accordingly, the mounting structure that the corrugated spacer **9** is inserted into a space between the side surface of the track rail **2** and the inner side surface of the groove **12** is effective.

[**0047**] **FIG. 8** and **FIG. 9** show a constitution example of the track rail mounting structure of the rectilinear guide apparatus according to the present invention. **FIG. 8** is a cross sectional view (about D-D of **FIG. 9**) and **FIG. 9** is a side view.

[**0048**] In **FIG. 8** and **FIG. 9**, like the aforementioned example, the base **10** is made from a material (for example, aluminum) having a different thermal expansion coefficient from that of a material (for example, iron) constituting the track rail **2**.

[**0049**] The base **10** has a belt-shaped base mounting portion **11** for mounting the track rail **2**. At a center portion of this base mounting portion **11**, there is formed a belt-shaped groove **12** into which a bottom portion of the track rail **2** is inserted.

[**0050**] On a side wall portion **11***a* of the groove **12**, at a predetermined interval, there are provided a plenty of holes **13** opening into one side surface of the groove **12** and arraigned in parallel to the upper surface of the base **10** and vertical to the one side surface. The bottom portion of the track rail **2** is inserted into the groove **12** and steel balls **14** are inserted into the holes **13** with a pressure, so as to press the one side surface of the track rail **2** in the groove **12** and to press the opposite side surface of the track rail **2** to an inner side surface of an opposite side wall portion **11***b*, thereby fixing the track rail **2** into the groove **12** of the base **10**.

[**0051**] As has been described above, by inserting with pressure the steel balls **14** into the respective holes **13** formed in the side wall portion **11***a* of the groove **12** and pressing the side surface of the track rail **2** to the side surface of the groove **12**, thereby fixing the track rail **2** to the base **10**, even when a difference is caused by a temperature change, between a thermal expansion of the track rail **2** and that of the base **10** in the longitudinal direction of the track rail **2**, contact portions of the steel balls **14** slide with respect to the one side surface of the track rail **2**, so as to absorb the thermal expansion difference. Accordingly, no distortion is caused in the track rail **2**.

[**0052**] **FIG. 10** shows another example of the track rail mounting structure of the rectilinear guide apparatus according to the present invention. This track rail mounting structure differs from the track rail mounting structure shown in **FIG. 8** and **FIG. 9** in that in order to reinforce a pressing force of the steel ball **14** inserted with pressure into the hole **13**, a pin **15** is inserted with pressure as a pressure reinforcing member from back of the steel ball **14** and a concave portions **16** is formed by caulking on the upper surface of the side wall portion **11***a* at a position corresponding to the pin **15**, thereby fixing the pin **15**.

[**0053**] As has been described above, by inserting and fixing pins **15** from back of the steel balls **14**, the pressing force of the steel balls **14** to press the side surface of the track rail **2** is reinforced and the mounting of the track rail **2** is reinforced. Simultaneously with this, even when a thermal expansion difference is caused between the track rail **2** and the base **10**, similarly as in the track rail mounting structure of **FIG. 8** and **FIG. 9**, the contact portions of the steel balls **14** with the one side surface of the track rail **2** slide to absorb the thermal expansion difference and no distortion is caused in the track rail **2**.

[0054] **FIG. 11** shows still another example of the track rail mounting structure of the rectilinear guide apparatus according to the present invention. In this track rail mounting structure, instead of the pin **15** which is the pressure reinforcement member of the track rail mounting structure shown in **FIG. 10, a** dedicated metal member **17** is used for holding the steel ball **14**. The metal member **17** holding the steel ball **14** is inserted into the hole **13** with pressure and a concave portion **16** is formed by caulking on the upper surface of the side wall portion **11***a*, thereby fixing the metal member **17**.

[0055] The metal member **17** has a tip end where a concave portion **17***a* is formed to hold the steel ball **14**. When the track rail mounting structure has such a constitution, it is also possible to obtain an effect approximately identical to that of the track rail mounting structure shown in **FIG. 8** and **FIG. 9**.

[0056] **FIG. 12** and **FIG. 13** show examples of deformation of the track rail **2** when the base **10** is heated. **FIG. 12** shows a case of the conventional track rail mounting structure in which the track rail **2** is fixed to the base by bolts as shown in **FIG. 2** while **FIG. 13** shows a case of the track rail mounting structure according to the present invention.

[0057] In **FIG. 12**, curves A, B, C, D, E, F, G, and H show displacement amounts δ (μm) of the track rail (made from iron) **2** when the base (made from aluminum) **10** is heated to 22.6° C., 40.5° C., 58.8° C., 70.7° C., 75.1° C., 81,7° C., 85.1° C., and 91.2° C., respectively.

[0058] In **FIG. 13**, curves A, B, C, and D show displacement amounts δ (μm) of the track rail (made from iron) **2** when the base (made from aluminum) **10** is heated to 90.5° C., 80.6° C., 41.0° C., and 21.4° C., respectively.

[0059] In the conventional track rail mounting structure of **FIG. 12**, with respect to a displacement amount of the track rail **2** indicated by the curve A when the base temperature is 22.6° C., the displacement amount δ is greatly changed as the heating temperature is increased as shown by the curves B, C, D, E, F, G, and H while in the track rail mounting structure of **FIG. 13** according to the present invention, with respect to a displacement amount of the track rail **2** indicated by the curve D when the base temperature is 21.4° C., the displacement amount δ does not change greatly when the heating temperature is increased as shown by the curves C, B, and A.

[0060] It should be noted that in the aforementioned example, the steel balls **14** are used as pressure members to press the one side surface of the track rail **2**. However, the pressure member is not limited to a spherical shape but may be, for example, an arc surface or a convex surface of a paraboloid, i.e., a surface providing a point-to-point contact with the one side surface of the track rail **2**.

[0061] Moreover, in the aforementioned example, explanation has been given on the track rail **2** of the rectilinear guide apparatus **1** using the balls **3** as rotating/running members. However, the rectilinear guide apparatus is not limited to this. The present invention can also be applied to a track rail mounting structure of the rectilinear guide apparatus using rolls as the rotating/running members.

[0062] According to the present invention, the pressure member is provided to press the side surface of the track rail toward the inner side surface of the groove. Accordingly, the side surface of the track rail is pressed by this pressure member so as to press the opposite side of the track rail to the inner side surface of the groove or both sides of the track rail are pressed by the pressure member so as to be fixed to the track rail. Accordingly, even when a thermal expansion difference is caused between the track rail and the base, the contact portion of the pressure member slides along the side surface of the track rail and absorbs the thermal expansion difference. Accordingly, no distortion is caused in the track rail.

[0063] Moreover, since the surface of the pressure member in contact with the track rail side surface is a convex surface, the track rail side surface and the convex surface are in contact with each other as a point-to-point contact or a linear contact. Accordingly, even when a thermal expansion difference is caused between the track rail and the base, the contact portion of the convex shape slides along the side surface of the track rail so as to absorb the thermal expansion difference and no distortion is caused in the track rail.

[0064] Moreover, since the pressure member inserted between the side surface of the track rail and the inner side surface of the groove is the elastic corrugated spacer, the contact portion between the side surface of the track rail and the corrugated spacer is a linear contact. Accordingly, even when a thermal expansion difference is caused between the track rail and the base, the contact portion of the corrugated spacer slides along the side surface of the track rail so as to absorb the thermal expansion difference and accordingly, no distortion is caused in the track rail.

[0065] Moreover, when the pressure member is a spherical body, the contact between the one side surface of the track rail and the spherical body is a point-to-point contact. Accordingly, even when a thermal expansion difference is caused between the track rail and the base, the contact portion of the spherical body slides along the one side surface of the track rail so as to absorb the thermal expansion difference and accordingly, no distortion is caused in the track rail.

[0066] Moreover, by inserting the pressure reinforcement member with pressure into the hole where the spherical body is inserted with pressure, the pressing force of the spherical body is reinforced by the pressure member and the track rail is fixed firmly. Simultaneously with this, even when a thermal expansion difference is caused between the track rail and the base, the contact portion of the spherical body slides along one side surface of the track rail so as to absorb the thermal expansion difference and accordingly, no distortion is caused in the track rail.

[0067] Moreover, a metal member holding a spherical body may be inserted with pressure into a plurality of holes opened at a predetermined interval on the inner surface of one side of the groove, so as to press one side surface of the track rail. In this case also, like in the invention claimed in claim 4, one side surface of the track rail is in contact with the spherical body to make a point-to-point contact. Even when a thermal expansion difference is caused between the track rail and the base, the contact portion of the spherical body slides along the one side surface of the track rail so as to absorb the thermal expansion difference and accordingly, no distortion is caused in the track rail.

What we claim is:

1. A track rail mounting structure of a rectilinear guide apparatus comprising a track rail having a rotating/running surface where a plenty of rotating/running bodies rotate and run; an endless circulation route for guiding the plenty of rotating/running bodies; and a slider movably arranged with respect to the track rail via the rotating/running bodies;

wherein a base where the track rail is mounted has a groove for inserting a bottom portion of the track rail, so that the bottom portion of the track rail is inserted into the groove and a pressure member is provided for pressing at least one side of track rail toward an inner side surface of the groove.

2. The track rail mounting structure of the rectilinear guide apparatus according to claim 1, wherein the pressure member has a convex contact surface which is brought into abutment with the track rail side surface.

3. The track rail mounting structure of the rectilinear guide apparatus according to claim 1, wherein the pressure member is an elastic corrugated spacer inserted between the side surface of the track rail and the inner side surface of the groove.

4. The track rail mounting structure of the rectilinear guide apparatus according to claim 1, wherein the pressure member is a spherical body which is inserted with pressure into a plurality of holes opened at a predetermined interval on the inner side surface of one side of the groove, so that the spherical body presses the side surface of the track rail.

5. The track rail mounting structure of the rectilinear guide apparatus according to claim 4, wherein a pressing force of the spherical body is reinforced by a pressing force reinforcing member inserted into the hole where the spherical body is inserted with pressure.

6. The track rail mounting structure of the rectilinear guide apparatus according to claim 1, wherein the pressure member is a spherical body which is held by a holding metal member, and the metal member holding the spherical body is inserted with pressure into a plurality of holes opened at a predetermined interval on the inner side surface of the groove, so that the spherical body presses the side surface of the track rail.

* * * * *

US 20030059134A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2003/0059134 A1

Mochizuki et al. (43) Pub. Date: Mar. 27, 2003

(54) SEAL DEVICE FOR A GUIDE DEVICE AND GUIDE DEVICE

(75) Inventors: **Hiroaki Mochizuki**, Yamanashi (JP); **Tetsuhiro Nishide**, Tokyo (JP)

Correspondence Address:
ARMSTRONG,WESTERMAN & HATTORI, LLP
1725 K STREET, NW
SUITE 1000
WASHINGTON, DC 20006 (US)

(73) Assignee: **THK CO., LTD.**, Tokyo (JP)

(21) Appl. No.: **10/247,630**

(22) Filed: **Sep. 20, 2002**

(30) **Foreign Application Priority Data**

Sep. 21, 2001 (JP) P2001-288247

Jun. 28, 2002 (JP) P2002-190931

Publication Classification

(51) **Int. Cl.**[7] **F16C 33/00**

(52) **U.S. Cl.** **384/15**; 384/45

(57) **ABSTRACT**

A seal device fixed to an end portion of a slider of a guide device includes: a casing; a plurality of seal members; and elastic members, wherein each seal member has a recess portion in which a rail penetrates. An inner circumferential face of the recess portion comes into contact with an outer surface of the rail when the seal member is pushed onto one side of the rail by the elastic members. The plurality of seal members are arranged in the casing in such a manner that when a seal portion of one seal member is pushed by the elastic member and contacted with one side of the rail, a seal portion of the next seal member is pushed by the elastic member and contacted with the other side of the rail.

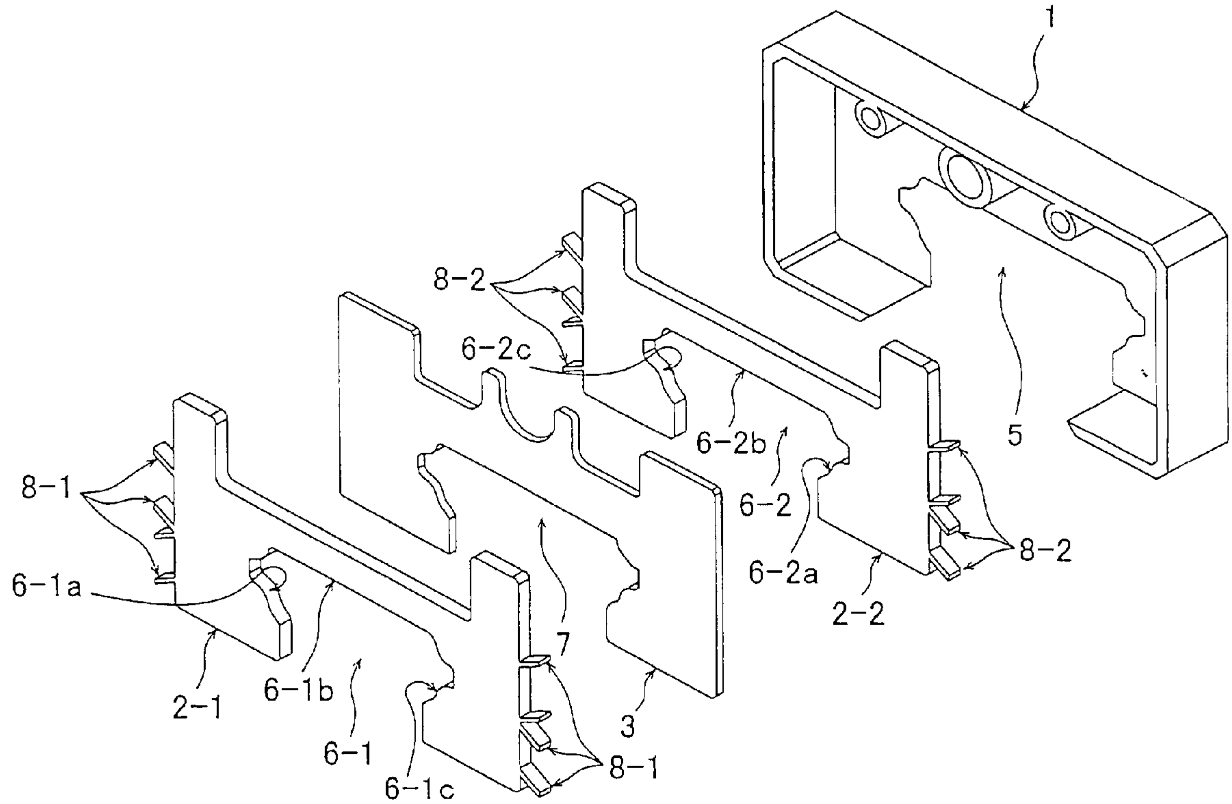


FIG. 1(a)

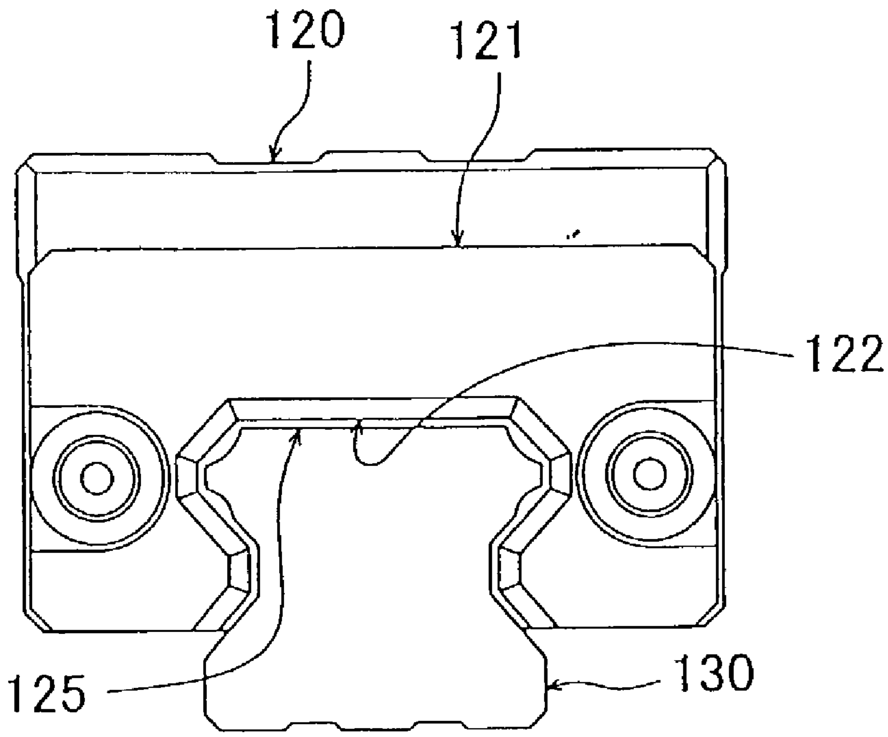


FIG. 1(b)

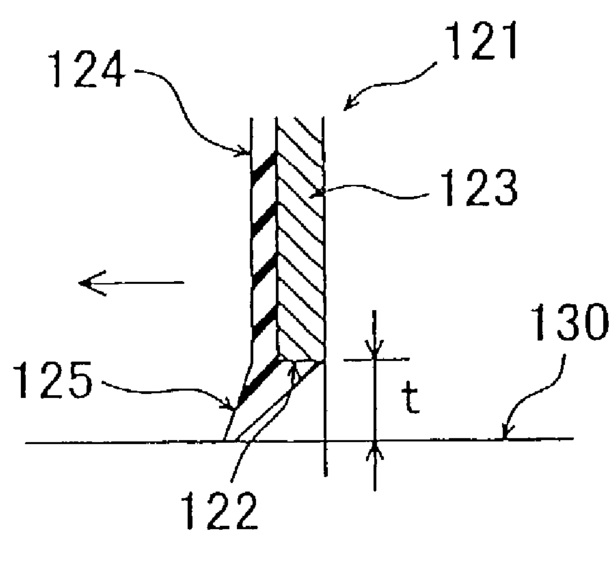
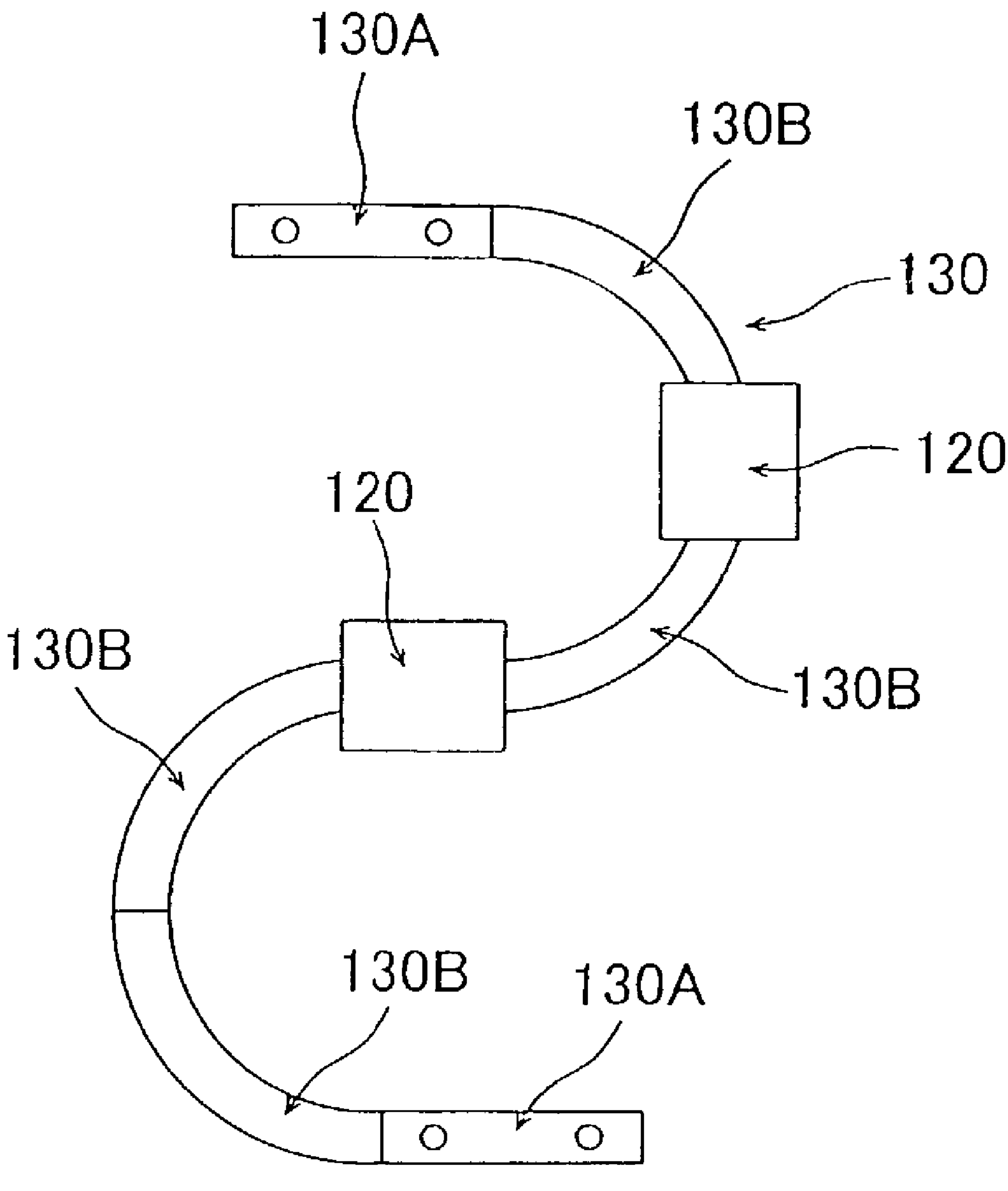


FIG. 2



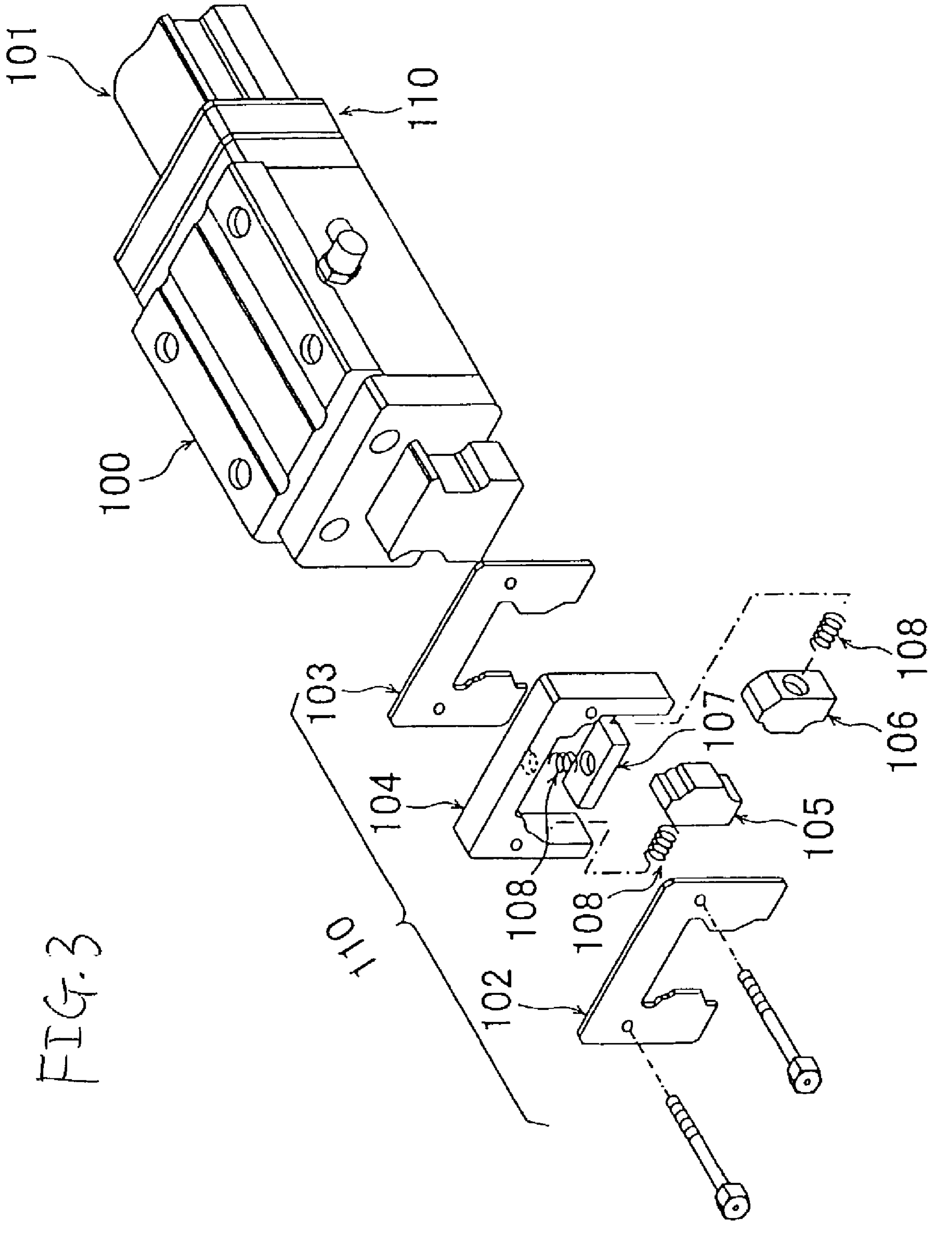


FIG. 3

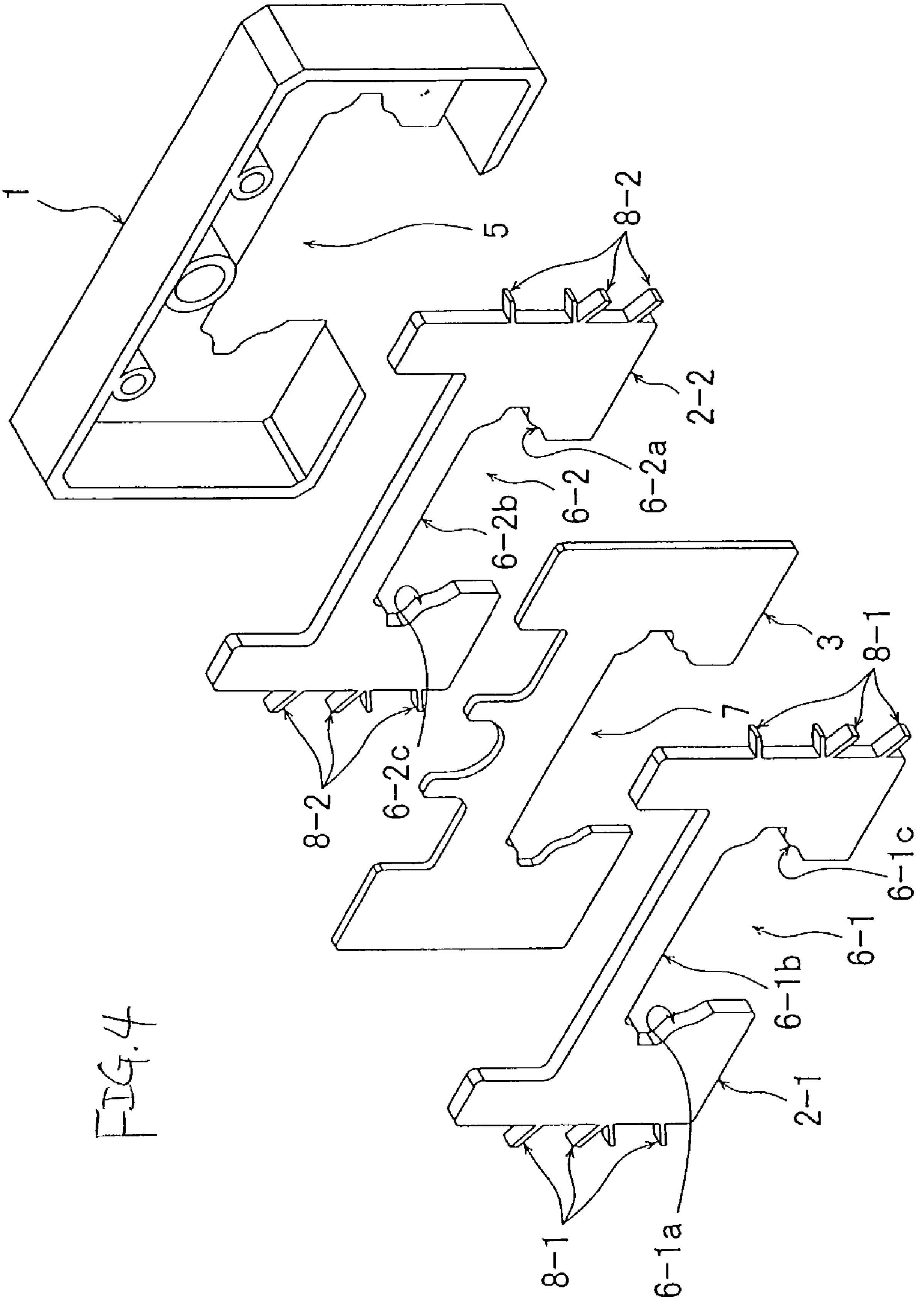


FIG. 4

FIG. 5

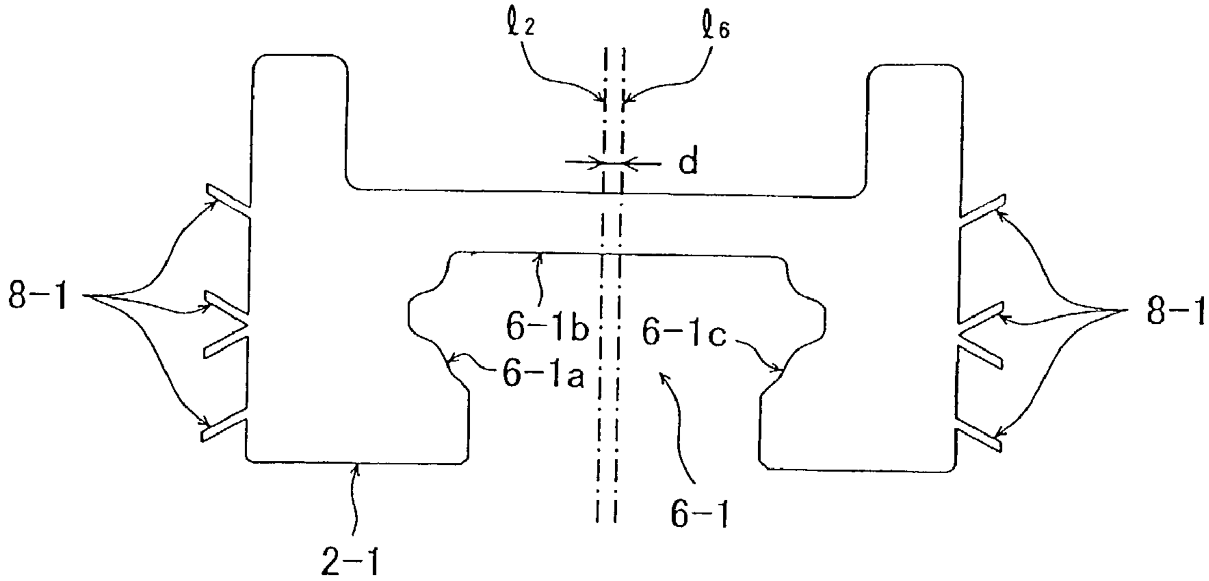


FIG. 6

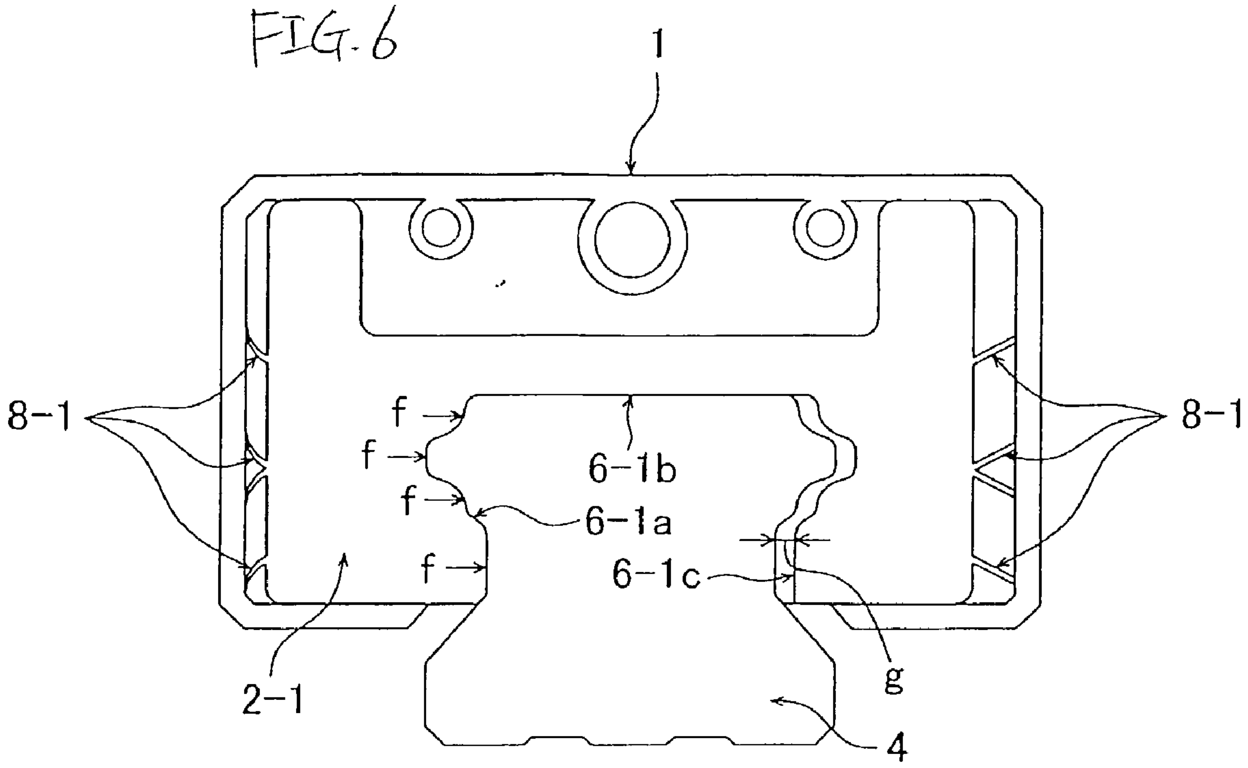
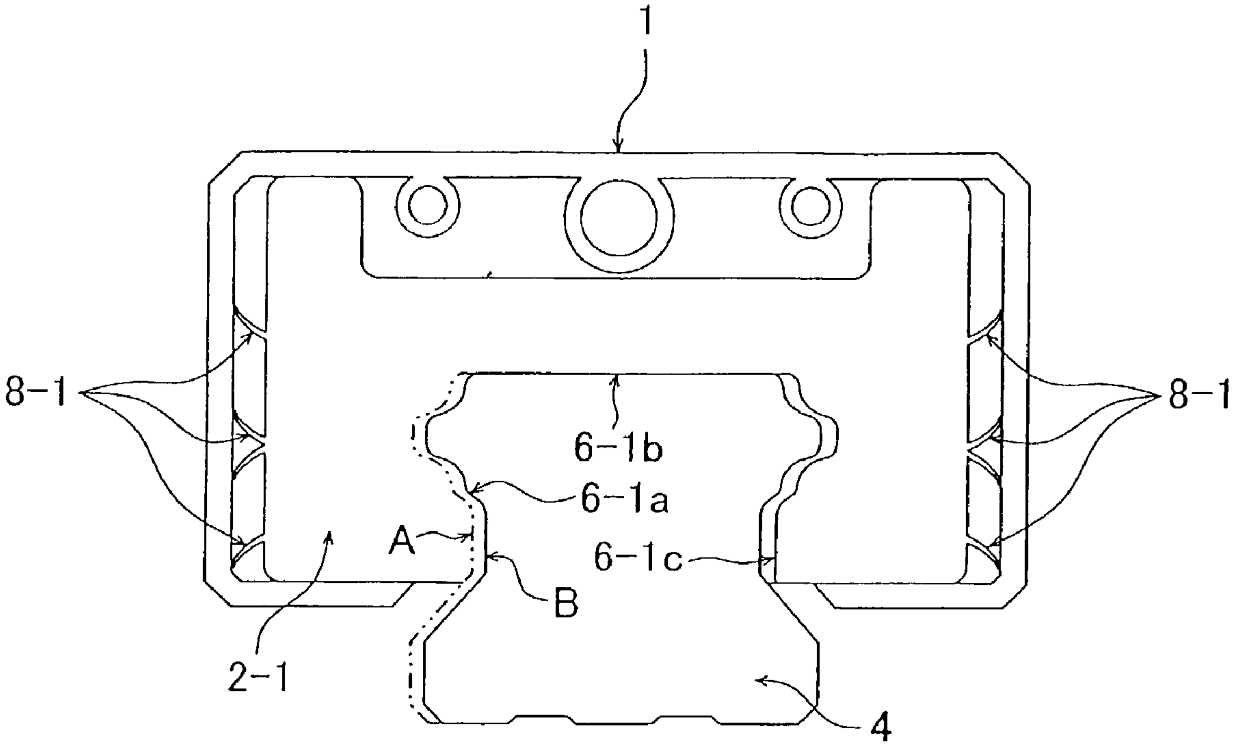


FIG. 7



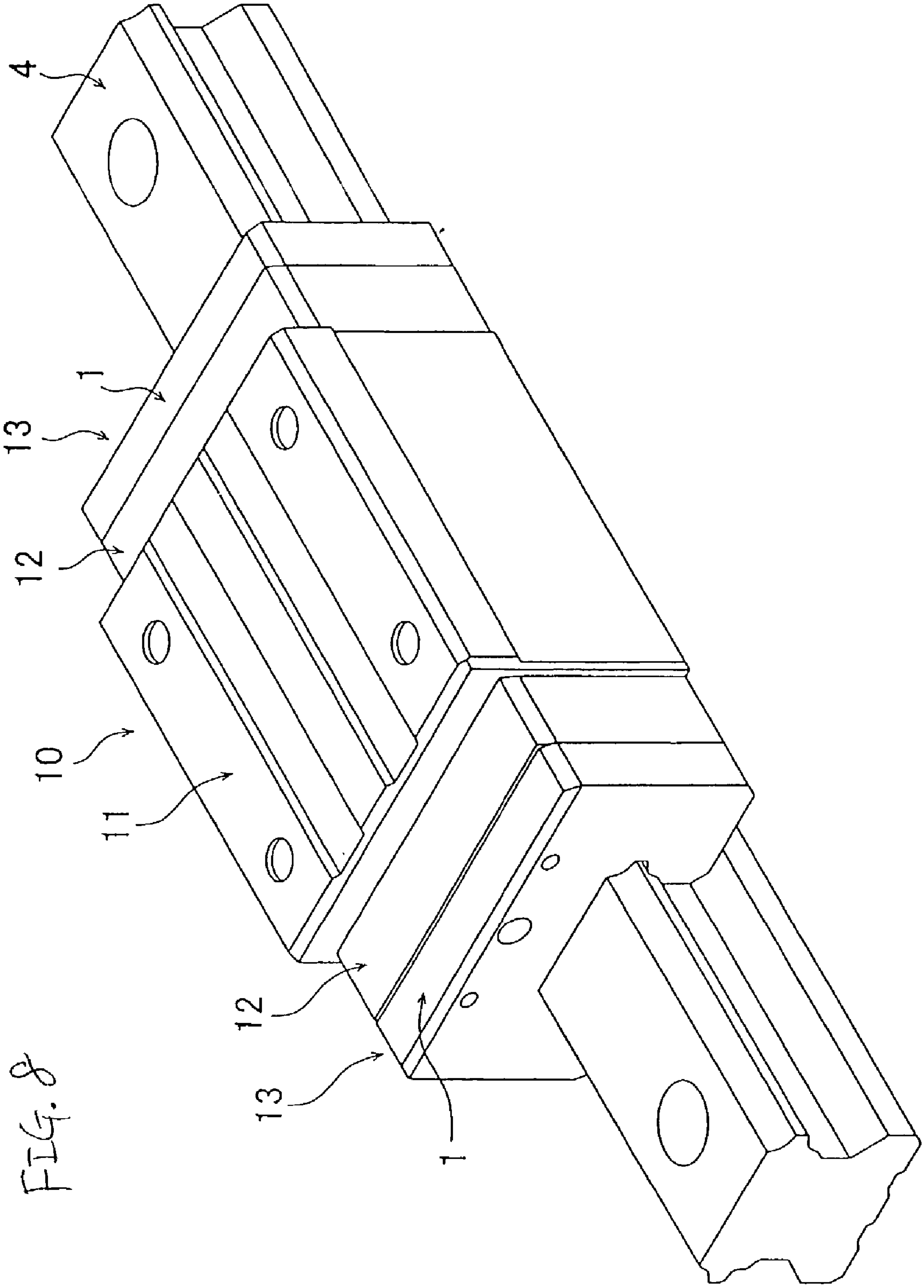


FIG. 8

FIG. 9

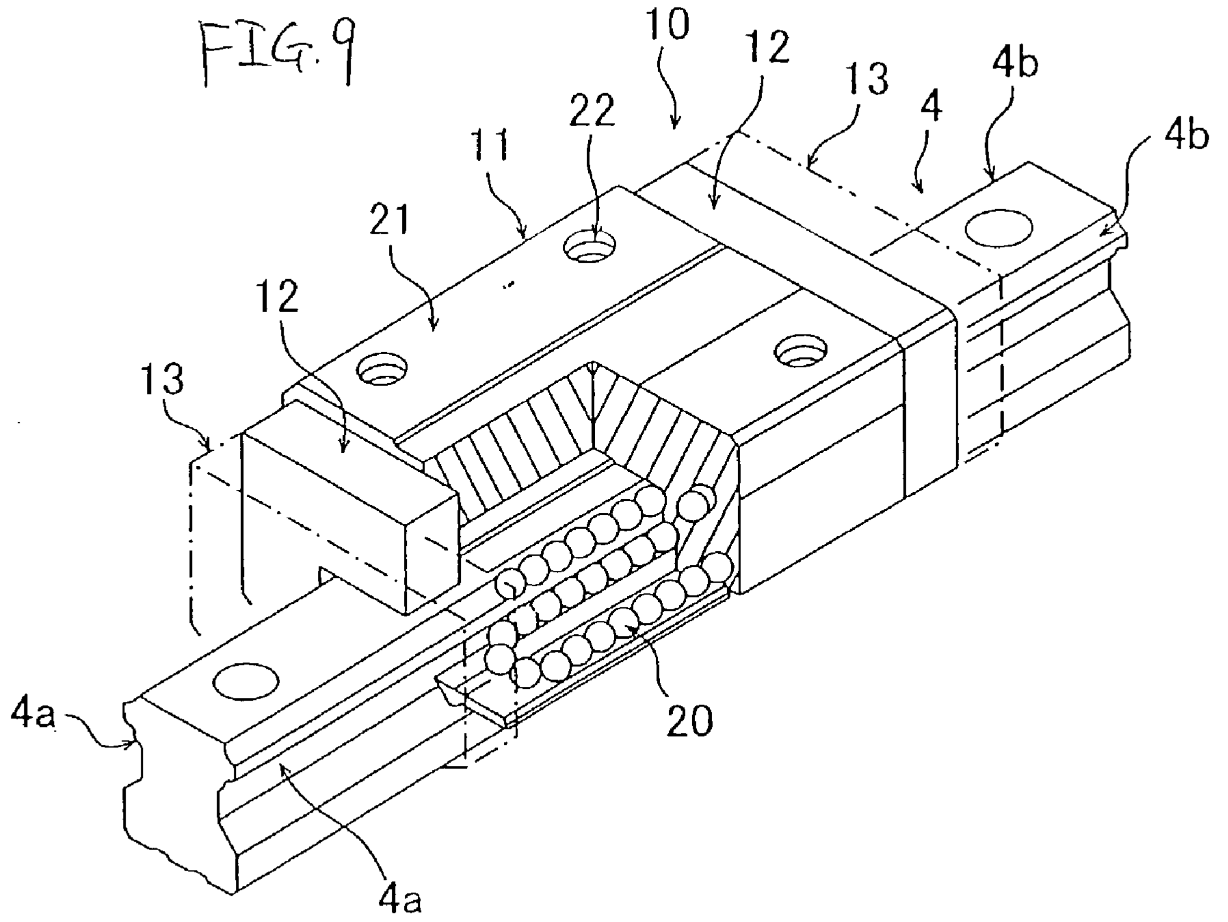


FIG. 10

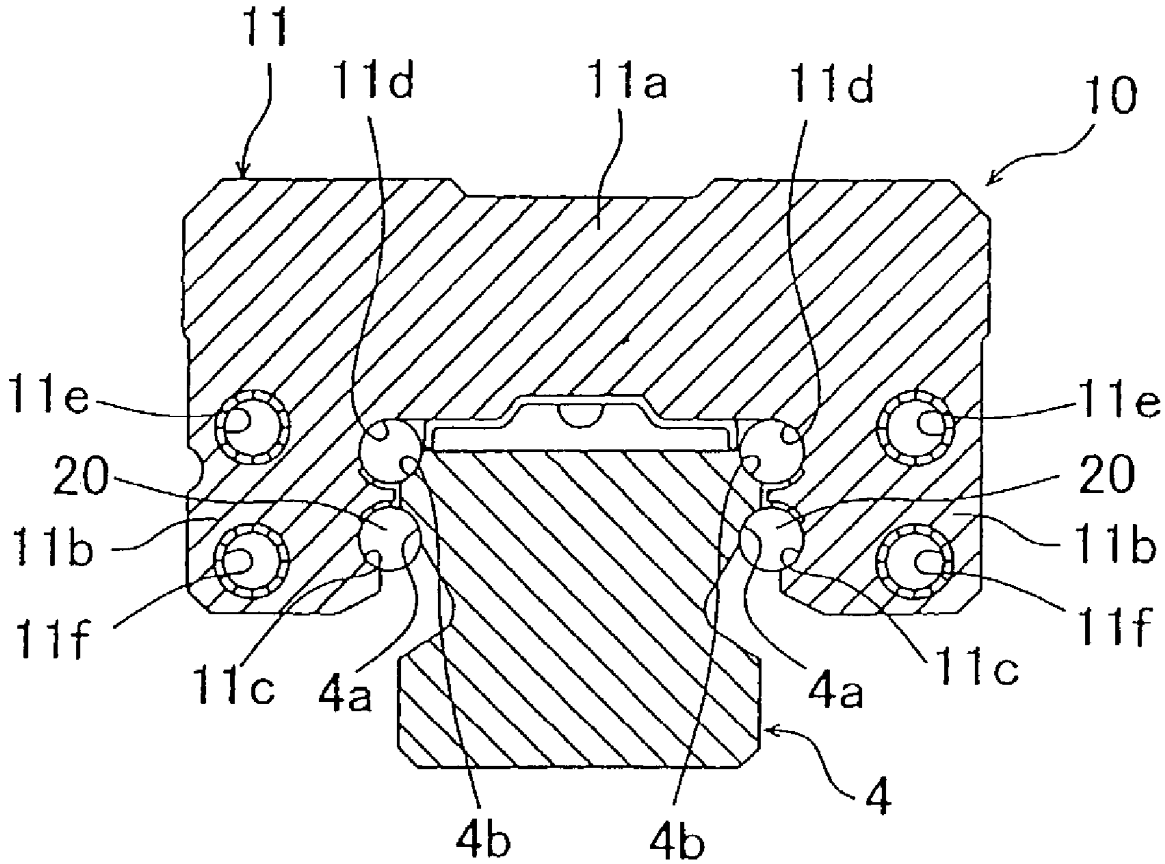

11
11d
11a
11d
10
11e
11e
20
20
11b
11b
11f
11f
11c
4a
4a
11c
4
4b
4b

FIG. 11

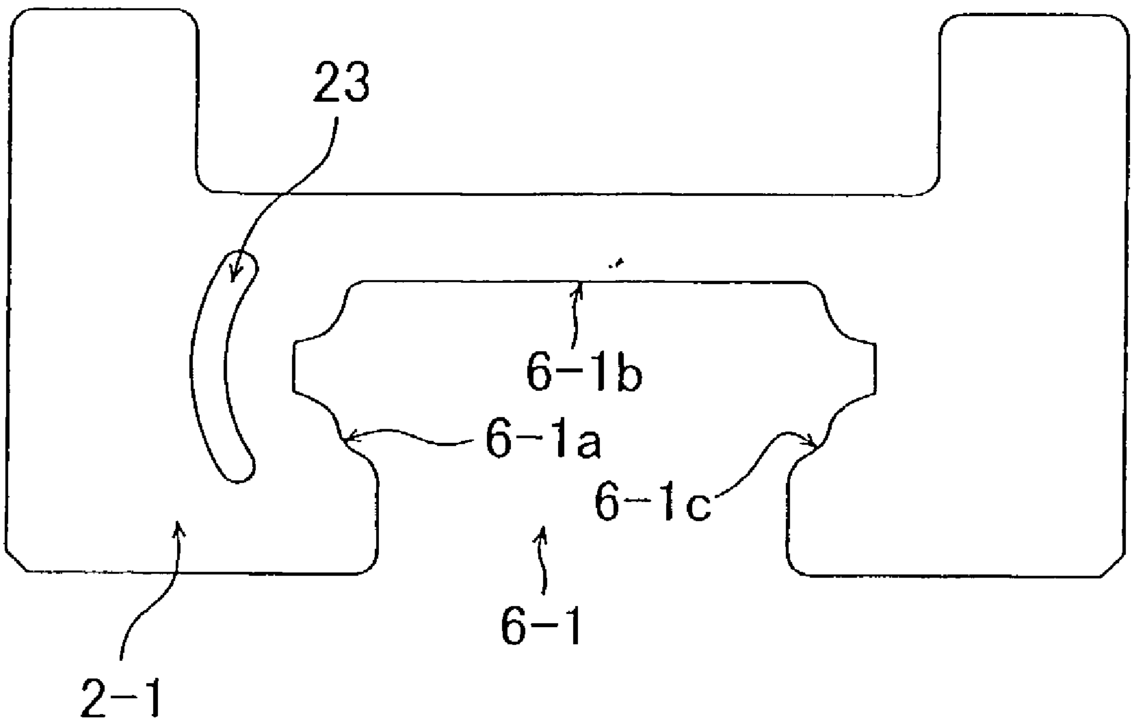


FIG. 12

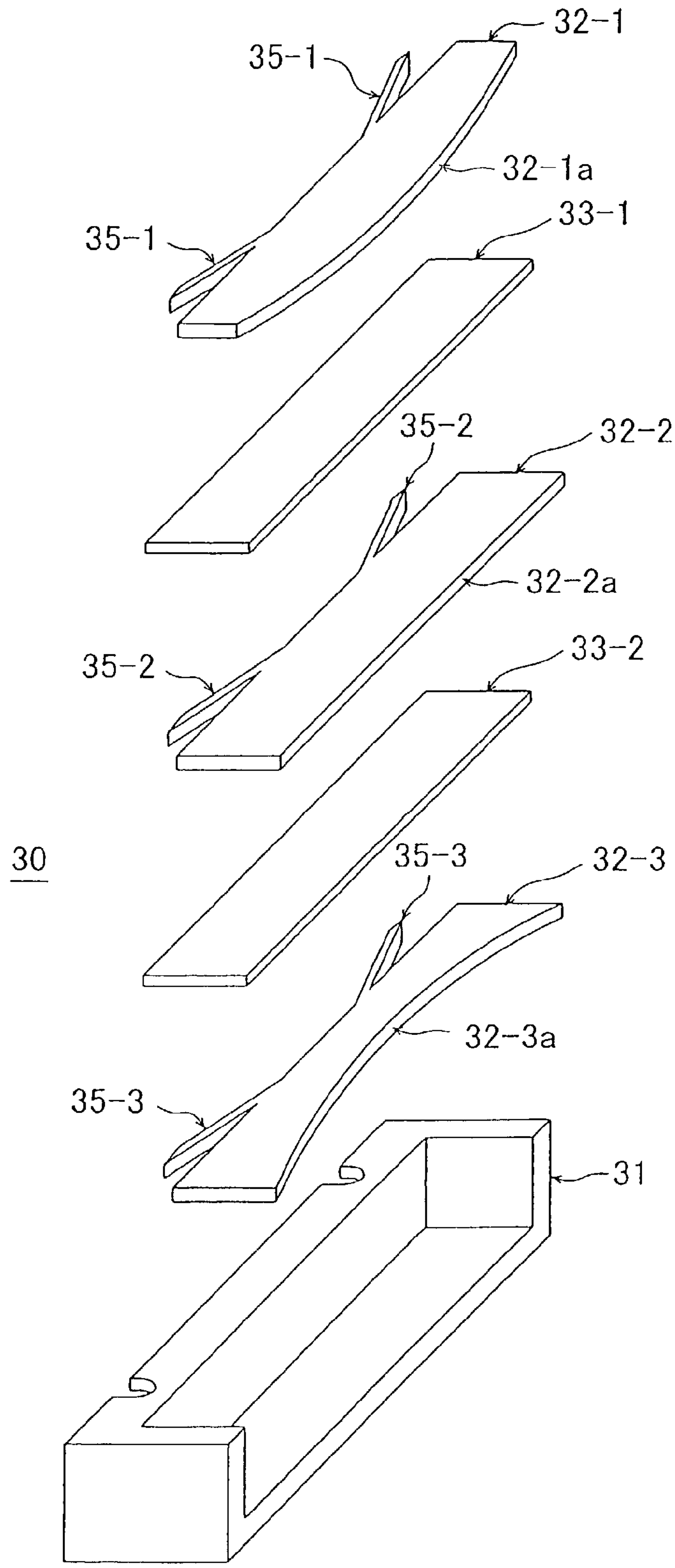


FIG. 13(a)

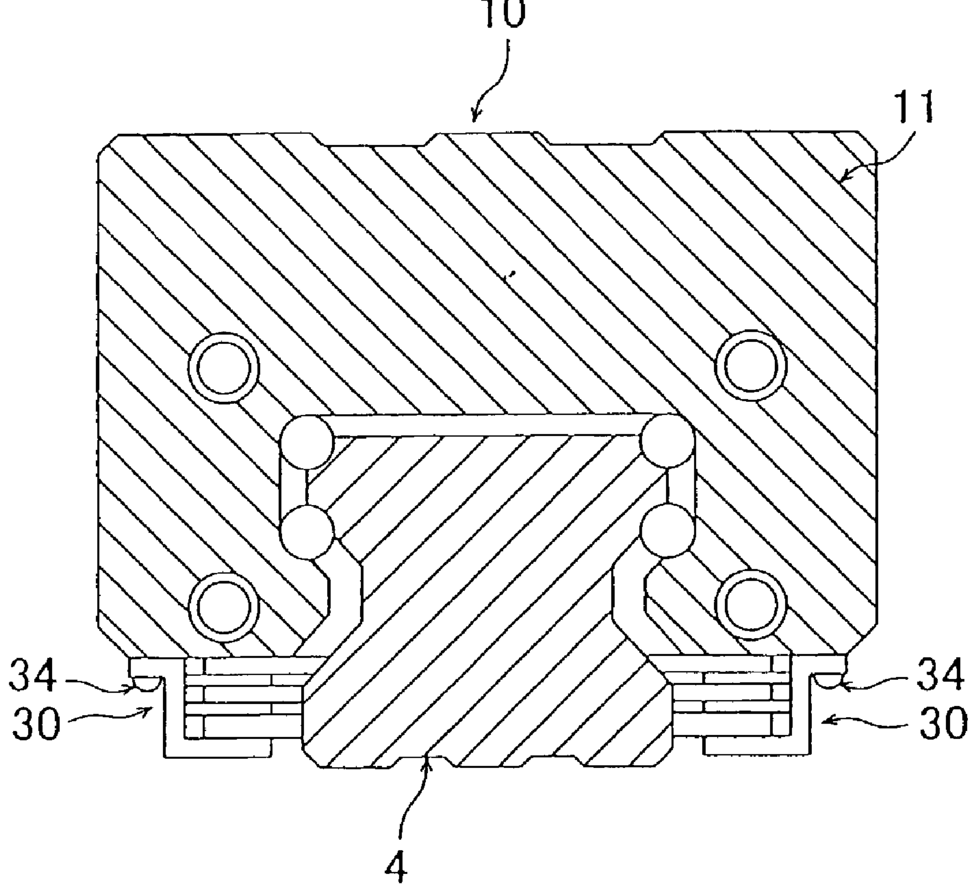


FIG. 13(b)

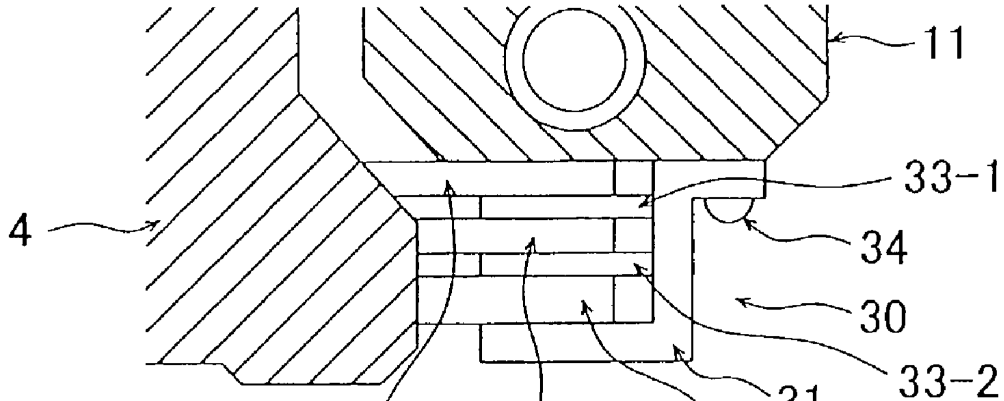


FIG. 14(a)

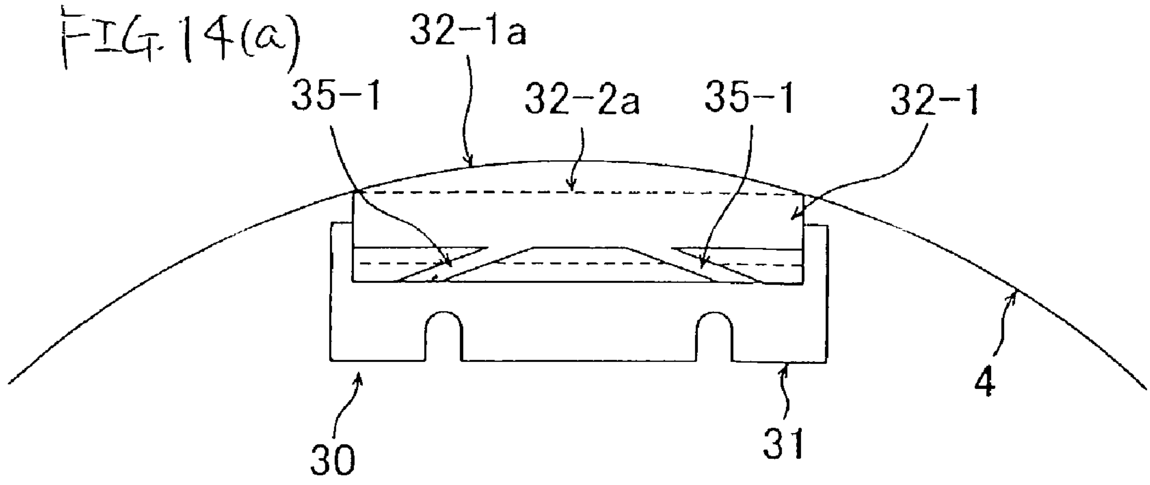


FIG. 14(b)

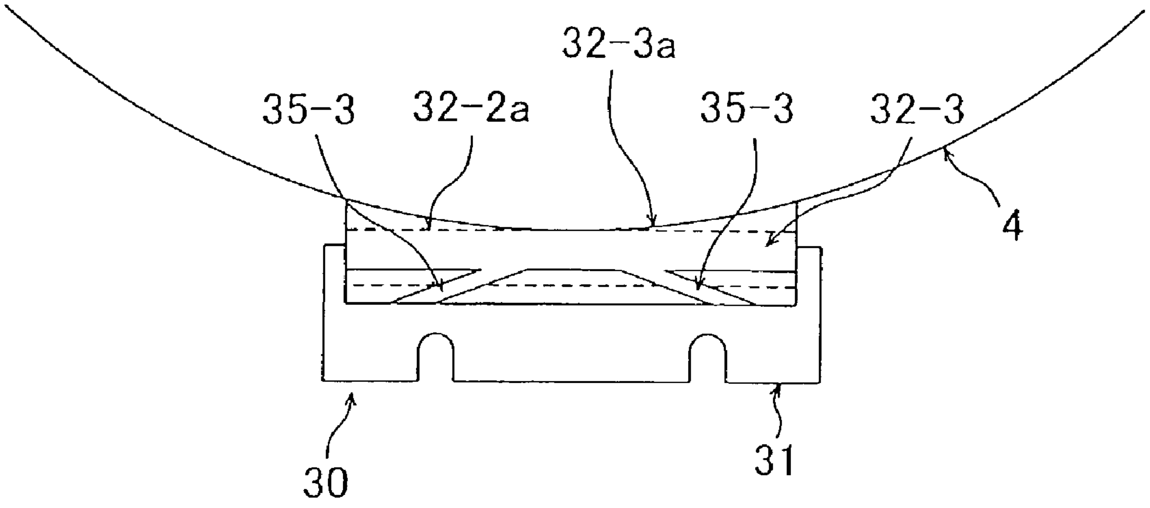


FIG. 14(c)

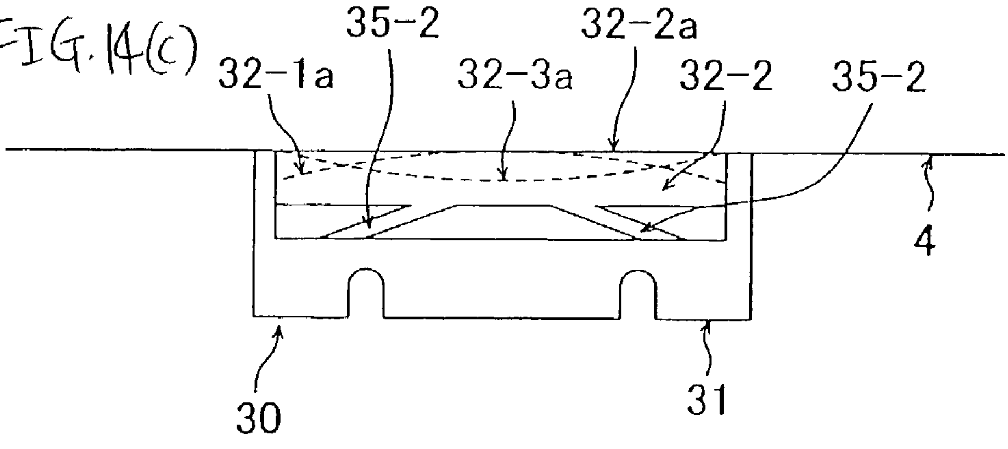


FIG. 15

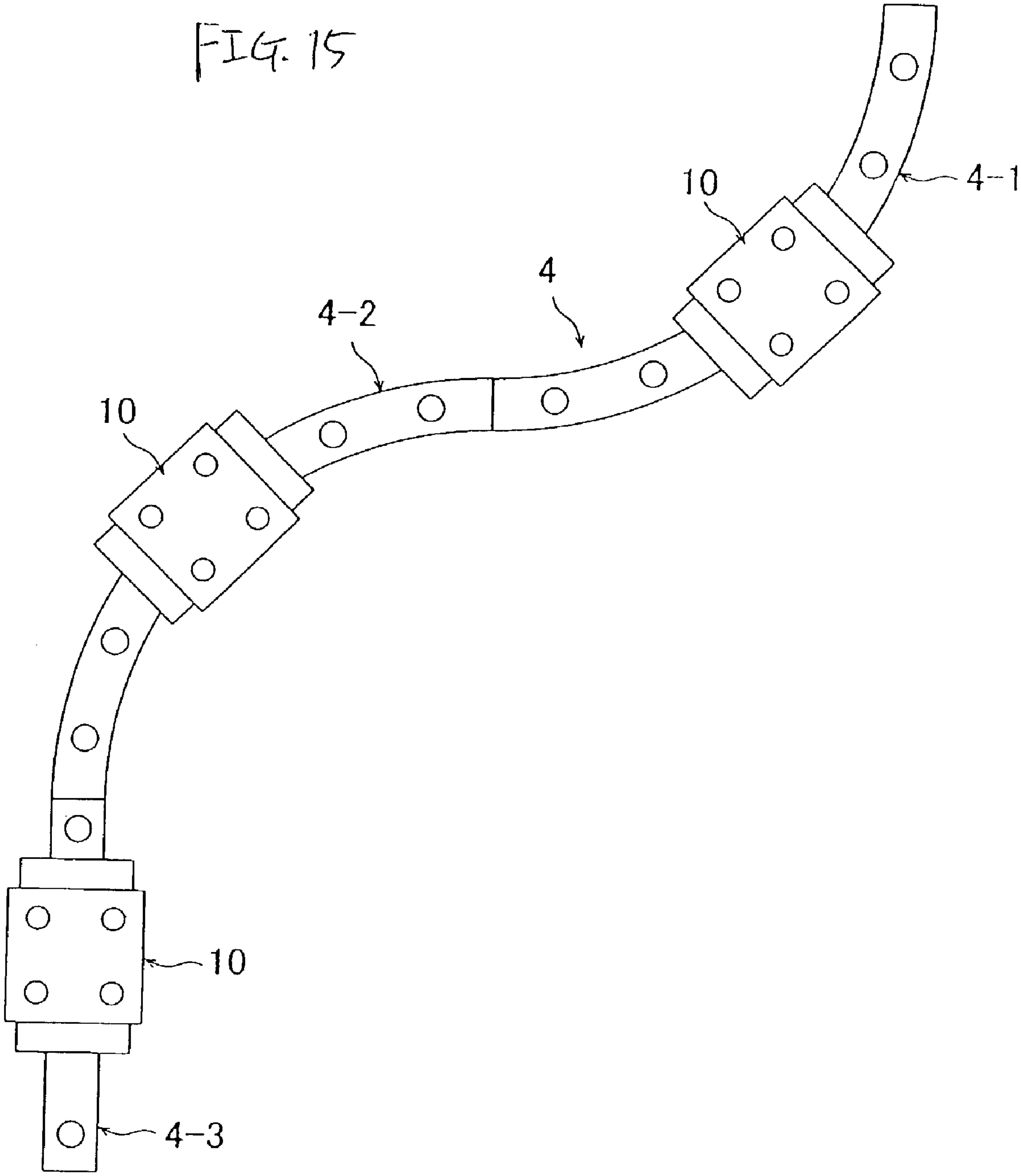


FIG. 16

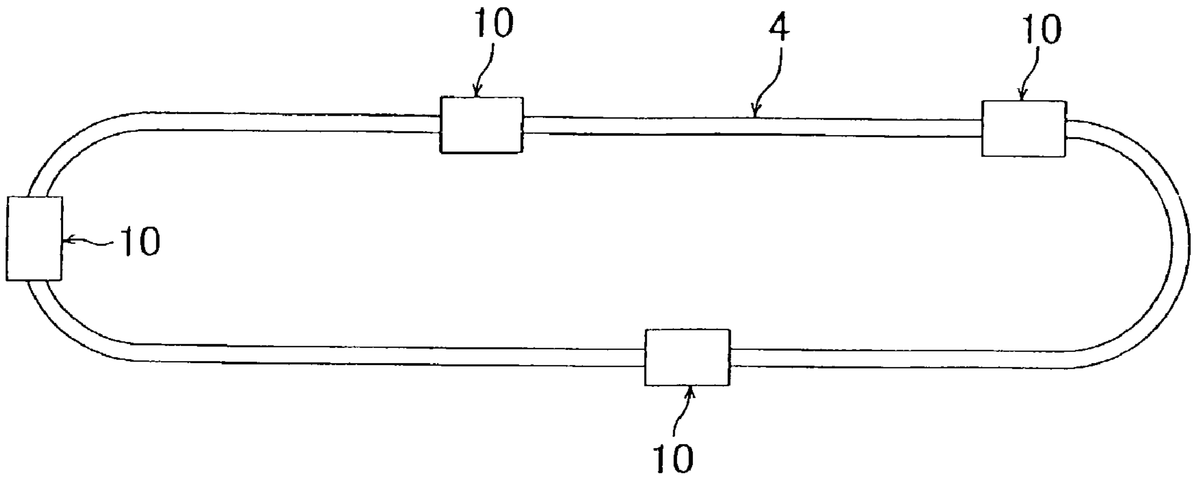


FIG. 17

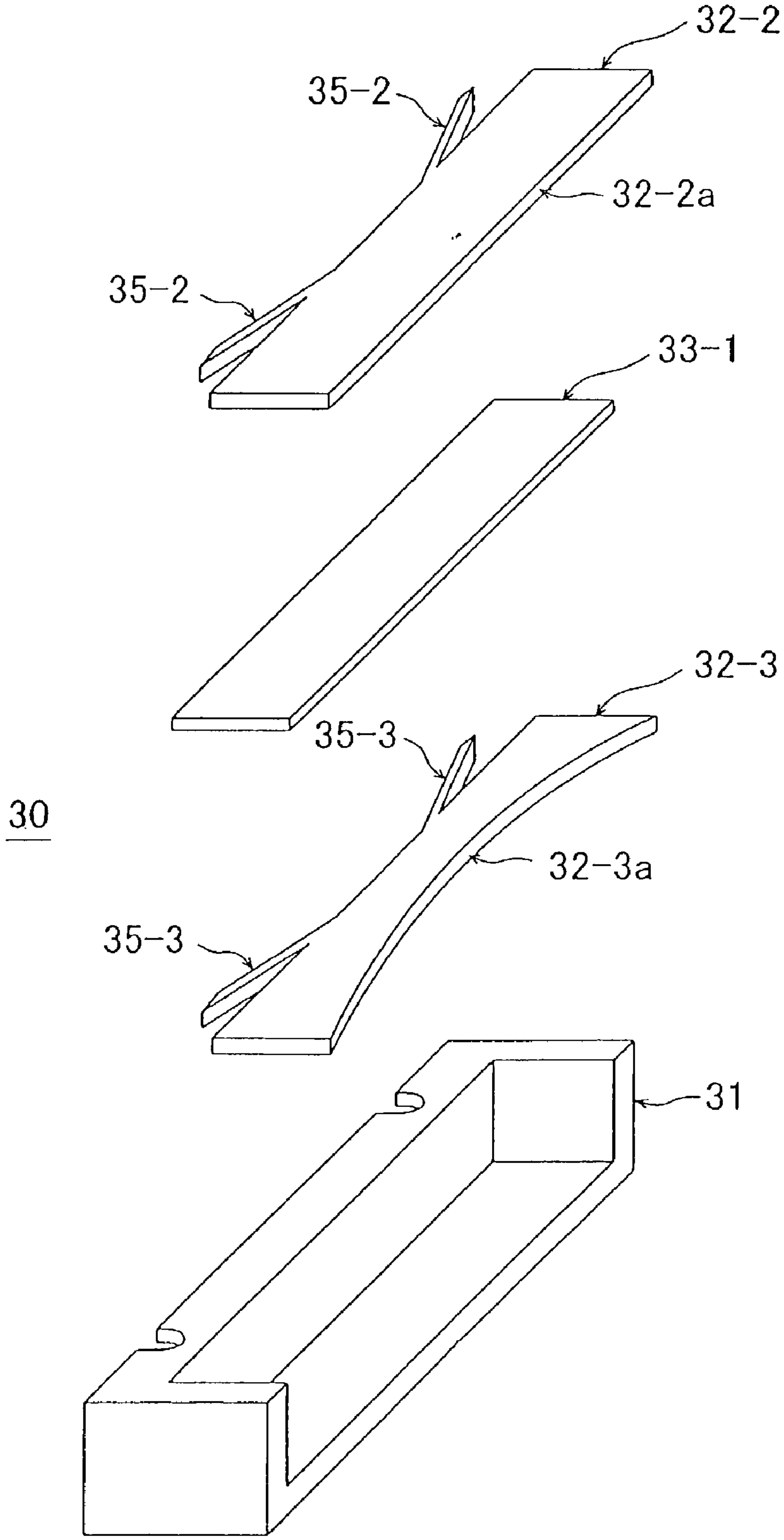
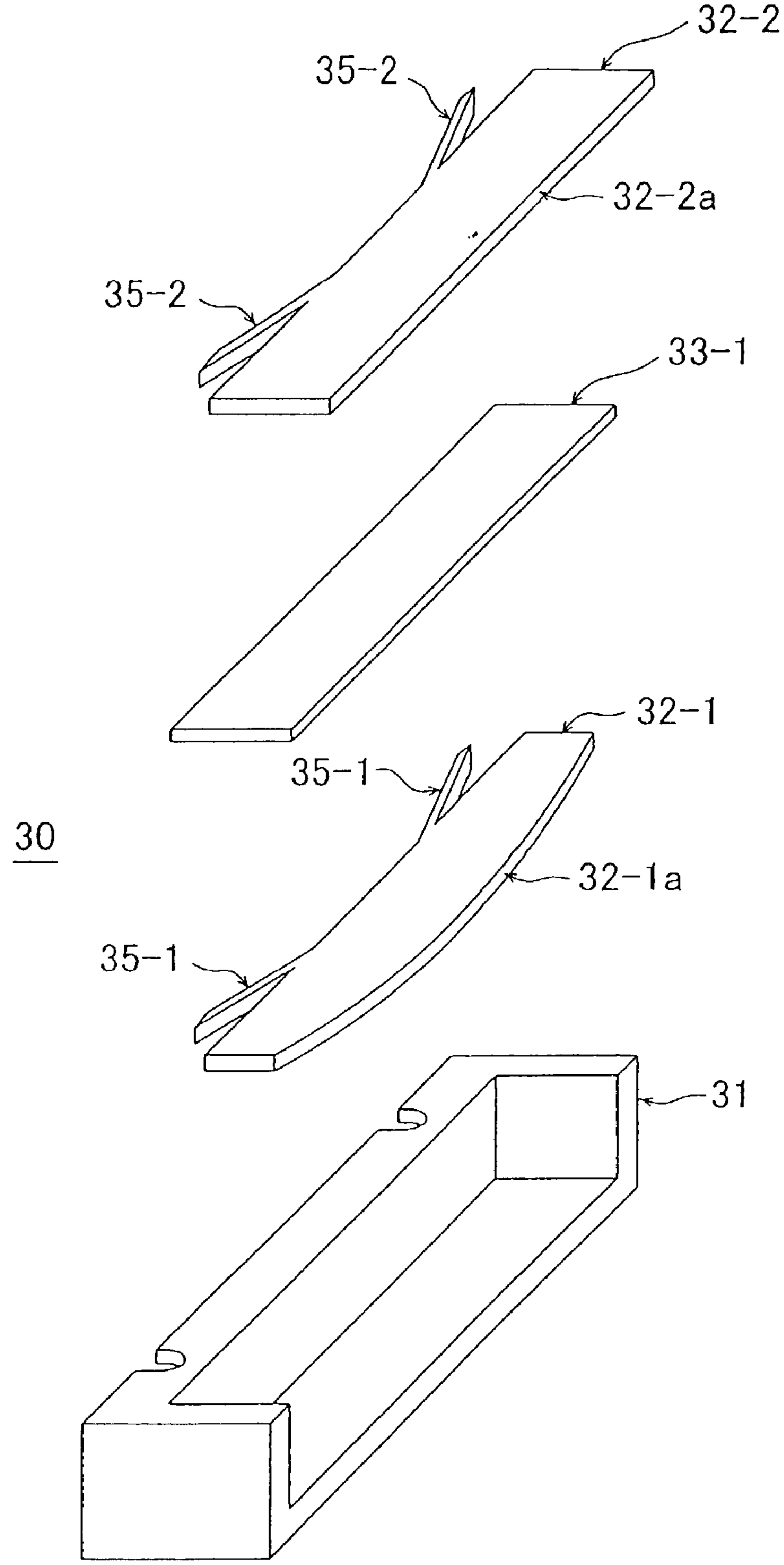


FIG. 18



SEAL DEVICE FOR A GUIDE DEVICE AND GUIDE DEVICE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a seal device for a guide device used for a moving portion of various machine tools, industrial robots or various common machines. Particularly, the present invention relates to a seal device for a guide device in which a slider striding over a rail is guided along the rail. More particularly, the present invention relates to a seal device which effectively exhibits a sealing function even in a guide device in which the rail width is partially different. The present invention also relates to a guide device in which the seal device is used.

[0003] 2. Description of the Related Art

[0004] Conventionally, there is provided a seal device for a guide device shown in FIGS. 1(*a*) and 1(*b*). In the drawings, reference numeral **121** is referred to as an end seal attached to an end portion of the slider **120** arranged striding over the rail **130** and moved along the rail **130**. This end seal **121** is composed in such a manner that a rubber member **124** is coated on a plate-shaped core metal **123**. The core metal **123** has a recess portion **122** in which the rail **130** penetrates. A seal portion **125**, which is called a lip, is formed at the inner circumferential edge of the recess portion **122**. Since a forward end portion of the seal portion **125** closely comes into contact with the outer circumferential face of the rail **130** and moves together with the slider **120**, foreign objects such as dust does not get into the slider **120**. **FIG. 1**(*a*) is a front view of the slider **120** and end seal **121**, and **FIG. 1**(*b*) is a sectional view of the inner circumferential portion of the end seal **121**.

[0005] In the conventional seal device, the following problem may be encountered. The dimension t (interval between the inner circumferential face of the core metal **123** and the outer circumferential face of the rail **130**) of the seal portion **125** of the end seal **121** is 1 to 2 mm. In case where the width of the rail **130** is different as shown in **FIG. 2**, for example, a transport device described in Japanese Unexamined Patent Publication No. 2001-99152 in which the slider **120** moves on the rail **130**, the rail width of the curved portion **130**B of the rail **130** is smaller than that of the straight portion **130**A, it is impossible for the elastic extension and contraction of the seal portion **125** to absorb a change in the width of the rail **130**. That is, it is impossible for the elastic extension and contraction of the seal portion **125** to absorb a reduction of the width in the small width portion. Therefore, the forward end portion of the seal portion **125** is separated from the outer circumferential face of the rail **130**, which results in a defective sealing function.

[0006] In order to solve the above problem, Japanese Patent Publication No. 2939846 discloses a seal device as shown in **FIG. 3**. This seal device **110** includes a pair of end face plates **102**, **103** made of metal arranged at the end portions of the slider **100** in the moving direction. The end face plates **102**, **103** have an inside shape formed into the same profile as that of the outer face of the rail **101**. A small gap is formed between the inside of the end face plates **102**, **103** and the rail **101**. The seal device further includes a support member **104** interposed between the end plates **102**, **103**; two side seal members **105**, **106** and one upper seal member **107** made of bearing metal and arranged in a cut-out portion provided inside the support member **104**. The two side seal members **105**, **106** and one upper seal member **107** are formed in shapes that correspond to the profile of the outer face of the rail **101**. The two side seal members **105**, **106** and one upper seal member **107** are restricted to move by the pair of end face plates **102**, **103**. The seal device further includes compression springs **108** for elastically pushing the seal members **105**, **106**, **107** onto the outer face of the rail **101**.

[0007] However, even in the seal device **110** composed as described above, the following problems may be encountered. In case where the slider **100** is guided along the rail **101** in which a straight portion and curved portion are continuously connected with each other, a gap is caused between the rail **101** and the side seal members **105**, **106** by an inner wheel difference of the curved portion, which deteriorates the sealing function of the seal member. Further, since the seal member is divided into three pieces of the side seal members **105**, **106** and the upper seal member **107** so that the seal members do not come into contact with each other, a gap is caused at each of the intersections (opposing faces) of the divided seal members. Further, in case where the inner wheel difference is caused in the curved portion of the rail **101**, it is impossible to absorb the inner wheel difference. Further, this device is disadvantageous in that the number of parts is large and the structure becomes complicated. For example, when such a structure is adopted that the divided seal members come into contact with each other, a gap is formed by the abrasion caused between the divided seal members.

[0008] In the conventional guide device, the end seal **121** is arranged at the end of the slider **120**, and the seal device **110** is arranged at the end of the moving member (slider) **100** as described above. However, no seal devices are arranged in the side portions of the slider **120** and the moving member (slider) **100**, that is, no seal devices are arranged in the portions opposed to the side of the rail **130**. Therefore, problems may be encountered in which dust gets into the slider from the side portion. Therefore, it is impossible to apply the conventional guide device, for example, to a wood working machine used in a dusty place.

SUMMARY OF THE INVENTION

[0009] The present invention has been accomplished to solve the above problems. It is an object of the present invention to provide a seal device for a guide device and a guide device which enable a simple structure and exhibit not only a sealing function of the slider end portion but also a sealing function of the slider side portion even in case where the rail width is changed and the shape of the rail is changed from a straight line to a curved line.

[0010] According to a first aspect of the present invention, there is provided a seal device for a guide device which is fixed to an end portion of a slider of the guide device so as to prevent foreign objects such as dust from getting into the seal device, the slider being arranged striding over a straight and/or curved rail and guided along the rail, the seal device comprising: a casing; a plurality of plate-shaped seal members accommodated in the casing; and an elastic member for pushing the seal members onto the rail, wherein each seal member has a recess portion in which the rail penetrates, an inner circumferential face of the recess portion includes a seal portion which comes into contact with an outer surface of the rail, and wherein the plurality of seal members are arranged in the casing in such a manner that the seal members are pushed by the elastic member, the seal portion of one seal member comes into contact with one side of the rail, and the seal portion of the next seal member comes into contact with the other side of the rail.

[0011] As described above, when the seal portion formed in the recess portion of one seal member in a plurality of seal members provided in the casing is pushed by the elastic member and contacted with one side of the guide rail, the seal portion formed in the next seal member is pushed onto the other side of the guide rail, that is, the plurality of seal members are arranged in the casing while the phase of the seal portion formed in the recess portion of one seal member and the phase of the seal portion formed in the recess portion of the other seal member are alternately changed from each other. Due to the above structure, sealing is performed in such a manner that the seal portions of a plurality of seal members (at least two seal members) slide on the circumferential face of the rail on which the slider moves. Therefore, a perfect sealing function can be provided. Especially when the rail width is locally different, for example even when the width of a curved portion is smaller than that of a straight portion, a difference in the width can be absorbed when the seal member is moved while being pushed by the elastic member. Therefore, the seal portion can be always contacted with the outer circumferential face of the guide rail, and the sealing function is not impaired.

[0012] According to a second aspect of the present invention, the elastic members are integrally formed on the outer periphery of the seal members.

[0013] When the elastic member is integrally formed in the outer periphery of the seal member, the number of parts composing the seal device can be decreased, and the assembling work can be easily performed.

[0014] According to a third aspect of the present invention, an isolation plate is arranged between the seal members.

[0015] When the isolation plate is arranged between the seal members as described above, each seal member can be smoothly moved regardless of the rail width by the function of the elastic member without interfering with the other seal members, and the seal portion comes into contact with the outer circumferential face of the guide rail. Therefore, the sealing function is effectively performed.

[0016] According to a fourth aspect of the present invention, there is provided a seal device for a guide device which is fixed to a side portion of a slider of the guide device so as to prevent foreign objects such as dust from getting into the seal device, the slider being arranged striding over a straight and/or curved rail and guided along the rail, the seal device comprising: a casing; a plurality of plate-shaped seal members accommodated in the casing; and an elastic member for pushing the seal members onto the rail, wherein a side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex or concave shape of a predetermined radius of curvature, a side of at least one seal member slidably coming into contact with the side of the rail is formed into a straight shape, and wherein the seal members are pushed by the elastic member and at least one portion of the side of each seal member comes into contact with the side of the rail.

[0017] As described above, the side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex or concave shape of a predetermined radius of curvature, and the side of at least one seal member slidably coming into contact with the side of the rail is formed into the straight shape. Therefore, in the straight portion of the rail, the straight side of the seal member closely comes into contact with the side of the rail, and in the curved portion of the seal member, the side of the seal member, which is formed into a convex or concave of a predetermined radius of curvature, closely comes into contact with the side of the rail. Therefore, even if the rail profile is changed from a straight shape to a curved shape, no foreign objects get into the slider from the side portion.

[0018] According to a fifth aspect of the invention, there is provided a seal device for a guide device which is fixed to a side portion of a slider of the guide device so as to prevent foreign objects such as dust from getting into the seal device, the slider being arranged striding over a straight and/or curved rail and guided along the rail, the seal device comprising: a casing; a plurality of plate-shaped seal members accommodated in the casing; and an elastic member for pushing the seal members onto the rail, wherein a side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex shape of a predetermined radius of curvature, a side of at least one seal member slidably coming into contact with the side of the rail is formed into a concave shape of a predetermined radius of curvature, and a side of at least one seal member slidably coming into contact with the side of the rail is formed into a straight shape, and wherein the seal members are pushed by the elastic member and at least one portion of the side of each seal member comes into contact with the side of the rail.

[0019] As described above, the side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex shape of a predetermined radius of curvature, and the side of at least one seal member slidably coming into contact with the side of the rail is formed into a concave shape of a predetermined radius of curvature, and further the side of at least one seal member slidably coming into contact with the side of the rail is formed into a straight-line-shape. Due to the above structure, in the straight rail portion, the straight side of the seal member closely comes into contact with the rail side. In the curved rail portion, the convex side of the seal member of a predetermined radius of curvature or the concave side of the seal member closely comes into contact with the rail side. In the portion where the rail is curved in the other direction, the concave side of the seal member of a predetermined radius of curvature or the convex side of the seal member closely comes into contact with the rail side. Therefore, even if the rail is curved from a straight shape to a curved shape which is curved to either the right or the left, no foreign objects get into the slider from the side portion of the slider.

[0020] According to a sixth aspect of the present invention, the elastic members of a guide device according to the fourth or fifth aspect are integrally formed on the outer periphery of the seal members.

[0021] When the elastic member is integrally formed in the outer periphery of the seal member, the number of parts composing the seal device can be decreased, and the assembling work can be easily performed.

[0022] According to a seventh aspect of the present invention, an isolation plate is arranged between the seal members of a guide device according to one of the fourth to sixth aspects.

[0023] When the isolation plate is arranged between the seal members as described above, each seal member can be smoothly moved regardless of the rail width by the function of the elastic member without interfering with the other seal members, and the seal portion comes into contact with the outer circumferential face of the guide rail. Therefore, the sealing function is effectively performed.

[0024] According to a eighth aspect of the present invention, there is provided a guide device comprising: a straight and/or curved rail; and a slider arranged striding over the rail, the slider having seal devices arranged at both end portions and both side portions respectively for preventing foreign objects from getting into the slider, wherein the seal device attached to both end portions of the slider is the seal device according to one of the first to third aspects, and the seal device attached to both side portions is the seal device according to one of the fourth to seventh aspects.

[0025] As described above, when the seal device attached to both end portions of the slider is the seal device according to one of the first to third aspects, and the seal device attached to both side portions is the seal device according to one of the fourth to seventh aspects, both end portions and both side portions of the slider are sealed. Accordingly, no foreign objects get into the slider.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] **FIG. 1**(*a*) is a front view showing a conventional seal device and **FIG. 1**(*b*) is a sectional view of an inner circumferential portion of an end seal;

[0027] **FIG. 2** is a plan view showing a conventional guide device using a rail in which a straight portion and curved portion are combined with each other;

[0028] **FIG. 3** is an exploded perspective view showing the conventional guide device;

[0029] **FIG. 4** is an exploded perspective view showing a seal device of a guide device of the present invention;

[0030] **FIG. 5** is a front view showing a seal member of the seal device of the guide device;

[0031] **FIG. 6** is a front view showing the seal device of the guide device;

[0032] **FIG. 7** is a front view showing an operation of the seal device of the guide device;

[0033] **FIG. 8** is a perspective view showing the guide device;

[0034] **FIG. 9** is a partially cutaway perspective view showing the guide device;

[0035] **FIG. 10** is a sectional view showing the guide device;

[0036] **FIG. 11** is a front view showing a seal member of a seal device of a second embodiment of the present invention;

[0037] **FIG. 12** is an exploded perspective view showing a seal device of a third embodiment of the present invention;

[0038] FIGS. **13**(*a*) and **13**(*b*) are sectional views showing the seal device;

[0039] FIGS. **14**(*a*) to **14**(*c*) are plan views showing an operation of the seal device;

[0040] **FIG. 15** is a plan view showing the guide device;

[0041] **FIG. 16** is a plan view showing the guide device;

[0042] **FIG. 17** is an exploded perspective view showing a seal device of a fourth embodiment of the present invention; and

[0043] **FIG. 18** is an exploded perspective view showing a seal device of a fifth embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFFERD EMBODIMENTS

[0044] Referring to the drawings, embodiments of the present invention will be described below. **FIG. 4** is an exploded perspective view showing an arrangement of a seal device of a guide device of the present invention. As shown in the drawing, this seal device includes: a casing **1**; a plurality of seal members **2-1**, **2-2** accommodated in the casing **1** (In the drawing, two seal members are shown.); and an isolation plate **3** interposed between the seal members **2-1**, **2-2**. In the casing **1**, there is formed a recess portion **5** in which the rail (shown in **FIG. 6**) penetrates. In the seal members **2-1**, **2-2**, there are respectively formed recess portions **6-1**, **6-2** in which the rail **4** penetrates. In the isolation plate **3**, there is formed a recess **7** in which the rail **4** penetrates.

[0045] At both side portions of each seal member **2-1**, **2-2**, there are integrally provided elastic members **8-1**, **8-1**. As shown in **FIG. 5**, the center line **16** of the recess portion **6-1** of the seal member **2-1** in the width direction is shifted from the center line **12** of the seal member **2-1** itself in the width direction by the distance d. The inner circumferential face **6-1***a* on one side and the inner circumferential face **6-1***b* on the upper side are formed into a shape closely coming into contact with the outer circumferential face of the rail **4**. Although not shown in the drawing, the structure of the seal member **2-2** is the same as that of the seal member **2-1**, and the inner circumferential face **6-2***a* on one side and the inner circumferential face **6-2***b* on the upper side are formed into a shape closely coming into contact with the outer circumferential face of the rail **4**.

[0046] **FIG. 6** is a view showing a positional relation of the seal member **2-1** with the rail **4** in the case where the seal member **2-1** is accommodated in the casing **1** and the rail **4** is inserted into its recess portion **6-1**. As shown in **FIG. 5**, the center line **16** of the recess portion **6-1** (not shown in **FIG. 6**) of the seal member **2-1** in the width direction is shifted from the center line **12** of the seal member **2-1** itself in the width direction by the distance d. Therefore, when the seal member **2-1** is accommodated in the casing **1** and the rail **4** is inserted into its recess portion **6-1**, the elastic member **8-1** on one side (on the left in the drawing) contracts and pushes the seal member **2-1** as shown by the arrow f, however, the elastic member **8-1** on the other side (on the right in the drawing) does not contract but extends. Due to the foregoing, the inner circumferential face **6-1***a* on one side of the recess portion **6-1** composing the seal portion closely comes into contact with the outer circumferential face on one side of the rail **4**, however, a gap g is formed between the inner circumferential face **6-1***c* on the opposite side of the recess portion **6-1** and the outer circumferential face on the opposite side of the rail **4**.

[0047] The seal member **2-2** is arranged in the casing **1** interposing the isolation plate **3** while the phase is shifted (inverted by 180°) as follows. On the contrary to the seal member **2-1**, the inner circumferential face **6-2***a* on one side of the recess portion **6-2** composing the seal portion closely comes into contact with the outer circumferential face on one side on the opposite side of the rail **4**, so that the gap g can be formed between the inner circumferential face **6-2***c* on one side of the recess portion **6-2** and the outer circumferential face on the opposite side of the rail **4**.

[0048] Due to the above structure, the inner circumferential faces **6-1***a*, **6-2***a* on one side composing the seal portion of the seal members **2-1**, **2-2**, which are arranged on both sides of the isolation plate **3** in the casing, are pushed by the elastic members **8-1**, **8-2** and respectively contacted with the opposed outer circumferential face of the rail **4**. Under the above condition, the inner circumferential faces **6-1***a*, **6-2***a* on one side composing the seal portion of the seal members **2-1**, **2-2** are moved on the rail **4** together with the slider. Therefore, foreign objects such as dust are removed from the outer circumferential face of the rail **4** by the seal portion of the seal members **2-1**, **2-2**. Accordingly, no foreign objects get into the slider. The inner circumferential faces **6-1***a*, **6-2***a* on side of the seal members **2-1**, **2-2** are contacted with the outer circumferential face of the rail **4** on the opposed side when they are pushed by the elastic members **8-1**, **8-2**. Therefore, even if the width of the rail **4** differs within the expansion and contraction range of the elastic members **8-1**, **8-2**, the width difference can be absorbed in this expansion and contraction range. Accordingly, no gaps are formed between the seal portion and the outer circumferential face of the rail **4**. Therefore, the sealing function is not impaired.

[0049] **FIG. 7** is a view to explain a sealing function in the case where the seal device of the present invention is applied to a guide device in which the rail width of a curved portion is smaller than the rail width of a straight portion like the transport device (shown in **FIG. 2**) described in Japanese Unexamined Patent Publication No. 2001-99152. In the drawing, two-dotted chain line A expresses an outer circumference of the rail **4** in the straight portion, and solid line B expresses an outer circumference of the rail **4** in the curved portion. As shown in the drawing, since the seal member **2-1** is pushed onto the rail side by the elastic member **8-1**, the inner circumferential face **6-1***a* on one side composing the seal portion always closely comes into contact with and slides on the outer circumferential face in either the straight portion (portion shown by two-dotted chain line A) in which the width of the rail **4** is large or the curved portion (portion shown by solid line B) in which the width of the rail **4** is small. Although not shown in the drawing, the seal member **2-2** is also pushed by the elastic member **8-2**, and the inner circumferential face **6-2***a* on one side always closely comes into contact with and slides on the outer circumferential face of the rail **4** in either the straight portion or the curved portion of the rail **4**.

[0050] Due to the foregoing, the inner circumferential faces **6-1***a*, **6-2***a* on one side of the seal members **2-1**, **2-2** and the upper side inner circumferential faces **6-1***b*, **6-2***b* always slidably come into contact with both the outer side faces and the upper face of the rail **4** irrespective of the width of the rail. Therefore, a sufficiently high sealing performance can be exhibited. In the above example, the width of the curved portion of the rail **4** is different from that of the straight portion. The seal device of the present invention is capable of exhibiting a sufficiently high sealing performance even in the case where the width is different within the curved portion and in the case where the width is different within the straight portion.

[0051] The seal members **2-1**, **2-2** are made of elastic material such as rubber or resin formed into a felt-shape, however, materials to compose the seal members **2-1**, **2-2** are not limited to the above specific examples. As far as the material is easily conformed to and seldom seized to and easily fitted to the rail **4**, any material such as resin or metal, for example, white metal used for a bearing metal may be used for the seal members **2-1**, **2-2**. In the above example, the cross sections of the inner circumferential faces **6-1***c*, **6-2***c* on one side of the seal members **2-1**, **2-2** which do not compose the seal portion are made to be similar to the cross section of the outer circumferential face of the rail **4**, however, the cross sections of the inner circumferential faces **6-1***c*, **6-2***c* are not limited to the above specific example.

[0052] **FIG. 8** is a view showing an appearance of the guide device to which the seal device of the present invention is applied. In the view, reference numeral **10** is a slider which is arranged striding over the rail. The slider **10** comprises a block **11**, the detail of which will be described later, and end plates **12**. The seal devices **13** of the present invention are arranged outside the end plates **12** which are attached to both ends of the slider **10**. The slider **10** is moved in the longitudinal direction of the rail **4**. When the slider **10** is moved, the inner circumferential faces **6-1***a*, **6-2***a* on one side of the seal members **2-1**, **2-2** (shown in **FIGS. 4 and 6**) and the inner circumferential faces **6-1***b*, **6-2***b* on the upper side of the seal members composing the seal device **13** closely come into contact with and slide on both the side faces and the upper face of the rail **4**. Due to the foregoing, foreign objects such as dust can be prevented from getting into the slider **10** from the surface of the rail **4**.

[0053] **FIGS. 9 and 10** are a partially cutaway perspective view and lateral sectional view showing a composition of the guide device from which the seal device **13** is removed. The cross section of the rail **4** is formed into a substantial rectangle. Four ball running grooves **4***a*, **4***b*, in which the balls **20** are running, are formed in the longitudinal direction. These ball running grooves **4***a*, **4***b* are formed on both side faces and at both edge portions on the upper face of the rail **4**. The ball running grooves **4***a* located on both side faces are formed downward by the angle of about 30 with respect to the lateral direction on the surface of **FIG. 9**. On the other hand, the ball running grooves **4***b* on the upper face are formed upward in the vertical direction.

[0054] The slider **10** includes: a block **11** having an attaching face **21**, onto which the movable body such as a table is attached, and tap holes **22** in which bolts for fixing the movable body are screwed; and a pair of end plates **12**, **12** attached (fixed) to both end portions of the block **11**. When the end plates **12**, **12** are attached, an infinite circulating path for the balls **20** is composed in the slider **10**.

[0055] The block **11** includes: a horizontal portion **11***a* on which the attaching face **21** is formed; and a pair of skirt portions **11***b*, lib which are hanging from the horizontal portion **11***a*. The cross section of the block **11** is substantially formed into a saddle. On the lower face side of the horizontal portion **11***a* and on the inside of each skirt portion **11***b*, four straight load running grooves **11***c*, **11***d*, which are opposed to the ball running grooves **4***a*, **4***b* of the rail **4**, are formed. In the horizontal portion **11***a* and each skirt portion **11***b*, the ball returning holes lie, **11***f* respectively corresponding to the load running grooves **11***c*, **11***d* are formed. By the U-shaped direction converting paths formed on the end plates **12**, **12**, the load running grooves **11***c*, **11***d* and the corresponding ball returning holes lie, **11***f* are connected with each other, so that the infinite circulating path of the balls can be formed.

[0056] Due to the foregoing, the balls **20** are running as follows. The balls **20**, which bear a load between the ball running grooves **4***a*, **4***b* of the rail **4** and the load running grooves **11***c*, **11***d* of the block **11**, run in the load running grooves **11***c*, **11***d* according to the movement of the slider **10** and are released from the load. Then the balls **20** get into the direction converting path formed on one end plate **12** and run in the opposite direction to the running direction of the load running grooves **11***c*, **11***d* while no load is being given to the balls **20**. In this way, the balls **20** run in the ball returning holes lie, **11***f* formed in the block **11**. After the balls **20** have run in the ball returning holes **11***e*, **11***f*, they get between the rail **4** and the block **11** again via the direction converting path formed on the other end plate **12**. Then, while the balls **20** are bearing a load, they run in the load running grooves **11***c*, **11***d*.

[0057] The above-described guide device is an example of the guide device into which the seal device of the present invention is incorporated. Therefore, the guide device of the present invention is not limited to the above specific example. After all, as far as the guide device is composed in such a manner that the slider is arranged striding over a straight and/or curved rail and guided along the rail and the seal device of the present invention is fixed to the end portion of the slider, it is possible to exhibit a sealing function by which foreign objects such as dust can be prevented from getting into the slider.

[0058] In the seal device of the above structure, two seal members **2-1**, **2-2** are arranged while the isolation plate **3** is being interposed between them. However, the number of the seal members is not limited to two, that is, not less than three seal members may be arranged. The isolation plate **3** is not necessarily required. In the case where each seal member can be smoothly moved even when the seal members **2-1**, **2-2** are contacted with each other, the isolation plate **3** may be omitted. In the above example, the elastic members **8-1**, **8-2** are respectively arranged on both side portions of the seal members **2-1**, **2-2** integrally with the seal members **2-1**, **2-2**. However, the elastic members **8-1**, **8-2** are not necessarily arranged integrally with the seal members **2-1**, **2-2**. As far as each seal member **2-1**, **2-2** can be individually pushed toward the rail **4**, the elastic members **8-1**, **8-2** may be composed separately from the seal members **2-1**, **2-2**.

[0059] The elastic members are not necessarily formed separately from the seal members **2-1**, **2-2**. The following structure may be adopted. When the seal members **2-1**, **2-2** are made of elastic material, the inner circumferential face **6-1***a*, **6-2***a* on one side can be always contacted with the outer circumferential face of the rail by the elastic extension and contraction caused between the one side of the seal members **2-1**, **2-2** and the inner circumferential faces **6-1***a*, **6-2***a* on one side even if the rail width is changed. Further, the following structure may be adopted. For example, as shown in **FIG. 11, a** predetermined shape of hole **23** is formed in the seal member **2-1**. Since the shape of the hole **23** can be deformed, the inner circumferential face **6-1***a* on one side composing the seal portion of the recess portion **6-1** can be always contacted with the outer circumferential face of the rail even if the rail width is changed. Although not shown in the drawing, the situations are the same in the case of the seal member **2-2**.

[0060] **FIG. 12** is an exploded perspective view showing an example of the arrangement of the seal device of the guide device of the present invention. As shown in the drawing, the seal device **30** includes: a casing **31**; a plurality of (three in the case shown in the drawing) plate-shaped seal members **32-1**, **32-2**, **32-3**; and two isolation plates **33-1**, **33-2** interposed between the seal member **32-1** and the seal member **32-2** and between the seal member **32-2** and the seal member **32-3**. The seal members **32-1**, **32-2**, **32-3** and the isolation plates **33-1**, **33-2** are superposed to each other and accommodated in the casing **31**. As shown in FIGS. **13**(*a*) and **13**(*b*), the seal members **32-1**, **32-2**, **32-3** and the isolation plates **33-1**, **33-2** are attached (fixed) to both side bottom portions of the block **11** of the slider **10** by screws **34**. The seal members **32-1**, **32-2**, **32-3** are pushed onto the sides of the rail **4** by the elastic members, and the sides are slidably contacted with the side faces of the rail **4** as described later. **FIG. 13**(*a*) is a lateral sectional view of the rail **4** and slider **10** of the guide device, and **FIG. 13**(*b*) is an enlarged sectional view of the neighborhood portion of the seal device **30**.

[0061] The side **32-1***a* of the seal member **32-1** slidably coming into contact with the side of the rail **4** is formed into a convex (an arcuate shape) of a predetermined radius of curvature, the side **32-2***a* of the seal member **32-2** slidably coming into contact with the side of the rail **4** is formed into a straight shape, and further the side **32-3***a* of the seal member **32-3** slidably coming into contact with the side of the rail **4** is formed into a concave (an arcuate shape) of a predetermined radius of curvature. On the sides of the seal members **32-1**, **32-2**, **32-3** arranged on the side opposite to the rail **4**, the elastic members **35-1**, **35-1**, **35-2**, **35-2**, **35-3**, **35-3** are respectively integrally arranged. When the thus composed seal device **30** is attached to both side bottom portions of the block **11** of the slider **10**, the seal members **32-1**, **32-2**, **32-3** are pushed by the elastic members **35-1**, **35-1**, **35-2**, **35-2**, **35-3**, **35-3**.

[0062] Since the side **32-1***a* of the seal member **32-1** is formed into a convex (an arcuate shape) of a predetermined radius of curvature, the side **32-2***a* of the seal member **32-2** is formed into a straight shape, and further the side **32-3***a* of the seal member **32-3** is formed into a concave (an arcuate shape) of a predetermined radius of curvature, in a portion where the rail **4** is curved convex by a predetermined radius of curvature as shown in **FIG. 14**(*a*), the side **32-1***a* of the seal member **32-1** closely comes into contact with the side of the rail **4** so as compose the seal portion. In a portion where the rail **4** is curved concave by a predetermined radius of curvature as shown in **FIG. 14**(*b*), the side **32-3***a* of the seal member **32-3** closely comes into contact with the side of the rail **4** so as compose the seal portion. In a portion where the rail **4** is straight as shown in **FIG. 14**(*c*), the side **32-2***a* of the seal member **32-2** closely comes into contact with the side of the rail **4** so as compose the seal portion.

[0063] In the case where the rail **4** snakes as shown in **FIG. 15**, the rail **4** is composed of curved portions **4-1**, **4-2** and a straight portion **4-3**, wherein the curved portions **4-1**, **4-2** are respectively formed into arcs, the radiuses of curvature of which are predetermined. Therefore, the convex (arcuate) side **32-1***a* of the seal member **32-1** and the concave (arcuate) side **32-3***a* of the seal member **32-3** are previously manufactured according to the radiuses of curvature of these curved portions **4-1**, **4-2**. Due to the foregoing, when the seal device **30** in which the seal members **32-1**, **32-2**, **32-3** are superposed as shown in **FIG. 12** is attached to both side bottom portions of the block **11** of the slider **10** as shown in **FIG. 13**, if the slider **10** is moved on the snaking rail **4**, either of the sides **32-1***a*, **32-2***a*, **32-3***a* of the seal members **32-1**, **32-2**, **32-3** closely comes into contact with the side of the rail **4**, so that the seal portion can be formed.

[0064] The seal members **32-1**, **32-2**, **32-3** can be made of the same material as that of the seal members **2-1**, **2-2**. The isolation plates **33-1**, **33-2** can be made of the same material as that of the above isolation plate **3**.

[0065] In the seal device **30** of the above structure, three seal members **32-1**, **32-2**, **32-3** are arranged while the isolation plates **33-1**, **33-2** are being interposed between them, however, the number of the seal members is not limited to three. That is, not less than three seal members maybe arranged. The isolation plates are not necessarily required. In the case where each seal member can be smoothly moved even when the seal members **32-1**, **32-2**, **32-3** are contacted with each other, the isolation plates may be omitted. In the above example, the elastic members **35-1**, **35-2**, **35-3** are respectively arranged on side portions of the seal members **32-1**, **32-2**, **32-3** integrally with the seal members **32-1**, **32-2**, **32-3**. However, the elastic members **35-1**, **35-2**, **35-3** are not necessarily arranged integrally with the seal members **32-1**, **32-2**, **32-3**. As far as each seal member **32-1**, **32-2**, **32-3** can be individually pushed toward the rail **4**, the elastic members **35-1**, **35-2**, **35-3** may be composed separately from the seal members **32-1**, **32-2**, **32-3**.

[0066] In the case of the guide device shown in **FIG. 15**, the rail **4** is snaking. However, for example, in the case where the rail **4** is annularly formed into an ellipse as shown in **FIG. 16**, the seal device located outside the annular rail **4** is the seal device **30** composed as shown in **FIG. 17**, and the seal device located inside the annular rail **4** is the seal device **30** composed as shown in **FIG. 18**. The seal device **30** shown in **FIG. 17** is composed in such a manner that the side **32-2***a* slidably coming into contact with the outer circumferential side face of the rail **4** is the straight seal member **32-2**, the isolation plate is the isolation plate **33-1**, and the side **32-3***a* slidably coming into contact with the outer circumferential side face of the rail **4** is the seal member **32-3** of a concave (arc) of a predetermined radius of curvature. The seal device **30** shown in **FIG. 18** is composed in such a manner that the side **32-2***a* slidably coming into contact with the inner circumferential side face of the rail **4** is the straight seal member **32-2**, the isolation plate is the isolation plate **33-1**, and the side **32-1***a* slidably coming into contact with the inner circumferential side face of the rail **4** is the seal member **32-1** of a convex (arc) of a predetermined radius of curvature.

[0067] As described above, the seal device **30** located outside the annular rail **4** is composed as shown in **FIG. 17**, and the seal device **30** located inside the annular rail **4** is composed as shown in **FIG. 18**. Due to the above structure, in the seal device **30** located outside, either the straight side **32-2***a* of the seal member **32-2** or the concave (arcuate) side **32-3***a* of the seal member **32-3** closely comes into contact with the outer circumferential side of the rail **4**, so that the seal portion can be formed. In the seal device **30** located inside, either the straight side **32-2***a* of the seal member **32-2** or the convex (arcuate) side **32-1***a* of the seal member **32-1** closely comes into contact with the inner circumferential side of the rail **4**, so that the seal portion can be formed. Accordingly, there is no possibility that foreign objects get into the slider **10** from the bottom side portion.

[0068] When the seal device **30** composed as shown in **FIG. 4** is arranged at both end portions of the slider **10** of the guide device and when the seal device **30** composed as shown in **FIG. 12** or the seal device **30** composed as shown in **FIGS. 17 and 18** is arranged at both side portions of the bottom portion of the slider **10**, it becomes possible to provide a guide device incorporated into a wood working machine used in a dusty environment in which both end portions and both side portions of the slider **10** are sealed so that no foreign objects can not get into the slider **10**.

[0069] As explained above, according to each aspects of the present invention, it is possible to provide the following excellent effects.

[0070] According to the first aspect of the invention, a plurality of seal members are arranged in the casing so that the phase of arranging the plurality of seal members can be alternately changed in such a manner that when a seal portion of one seal member is pushed by the elastic member and contacted with one side of the rail, a seal portion of the next seal member is pushed by the elastic member and contacted with the other side of the rail. Accordingly, the seal portions of the plurality of seal members (at least two seal members) conduct sealing while they are sliding on the outer circumferential face of the rail on which the slider moves. Therefore, it is possible to provide a perfect sealing function. Especially when the rail width is locally different, for example even when the width of a curved portion is smaller than the width of a straight portion, a difference in the width can be absorbed when the seal member is moved while being pushed by the elastic member. Therefore, the seal portion can be always contacted with the outer circumferential face of the guide rail. Accordingly, the sealing function is not impaired.

[0071] According to the second aspect of the invention, when the elastic member is formed in the outside portion of the seal member integrally with the seal member as described above, the number of parts composing the seal device can be decreased, and the assembling work can be easily performed.

[0072] According to the third aspect of the invention, the isolation plate is arranged between the seal members. Therefore, each seal member can be smoothly moved according to the rail width without interfering with the other seal members by the action of the elastic member, and the seal portion comes into contact with the outer circumferential face of the guide rail. Therefore, the sealing function can be effectively performed.

[0073] According to the fourth aspect of the invention, the side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex or concave of a predetermined radius of curvature, and the side of at least one seal member slidably coming into contact with the side of the rail is formed into the straight-line-shape. Therefore, in the straight portion of the rail, the straight side of the seal member closely comes into contact with the side of the rail, and in the curved portion of the seal member, the side of the seal member, which is formed into a convex or concave of a predetermined radius of curvature, closely comes into contact with the side of the rail, so that the seal portion can be formed. Therefore, even if the rail profile is changed from a straight shape to a curved shape, no foreign objects get into the slider from the side portion.

[0074] According to the fifth aspect of the invention, the side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex of a predetermined radius of curvature, and the side of at least one seal member slidably coming into contact with the side of the rail is formed into a concave of a predetermined radius of curvature, and further the side of at least one seal member slidably coming into contact with the side of the rail is formed into a straight shape. Due to the above structure, in the straight rail portion, the straight side of the seal member closely comes into contact with the rail side, so that the seal portion can be formed. In the curved rail portion, the convex side of the seal member of a predetermined radius of curvature or the concave side of the seal member closely comes into contact with the rail side, so that the seal portion can be formed. In the portion where the rail is curved in the other direction, the concave side of the seal member of a predetermined radius of curvature or the convex side of the seal member closely comes into contact with the rail side, so that the seal portion can be formed. Therefore, even if the rail is curved from a straight shape to a curved shape which is curved to either the right or the left, no foreign objects gets into the slider from the side portion of the slider.

[0075] According to the sixth aspect of the invention, the elastic members are formed on the outside of the seal members integrally with the seal members. Therefore, the number of parts composing the seal device can be reduced, and the assembling work can be easily performed.

[0076] According to the seventh aspect of the invention, the isolation plate is arranged between the seal members. Therefore, each seal member is pushed by the elastic member and smoothly moved according to the curved rail without interfering with the other seal members, and the side of the seal member comes into contact with the rail side. Therefore, the sealing function can be effectively performed.

[0077] According to the eighth aspect of the invention, when the seal device attached to both end portions of the slider is the seal device according to one of the first to third aspects and the seal device attached to both side portions is the seal device according to the fourth to seventh aspects, both end portions and both side portions of the slider are sealed. Accordingly, it becomes possible to provide a guide device, into the slider of which no foreign objects get.

What is claimed is:

1. A seal device for a guide device which is fixed to an end portion of a slider of the guide device so as to prevent foreign objects such as dust from getting into the seal device, the slider being arranged striding over a straight and/or curved rail and guided along the rail, the seal device comprising:

a casing;

a plurality of plate-shaped seal members accommodated in the casing; and

an elastic member for pushing the seal members onto the rail,

wherein each seal member has a recess portion in which the rail penetrates, an inner circumferential face of the recess portion includes a seal portion which comes into contact with an outer surface of the rail, and

wherein the plurality of seal members are arranged in the casing in such a manner that the seal members are pushed by the elastic member, the seal portion of one seal member comes into contact with one side of the rail, and the seal portion of the next seal member comes into contact with the other side of the rail.

2. A seal device for a guide device according to claim 1, wherein the elastic member is integrally formed on the outer periphery of each seal member.

3. A seal device for a guide device according to claim 1, further comprising an isolation plate arranged between the seal members.

4. A seal device for a guide device according to claim 2, further comprising an isolation plate arranged between the seal members.

5. A seal device for a guide device which is fixed to a side portion of a slider of the guide device so as to prevent foreign objects such as dust from getting into the seal device, the slider being arranged striding over a straight and/or curved rail and guided along the rail, the seal device comprising:

a casing;

a plurality of plate-shaped seal members accommodated in the casing; and

an elastic member for pushing the seal members onto the rail,

wherein a side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex or concave shape of a predetermined radius of curvature, a side of at least one seal member slidably coming into contact with the side of the rail is formed into a straight shape, and

wherein the seal members are pushed by the elastic member and at least one portion of the side of each seal member comes into contact with the side of the rail.

6. A seal device for a guide device which is fixed to a side portion of a slider of the guide device so as to prevent foreign objects such as dust from getting into the seal device,

the slider being arranged striding over a straight and/or curved rail and guided along the rail, the seal device comprising:

a casing;

a plurality of plate-shaped seal members accommodated in the casing; and

an elastic member for pushing the seal members onto the rail,

wherein a side of at least one seal member slidably coming into contact with the side of the rail is formed into a convex shape of a predetermined radius of curvature, a side of at least one seal member slidably coming into contact with the side of the rail is formed into a concave shape of a predetermined radius of curvature, and a side of at least one seal member slidably coming into contact with the side of the rail is formed into a straight shape, and

wherein the seal members are pushed by the elastic member and at least one portion of the side of each seal member comes into contact with the side of the rail.

7. A seal device for a guide device according to claim 5, wherein the elastic member is integrally formed on the outer periphery of each seal member.

8. A seal device for a guide device according to claim 6, wherein the elastic member is integrally formed on the outer periphery of each seal member.

9. A seal device for a guide device according to claim 5, further comprising an isolation plate arranged between the seal members.

10. A seal device for a guide device according to claim 6, further comprising an isolation plate arranged between the seal members.

11. A seal device for a guide device according to claim 7, further comprising an isolation plate arranged between the seal members.

12. A seal device for a guide device according to claim 8, further comprising an isolation plate arranged between the seal members.

13. A guide device comprising:

a straight and/or curved rail; and

a slider arranged striding over the rail, the slider having seal devices arranged at both end portions and both side portions respectively for preventing foreign objects from getting into the slider,

wherein the seal device attached to both end portions of the slider is the seal device described in one of claims 1 to 4, and the seal device attached to both side portions is the seal device described in one of claims 5 to 12.

* * * * *

US 20030039414A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2003/0039414 A1**

Niwa et al. (43) **Pub. Date: Feb. 27, 2003**

(54) **ROLLING ELEMENT SPACER IN ROLLING GUIDE DEVICE**

(75) Inventors: **Hiroshi Niwa**, Tokyo (JP); **Kentarou Nishimura**, Tokyo (JP); **Yasuyuki Abe**, Tokyo (JP); **Kiyomi Tamura**, Tokyo (JP)

Correspondence Address:
ARENT FOX KINTNER PLOTKIN & KAHN
1050 CONNECTICUT AVENUE, N.W.
SUITE 400
WASHINGTON, DC 20036 (US)

(73) Assignee: **THK CO., LTD**

(21) Appl. No.: **10/268,938**

(22) Filed: **Oct. 11, 2002**

Related U.S. Application Data

(62) Division of application No. 09/838,183, filed on Apr. 20, 2001.

(30) **Foreign Application Priority Data**

May 2, 2000 (JP) 133266/2000

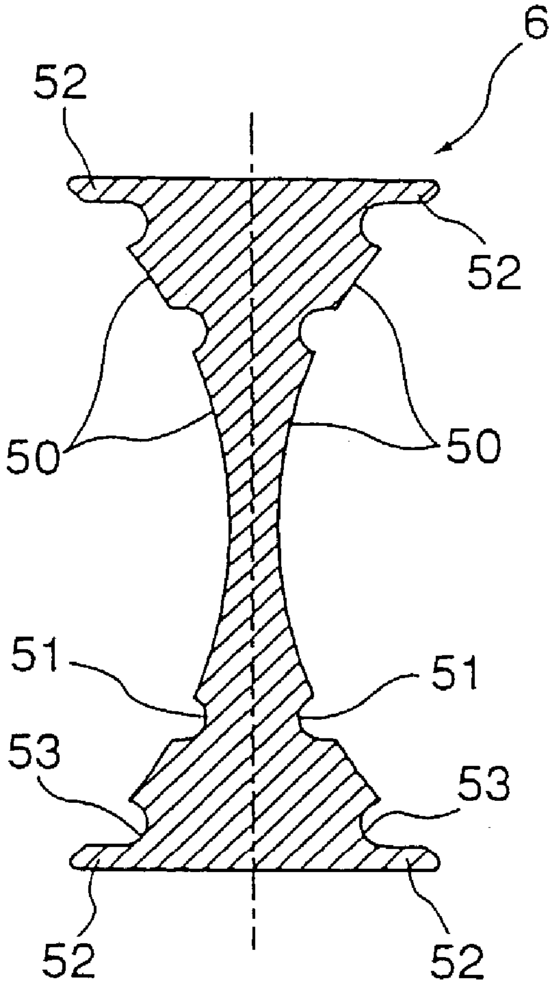
Publication Classification

(51) **Int. Cl.**[7] **F16C 19/00**; F16H 55/02; F16H 1/24; F16C 29/06

(52) **U.S. Cl.** **384/51**; 384/45; 74/424.88

(57) **ABSTRACT**

There is provided a rolling element spacer used in a rolling guide device having an endless circulation passage of balls, arranged alternately with many balls in the endless circulation passage, and circulating together with the balls in the endless circulation passage. It has a pair of ball holding seats each of which is formed in a concave spherical face form nearly approximating a spherical face of the ball and sliding-contacts with the ball and, around each ball holding seat, there is formed an annular dropout prevention portion protruding in a ball arranging direction than an edge portion of the ball holding seat and kept in non-contact with respect to the ball seated on the ball holding seat.



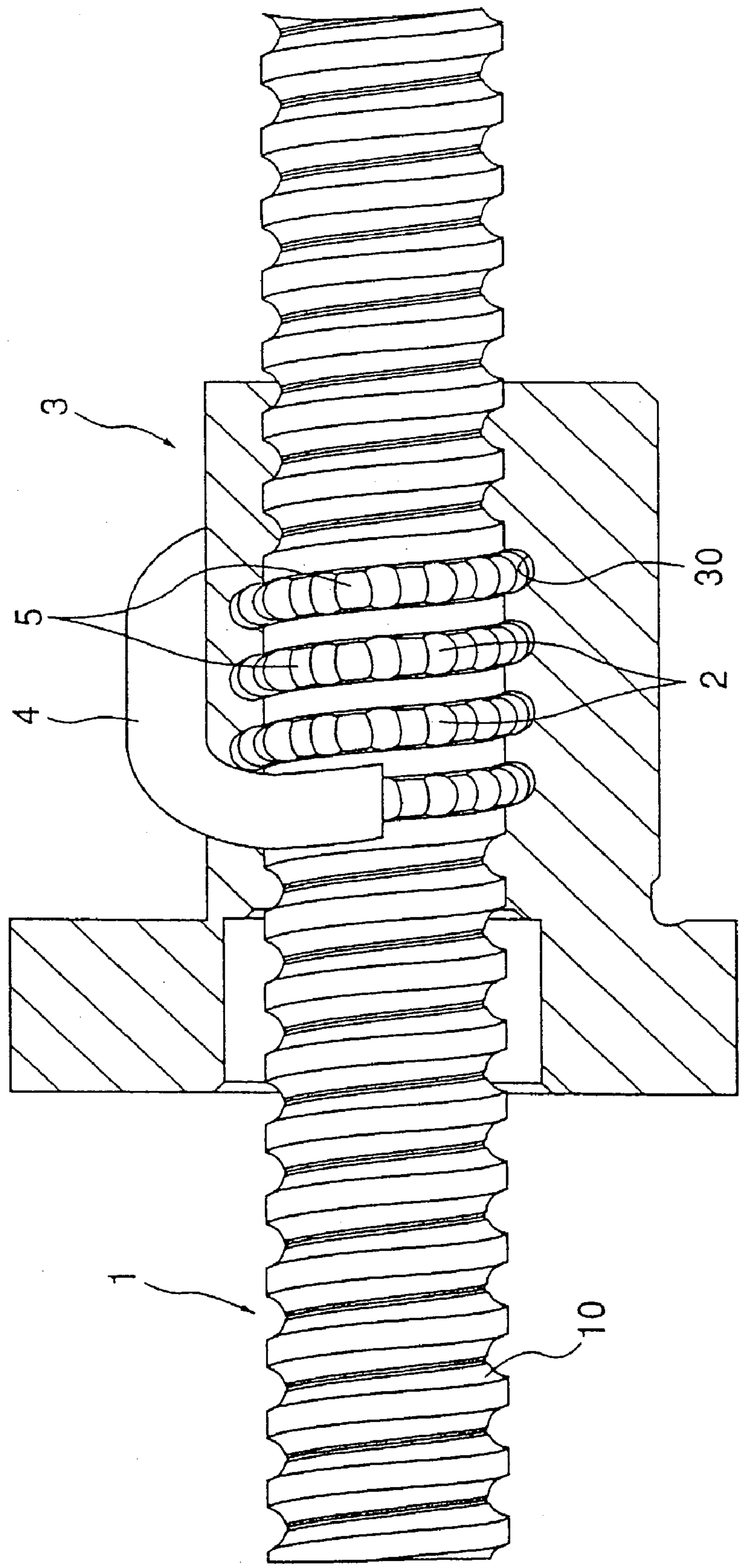


Fig.1

Fig.2

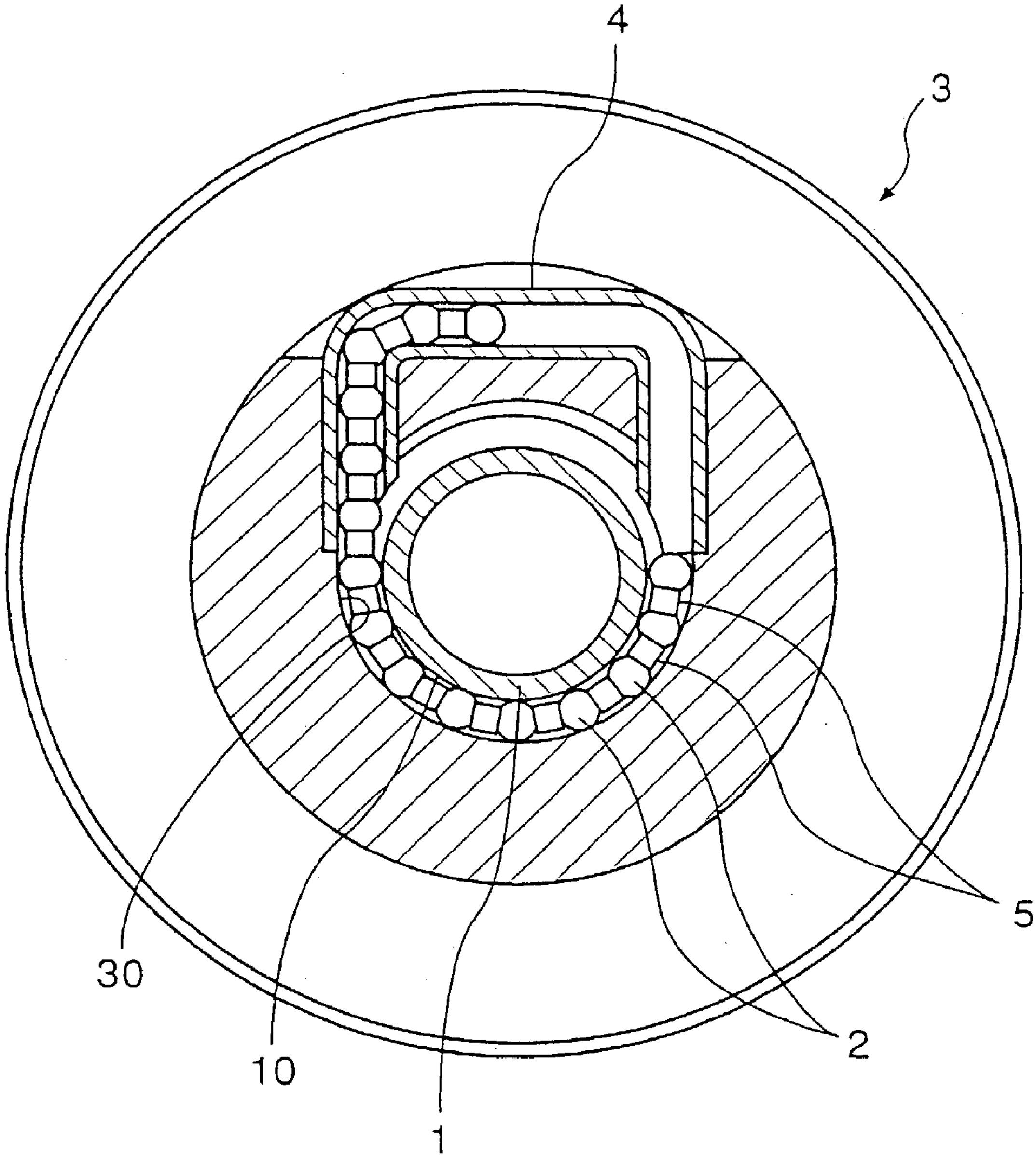


Fig.3

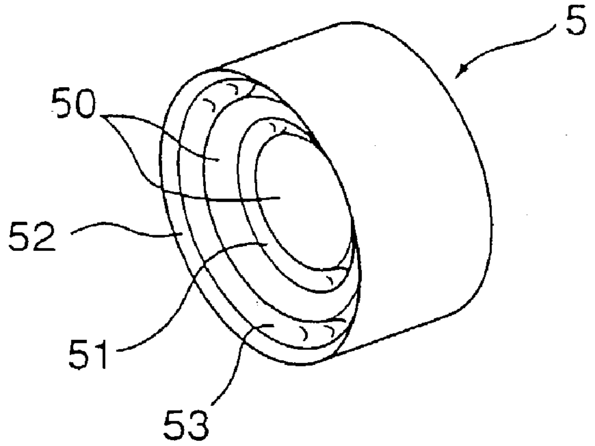


Fig.4

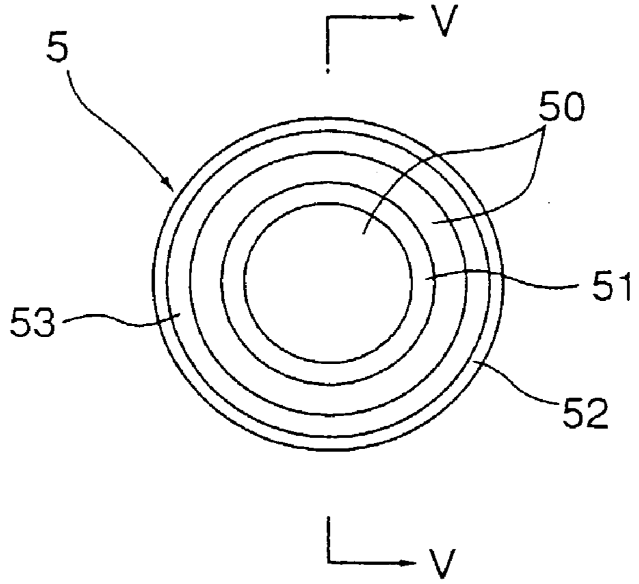


Fig.5

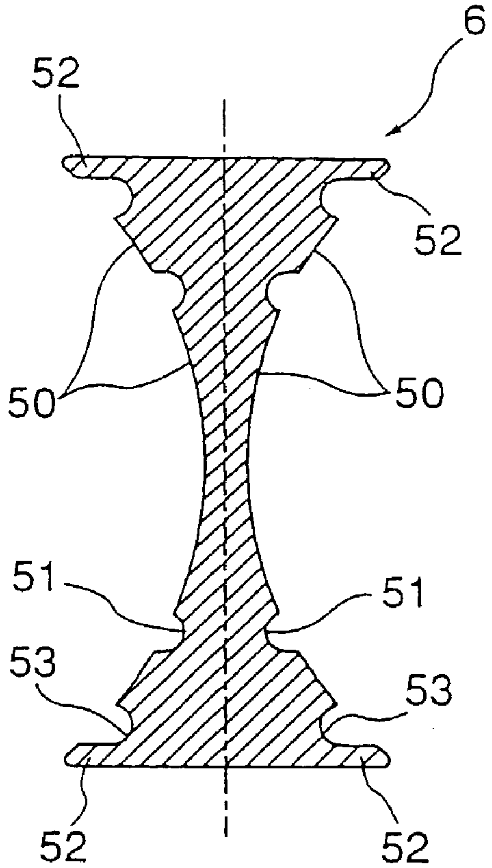


Fig.6

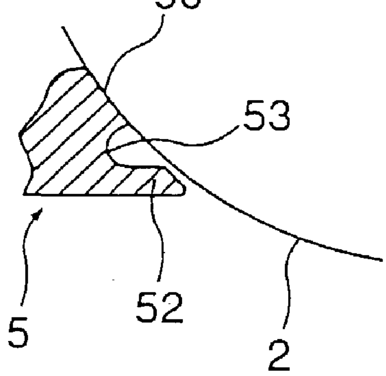


Fig.7

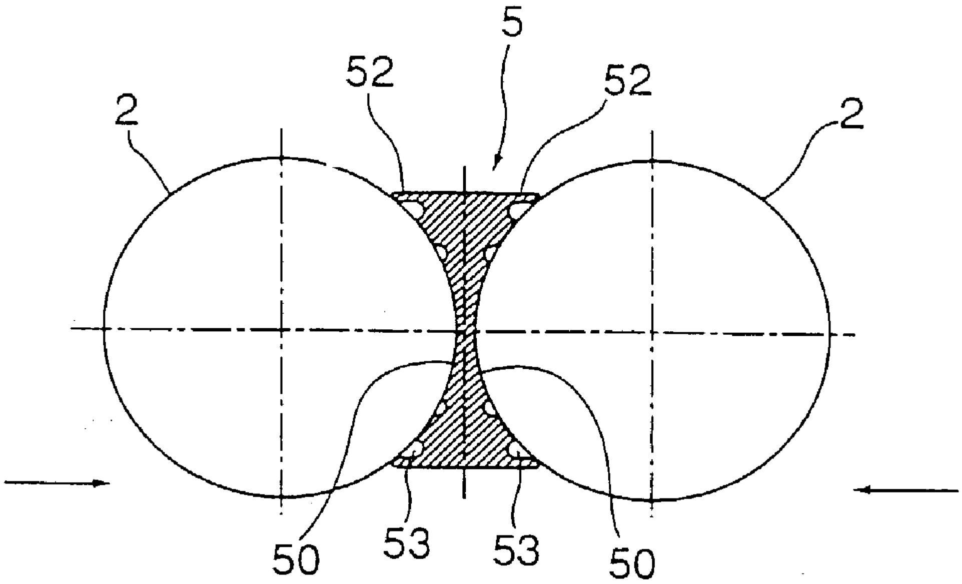


Fig.8

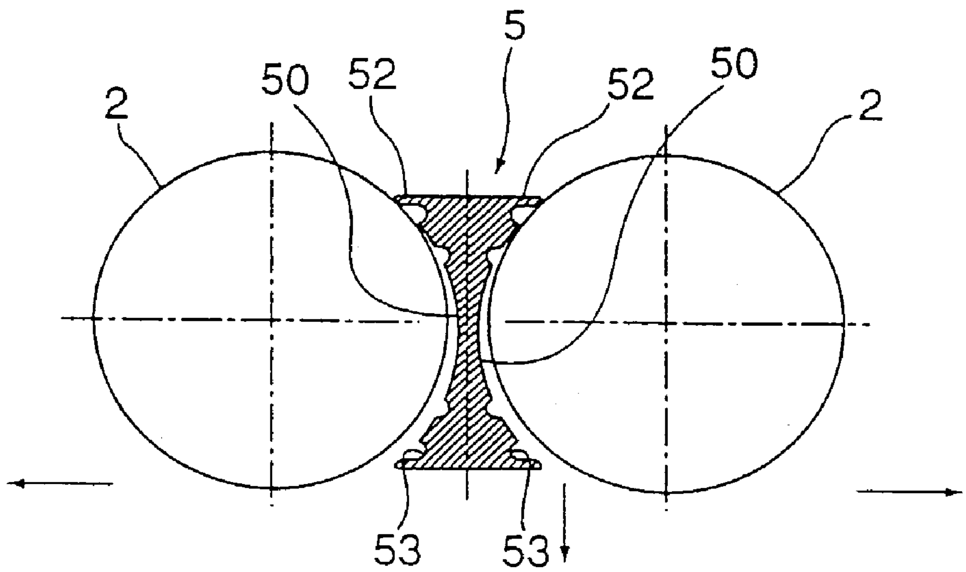


Fig.9

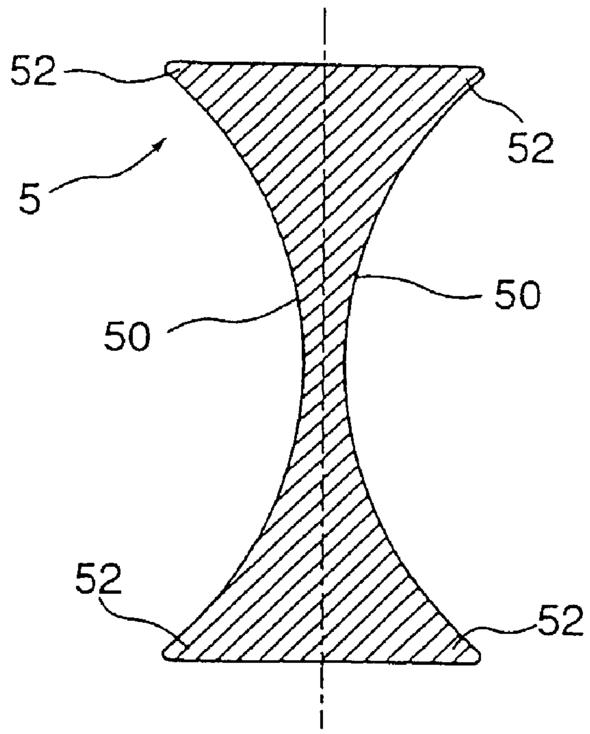


Fig.10

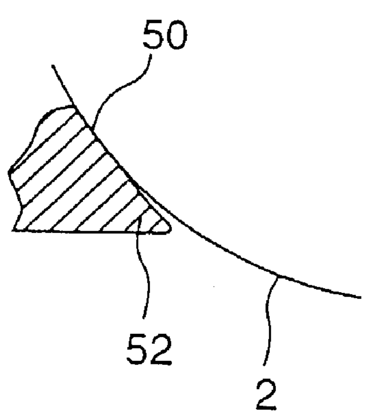
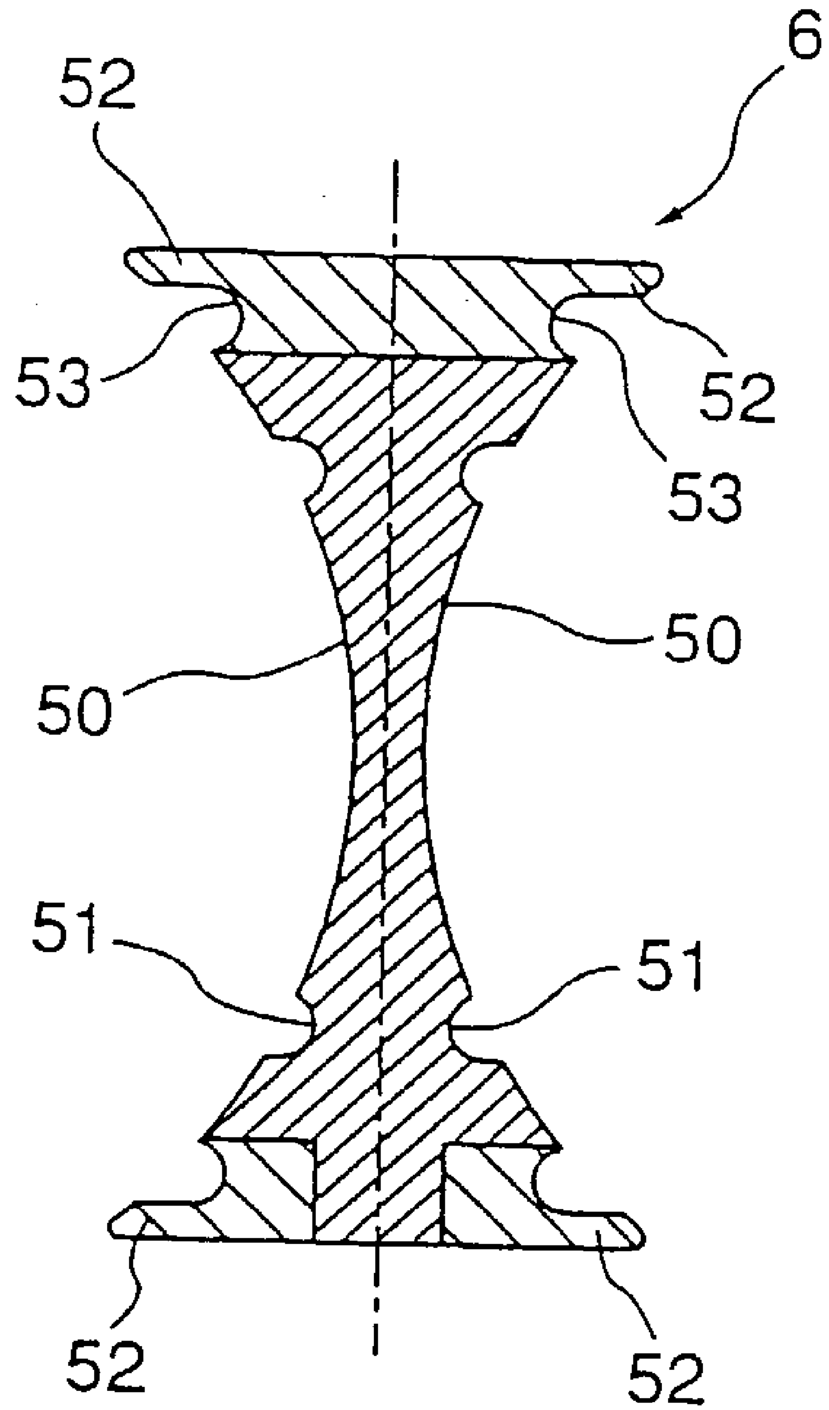


Fig. 11



ROLLING ELEMENT SPACER IN ROLLING GUIDE DEVICE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a rolling element spacer which, in various rolling guide devices each having an endless circulation passage for balls such as a linear guide device and a ball screw device, is interposed between the mutually adjoining balls in the endless circulation passage and reduces frictions between the balls and a heat generation to thereby smoothen the rolling thereof.

[0003] 2. Description of the Related Art

[0004] Hitherto, as a rolling guide device in which a pair of members continuously performing a relative motion through an endlessly circulating ball row, there have been known devices such as a linear guide device which is used in a linear guide portion in a machine tool, a carrying device and the like and which guides a movable body such as a table on a stationary portion such as a bed or a saddle, and a ball screw which is used together with this linear guide device and which gives a stroke of a linear motion corresponding to a rotation amount of a motor to the movable body.

[0005] The former linear guide device comprises a bearing rail which is disposed on the stationary portion and in which a rolling groove for the balls is formed along a longitudinal direction, and a sliding base which has a load rolling groove facing the rolling groove of the bearing rail through many balls and in which there is formed an endless circulation groove for the balls rolling on the load rolling groove, and it is constituted such that, in accompaniment with the endless circulation of the balls, the sliding base supporting the movable body continuously performs the linear motion along the bearing rail. Further, reversely to this, there is a case where it is constituted such that the bearing rail is moved relative to the fixed sliding base.

[0006] On the other hand, the latter ball screw comprises a screw shaft in which there is formed a spiral ball rolling groove with a predetermined lead, and a nut member which has a load rolling groove facing the ball rolling groove through many balls and in which there is formed an endless circulation passage for the balls rolling on the load rolling groove, and it is constituted such that, in accompaniment with a relative rotation motion between the screw shaft and the nut member, the balls circulate in the endless circulation passage, and the nut member and the screw shaft relatively move in an axial direction.

[0007] On the other hand, in such a rolling guide device, since the individual ball circulating in the endless circulation passage mutually contacts with the balls positioned before and after it, in case that it is used at a high speed, there have been such possibilities that, besides the fact that the balls are worn in relatively short time by a friction between the balls for instance, there arises a disadvantage such as the fact that the ball or the load rolling groove generates a seizure owing to a friction heat. Further, when reversing a motion direction, i.e., when reversing a circulation direction, an arrangement of the balls in the endless circulation passage is liable to be disturbed and, in an extreme case, there arises a so-called lock phenomenon in which the balls clog in the endless circulation passage, so that there has been a possibilities that the rolling guide device itself becomes impossible to operate. Therefore, as one for solving such drawbacks, in Japanese Patent Laid-Open No. 315835/1999 Gazette, there is disclosed a rolling guide device in which a rolling element spacer is interposed between the balls mutually adjoining in the endless circulation passage.

[0008] In the rolling guide device disclosed in the above Gazette, it is adapted such that a synthetic resin made rolling element spacer referred to as separator is arranged alternately with the ball in the endless circulation passage, thereby preventing the balls from mutually contacting. Such a separator is formed in a disk-like form whose outer diameter is smaller than a diameter of the ball and, in its both front/rear faces contacting with the balls, there are formed ball holding seats whose curvatures are larger than a curvature of a spherical face of the ball. By this, if the ball and the separator are alternately arranged without a gap in the endless circulation passage, each ball becomes a state of being sandwiched by a pair of separators adjoining before and after it, so that it circulates in the endless circulation passage together with the separators without disturbing a row even when reversing the circulation direction.

[0009] However, like the rolling element spacer shown in the Japanese Patent Laid-Open No. 315835/1999 Gazette, if the ball holding seat which sliding-contacts with the ball is formed in a concave curved face form whose curvature is larger than the spherical face of the ball, since a gap is formed between a peripheral edge portion of the ball holding seat and the ball, the ball rocks with respect to the rolling element spacer, so that there is a problem that it is impossible to completely eliminate a meander of the balls in the endless circulation passage.

[0010] On the other hand, from a viewpoint of preventing the meander of the balls in the endless circulation passage, it is necessary that the ball settles on the ball holding seat of the rolling element spacer without rocking, and therefor it is necessary that ball holding seat is formed in a concave spherical face form nearly approximating the spherical face of the ball. However, in case that the ball holding seat is formed in such a concave spherical face form, a contact area between the ball and the ball holding seat becomes large, so that there are possibilities of an increase in sliding contact resistance of the rolling element spacer with respect to the ball, a premature wear of the rolling element spacer, and the like.

[0011] Further, in case that the ball holding seat is designed such that its diameter is small in order to avoid the increase in sliding contact resistance with respect to the ball, there has been a disadvantage that the rolling element spacer falls out from between the mutually adjoining balls even if a slight gap is generated between the ball and the rolling element spacer.

SUMMARY OF THE INVENTION

[0012] The invention has been made in view of such a problem, and its object is to provide a rolling element spacer which makes a sitting of the ball with respect to the ball holding seat good to thereby intend to stabilize an alignment of the balls and the rolling element spacers in the endless circulation passage, can reduce the sliding contact resistance acting to the ball, and can effectively prevent the rolling element spacer from falling out from between the balls.

[0013] In order to achieve the above object, the invention provides a rolling element spacer used in a rolling guide device in which a pair of members perform a relative continuous motion through an endlessly circulating ball row, interposed between balls mutually adjoining in its endless circulation passage, and circulating together with the balls, characterized in that it has a pair of ball holding seats each of which is formed in a concave spherical face form nearly approximating a spherical face of the ball and sliding-contacts with the ball and, around each ball holding seat, there is formed an annular dropout prevention portion protruding in a ball arranging direction than an edge portion of the ball holding seat and kept in non-contact with respect to the ball seated on the ball holding seat.

[0014] According to such a technical means, since the ball folding seat with which the ball sliding-contacts is formed in the concave spherical face form nearly approximating the spherical face of the ball, a gap is scarcely formed between the spherical face of the ball and the ball holding seat, so that the siting of the ball with respect to the ball holding seat is stabilized. Therefore, in case that the rolling element spacers and the balls are alternately arranged in the endless circulation passage of the rolling guide device, it is intended to stabilize the alignment of the balls and the rolling element spacers, so that it become possible to prevent a meander of the balls in the endless circulation passage.

[0015] Further, since the annular dropout prevention portion kept in non-contact with respect to the ball is formed around the ball holding seat and the dropout prevention portion protrudes in the ball arranging direction than the edge portion of the ball holding seat, even if a gap is generated between the ball and the rolling element spacer and thus the rolling element spacer becomes likely to fall out from between the mutually adjoining balls, it becomes possible to prevent beforehand a dropout accident of the rolling element spacer by the fact that the dropout prevention portion engages with the ball. Accordingly, since a diameter of the ball holding seat can be determined irrespective of the dropout of the rolling element spacer and thus the ball holding seat can be formed in a size as minimum as necessary, it becomes possible to make a contact area between the ball holding seat and the ball small, thereby reducing the sliding contact resistance acting to the ball. Further, since the dropout prevention portion is kept in non-contact with respect to the ball under a state that the ball seats on the ball holding seat, there is no case that the sliding contact resistance acting to the ball increases, by the fact that the dropout prevention portion is provided.

[0016] In case that the ball holding seat is formed in the concave spherical face form nearly approximating the spherical face of the ball, since a peripheral edge portion of the ball holding seat contacts with the spherical face of the ball, a lubricant adhered on the ball is scraped by the peripheral edge portion, so that the ball is liable to come into a state of insufficient lubrication. However, according to the rolling element spacer of the invention, since the dropout prevention portion provided around the ball holding seat is kept in non-contact with the spherical face of the ball, the lubricant is liable to enter into the gap between the dropout prevention portion and the ball, so that a lubricating state of the ball can be maintained well even in case that the ball holding seat is formed in the concave spherical face form nearly approximating the spherical face of the ball. Accordingly, from a viewpoint of making a holding state of the lubricant in the rolling element spacer of the invention further good, it is preferable to form an annular groove between the ball holding seat and the dropout prevention portion surrounding it and utilize this annular groove as a lubricant sump. If constituted in this manner, since the lubricant flowing into the gap between the ball and the dropout prevention portion is stored in the annular groove, it becomes possible to always apply the lubricant to a surface of the ball.

[0017] On the other hand, in the endless circulation passage of the rolling guide device, since it is difficult to completely eliminate a gap between the ball and the rolling element spacer, it follows that the rolling element spacer and the ball are repeating collisions bit by bit during a circulation of the balls. Therefore, from a viewpoint of reducing a fatigue and decreasing a collision noise of the balls owing to such collisions, it is preferable that the ball holding seat with which the ball sliding-contacts is formed of a suitably soft material. In contrast to this, since the dropout prevention portion is one for preventing the rolling element spacer from falling out from between the mutually adjoining balls, it must not be easily deformed by being pushed by the ball in case that such a situation occurs, so that it is preferable that it is formed of a hard material. Accordingly, from such a viewpoint, it is preferable that the ball holding seat and the dropout prevention portion provided in the rolling element spacer of the invention are molded respectively by different resin materials, and the dropout prevention portion is molded by the resin material harder than the ball holding seat.

[0018] Incidentally, the dropout prevention portion may be formed in a continuous annular form, but the dropout prevention portion may be made by providing a protrusion separated by a slit in the annular form.

[0019] As explained above, according to the rolling element spacer of the invention, since each of a pair of ball holding seats with which the balls sliding-contact is formed in the concave spherical face form nearly approximating the spherical face of the ball and, around each ball holding seat, there is formed the annular dropout prevention portion protruding in the ball arranging direction than the edge portion of the ball holding seat and kept in non-contact with respect to the ball seated on the ball holding seat, it is possible to intend to stabilize the alignment of the balls and the rolling element spacers in the endless circulation passage while making the sitting of the ball with respect to the ball holding seat good and intend to decrease the sliding contact resistance acting to the ball, and additionally it becomes possible to effectively prevent the rolling element spacer from falling out from between the balls.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] **FIG. 1** is a side sectional view showing one embodiment of a ball screw device in which rolling element spacers of the invention are arranged together with balls in an endless circulation passage;

[0021] **FIG. 2** is a front sectional view of the ball screw device shown in **FIG. 1**;

[0022] **FIG. 3** is a perspective view showing a 1st embodiment of the rolling element spacer of the invention;

[0023] **FIG. 4** is a front view showing the rolling element spacer according to the 1st embodiment;

[0024] **FIG. 5** is a sectional view along a V-V line in **FIG. 4**;

[0025] **FIG. 6** is an enlarged sectional view showing a relation between a dropout prevention portion of the rolling element spacer according to the 1st embodiment and a ball;

[0026] **FIG. 7** is sectional view showing a state that the balls seat on ball holding seats of the rolling element spacer according to the 1st embodiment;

[0027] **FIG. 8** is a sectional view showing a state that the balls float from the ball holding seats of the rolling element spacer according to the 1st embodiment;

[0028] **FIG. 9** is a sectional view showing an example in which an annular groove and a lubricating oil sump are omitted from the rolling element spacer according to the 1st embodiment;

[0029] **FIG. 10** is an enlarged sectional view showing a relation between the dropout prevention portion of the rolling element spacer shown in **FIG. 9** and the ball; and

[0030] **FIG. 11** is a sectional view showing a 2nd embodiment of the rolling element spacer of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0031] Hereunder, a rolling element spacer of the invention is detailedly explained on the basis of the drawings.

[0032] **FIG. 1** and **FIG. 2** show one embodiment of a ball screw device in which the rolling element spacers of the invention are arranged together with balls in an endless circulation passage. In these drawings, the reference numeral i denotes a screw shaft, the reference numeral **2** a ball and the reference numeral **3** a nut member, and the nut member **3** meshes with the screw shaft **1** through many balls **2**.

[0033] A spiral ball rolling groove **10** is formed in an outer periphery face of the screw shaft **1**, while a spiral load rolling groove **30** facing the ball rolling groove **10** of the screw shaft **1** is formed in an inner periphery face of the nut member **3**, and the ball rolling groove **10** and the load rolling grove **30** form a spiral load ball passage between the screw shaft **1** and the nut member **3**. That is, if a relative rotary motion occurs between the screw shaft land the nut member **3**, the ball **2** spirally rolls in the load ball passage while bearing a load. Further, a return pipe **4** mutually communicating both ends of the load ball passage to thereby constitute the endless circulation passage for the balls **2** is attached to the nut member **3**, so that the ball **2** having finished rolling in the load ball passage and having been released from the load becomes a no-load state and rolls in the return pipe **4**, and is returned to an inlet of the load ball passage while jumping the ball rolling groove **10** by several turns. Accordingly, if the screw shaft **1** and the nut member **3** are relatively rotated, it follows that the ball **2** rolls from the load ball passage to the return pipe **4** and from the return pipe **4** to the load ball passage, and is circulated inside the endless circulation passage constituted by the load ball passage and the return pipe **4**.

[0034] In this ball screw device, in order to prevent the balls **2** incorporated in the endless circulation passage from mutually contacting, a rolling element spacer **5** is interposed between the mutually adjoining balls **2**, **2**. As shown in **FIG. 3** to **FIG. 5**, the rolling element spacer **5** is formed by deforming a synthetic resin into an approximately disk form and, in its both front/rear faces, there are respectively formed ball holding seats **50** with which the balls **2** sliding-contact. The ball **2** and the rolling element spacer **5** are alternately arranged in the endless circulation passage. By this, it is adapted such that the balls **2** rolling in the endless circulation passage are prevented from mutually contacting, a smooth circulation of the ball and, in turn, smoothening of the rotary motion of the nut member **3** relative to the screw shaft **1** are intended, and additionally a generation of noise owing to a collision between the balls during an operation of the ball screw device is reduced.

[0035] The ball holding seat **50** is formed in a concave spherical face form nearly approximating a spherical face of the ball **2**, and it is constituted such that the adjoining ball **2** contacts with the ball holding seat **50** almost without a gap. Further, an annular lubricating oil sump **51** is formed in the ball holding seat **50**, and it is adapted such that a lubrication between the ball holding seat **50** and the ball **2** is intended. Further an annular dropout prevention portion **52** is formed around the ball holding seat **50** so as to surround the ball holding seat **50**. A tip of the dropout prevention portion **52** protrudes than an edge portion of the ball holding seat **50** with respect to a arranging direction of the balls **2** (horizontal direction in **FIG. 5**). However, as shown in **FIG. 6**, it is adapted such that, under a state that the ball **2** seats on the ball holding seat **50**, a gap is formed between the ball **2** and the tip of the dropout prevention portion **52**. Additionally, between the dropout prevention portion **52** and the ball holding seat **50**, there is formed an annular groove **53** separating them, and it is adapted such that the annular groove **53** functions as a lubricating oil sump.

[0036] **FIG. 7** shows a state that the balls **2** seat on the ball holding seats **50** of the rolling element spacer **5**. As mentioned before, since the ball holding seat **50** is formed in the concave spherical face form nearly approximating the spherical face of the ball **2**, the seated ball **2** contacts with the ball holding seat **50** almost without the gap as shown in this drawing. By this, in case that the balls **2** and the rolling element spacers **50** are arranged without gaps in the endless circulation passage of the ball screw device, the balls **2** don't rock unstably on the ball holding seats **50** of the rolling element spacers **5**, so that the balls **2** and the rolling element spacers **5** can be circulated without meandering in the endless circulation passage.

[0037] Further, since the dropout prevention portion **52** formed around the ball holding seat **50** does not contact with the ball **2** seated on the ball holding seat **50**, it follows that a lubricant such as grease adhered on the ball **2** enters into the annular groove **53** from a gap between the dropout prevention portion **52** and the spherical face of the ball **2** and is collected in the annular groove **53**. Therefore, the lubricant is liable to be drawn between the ball **2** and the ball holding seat **50** which mutually sliding-contact, so that it is possible to surely lubricate between the ball **2** and the rolling element spacer **5** and, besides, the lubricant becomes liable to adhere also to a surface, of the ball **2**, moving outside after passing the annular groove **53**, so that it becomes possible to surely lubricate between the ball **2** and the rolling groove **10** of the ball screw device.

[0038] On the other hand, **FIG. 8** shows a state that a gap between the mutually adjoining balls **2** increases during circulating in the endless circulation passage, and thus the balls **2** float from the ball holding seats **50** of the rolling element spacer **5**. Such a state occurs somewhere in the endless circulation passage because it is difficult to arrange the balls **2** and the rolling element spacers **5** without gaps relative to the endless circulation passage of the ball screw device for instance, and the ball **2** and the rolling element spacer **5** wear during being used for a long time. And, if the balls **2** float from the ball holding seats **50** in the above manner, the rolling element spacer **5** sandwiched by the balls **2** from both sides loses its support and attempts to fall out from between the balls **2**. However, in the rolling element spacer **5** of this embodiment, since the tip of the dropout prevention portion **52** protrudes than the edge portion of the ball holding seat **50** with respect to the arranging direction of the balls **2**, if the rolling element spacer **5** becomes likely to drop out from between the mutually adjoining balls **2**, the dropout prevention portions **52** having been in a non-contacting state up to that time engage with the balls **2**, thereby acting so as to prevent the rolling element spacer **5** from falling out from between the balls **2**. Accordingly, in the rolling element spacer **5** of this embodiment, it is unnecessary to set a diameter of the ball holding seat **50** uselessly large for the purpose of dropout prevention from between the balls **2**, so that the ball holding seat **50** can be formed in a size as minimum as necessary. Therefore, a contact area between the ball **2** and the ball holding seat **50** can be made small, so that a sliding contact resistance of the ball **2** with respect to the rolling element spacer **5** can be reduced correspondingly. From a viewpoint of the ball screw device in which the rolling element spacers **5** are arranged in the endless circulation passage, this fact leads to an achievement of a motion whose torque fluctuation is little and which is smooth.

[0039] Incidentally, in the rolling element spacer **5** of the aforesaid 1st embodiment, the annular groove **53** is formed between the ball holding seat **50** and the dropout prevention portion **52**, and the annular lubricating oil sump **51** is formed in the ball holding seat **50** but, as shown in **FIG. 9**, the annular groove **53** and the lubricating oil sump **51** may be omitted in the invention. However, even in this case, as shown in **FIG. 10**, the dropout prevention portion **52** does not contact with the spherical face of the ball **2** seated on the ball holding seat **50**, and a gap is formed between the dropout prevention portion **52** and the spherical face of the ball **2**. By this, since the lubricant such as grease adhered on the ball **2** enters into the gap, the lubricant becomes liable to be drawn into between the ball **2** and the ball holding seat **50** which mutually sliding-contact although an amount of the lubricant held in the gap is reduced in comparison with a case in which the annular groove **53** is formed, so that it becomes possible to surely lubricate between the ball **2** and the rolling element spacer **5**.

[0040] **FIG. 11** shows a 2 nd embodiment of the rolling element spacer of the invention.

[0041] In the rolling element spacer **5** of the aforesaid 1st embodiment, the ball holding seat **50** and the dropout prevention portion **52** are injection-molded integrally from a single synthetic resin. However, in a rolling element spacer **6** of the 2nd embodiment, the ball holding seat **50** and the dropout prevention portion **52** are molded respectively by different synthetic resins. Incidentally, since other constitutions are common to the rolling element spacer **5** of the 1st embodiment, the same reference numerals as the 1st embodiment are affixed in **FIG. 11**, and detailed explanations thereof are omitted here.

[0042] Since the rolling element spacer performs a role of cushion between the mutually adjoining balls **2** to there by reduce generations of fatigue and noise of the balls **2** owing to a collision, it is preferable that the ball holding seat **50** is formed of a suitably soft material in order to be able to sufficiently exhibit this function. However, since the dropout prevention portion **52** is one which, in case that a spacing between the mutually adjoining balls **2** becomes increased, engages with the ball **2** to thereby prevent the rolling element spacer from falling out, it is preferable that it is formed of a hard material in order not to be deformed easily. Here, as an aim of selecting a resin material for molding the dropout prevention portion and the ball holding seat, a bending modulus of elasticity of such a synthetic resin can be made the aim. That is, this is because it is considered that a material whose bending modulus of elasticity is small deforms easily, while a material whose bending modulus of elasticity is large is difficult to deform.

[0043] Accordingly, according to the rolling element spacer **6** of the 2nd embodiment, the dropout prevention portion **52** can be molded by a hard synthetic resin in comparison with the ball holding seat **50**, so that it become possible to exhibit in maximum the functions of the respective portions.

What is claimed is:

1. A rolling element spacer used in a rolling guide device in which a pair of members perform a relative continuous motion through an endlessly circulating ball row, interposed between balls mutually adjoining in its endless circulation passage, and circulating together with the balls,

characterized in that it has a pair of ball holding seats each of which is formed in a concave spherical face form nearly approximating a spherical face of the ball and sliding-contacts with the ball, and

around each ball holding seat, there is formed an annular dropout prevention portion protruding in a ball arranging direction than an edge portion of the ball holding seat and kept in non-contact with respect to the ball seated on the ball holding seat.

2. A rolling element spacer set forth in claim 1, characterized in that an annular groove is formed between the ball holding seat and the dropout prevention portion, and the annular groove functions as a lubricating oil sump.

3. A rolling element spacer set forth in claim 1, characterized in that a lubricating oil sump is formed in the ball holding seat.

4. A rolling element spacer set forth in claim 1, characterized in that the ball holding seat and the dropout prevention portion are molded by different resin materials, and the dropout prevention portion is molded by the resin material harder than the ball holding seat.

* * * * *

US 20020136472A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2002/0136472 A1**

Mochizuki et al. (43) **Pub. Date: Sep. 26, 2002**

(54) **LINEAR MOTION GUIDE DEVICE**

(76) Inventors: **Hiroaki Mochizuki**, Yamanashi-ken (JP); **Hiroshi Takamatsu**, Yamanashi-ken (JP)

Correspondence Address:
ARMSTRONG,WESTERMAN & HATTORI, LLP
1725 K STREET, NW.
SUITE 1000
WASHINGTON, DC 20006 (US)

(21) Appl. No.: **09/926,759**

(22) PCT Filed: **May 25, 2001**

(86) PCT No.: **PCT/JP01/04403**

(30) **Foreign Application Priority Data**

May 29, 2000 (JP) 2000-157728
May 23, 2001 (JP) 2001-153444

Publication Classification

(51) **Int. Cl.**[7] **F16C 29/06**
(52) **U.S. Cl.** **384/45**

(57) **ABSTRACT**

A linear motion guide device having a long scale can be easily manufactured, and there is provided a motion guide device capable of preventing thin and long-scaled support member and escape passage constituting member from being flexed and preventing an inner periphery guide section constituting member from being opened. Support members **11, 12, 13** for preventing rolling members from coming off from loaded rolling member rolling passages **4***d*, **4***d* at a time of removing a movable block **2** from a track rail **1,** escape passage constituting members **14, 14** constituting escape passages and the inner periphery guide section constituting members **15***a*, **15***b* constituting inner periphery guide section for direction changing of the rolling members are formed of resin so as to be respectively independent from the block body **4** and from each other, these members can be manufactured by preliminarily calculating respective shrinkage cavities of the support members **11, 12, 13,** the escape passage constituting members **14, 14** and the inner periphery guide section constituting members **15***a*, **15***b*. As a result, the long and thin support members **11, 12, 13** and escape passage constituting members **14, 14** can be prevented from being flexed, and the inner periphery guide section constituting members **15***a*, **15***b* can be also prevented from being opened.

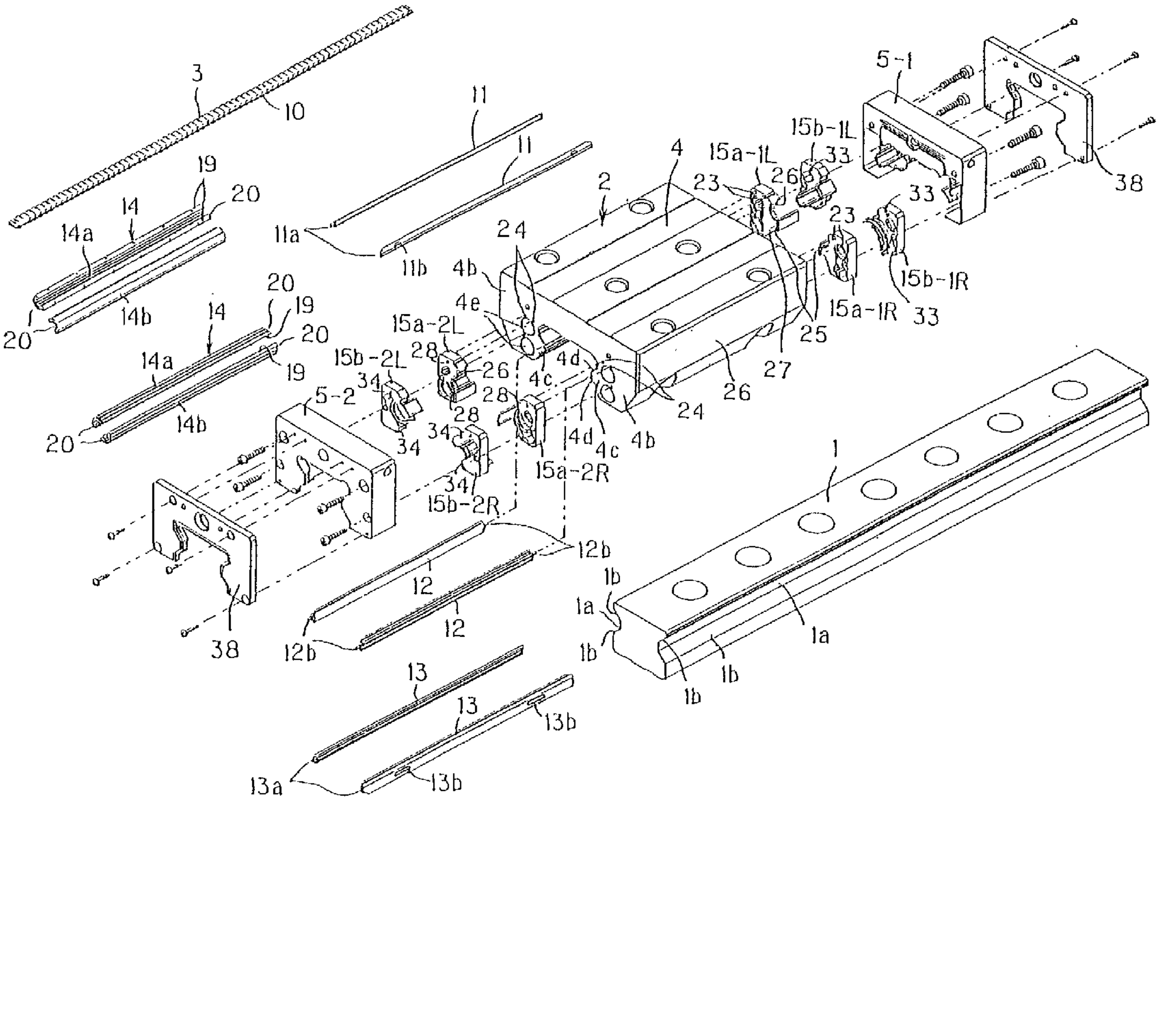


FIG. 1

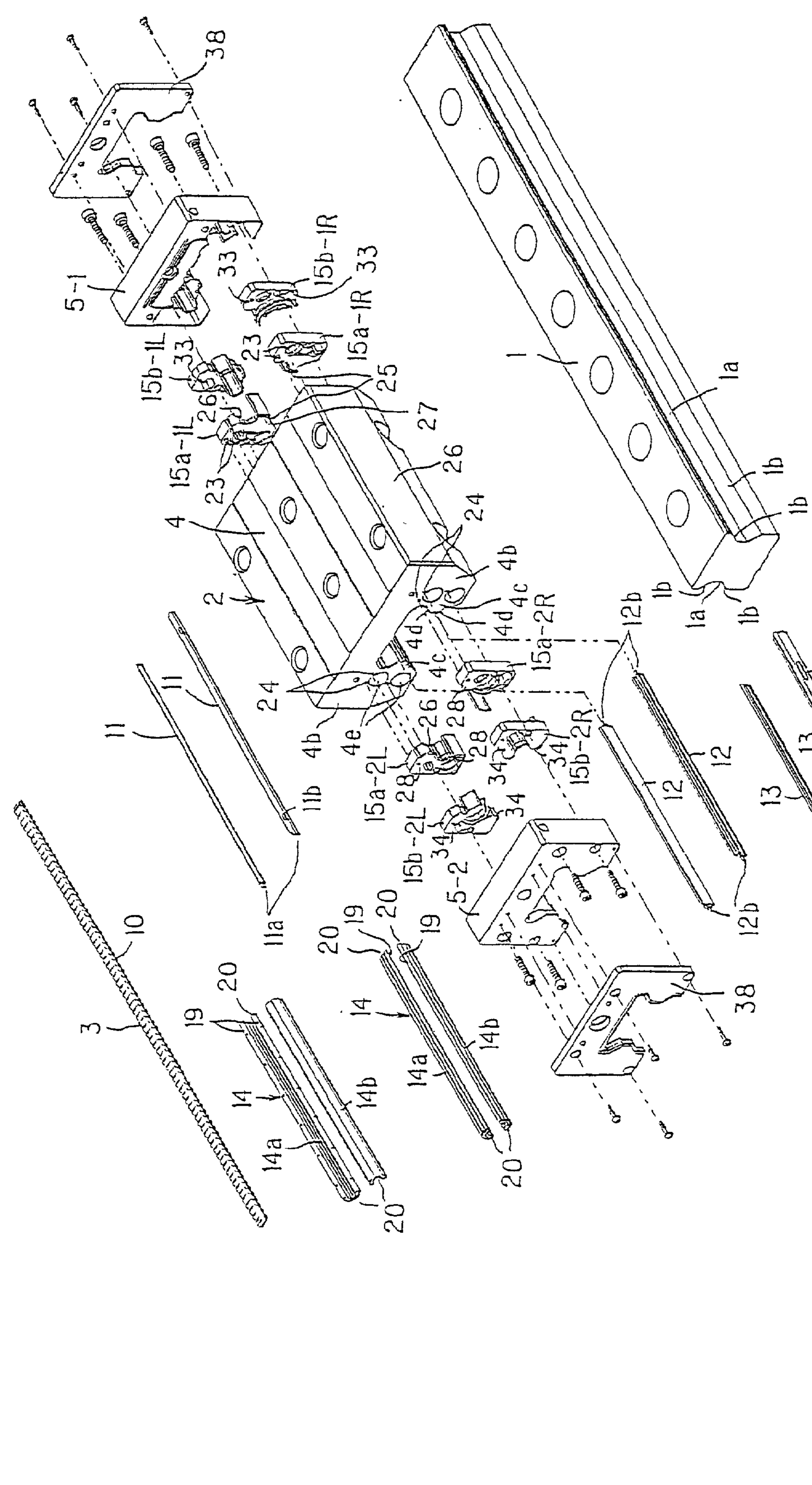

38
5-1
15b-1R
33
15a-1R
23
15b-1L
25
15a-1L
26
27
1
1a
1b
4
2
24
4b
4c
4d
4e
15a-2R
15b-2R
15a-2L
15b-2L
28
34
5-2
11
11a
11b
12
12b
13
13a
13b
10
3
14
14a
14b
19
20

FIG. 2

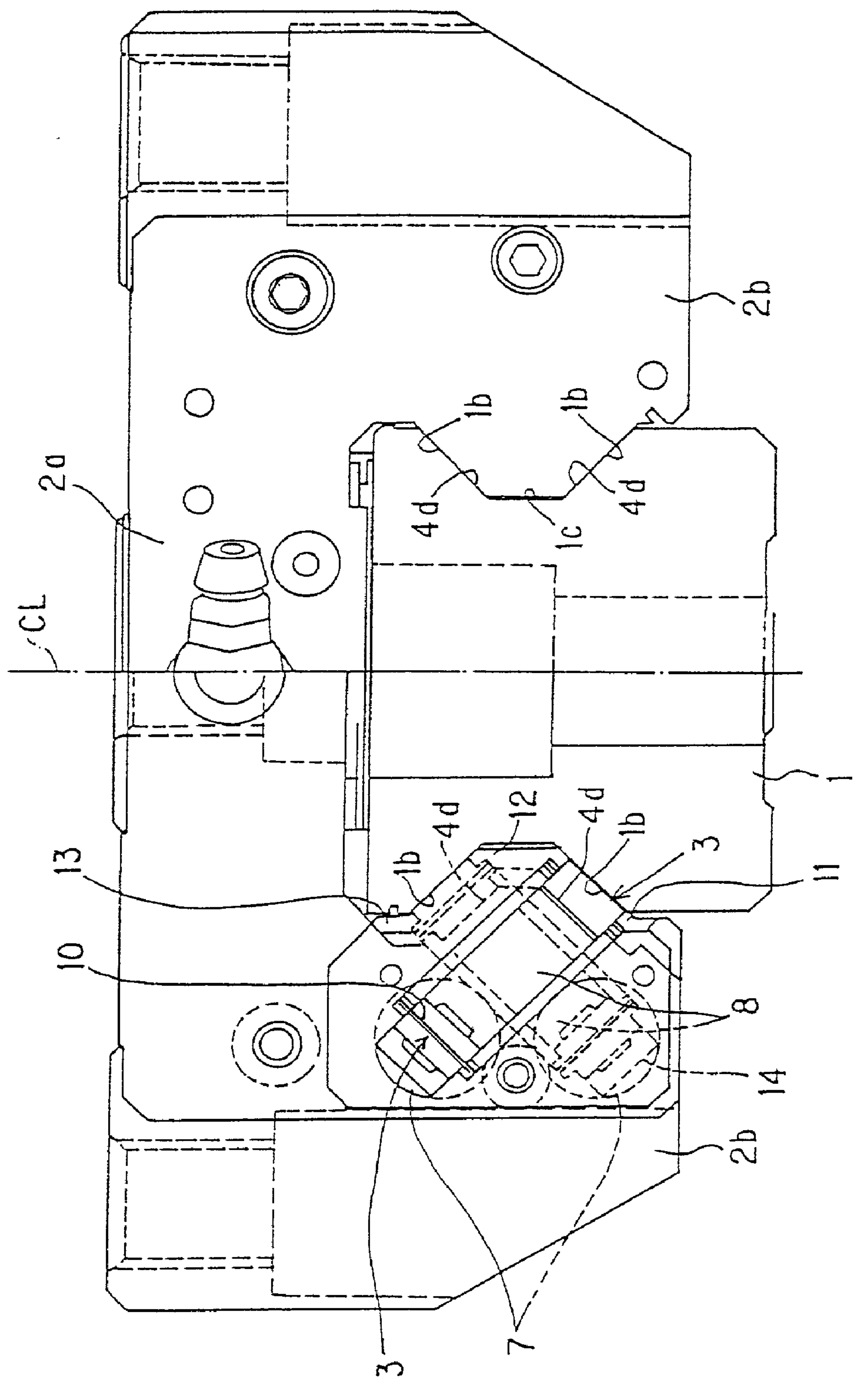


FIG. 3

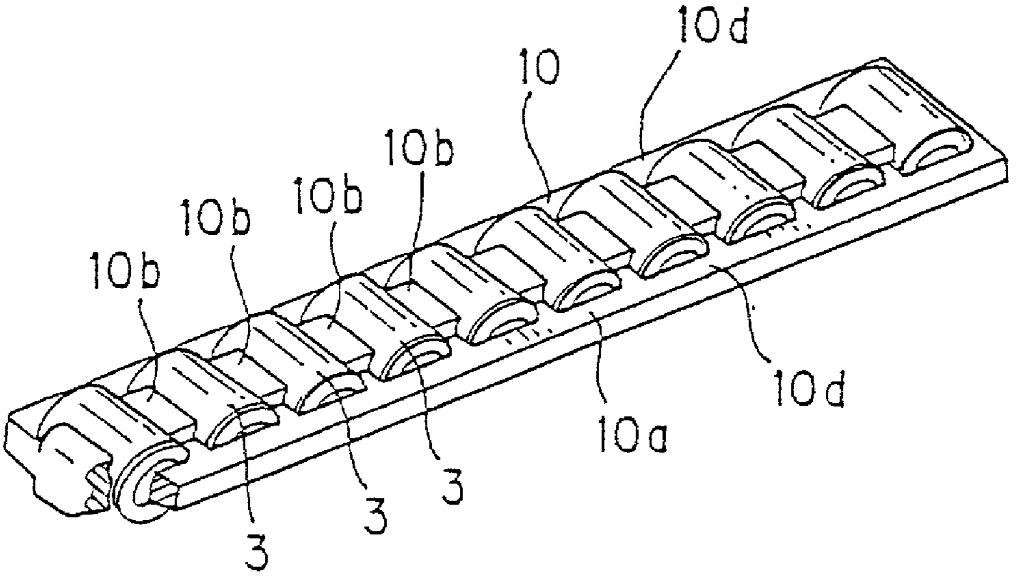


FIG. 4A

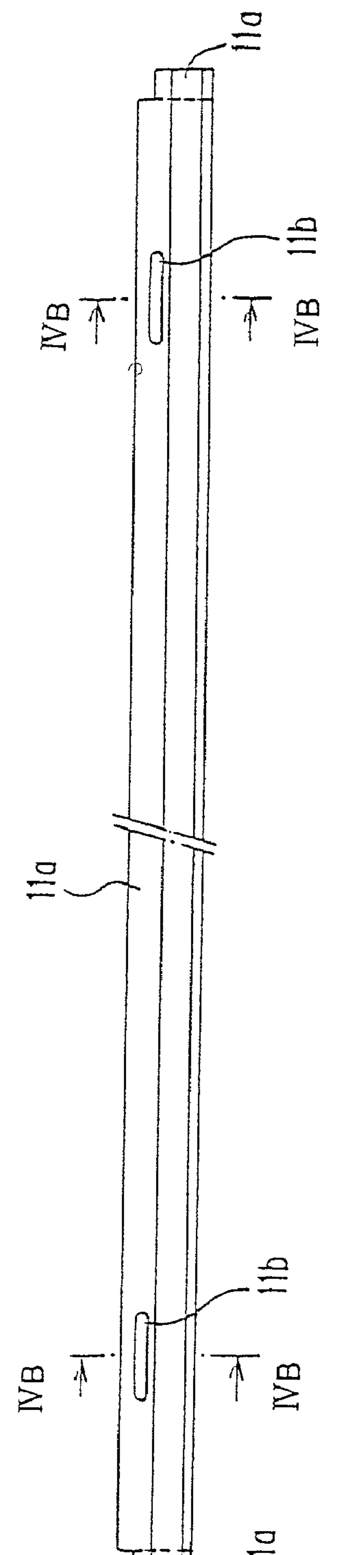
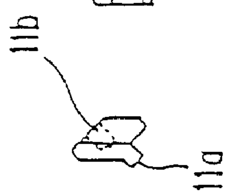


FIG. 4B



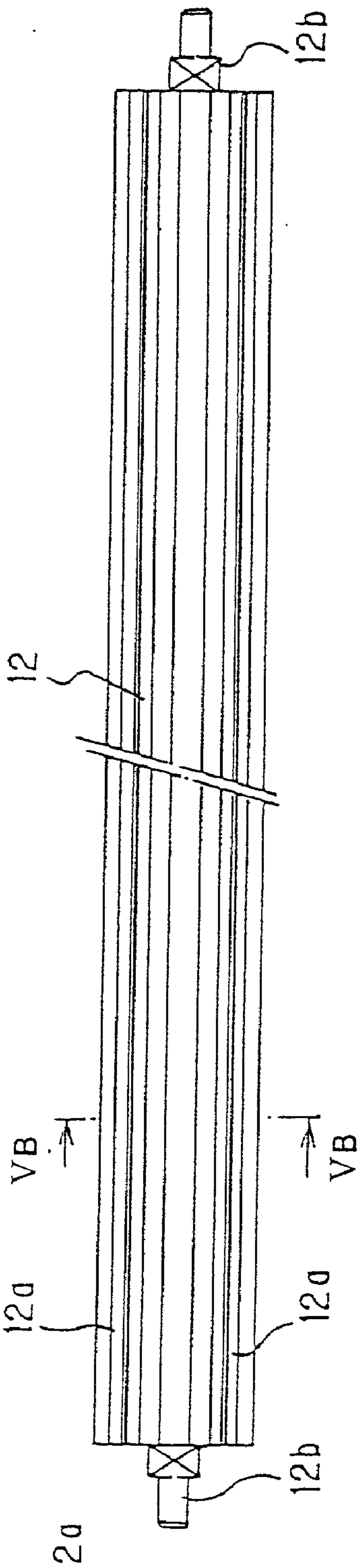


FIG. 5A

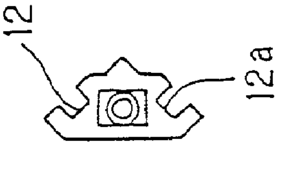


FIG. 5B

FIG. 6A

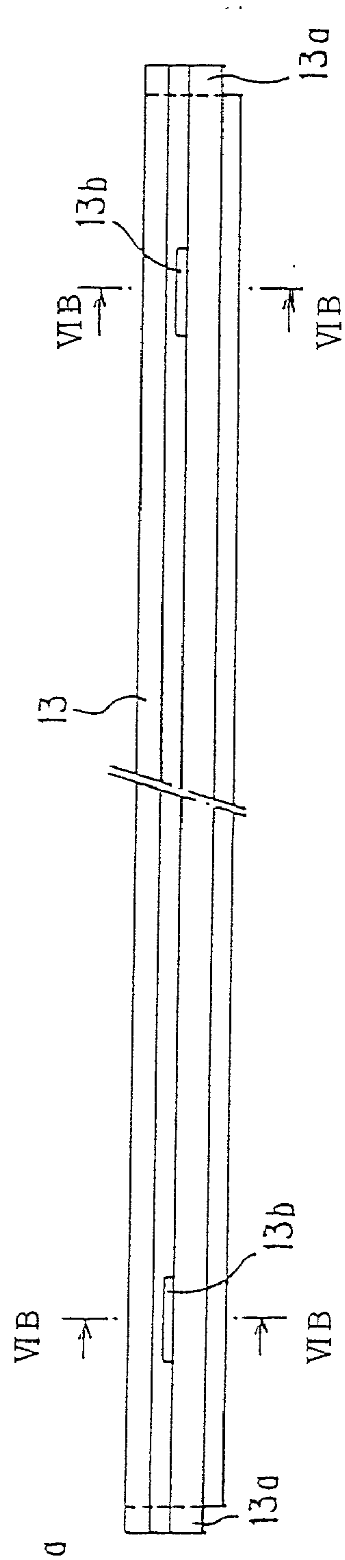


FIG. 6B

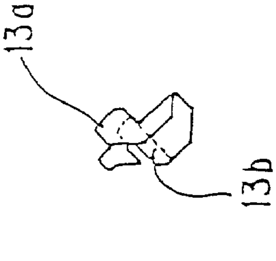


FIG. 7C

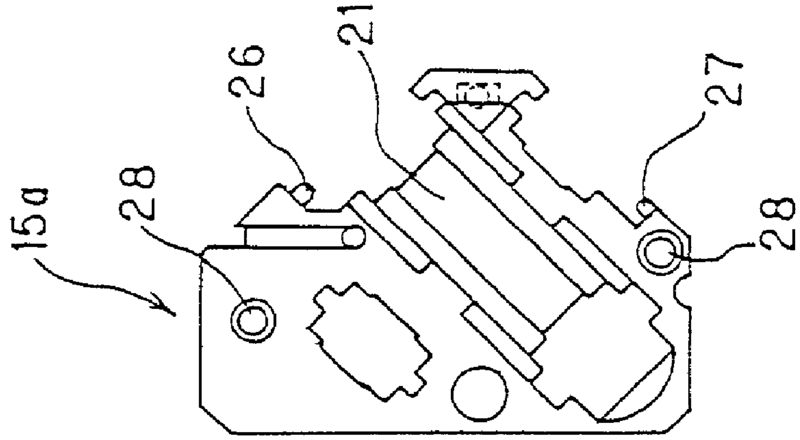


FIG. 7B

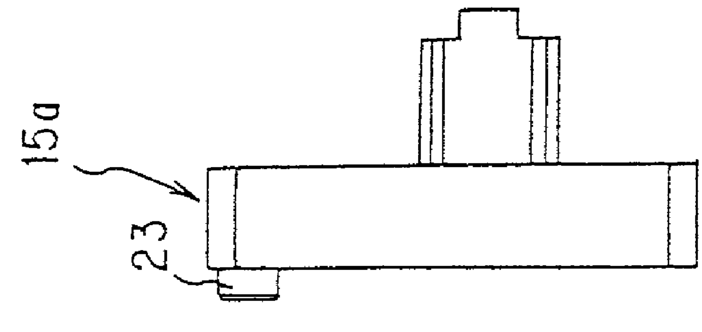


FIG. 7A

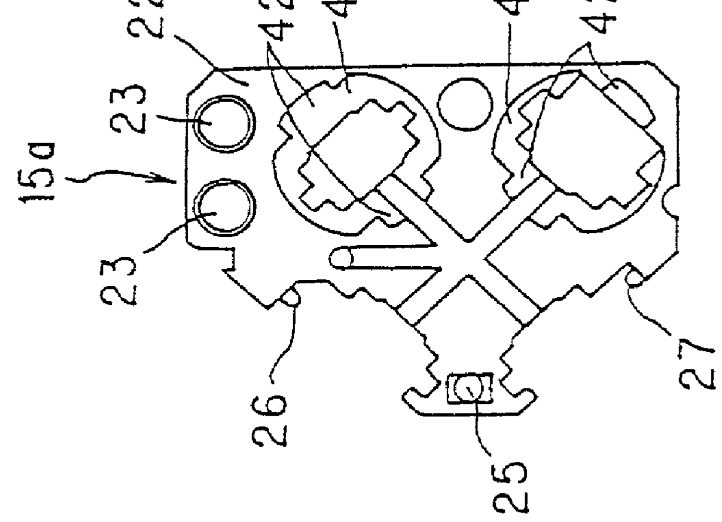


FIG. 8A

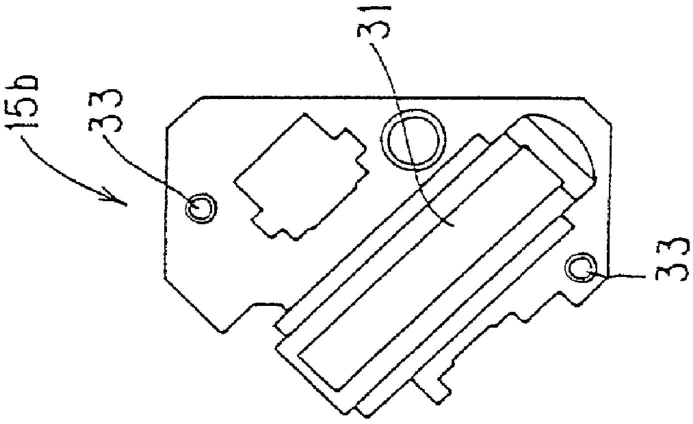


FIG. 8B

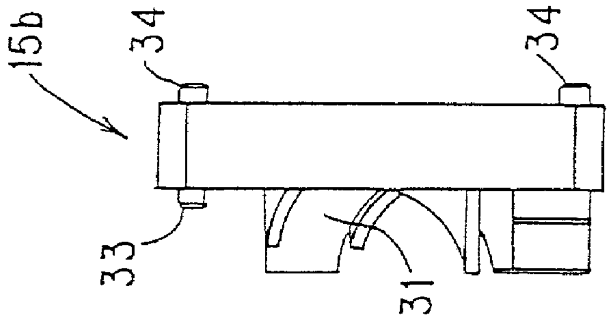


FIG. 8C

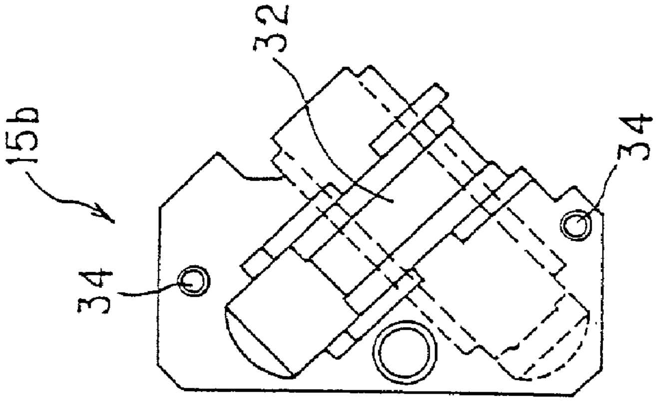


FIG. 9

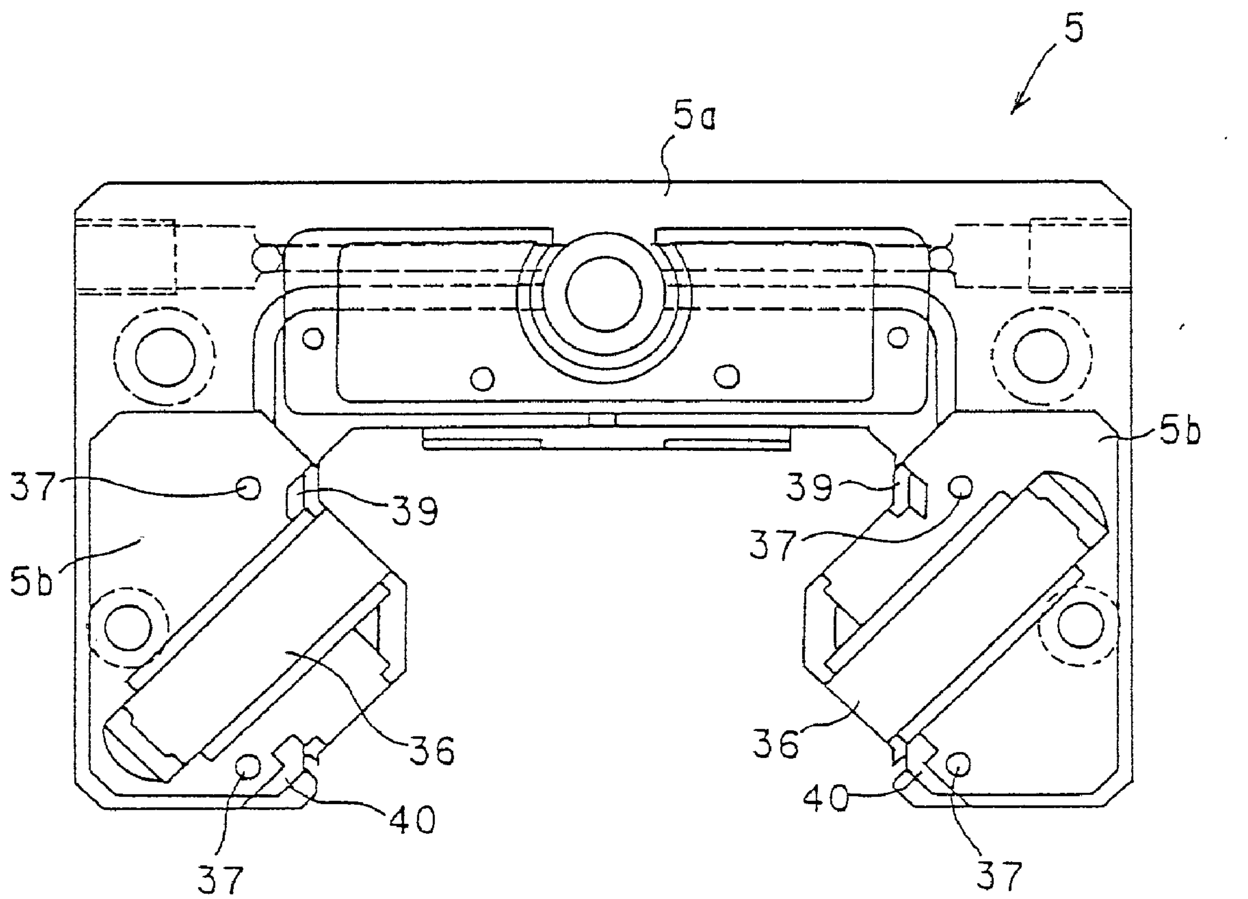


FIG. 10

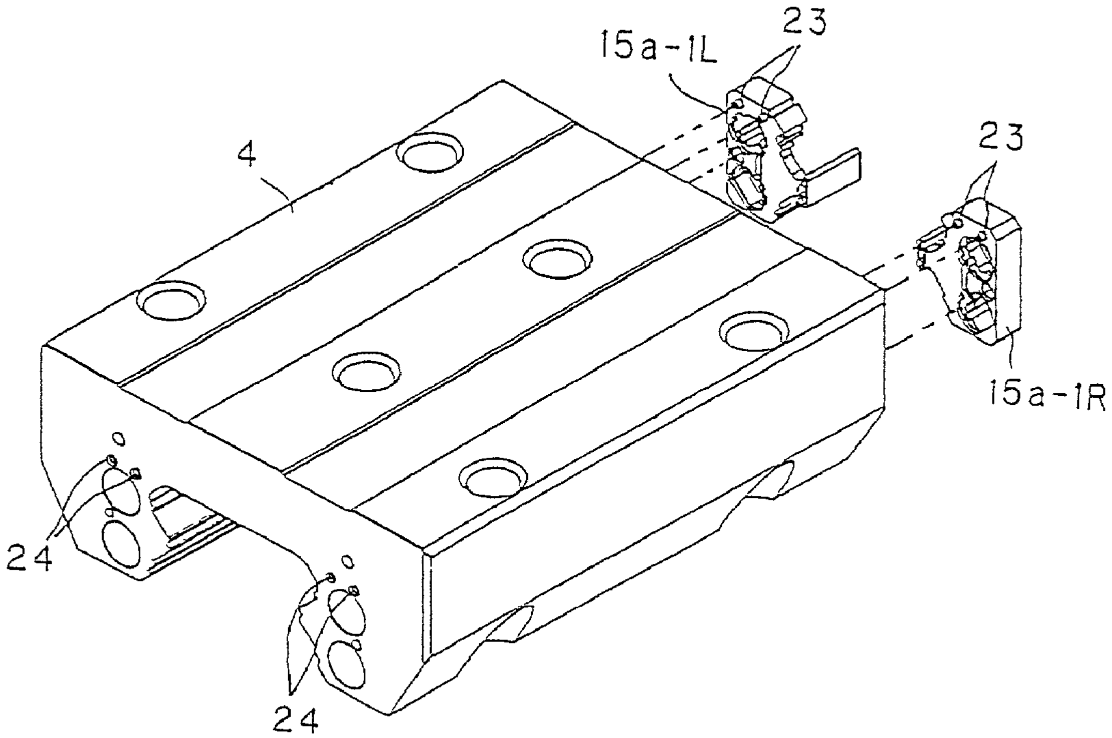


FIG. 11

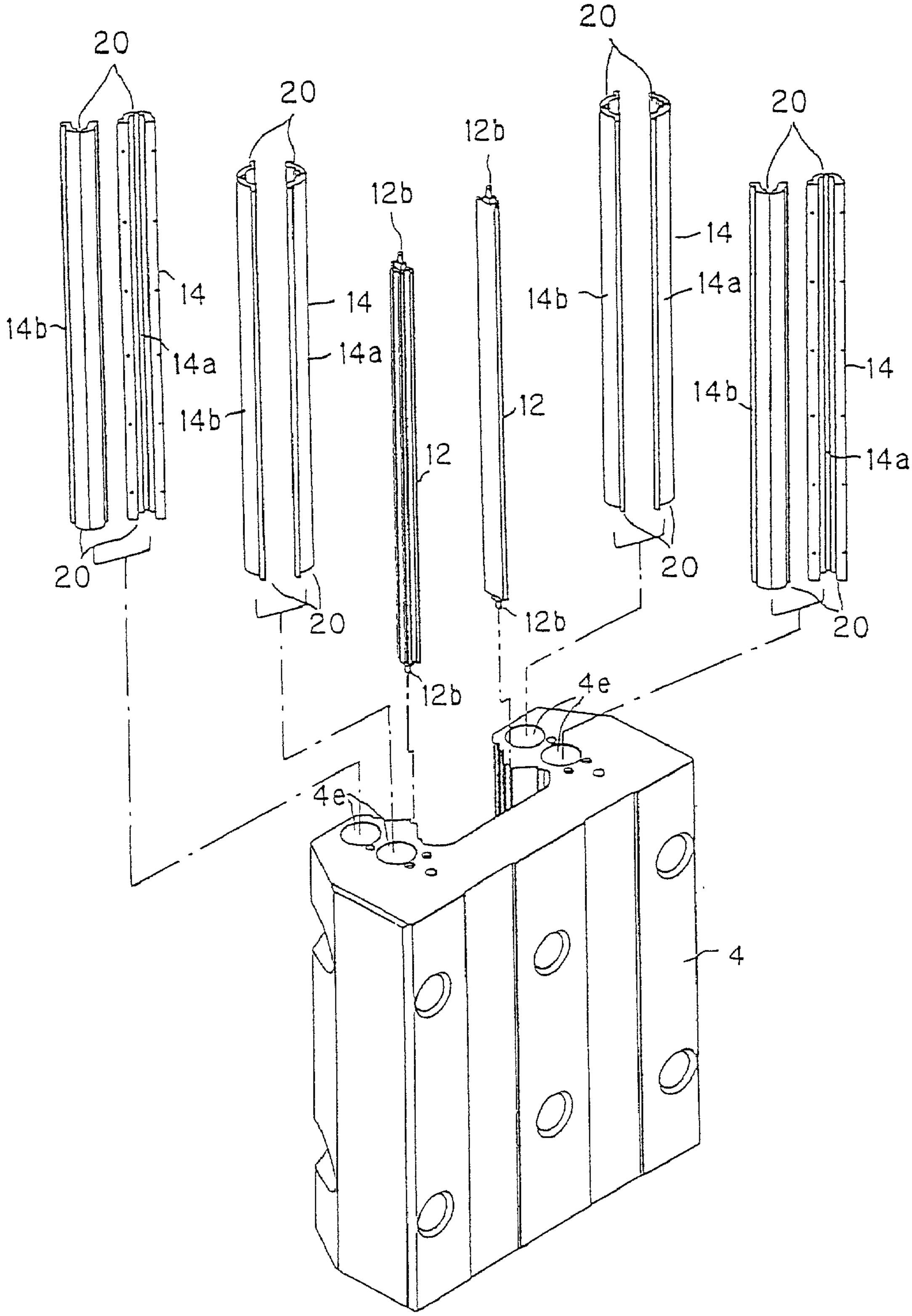
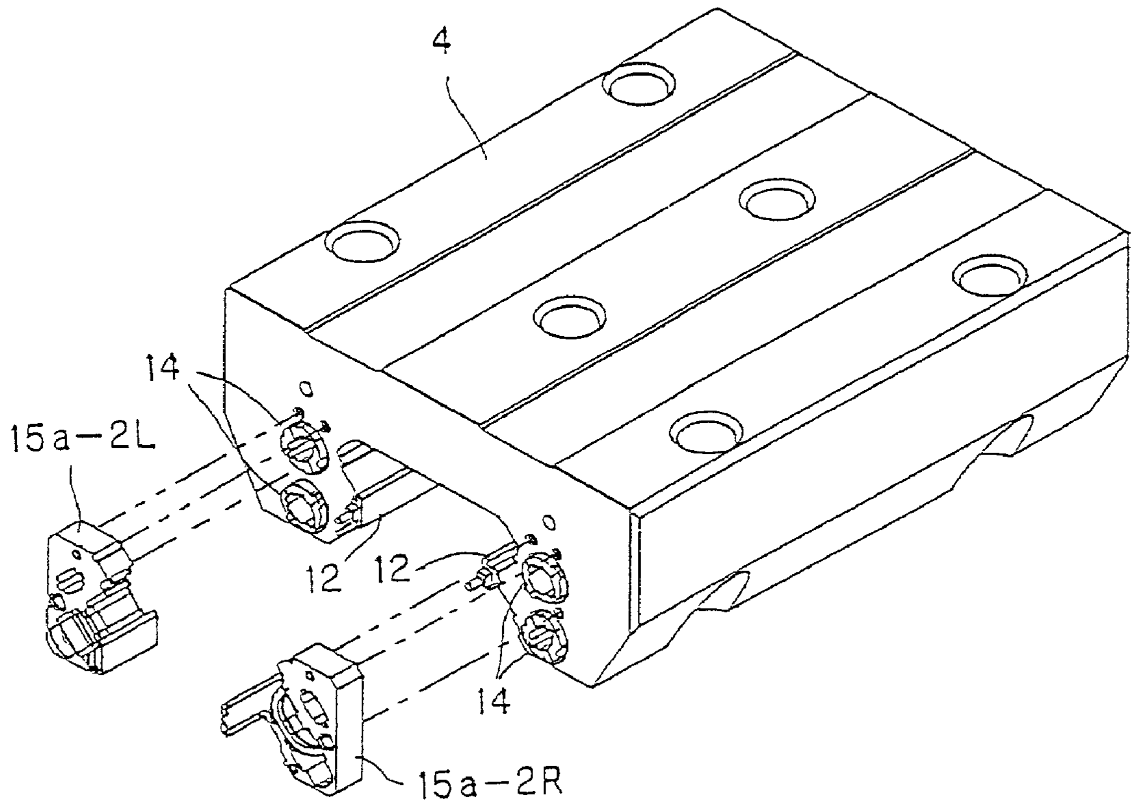

20
20
12b
12b
20
20
14b
14
14a
14
14a
14b
12
12
14
14b
14a
14b
14
14a
20
20
12b
20
20
12b
4e
4e
4

FIG. 12



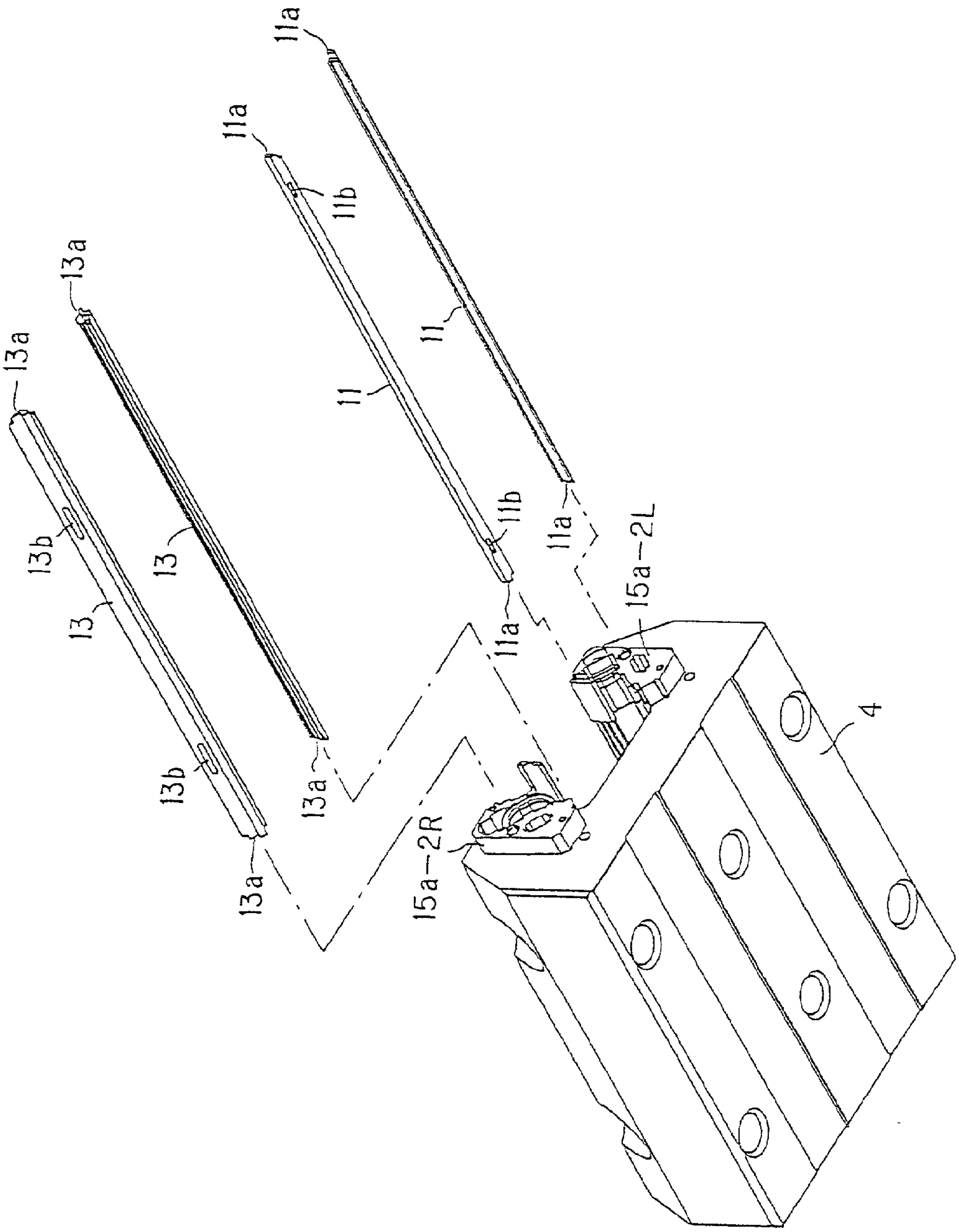

11a
11a
11b
13a
13a
11
11
13
13b
13
11b
11a
15a−2L
13
11a
4
13b
13a
15a−2R
13a

FIG. 13

FIG. 14

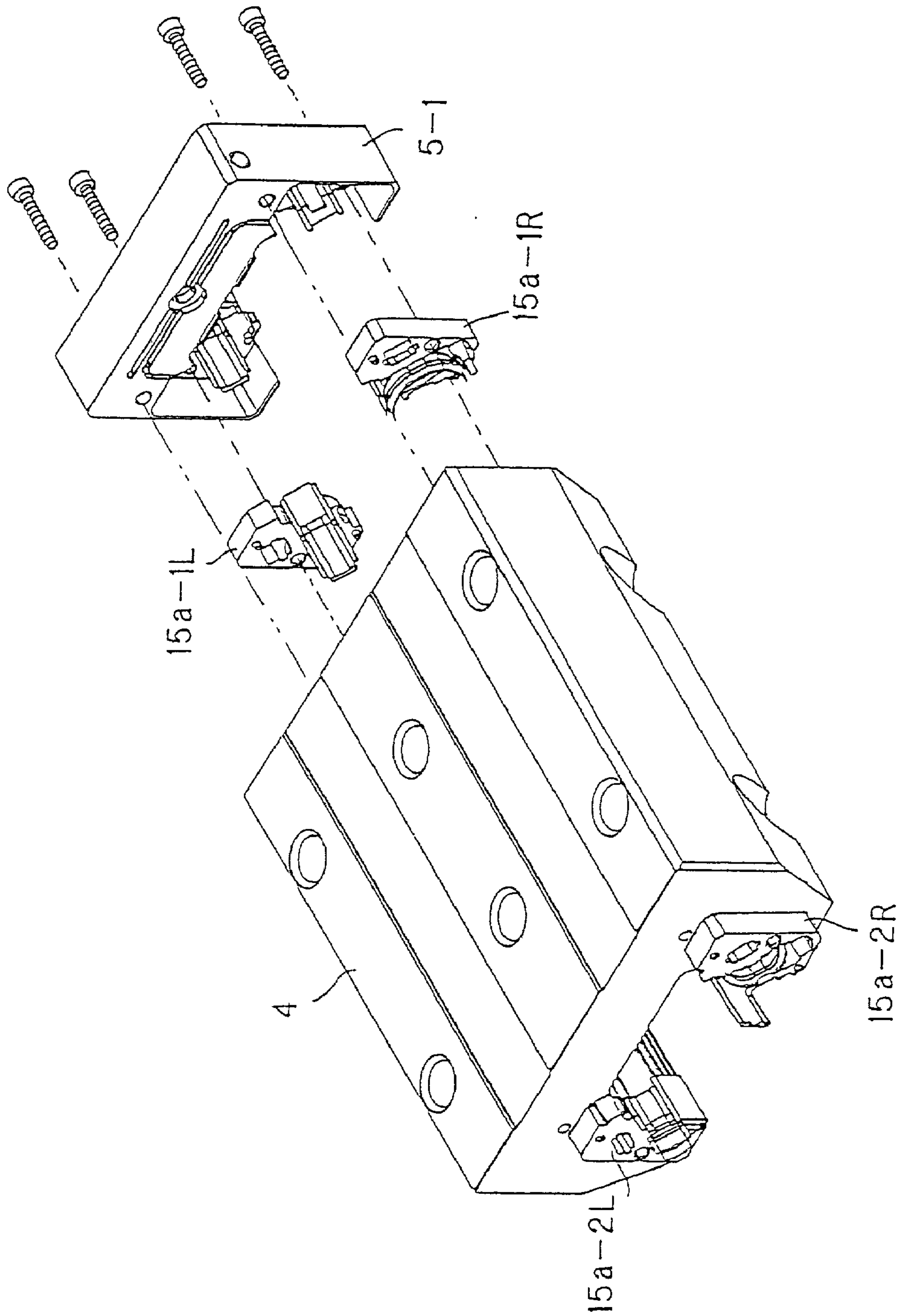


FIG. 15

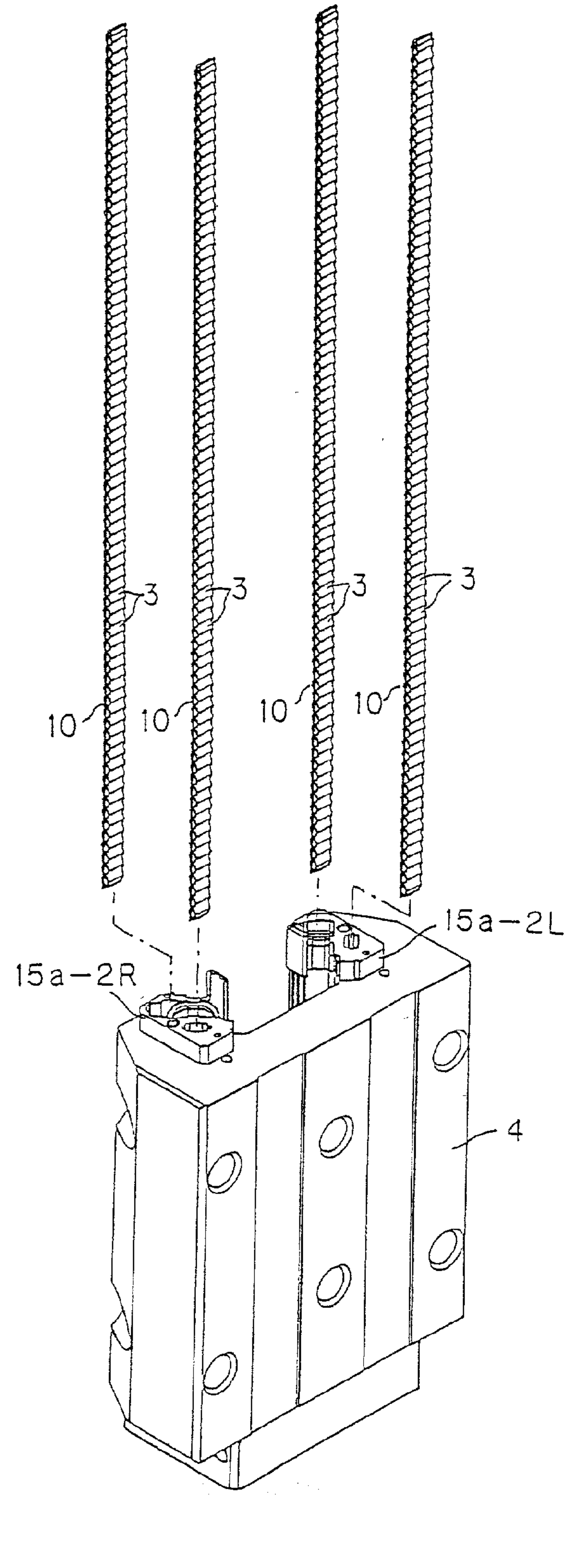


FIG. 16

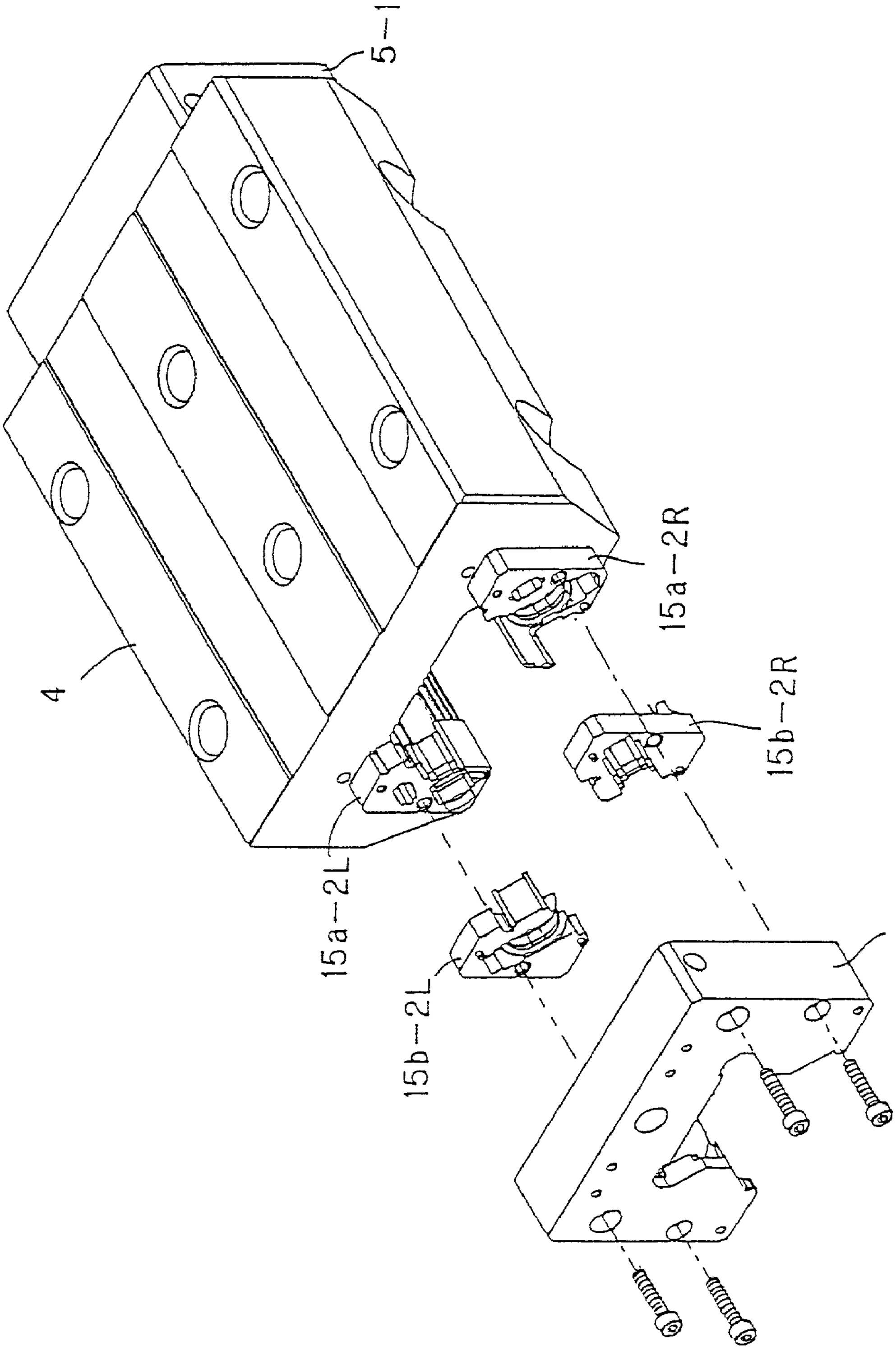


FIG. 17

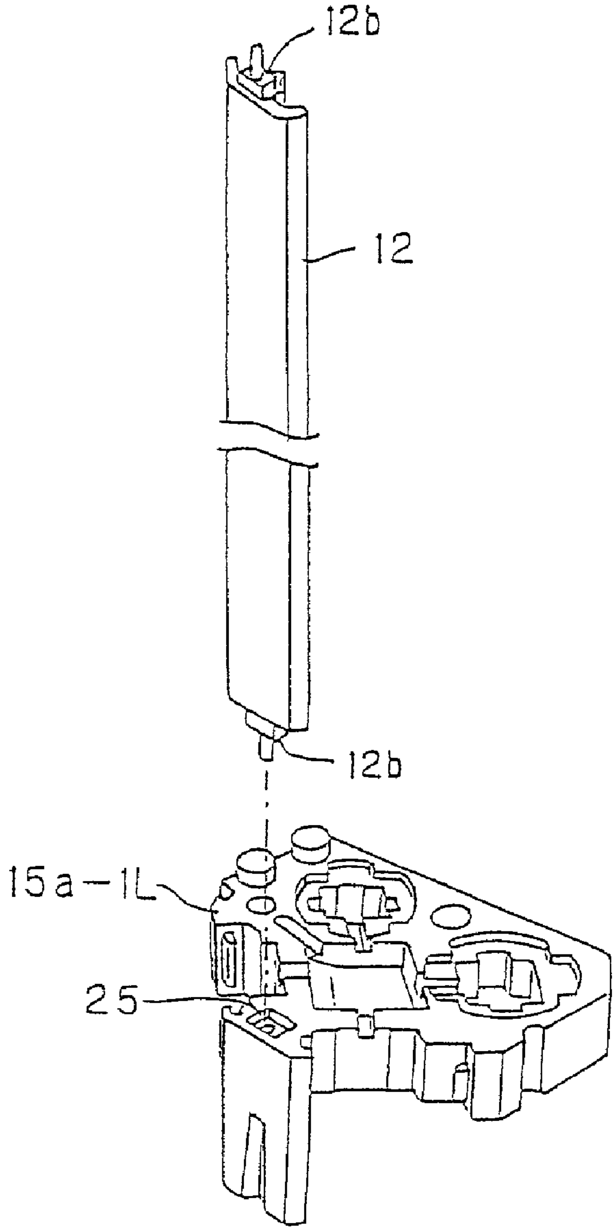


FIG. 18A

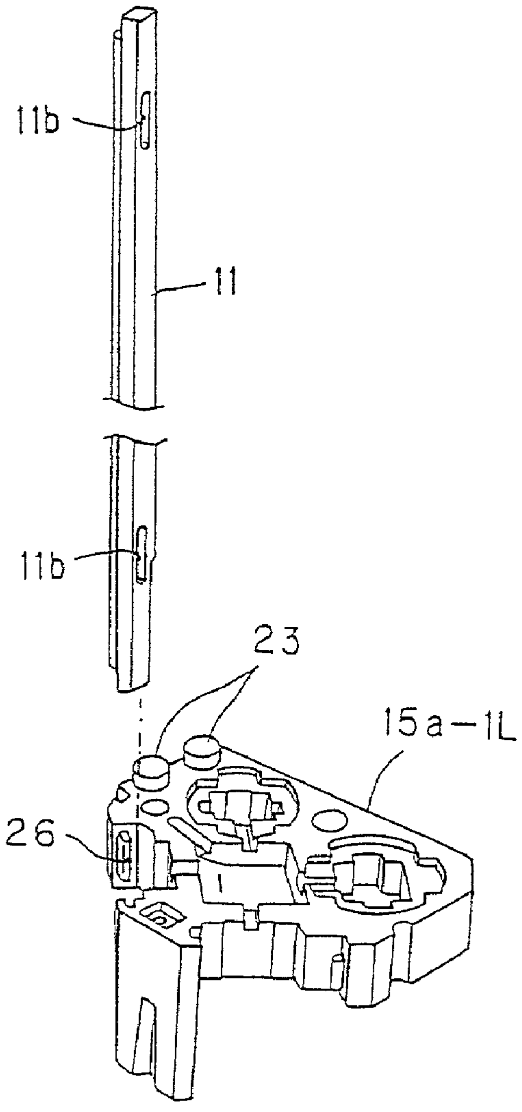


FIG. 18B

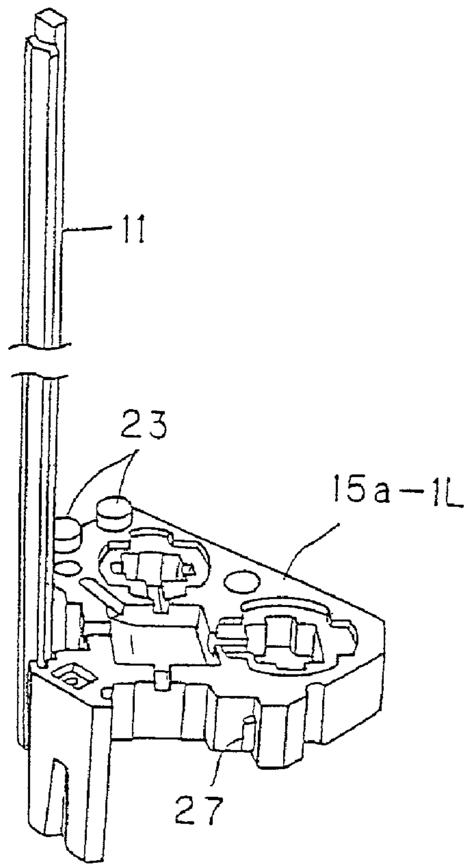


FIG. 19

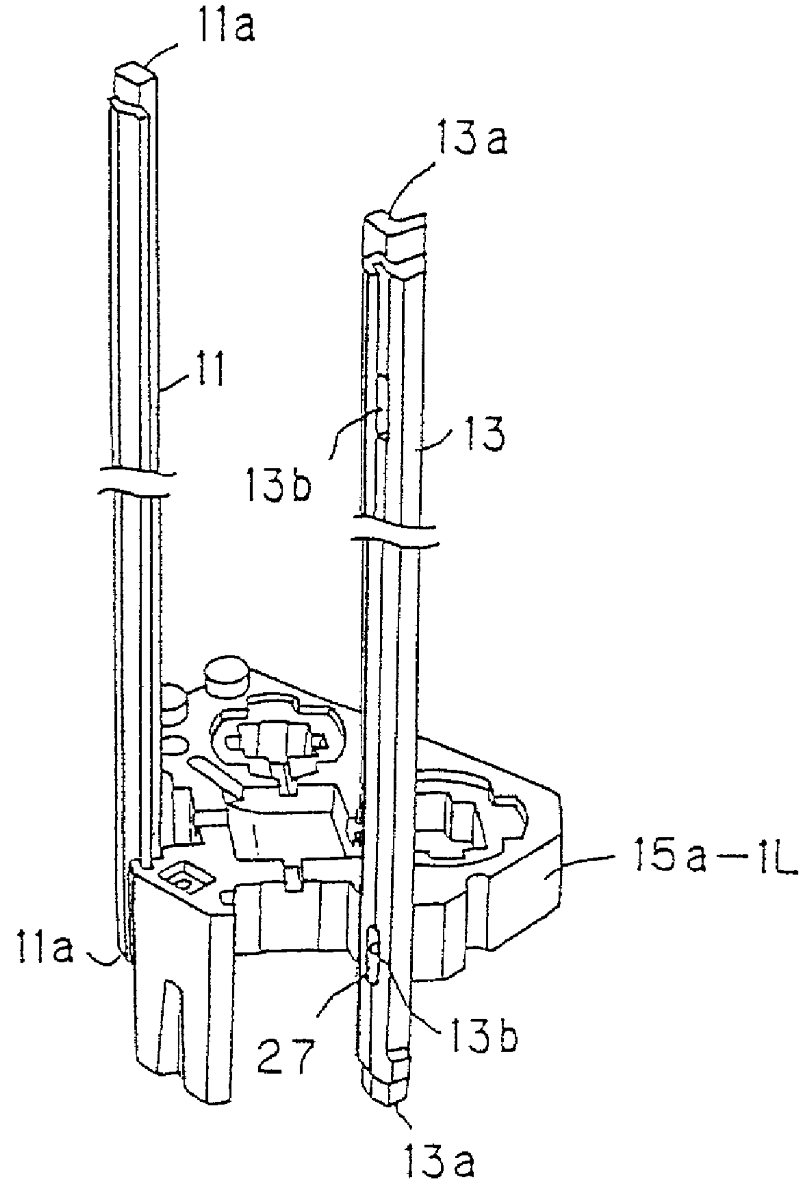


FIG. 20A

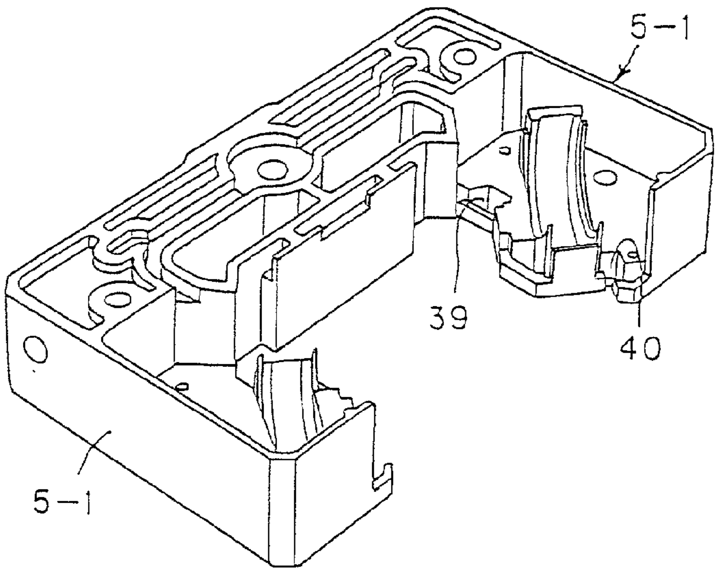


FIG. 20B

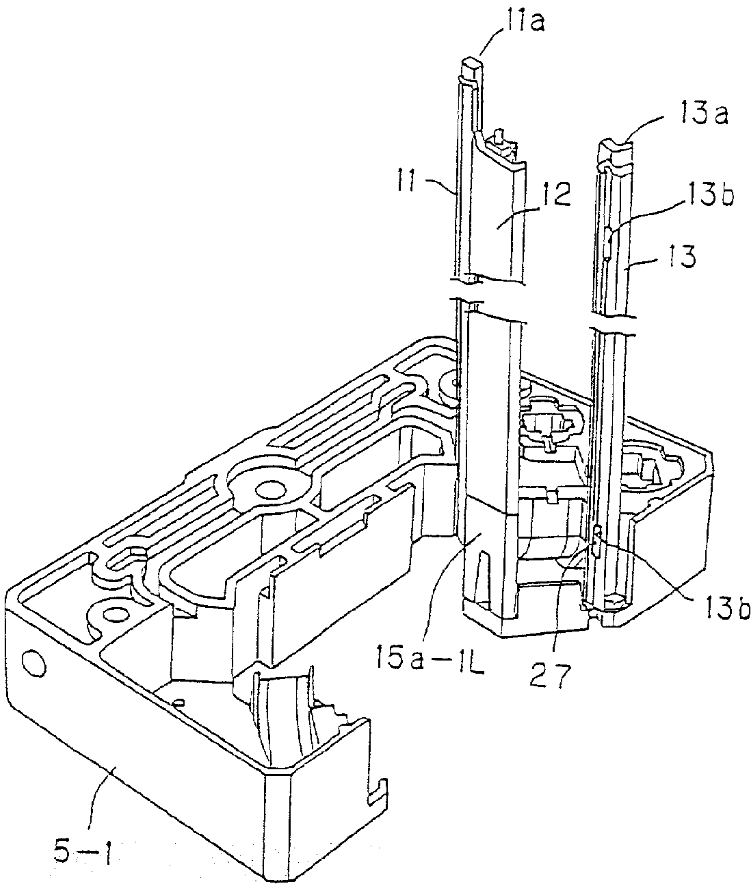


FIG. 21

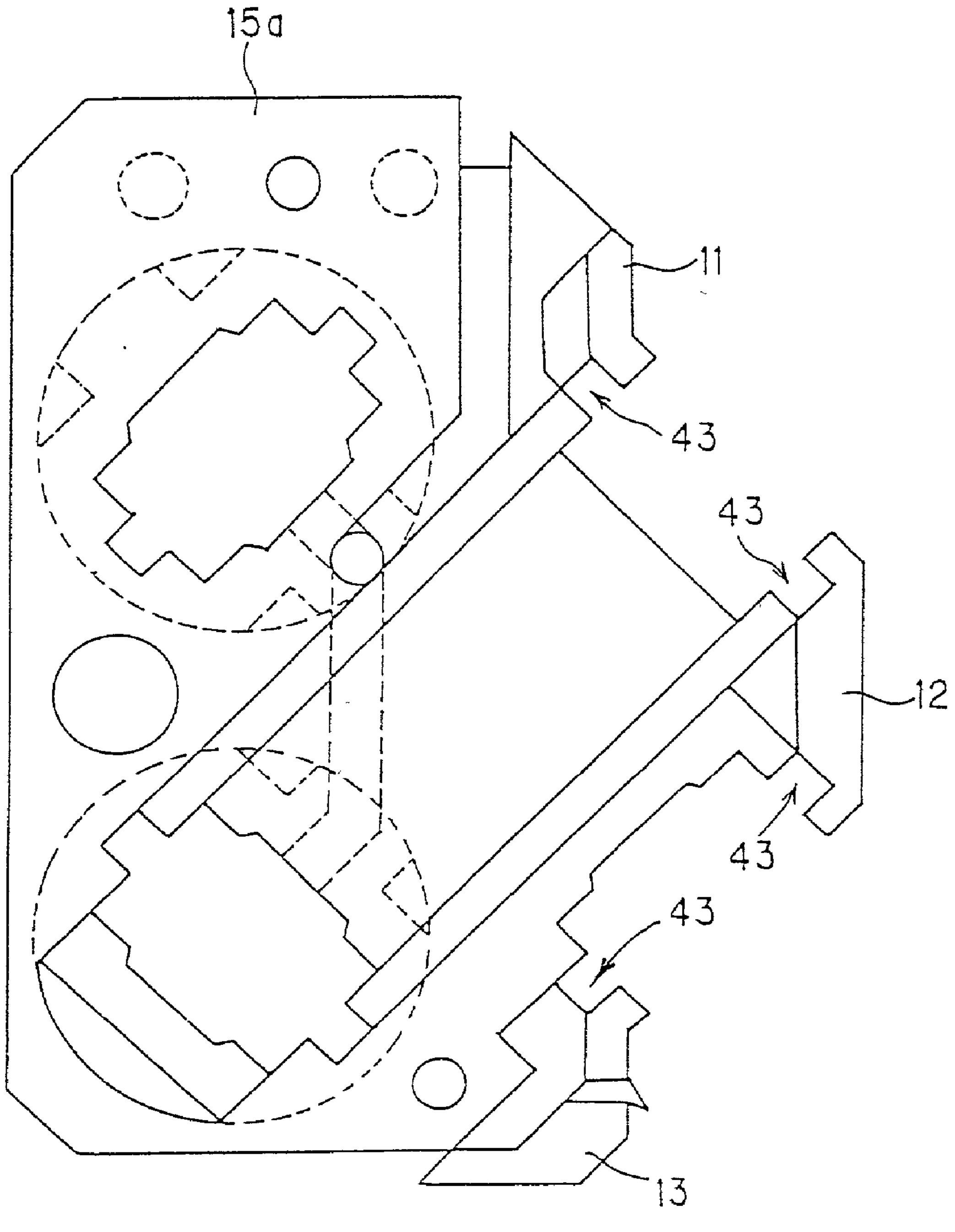
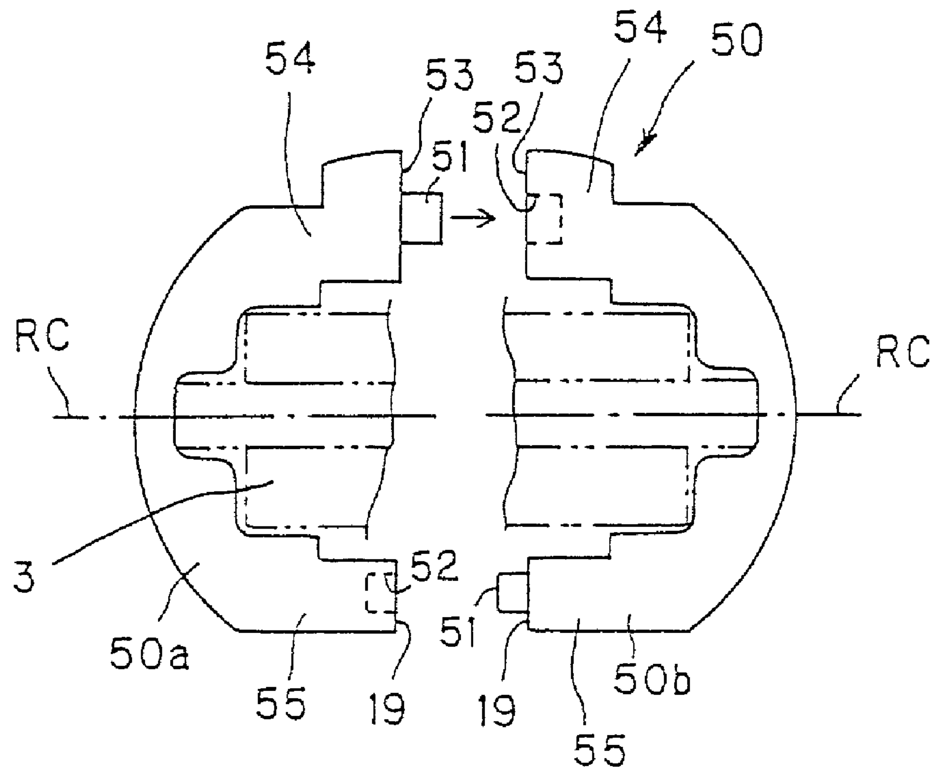


FIG. 22



LINEAR MOTION GUIDE DEVICE

FIELD OF THE INVENTION

[0001] The present invention relates to a motion guide device provided with a movable member having a body into which passage constituting members formed of resin material are assembled.

BACKGROUND ART

[0002] A motion guide device is provided with a track rail on which a rolling member rolling portion is formed and a movable block disposed to be movable along the track rail through a number of rolling members such as bolls or rollers. The movable block is formed with a loaded rolling member rolling portion corresponding to a rolling member rolling portion of the track rail, a rolling member escape passage formed in parallel to the loaded rolling member rolling portion with a predetermined space therefrom, and a pair of rolling member rolling direction changing passages each of which connects the loaded rolling member rolling portion and the rolling member escape passage to each other to thereby constitutes a rolling member circulation passage along which the rolling members circulate.

[0003] The applicant of the subject application has proposed a technology, such as Japanese Patent Laid-open Publication No. HEI 7-317762, in which support members (retainers) extending along both side edges of the rolling member rolling groove in a loaded area of the movable block, an escape passage constituting member constituting the escape passage of the rolling member, and inner periphery guide section constituting member constituting an inner periphery guide section of the rolling direction changing passage are integrally formed with a body of the movable block through a resin molding process.

[0004] However, in such movable block with which the resin portions or members are integrally formed, when the movable block body has a large size or scale, it is necessary to prepare a large-sized mold, which makes it difficult to manufacture such mold. Furthermore, the support members extending along both the side edges of the rolling member rolling groove have thin thickness and long length. Therefore, there may cause a case that resin may not sufficiently be supplied at the time of the molding, thus being also inconvenient.

[0005] In order to solve such problems or inconveniences mentioned above, the applicant of the subject application has also provided a motion guide device in which the support members, the escape passage constituting member and the inner periphery guide section constituting member, which are all formed of resin, were formed as separate units independent from the movable block body and then assembled with the movable block body to thereby make easy the molding process and constitute the movable block.

[0006] In such motion guide device, connecting portions of the support members, the escape passage constituting members and the inner periphery guide section constituting members are formed to be continuous so as to make smooth the circulation of the rolling members. That is, at least one of connecting portions of these members is integrally formed.

[0007] However, even in such structure, these support members, the escape passage constituting members and the inner periphery guide section constituting members have shapes different from each other and amounts (volumes) of resin shrinkage cavities thereof are also different from each other. Accordingly, in the case where the connecting portions of the support members, the escape passage constituting members and the inner periphery guide section constituting members are integrally formed, the thin and long support members and escape passage constituting members may be flexed and the inner periphery guide section constituting members may be opened, which constitutes a further problem. That is, since the rolling members circulate at high speed in the circulation passage constituted by such support members, escape passage constituting members and inner periphery guide section constituting members, such flexible structure of the support members and the escape passage constituting members and the opening (widening) of the inner periphery guide section constituting members will disturb the smooth circulation of the rolling members in the circulation passage.

DISCLOSURE OF THE INVENTION

[0008] The present invention has been conceived in consideration of the above matters, and an object of the present invention is to provide a motion guide device which can be easily manufactured even having a large scale and, moreover, in which the long and thin support members and escape passage constituting members are not flexed and the inner periphery guide section constituting members are not opened (widened).

[0009] Hereunder, the present invention will be described. Further, it is to be noted that although reference numerals used in the accompanying drawings are added to respective members or portions by applying ( ) for the sake of easy understanding of the present invention, the present invention is not limited to the embodiments shown in the drawings.

[0010] The above object can be achieved according to the present invention by providing a motion guide device which comprises a track member (**1**) provided with rolling member rolling portions (**1***b*, **1***b*) and a movable member (**2**) disposed to be movable along the track member (**1**) through a number of rolling members (**3** - - -) and in which the movable member (**2**) is provided with loaded rolling member rolling portions (**4***d*, **4***d*) corresponding to the rolling member rolling portions (**1***b*, **1***b*) of the track member (**1**), rolling member escape passages disposed in parallel to the loaded rolling member rolling portions (**4***d*, **4***d*) with a predetermined distance and a pair of direction changing passages connecting the loaded rolling member rolling portions (**4***d*, **4***d*) and the rolling member escape passages to thereby circulate the rolling members,

> [0011] wherein support members (**11**, **12**, **13**) extending along both side edges of the loaded rolling member rolling portions (**4***d*, **4***d*), escape passage constituting members (**14**, **14**) constituting the rolling member escape passages and a pair of inner periphery guide section constituting members (**15***a*, **15***a*) constituting the inner peripheral portions of the direction changing passages are formed to be independent from a body (**4**) of the movable member and also independent from each other and are assembled to the body (**4**) of the movable member.

[0012] According to this invention, since the support members, the escape passage constituting members and the inner periphery guide section constituting members are formed independently from the body of the movable member and from each other, these members can be manufactured by preliminarily calculating amounts of respective shrinkage cavities of the support members, the escape passage constituting members and the inner periphery guide section constituting members. As a result, the long and thin support members and escape passage constituting members can be prevented from being flexed, and the inner periphery guide section constituting members can be also prevented from being opened.

[0013] In one preferred embodiment of this invention, the support members act to prevent the rolling members **(3 - - -)** from coming off from the loaded rolling member rolling portions **(4*d*, 4*d*)** at a time when the movable member **(2)** is removed from the track member **(1)**.

[0014] In another preferred embodiment of this invention, either one of the inner periphery guide section constituting members **(15*a*, 15*a*)** and the body **(4)** of the movable member is formed with a positioning recess **(24)** for positioning the inner periphery guide section constituting members **(15*a*, 15*a*)** with respect to the body **(4)** of the movable member and the other one thereof is formed with a movable member body positioning protrusion **(23)** to be engaged with the movable member body positioning recess **(24)**; either one of the inner periphery guide section constituting members **(15*a*, 15*a*)** and the escape passage constituting members **(14, 14)** is formed with a positioning recess **(42)** for positioning the escape passage constituting members with respect to the inner periphery guide section constituting members **(15*a*, 15*a*)** and the other one thereof is formed with an escape passage constituting member positioning protrusion **(20)** to be engaged with the escape passage constituting member positioning recess **(42)**; and either one of the inner periphery guide section constituting members **(15*a*, 15*a*)** and the support members **(11, 12, 13)** are formed with positioning recesses **(11*b*, 13*b*, 25)** for positioning the support members **(11, 12, 13)** with respect to the inner periphery guide section constituting members **(15*a*, 15*a*)** and the other one thereof is formed with support member positioning protrusions **(26, 27, 12*b*)** to be engaged with the support member positioning recesses **(11*b*, 13*b*, 25)**.

[0015] According to the above embodiment, in the case where the support member, the escape passage constituting member and the inner periphery guide section constituting member are manufactured independently from the body of the movable member and also independently from each other, the number of constitutional members or parts increases and, hence, the assembling working may be made difficult. According to the present invention, however, since the support member and the escape passage constituting member are positioned with reference to the inner periphery guide section constituting member which is positioned to the body of the movable member, the working precision or performance of the support member, escape passage constituting member and inner periphery guide section constituting member can be improved. As a result, even in the case where the support member, the escape passage constituting member and the inner periphery guide section constituting member are manufactured independently from the body of the movable member and also independently from each other, these circulation passage constituting members never make worse the motion of the rolling members. Moreover, since the support member and the escape passage constituting member are positioned and assembled with the inner periphery guide section constituting member being one reference member, the support member, the escape passage constituting member and the inner periphery guide section constituting member can be easily assembled with high reproductivity.

[0016] Furthermore, in a further preferred embodiment of the present invention, a pair of side lids **(5, 5)** constituting outer periphery guide sections of the direction changing passages are mounted to both longitudinal end portions of the movable member body **(4)**, both the end portions of the support member **(11, 13)** are inserted into the side lids **(5, 5)**, and either one of the inner periphery guide section constituting members **(15*a*, 15*a*)** and the support members **(11, 13)** is formed with a positioning recess **(11*b*, 13*b*)** for positioning the support members with respect to the inner periphery guide section constituting members **(15*a*, 15*a*)** and the other one thereof is formed with support member positioning protrusions **(26, 27)** to be engaged with the support member positioning recesses **(11*b*, 13*b*)**.

[0017] According to this invention, since both the end portions of the support members are inserted into the paired side lids mounted to the body of the movable member, the support member can be firmly fixed thereto. Moreover, in the case where both the end portion of the support member are fitted into the side lids, when it is required to carry out the assembling working, it is necessary that the support member is once inserted into one of the side lids, the rolling members are fitted and, then, the other side lid is inserted into the other end portion of the support member. In the process that the other side lid is inserted, there is a fear that the support member falls down and, hence, the side lids may not be precisely fitted to the support member. According to this invention, however, the support member can be positioned by the inner periphery guide section and the side lids, so that the support member is supported at two portions, and accordingly, the fear of falling-down of the support member in the assembling process will be reduced. Thus, the side lids can be simultaneously inserted into a plurality of support members, enabling the assembling process to be easy.

[0018] Furthermore, in a preferred embodiment of this invention, a number of rolling members **(3, 3, - - -)** are held in series with predetermined distance by a rolling member support belt **(10)** having side edge portions **(10*d*)** projecting over both side end portions of the rolling members, and by assembling the support members **(11, 12, 13)** to the body **(4)** of the movable member, a guide section **(43)** for guiding the side edge portions **(10*d*)** of the rolling member support belt **(10)** is formed.

[0019] According to this invention, the rolling member support belt is held by the support member and the guide section formed by the body of the movable member, thus being prevented from coming off from the movable member. On the other hand, the rolling members can be held by the rolling member support belt, and accordingly, the rolling member support belt and the rolling members never come off from the movable member.

[0020] In a further preferred embodiment of the present invention, the track member is a track rail **(1)** and the movable member is a movable block **(2)** provided with a pair of sleeve portions disposed so as to oppose to both side surfaces of the track rail, the rolling member rolling portions are vertical two rows of rolling member rolling passages (**1**b, **1**b) formed on each of lateral side surfaces of the track rail (**1**), totally, four rows thereof, the loaded rolling member rolling portions are vertical two rows of loaded rolling member rolling passages (**4**d, **4**d) formed on each of inner side surfaces of the lateral sleeve portions (**2**b, **2**b) of the movable block (**2**), totally, four rows thereof, the escape passage constituting passage includes vertical two rows thereof formed on each of the lateral sleeve portions (**2**b, **2**b) of the movable block, totally, four rows thereof, the direction changing passages connect an upper loaded rolling member rolling passage and a lower rolling member escape passage (**14, 14**) and connect an lower loaded rolling member rolling passage and an upper rolling member escape passage so as to constitute grade separation structure, and the inner periphery guide section constituting member is composed of a pair of divided blocks (**15**a, **15**b) divided in the longitudinal direction of the track rail (**1**).

[**0021**] According to this invention, the inner periphery guide sections to which the direction changing passages in grade separation can be easily manufactured.

[**0022**] In a still further preferred embodiment of this invention, either one of the paired divided blocks (**15**a, **15**b) is formed with a positioning recess (**28**) for positioning the paired divided blocks and the other one thereof is formed with a divided block positioning protrusion (**33**) to be engaged with the divided block positioning recess (**28**).

[**0023**] According to this invention, even in the case of the divided inner periphery guide section, the inner periphery guide section can be assembled with high precision.

[**0024**] In a still further preferred embodiment of the present invention, the support members (**11, 12, 13**) include a first support member (**11**) disposed above the upper loaded rolling member rolling passage (**4**d), a second support member (**12**) disposed between the upper loaded rolling member rolling passage (**4**d) and the lower rolling member rolling passage (**4**d) and a third support member (**13**) disposed below the lower loaded rolling member rolling passage (**4**d).

[**0025**] According to this invention, the second support member is commonly utilized with the upper loaded rolling member rolling passage and the lower rolling member rolling passage, so that the number of the parts or members to be used can be reduced in comparison with the case where the second support members are disposed respectively to the upper loaded rolling member rolling passage and the lower rolling member rolling passage.

[**0026**] Still furthermore, the object of the present invention mentioned above can be also achieved by a motion guide device which comprises a track member (**1**) provided with rolling member rolling portions (**1**b, **1**b) and a movable member (**2**) disposed to be movable along the track member (**1**) through a number of rolling members (**3, 3**, - - -) and in which the movable member (**2**) is provided with loaded rolling member rolling portions (**4**d, **4**d) corresponding to the rolling member rolling portions (**1**b, **1**b) of the track member (**1**), rolling member escape passages disposed in parallel to the loaded rolling member rolling portions (**4**d, **4**d) with a predetermined distance and a pair of direction changing passages connecting the loaded rolling member rolling portions (**4**d, **4**d) and the rolling member escape passages to thereby circulate the rolling members,

[**0027**] wherein support members (**11, 12, 13**) extending along both side edges of the loaded rolling member rolling portions (**4**d, **4**d) and a pair of inner periphery guide section constituting members (**15**a, **15**b) constituting the inner peripheral portions of the direction changing passages are formed to be independent from a body (**4**) of the movable member and also independent from each other and are assembled to the body (**4**) of the movable member, and the rolling member escape passages are constituted by through holes perforated to the body (**4**) of the movable member.

[**0028**] According to this invention, since the support members and the inner periphery guide section constituting members are formed independently from the body of the movable member and from each other, these members can be manufactured by preliminarily calculating respective shrinkage cavities of the support members and the inner periphery guide section constituting members. As a result, the long and thin support members can be prevented from being flexed and the inner periphery guide section constituting members can be also prevented from being opened.

BRIEF DESCRIPTION OF THE DRAWINGS

[**0029**] In the accompanying drawings:

[**0030**] **FIG. 1** is a developed perspective view of a linear motion guide device according to a first embodiment of the present invention;

[**0031**] **FIG. 2** is a side (end) view, partially including a cross sectional area, of the linear motion guide device of **FIG. 1**;

[**0032**] **FIG. 3** shows an arrangement of rollers held by and accommodated in a roller support (holding) belt;

[**0033**] **FIG. 4A** is an illustrated side view of a first support member (retainer) and

[**0034**] **FIG. 4B** is a sectional view taken along the line IVB-IVB in **FIG. 4A**;

[**0035**] **FIG. 5A** is an illustrated side view of a second support member and

[**0036**] **FIG. 5B** is a sectional view taken along the line VB-VB in **FIG. 5A**;

[**0037**] **FIG. 6A** is an illustrated side view of a third support member and

[**0038**] **FIG. 6B** is a sectional view taken along the line VIB-VIB in **FIG. 6A**;

[**0039**] **FIG. 7** shows an inner side inner periphery guide section constituting member and includes

[**0040**] **FIG. 7A** being a front view thereof,

[**0041**] **FIG. 7B** being a side view thereof and

[**0042**] **FIG. 7C** being a back side view thereof;

[**0043**] **FIG. 8** shows an outer side inner periphery guide section constituting member and includes

[0044] **FIG. 8A** being a front view thereof,

[0045] **FIG. 8B** being a side view thereof and

[0046] **FIG. 8C** being a back side view thereof;

[0047] **FIG. 9** is a side view of a side lid (end plate) mounted to longitudinal end surfaces of a block body;

[0048] **FIG. 10** is a developed perspective view showing a step for assembling the linear motion guide device, in which the inner periphery guide section constituting member (inner divided block) (on one side) is mounted to the block body;

[0049] **FIG. 11** is a developed perspective view showing an assembling process of the linear motion guide device, in which an escape passage constituting member and the second support member are mounted to the block body;

[0050] **FIG. 12** is a developed perspective view showing an assembling process of the linear motion guide device, in which the inner periphery guide section constituting member (inner divided block) (on the other side) is mounted to the block body;

[0051] **FIG. 13** is a developed perspective view showing an assembling process of the linear motion guide device, in which the first and third support members are mounted to the block body;

[0052] **FIG. 14** is a developed perspective view showing an assembling process of the linear motion guide device, in which the inner periphery guide section constituting member (outer divided block) (on one side) is mounted to one end surface of the block body and a side lid is mounted to this end surface of the block body;

[0053] **FIG. 15** is a developed perspective view showing an assembling process of the linear motion guide device, in which rollers held by roller support belts are fitted to the block body;

[0054] **FIG. 16** is a developed perspective view showing an assembling process of the linear motion guide device, in which the inner periphery guide section constituting member (outer divided block) (on the other one side) is mounted to the other one end surface of the block body and the other side lid is mounted to this other end surface of the block body;

[0055] **FIG. 17** is a perspective view showing a detail of mounting the second support member to the inner periphery guide section constituting member (inner divided block);

[0056] **FIG. 18** is a perspective view showing a detail of mounting the first support member to the inner periphery guide section constituting member (inner divided block), in which

[0057] **FIG. 18A** represents a state before the mounting thereof and

[0058] **FIG. 18B** represents a state after the mounting thereof;

[0059] **FIG. 19** is a perspective view showing a detail of mounting the first and third support members to the inner periphery guide section constituting members (inner divided block);

[0060] **FIG. 20** shows a detail of a process of inserting the first and third support members into the side lid, in which

[0061] **FIG. 20A** are presents a state before the insertion and

[0062] **FIG. 20B** represents a state after the insertion; and

[0063] **FIG. 21** is a front view showing the inner periphery guide section constituting member to which the first and third support members are mounted.

[0064] **FIG. 22** is a disassembled view showing another example of the escape passage constituting members.

BEST MODE FOR EMBODYING THE INVENTION

[0065] **FIGS. 1 and 2** represent a linear motion guide device according to a first embodiment of a motion guide device of the present invention, and the linear motion guide device comprises a track rail **1** as a linearly extending track member and a movable block as a movable member assembled with the track rail **1** to be movable through a number of balls **3** as rolling members.

[0066] The track rail **1** has a longitudinally extending structure having approximately rectangular cross section, and the track rail **1** has both lateral side surfaces on which grooves **1***a* are respectively formed. The groove **1***a* has side wall sections **1***b*, **1***b* and bottom wall section **1***c*.

[0067] As shown in **FIG. 2**, the extensions of the side wall sections **1***b*, **1***b* of the groove **1***a* intersect each other at a right angle of 90° degrees, and in the illustration, upper and lower side wall sections **1***b*, **1***b* constitute roller rolling surfaces along which the rollers roll. That is, both the side surfaces of the track rail **1** are formed with two upper and lower roller rolling surfaces **1***b*, **1***b* as, totally, four rolling member rolling surfaces.

[0068] On the other hand, the movable block **2** is provided with a flat (horizontal) section **2***a* corresponding to the upper surface of the track rail **1** when assembled and a lateral pair of sleeve (skirt) sections **2***b*, **2***b* extending downward from both side ends of the flat section **2***a* so as to oppose to the side surfaces of the track rail **1**. The movable block **2** is composed of a block body **4** made of steel, a circulation passage forming structure made of resin (circulation passage structure, hereinlater) which is assembled with the block body **4** and a pair of side lids **5**, **5** with which the circulation passage structure is assembled. The side lids **5**, **5** may be called as end plates **5**, **5** which are mounted to both the longitudinal end portions of the block body **4**.

[0069] The sleeve sections **4***b*, **4***b* of the block body **4** are formed with projections **4***c*, **4***c* each having an outer shape substantially in conformity with the shape of the groove **1***a* formed on each side surface of the track rail. The projections **4***c* are formed with two loaded roller rolling surfaces **4***d*, **4***d*, as loaded rolling member rolling surfaces, corresponding to the roller rolling surfaces **1***b*, **1***b* of the track rail **1**. That is, upper and lower (two) loaded roller rolling surfaces **4***d*, **4***d* are formed on each of the lateral sleeve sections **4***b*, **4***b* of the block body **4**. (Totally, four surfaces **4***d*, **4***d* are formed).

[0070] Furthermore, each of the sleeve sections **2***b*, **2***b* of the movable block **4** is formed with upper and lower (two) roller escape passages **7**, **7** in parallel to the upper and lower loaded roller rolling surfaces **4***d,* **4***d,* respectively with a predetermined space and U-pipe-shaped direction changing passages **8, 8** connecting both end portions of the loaded roller rolling surfaces **4***d,* **4***d* and the roller escape passages **7, 7**, respectively, so as to circulate the rollers **3, 3**, - - - , **3**, as shown in **FIG. 3**. That is, these loaded roller rolling surfaces **4***d,* **4***d,* the paired rolling direction changing passages **8, 8** and the roller escape passages **7, 7** constitute a roller circulation passage.

[0071] The four, each two, rows of the upper and lower roller escape passages **7, 7** are formed on each of the lateral sleeve sections **2***b,* **2***b,* and the rolling direction changing passages **8, 8** are formed so as to connect the upper loaded roller rolling surface **4***b* and the lower roller escape passage **7** and connect the lower loaded roller rolling surface **4***b* and the upper roller escape passage **7** in the illustrated state, in which the flat section **2***a* of the movable member **2** is disposed upward, to thereby establish a grade separation arrangement.

[0072] Four, respectively two, roller circulation passages are formed on the lateral sleeve sections **2***b*, **2***b* of the block body **4**, and each of the roller circulation passages is formed in one plane so that the rollers **3, 3**, - - - , **3** circulate two-dimensionally along the roller circulation passages. A plane in which one of the roller circulation passages is positioned and another plane in which the other one of the roller circulation passages is arranged are crossed each other at the right angle, so that one of the roller circulation passages is positioned on the inner peripheral side of the other one.

[0073] With reference to **FIG. 3**, the rollers **3, 3**, - - - , **3** are arranged in series through a roller support (holding) belt **10**, as rolling member support belt, and the rollers **3, 3**, - - - , **3** circulate in the state held (retained) by the roller support belt **10**. The roller support belt **10** is composed of a flexible belt member **10***a* formed with roller holes into which the rollers are accommodated and held, respectively, and spacers **10***b,* **10***b* each disposed between the rollers in the roller holes. The flexible belt member **10***a* has side edge portions **10***d,* **10***d* positioned outside the axial ends of the rollers **3, 3**, - - - , **3**.

[0074] The resin circulation passage structure comprises: support members **11, 12** and **13** extending along both side edges of the loaded roller rolling surfaces **4***d*, **4***d* and preventing the rollers, **3, 3**, - - - , **3** from coming off from the loaded roller rolling surfaces **4***d*, **4***d* at a time when the movable block **2** is removed from the track rail **1**; escape passage constituting members **14, 14** constituting the roller escape passages; and a pair of inner periphery guide section constituting members **15***a* and **15***b* constituting the inner periphery guide sections of the rolling direction changing passages. The support members **11, 12, 13**, the escape passage constituting members **14, 14** and the paired inner periphery guide section constituting members **15***a*, **15***b* are formed respectively of resin independent from the block body **4**, and these members are assembled to the block body **4** after the molding processes thereof.

[0075] According to this first embodiment of the present invention mentioned above, the support members **11, 12, 13**, the escape passage constituting members **14, 14** and the paired inner periphery guide section constituting members **15***a,* **15***b* are formed of resin independently (separately) from the block body **4**, shrinkage cavities (shrinkage amounts) of these members can be preliminarily calculated and then manufactured through the molding process. As a result, the support members **11, 12** and **13** having thin and long extensions and the escape passage constituting members **14, 14** are not flexed or adversely bent, and moreover, the inner periphery guide section constituting members **15***a* and **15***b* are also not opened (widened).

[0076] In the support members **11, 12** and **13**, as shown in **FIGS. 1 and 2**, the first support member **11** supports the lower sides of the lower rollers **3, 3**, - - - , **3**, the second support member **12** supports the upper sides of the lower rollers **3, 3**, - - - , **3** and the lower sides of the upper rollers **3, 3**, - - - , **3** and the third support member **13** supports the upper sides of the upper rollers **3, 3**, - - - , **3**.

[0077] **FIG. 4** shows the first support member **11**. The first support member **11** is formed of a resin material so as to provide a thin structure having a long scale. By incorporating the first support member **11** into the block body **4**, a guide groove for guiding the side edge portion of the roller support belt is formed. This first support member **11** is mounted to the movable block **2** in a state that the first support member **11** is disposed between both the side lids **5, 5** and supported thereby at both longitudinal ends thereof. The first support member **11** is formed, at both end portions thereof, with protruded portions **11***a,* **11***a,* which are to be fitted into the side lids **5, 5**. Furthermore, the side surface portions of the first support member **11** are formed with recessed portions such as slots **11***b,* **11***b* for positioning the first support member **11** with respect to the inner periphery guide section constituting members **15***a* and **15***b*.

[0078] **FIG. 5** shows the second support member **12**. The second support member **12** is also formed of a resin material so as to provide a thin structure having a long scale. The second support member **12** has both side portions on which guide grooves **12***a,* **12***a* are formed for guiding the side edge portions of the roller support belt **10**. This second support member **12** is mounted to the movable block **2** in a state that the second support member **12** is disposed between the paired inner periphery guide section constituting members **15***a*, **15***a* and supported thereby at both longitudinal ends thereof. The second support member **12** is formed, at both end portions thereof, with protruded portions (protrusion) **12***b,* **12***b,* which are to be fitted into the inner periphery guide section constituting members **15***a,* **15***a*. Each of the protrusions **12***b,* **12***b* has a portion of rectangular section and a portion of circular section.

[0079] **FIG. 6** shows the third support member **13**. The third support member **13** is also formed of a resin material so as to provide a thin structure having a long scale. By incorporating the third support member **13** into the block body **4**, a guide groove for guiding the side edge portions of the roller support belt **10** is formed. This third support member **13**, like the first support member **11**, is mounted to the movable block **2** in a state of being disposed between both the side lids **5, 5** and supported thereby at both longitudinal ends thereof. The third support member **13** is formed, at both end portions thereof, with protruded portions **13***a,* **13***a,* which are to be fitted into the side lids **5, 5**. Furthermore, the side surface portions of the third support member **13** are formed with recessed portions such as slots

13*b*, **13***b* for positioning the third support member **13** with respect to the inner periphery guide section constituting member **15***a*, **15***a*.

[**0080**] As shown in **FIG. 1**, the escape passage constituting members **14**, **14** are composed of a pair of pipe halves **14***a*, **14***b* formed by dividing a pipe along the axial direction of the pipe. Each of these pipe halves **14***a*, **14***b* is provided with a groove conformed with the shape of the roller **3** in the axial direction, a guide groove guiding a belt side edge portion **10***d* and a flange **19** extending in the longitudinal direction along both the side edges of the grooves. Each of these pipe halves **14***a*, **14***b* has a length slightly longer than the length of the block body **4**. The escape passage constituting members **14**, **14**, each being formed by assembling the pipe halves **14***a*, **14***b*, are positioned at their both end portions to recessed portions **42**, **42** (mentioned hereinlater) of the inner periphery guide section constituting members **15***a*, **15***a*, and, in a state that both the end portions of the escape passage constituting members are supported, are fixed to the movable block **2** through the inner periphery guide section constituting members **15***a*, **15***a*. To both the end portions of the escape passage constituting members **14**, **14** are formed positioning protrusion (protruded portions) **20** for positioning the escape passage constituting members **14**, **14** with respect to the inner periphery guide section constituting members **15***a*, **15***a*.

[**0081**] **FIGS. 7 and 8** represent the inner periphery guide section constituting members **15***a* and **15***b*, respectively. Each of the inner periphery guide section constituting members **15***a* and **15***b* is composed of a divided blocks divided into tow parts along the longitudinal direction of the track rail **1**. These two divided blocks are combined, and the U-shaped direction changing passages, which have grade separation structures, are formed. The grade separation direction changing passages have rectangular shapes in cross sections. Furthermore, The direction changing passage is formed with a guide groove for guiding the side edge portions **10***d*, **10***d* of the roller support belt **10**.

[**0082**] **FIG. 7** shows an inner side divided block (i.e., the inner periphery guide section constituting member). The divided block **15***a* on the side of the movable block **2** (i.e., inner side divided block) is formed with an inner periphery guide section **21** of the inner peripheral side roller circulation passage. This inner periphery guide section **21** is formed to provide approximately semicircular shape. The inner side divided block **15***a* has a front surface portion **22** abutting against the block body **4** and the front surface portion **22** is formed with positioning protrusions (protruded portions) **23** for positioning the divided block with respect to the block body **4**. The block body **4** is formed with positioning recessed portions for positioning the block body to be fitted to the positioning protrusions **23** (see **FIG. 1**). Further, there are also formed, on the front surface portion **22**, positioning recessed portions **42**, **42** for positioning escape passage groove constituting members **14**, **14**, to which are fitted the positioning protrusions **20**, **20**, mentioned hereinbefore, for positioning the escape passage section constituting members **14**, **14**. The positioning protrusions **20**, **20** for positioning the escape passage groove constituting members **14**, **14** have flanged portions which are fitted to expanded portions **42***a*, **42***a* of the recessed portions for positioning the escape passage section constituting members, whereby the escape passage section constituting members **14**, **14** are prevented from being rotated. Furthermore, the front surface portion **22** is further formed with a positioning recess **25** for positioning a second support member **12** with respect to the divided block **15***a*, and this second support member positioning recess **25** is fitted with the second support member positioning protrusion **12***b* mentioned hereinbefore. The divided block **15***a* is formed, at its side surface, with a first support member positioning protrusion **26** for positioning the first support member **11** and a third support member positioning protrusion **27** for positioning the third support member **13** with respect to the divided block **15***a*. These first and third support member positioning protrusions **26** and **27** are fitted to the first and third support member positioning recesses **11***b* and **13***b*, respectively. Further, divided block positioning recesses **28**, **28** for positioning the other, i.e. outer divided block **15***b* with respect to the inner divided block **15***a* are formed on the back surface of the divided block **15***a*.

[**0083**] **FIG. 8** represents the outer (side lid side) divided block **15***b*. The outer divided block **15***b* is formed with an outer periphery guide section **31** of the inner side roller circulation passage and an inner periphery guide section **32** of the outer side roller circulation passage. These inner and outer periphery guide sections **32** and **31** have substantially semi-circular shapes. Further, the outer divided block **15***b* is formed with divided block positioning protrusions **33**, **33** fitted to the divided block positioning recesses **28**, **28** formed on the inner side divided block **15***a*. Furthermore, side lid positioning protrusions **34**, **34** for positioning the outer divided block **15***b* with respect to the side lids **5**, **5** are formed on the back surface of the outer divided block **15***b*.

[**0084**] **FIG. 9** represents the side lid (i.e., longitudinal endplate) **5** having a sectional shape corresponding to that of the block body **4** and provided with horizontal flat portion **5***a* and a sleeve, i.e. side skirt, portions **5***b*, **5***b*, on which outer periphery guide section **36**, **36** of the outer peripheral side roller circulation passage is formed. Furthermore, the inner periphery guide section constituting members **15***a* and **15***b* in the state assembled together are fitted to these sleeve portions **5***b*, **5***b*. The sleeve portions **5***b*, **5***b* are formed with side lid positioning recesses **37**, **37** for positioning the side lid **5** which are fitted with the side lid positioning protrusions **34**, **34** formed on the outer divided block **15***b*. Still furthermore, the sleeve portions **5***b*, **5***b* are formed with recesses **39** and **40** into which the protrusions **11***a* and **13***a* of the first and third support members **11** and **13** are forcibly inserted.

[**0085**] As shown in **FIG. 1**, the side lids **5**, **5** are mounted to both longitudinal ends of the block body **4**. Bolts are inserted into bolt insertion holes formed on the side lids **5**, **5** and the bolts are screwed into screw holes formed on the end surfaces of the block body **4**, whereby the side lids **5**, **5** are fastened and fixed to the block body **4**, and accordingly, the inner periphery guide section constituting members **15***a*, **15***b* are fixed to the block body **4**. Further, decorative plates **38**, **38** are attached to the outer side portions of the side lids **5**, **5**.

[**0086**] Incidentally, in a case where the support members **11**, **12**, **13**, the escape passage constituting members **14**, **14**, and the inner periphery guide section constituting members **15***a*, **15***b* are formed out of resin material independently from the block body **4** and also independently from each other, there may cause fears such that the number of constitutional members or parts for constituting the motion guide device is increased and the assembling working thereof will be made difficult and troublesome. On the other hand, according to the present invention, as mentioned above, the support members **11**, **12**, **13** and the escape passage constituting members **14**, **14** are positioned with reference to the inner periphery guide section constituting member **15***a* which is positioned to the block body **4**, so that the support members **11**, **12**, **13** and the escape passage constituting members **14**, **14** can be positioned with high precision to the block body **4**. As a result, even in the case where the support members **11**, **12**, **13**, the escape passage constituting members **14**, **14**, and the inner periphery guide section constituting members **15***a*, **15***b* are formed independently from the block body **4** and from each other, these circulation passage forming members do not interfere the motion of the rollers. Furthermore, the support members **11**, **12**, **13** and the escape passage constituting members **14**, **14** are positioned and assembled with the inner periphery guide section constituting member **15***a* being as one reference member, so that the inner periphery guide section constituting members **15***a*, **15***b*, the support members **11**, **12**, **13** and the escape passage constituting members **14**, **14** can be easily assembled with high reproductivity.

[0087] The roller support belt **10** is supported by guide grooves **43** (**FIG. 21**) formed by the support members **11**, **12**, **13** and the block body **14** so as to prevent rollers **3**, **3**, - - - , **3** from coming of f from the movable block **2**. The rollers **3**, **3**, - - - , **3** are supported by the roller support belt **10**. Accordingly, the roller support belt **10** and the rollers **3**, **3**, - - - , **3** never come off from the movable block **2**. Further, the rollers **3**, **3**, - - - , **3** are guided in the predetermined track by the contact of the support members **11**, **12**, **13** at the axial end surfaces of the rollers **3**, and hence, the generation of inclination of the rollers **3** with respect to their rotation axes, so-called, the generation of skew can be prevented.

[0088] Next, the method of assembling such motion guide device will be described hereunder. The assembling of the motion guide device is performed along the steps or processes represented by FIGS. **10** to **16**.

[0089] First, as shown in **FIG. 10**, the inner divided blocks **15***a*-**1**L and **15***a*-**1**R of the inner periphery guide section constituting member are fixed to one end side, and to left and right sides, of the block body **4**. Further, it is to be noted, for the sake of easy understanding of the explanation, that references "-**1**" and "-**2**" are additionally applied to the reference numerals of the respective members or elements which are disposed to one and the other end sides of the block body **4** and, furthermore, the capitals "L" and "R" are further added to "-**1**" and "-**2**" to elements or members disposed on left and right sides of the block body **4**, for example, as shown in **FIG. 10**, such as **15***a*-**1**L or **15***a*-**1**R.

[0090] The mounting of these divided blocks **15***a*-**1**L and **15***a*-**1**R with respect to the block body **4** will be completed by fitting the positioning protrusions **23** formed on the divided blocks **15***a*-**1**L and **15***a*-**1**R into the positioning recesses **24** formed on the end surfaces of the block body **4**.

[0091] In the next step shown in **FIG. 11**, the escape passage constituting members **14** are inserted respectively into four slots (long holes) of the block body **4** from the side opposite to the other side of the block body **4**, i.e., mounting side of the divided blocks **15***a*-**1**L and **15**-**1**R. These escape passage constituting members **14** are each composed of pipe members **14***a*, **14***b* in combination thereof, and the positioning protrusions **20** for positioning the escape passage constituting members **14** are engaged with the positioning recesses **42** for positioning the escape passage constituting members of the divided blocks **15***a*-**1**L and **15***a*-**1**R with the positioning protrusions **20** being disposed upper side.

[0092] Further, as shown in **FIG. 11, a** pair of second support members **12** are mounted. More in detail, as shown in **FIG. 17**, the positioning protrusions **12***b* for positioning the second support members on one end side of the second support members **12** are engaged with the second positioning recesses **25** formed on the divided blocks **15***a*-**1**L and **15***a*-**1**R with the positioning protrusions **12***b* being disposed upper side.

[0093] Next, with reference to **FIG. 12**, the inner divided blocks **15***a*-**2**L and **15***a*-**2**R of the other side lateral inner periphery guide section constituting members are mounted to the other side end portions of the block body **4**. These divided blocks **15***a*-**2**L and **15***a*-**2**R are also positioned to the block body **4**, as like as the divided blocks **15***a*-**1**L and **15***a*-**1**R mentioned before, by fitting the positioning protrusions **23** formed on the divided blocks into the positioning recesses **24** formed on the block body **4**. Furthermore, the positioning recesses **42** for the escape passage constituting members of the divided blocks **15***a*-**2**L and **15***a*-**2**R are then engaged with the positioning protrusions **20** of the other end side escape passage constituting members **14** which have already been mounted to the block body **4**, respectively, and at the same time, the positioning recesses **25** of the-respective second support members of the divided blocks **15***a*-**2**L and **15***a*-**2**R are engaged with the protrusions for positioning the second support member on the other side thereof. According to the described manner, the respective inner divided blocks **15***a*-**1**L, **15***a*-**1**R, **15***a*-**2**L, **15***a*-**2**R, the escape passage constituting members **14** and the second support members **12** are united with respect to the block body **4** in the firm engaging state requiring no pressing force of, for example, finger pressing to thereby prevent them from coming off from the block body **4**.

[0094] Under the state mentioned above, as shown in **FIG. 13**, the first support member **11** and the third support member **13** are mounted to the block body **4**. Specifically, for example, with respect to the first support member **11**, as shown in FIGS. **18**(*a*) and (*b*), the positioning recesses **11***b* for positioning the first support member formed on both end portions of the first support member **11** are engaged with the positioning protrusions **26** for positioning the first support member of the divided block **15***a*-**1**L (further, since substantially the same is applicable to the other divided blocks **15***a*-**1**R, **15***a*-**2**L and **15***a*-**2**R, only the case of the divided block **15***a*-**1**L will be discussed herein).

[0095] Furthermore, as shown in **FIG. 19**, substantially the same matter as that mentioned above will be described with respect to the third support member **13**. That is, the positioning recesses **13***b* for positioning the third support member formed on both end portions of the third support member **13** are engaged with the positioning protrusions **27** for positioning the third support member of the divided block **15***a*-**1**L (further, substantially the same is applicable to the other divided blocks **15***a*-**1**R, **15***a*-**2**L and **15***a*-**2**R).

[0096] Further, the engagements between the recesses **11***b* for positioning the first support member and the positioning protrusions **26** for positioning the first support member and between the recesses **13***b* for positioning the third support member and the positioning protrusions **27** for positioning the third support member are made with a little close fit state, and after the fitting, these support members never come off from the block body, with no support, by means of, for example, fingers.

[0097] Next, as shown in **FIG. 14**, the outer divided blocks **15***b*-**1**L, **15***b*-**1**R of the inner periphery guide section constituting members are mounted to bilateral both sides on one end side portion of the block body **4**, and the side lid **5-1** is further attached to this one end side portion. More in detail, with reference to the divided blocks **15***b*-**1**L and **15***b*-**1**R, the divided block positioning protrusions **33** formed thereto are engaged with the divided block positioning recesses **28** formed on the inner divided blocks **15***a*-**1**L and **15***a*-**1**R, respectively. On the other hand, with reference to the side lid **5-1**, as shown in FIGS. **20**(*a*) and (*b*), the protrusions **11***a* and **13***a* formed on the first and third support members **11** and **13** are inserted into and then mounted to the recesses **39** and **40**, respectively, formed on the divided blocks **15***a*-**1**L and **15***a*-**1**R, and then, fastened to the block body **4** by means of bolts.

[0098] Thereafter, as shown in **FIG. 15**, the rollers **3**, **3**, - - - , **3** (four rows) aligned and supported by the roller support belts **10** are inserted into the respective roller circulation passages from the other side of the block body **4**, i.e. the side opposite to the side lid mounting side.

[0099] Then, as shown in **FIG. 16**, the outer periphery divided blocks **15***b*-**2**L, **15***b*-**2**R and the side lid **5-2** are mounted to the other side end portion of the block body **4**. The mounting of these outer periphery divided blocks **15***b*-**2**L, **15***b*-**2**R and the side lid **5-2** is performed by substantially the same manner as that performed for the mounting of the outer periphery divided blocks **15***b*-**1**L, **15***b*-**1**R and the side lid **5-1** on the one side of the block body **4** mentioned before. Now, since the support members **11** and **13** are positioned by the inner divided blocks **15***a*-**1**L, **15***a*-**1**R and the side lid **5-1**, the support members are positioned at two portions in the longitudinal direction thereof. Accordingly, in the assembling process, there is no fear of tilting (falling) and the side lid **5-2** can be simultaneously inserted into a plurality of support members **11** and **13**, thus making easy the assembling process.

[0100] **FIG. 21** represents the inner periphery guide section constituting member **15***a* mounted with the first, second and third support members **11**, **12** and **13**. By assembling the inner periphery guide section constituting member **15***a* mounted with the first, second and third support members **11**, **12** and **13**, the guide grooves **43**, **43**,—guiding the side edge portions **10***d* of the belt portions **10***a* of the roller support belts **10** in the loaded area are formed. The guide groove **43** can attain the functions of preventing the roller support belt **10** from being swung at the time of rolling motion of the rollers **3**, **3**, - - - , **3** and preventing the belt portion **10***a* from coming off through engagement of the side edge portion **10***d* of the belt portion **10** at the time of removing the movable block **2** from the track rail **1**. The rollers **3** are held by the roller support belt **10** so as not to come off therefrom to thereby support without coming off from the movable block **2** by way of the roller support belt **10**.

[0101] **FIG. 22** shows a disassembled view of another example of the escape passage constituting member. This escape passage constituting member **50** is composed, as like as the escape passage constituting member **14** mentioned hereinbefore, by assembling a pair of pipe halves **50***a*, **50***b* divided in a direction perpendicular to the axial direction of a pipe. The respective pipe halves **50***a*, **50***b* have flanged portions **53**, **53** on which positioning protrusion and recess **51** and **52** are formed, respectively. The flanged portions **53**, **53** constituting the divided surfaces of the pipe halves **50***a*, **50***b* intersect at right angle with respect to the axial line RC of the roller **3** so as to be parallel to a plane including the circulation passage. The escape passage constituting member **50** is formed bilaterally asymmetrically with respect to the axial line RC of the roller **3**. According to such structure, the escape passage constituting member **50** has a shape different on the inner peripheral side **55** and the outer peripheral side **54** of the circulation passage. As shown in **FIG. 11** mentioned before, the escape passage constituting member **50** is inserted into four slots **4***a* of the block body **4**. The positioning recesses **42** for positioning the escape passage constituting member, in conformity with the sectional shape thereof, are formed on the inner divided blocks **15***a*-**1**L and **15***a*-**1**R so as to be fitted with the positioning protrusions formed on both the axial end portions of the escape passage constituting member **50**.

[0102] As shown in **FIG. 22**, according to the structure in which the inner peripheral side **55** and the outer peripheral side **54** of the circulation passage of the escape passage constituting member **50** are made different in shapes from each other, there is no fear of causing the erroneous insertion of the inner peripheral side **55** and the outer peripheral side **54** of the escape passage constituting member **50** during the insertion working thereof into the block body **4**. On the other hand, in an arrangement in which the escape passage constituting member **50** is formed laterally symmetrically with respect to the axial line RC of the roller **3**, it is inevitable to cause a fear of erroneous insertion of the inner peripheral side **55** and the outer peripheral side **54** of the escape passage constituting member **50** during the insertion working thereof into the block body **4**.

[0103] Further, in the described embodiment, although four rows of the roller rolling surfaces **1***b*, **1***b* and the loaded roller rolling surfaces **4***d*, **4***d* are formed (two in each lateral side), the number of these rows may be variously set on the basis of kinds of rolling motion guide devices. Furthermore, although the inner periphery guide section constituting members **15***a*, **15***b* are divided into two blocks and the direction changing passages are formed on the inner periphery guide section constituting members **15***a*, **15***b* so as to intersect as grade separation structure, it is not necessary to divide the inner periphery guide section constituting members **15***a*, **15***b* in accordance with the form of the circulation passage. Still furthermore, balls may be also utilized as rolling members in place of the rollers **3**.

[0104] Moreover, in the described embodiment, although the linear motion guide device was described, the present invention may be applied to a curvilinear motion guide device guiding a curved motion.

[0105] Furthermore, in the described embodiment, although the escape passage is composed of a pipe-shaped escape passage constituting member, the escape passage may be formed by a through-hole perforated in the block body.

[0106] As mentioned hereinbefore, according to the present invention, the support members, the escape passage constituting members and the inner periphery guide section constituting members constituting the rolling member circulation passages are formed respectively of resin material independent (separately) from the body of the movable member and these members are assembled with the body of the movable member. Accordingly, the respective shrinkage cavity amounts of the support members, the escape passage constituting members and the direction changing passages are preliminarily calculated and manufactured according thereto. As a result, the thin and long-scale support members and escape passage constituting members can be prevented from being bent or flexed and the inner periphery guide section constituting members can be also prevented from being opened.

1. A motion guide device which comprises a track member provided with a rolling member rolling portion and a movable member disposed to be movable along the track member through a number of rolling members and in which said movable member is provided with a loaded rolling member rolling portion corresponding to the rolling member rolling portion of the track member, a rolling member escape passage disposed in parallel to the loaded rolling member rolling portion with a predetermined distance and a pair of direction changing passages connecting the loaded rolling member rolling portion and the rolling member escape passage to thereby circulate the rolling members,

wherein support members extending along both side edges of the loaded rolling member rolling portion, escape passage constituting members constituting the rolling member escape passages and a pair of inner periphery guide section constituting members constituting the inner peripheral portions of the direction changing passages are formed to be independent from a body of the movable member and also independent from each other and are assembled to the body of the movable member.

2. A motion guide device according to claim 1, wherein said support members act to prevent the rolling members from coming off from the loaded rolling member rolling portion at a time when the movable member is removed from the track member.

3. A motion guide device according to claim 1 or **2**, wherein:

either one of the inner periphery guide section constituting member and the body of the movable member is formed with a positioning recess for positioning the inner periphery guide section constituting member with respect to the body of the movable member and the other one thereof is formed with a movable member body positioning protrusion to be engaged with said movable member body positioning recess;

either one of the inner periphery guide section constituting member and the escape passage constituting member is formed with a positioning recess for positioning the escape passage constituting member with respect to the inner periphery guide section constituting member and the other one thereof is formed with an escape passage constituting member positioning protrusion to be engaged with said escape passage constituting member positioning recess; and

either one of the inner periphery guide section constituting member and the support member is formed with a positioning recess for positioning the support member with respect to the inner periphery guide section constituting member and the other one thereof is formed with a support member positioning protrusion to be engaged with said support member positioning recess.

4. A motion guide device according to claim 1 or **2**, wherein a pair of side lids constituting outer periphery guide sections of the direction changing passages are mounted to both longitudinal end portions of the movable member body, both the end portions of said support member are inserted into said side lids, and either one of the inner periphery guide section constituting member and the support member is formed with a positioning recess for positioning the support member with respect to the inner periphery guide section constituting member and the other one thereof is formed with a support member positioning protrusion to be engaged with said support member positioning recess.

5. A motion guide device according to any one of claims 1 to 4, wherein a number of rolling members are held in series with predetermined distance by a rolling member support belt having side edge portions projecting over both side end portions of the rolling members, and by assembling the support member to the body of the movable member, a guide section for guiding the side edge portions of the rolling member support belt is formed.

6. A motion guide device according to claim 1 to **5**, wherein said track member is a track rail and said movable member is a movable block provided with a pair of sleeve portions disposed so as to oppose to both side surfaces of the track rail, said rolling member rolling portion includes vertical two rows of rolling member rolling passages formed on each of lateral side surfaces of the track rail, totally, four rows thereof, said loaded rolling member rolling portion includes vertical two rows of loaded rolling member rolling passages formed on each of inner side surfaces of the lateral sleeve portions of the movable block, totally, four rows thereof, said escape passage constituting passage includes vertical two rows thereof formed on each of the lateral sleeve portions of the movable block, totally, four rows thereof, said direction changing passages connect an upper loaded rolling member rolling passage and a lower rolling member escape passage and connect an lower loaded rolling member rolling passage and an upper rolling member escape passage so as to provide a grade separation structure, and said inner periphery guide section constituting member is composed of a pair of divided blocks divided in the longitudinal direction of the track rail.

7. A motion guide device according to claim 6, wherein either one of said paired divided blocks is formed with a divided block positioning recess and the other one thereof is formed with a divided block positioning protrusion to be engaged with the divided block positioning recess.

8. A motion guide device according to claim 6 or **7**, wherein said support members include a first support member disposed above the upper loaded rolling member rolling passage, a second support member disposed between the upper loaded rolling member rolling passage and the lower rolling member rolling passage and a third support member disposed below the lower loaded rolling member rolling passage.

9. A motion guide device which comprises a track member provided with a rolling member rolling portion and a movable member disposed to be movable along the track member through a number of rolling members and in which said movable member is provided with a loaded rolling member rolling portion corresponding to the rolling member rolling portion of the track member, a rolling member escape passage disposed in parallel to the loaded rolling member rolling portion with a predetermined distance and a pair of direction changing passages connecting the loaded rolling member rolling portion and the rolling member escape passage to thereby circulate the rolling members,

wherein support members extending along both side edges of the loaded rolling member rolling portion and a pair of inner periphery guide section constituting members constituting the inner peripheral portions of the direction changing passages are formed to be independent from a body of the movable member and also independent from each other and are assembled to the body of the movable member, and said rolling member escape passage is constituted by a through hole perforated to the body of the movable member.

* * * * *

US 20020134622A1

(19) United States
(12) Patent Application Publication
Michioka et al.
(10) Pub. No.: US 2002/0134622 A1
(43) Pub. Date: Sep. 26, 2002

(54) DUST PREVENTING STRUCTURE OF GUIDE UNIT

(75) Inventors: **Hidekazu Michioka**, Tokyo (JP); **Yoshiaki Saitou**, Yamanashi-ken (JP); **Yasuhide Katsumata**, Yamanashi-ken (JP); **Mitsuaki Honma**, Yamanashi-ken (JP)

Correspondence Address:
ARENT FOX KINTNER PLOTKIN & KAHN
1050 CONNECTICUT AVENUE, N.W.
SUITE 400
WASHINGTON, DC 20036 (US)

(73) Assignee: **THK CO., LTD.**

(21) Appl. No.: **10/144,390**

(22) Filed: **May 14, 2002**

Related U.S. Application Data

(63) Continuation of application No. 09/450,249, filed on Nov. 29, 1999.

(30) **Foreign Application Priority Data**

Dec. 4, 1998 (JP) 10/345325
Sep. 21, 1999 (JP) 11/267212

Publication Classification

(51) **Int. Cl.**[7] **F16N 1/00**
(52) **U.S. Cl.** **184/5**

(57) **ABSTRACT**

This invention relates to a dust preventing structure of a guide unit comprising a track shaft and a sliding member engaging the track shaft via a plurality of rolling bodies such that it is capable of reciprocating in a length direction thereof. Elastic members in firm contact with the track shaft are overlaid in the length direction of the track shaft. A lubricant pocket forming member having a concave groove portion for forming a lubricant pocket constituted of the elastic members and filled with lubricant by a help of the surface of the track shaft as well is provided so as to achieve a smooth reciprocating motion of the sliding member with respect to the track shaft with less sliding friction. Particularly, under even a severe use condition in which use of coolant is required or dust, dirt, wooden pieces, cutting powder or the like falls on the guide unit, a smooth reciprocating motion of the sliding member with respect to the track shaft can be maintained in a long period.

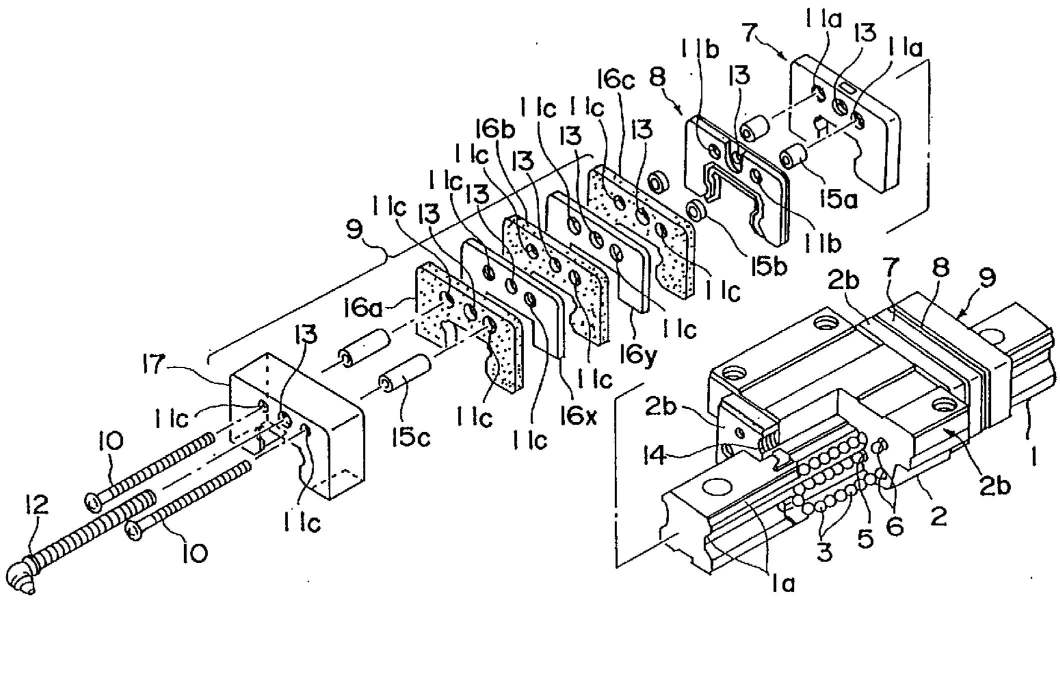


Fig. 1

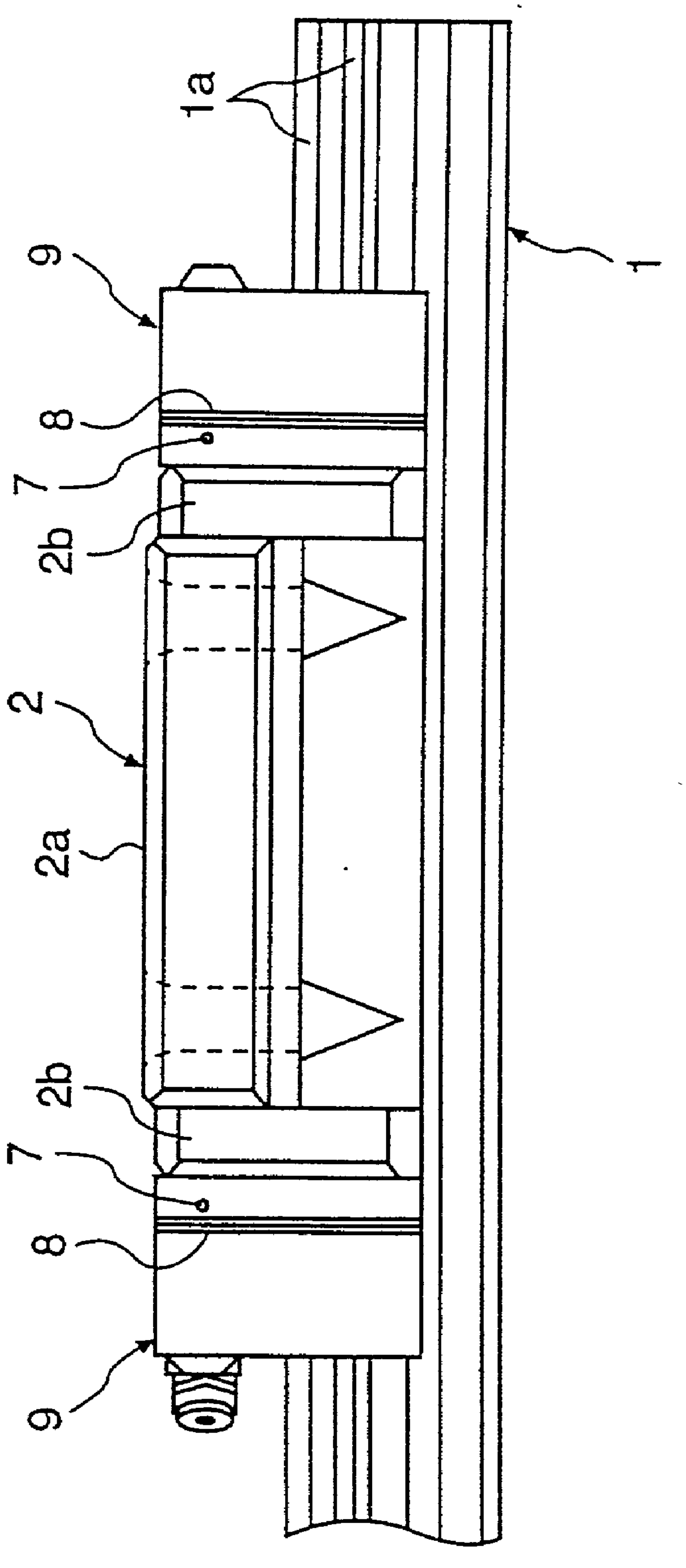
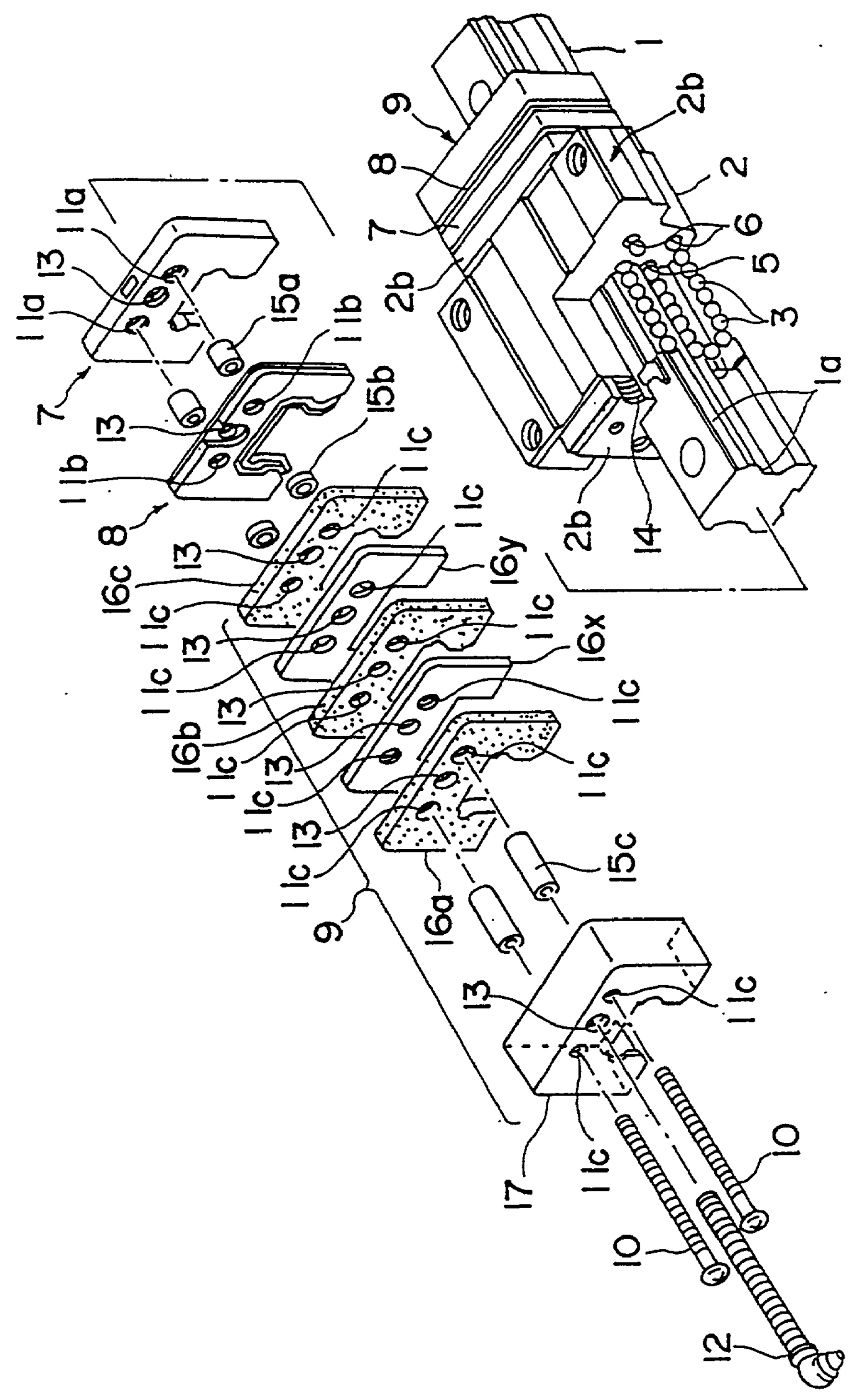


Fig.2



1
9
8
7
2b
2
6
5
3
1a
2b
14
11a
13
15a
7
11b
15b
8
11c
16c
16y
16x
16b
13
16a
15c
9
17
10
12

Fig.3

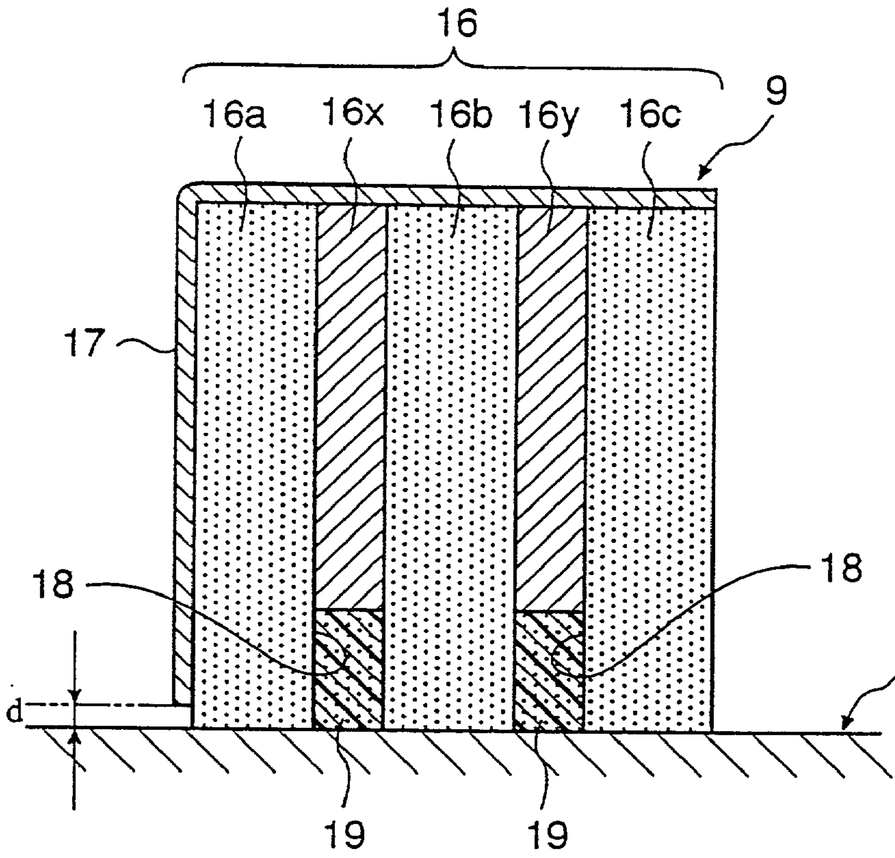


Fig.4

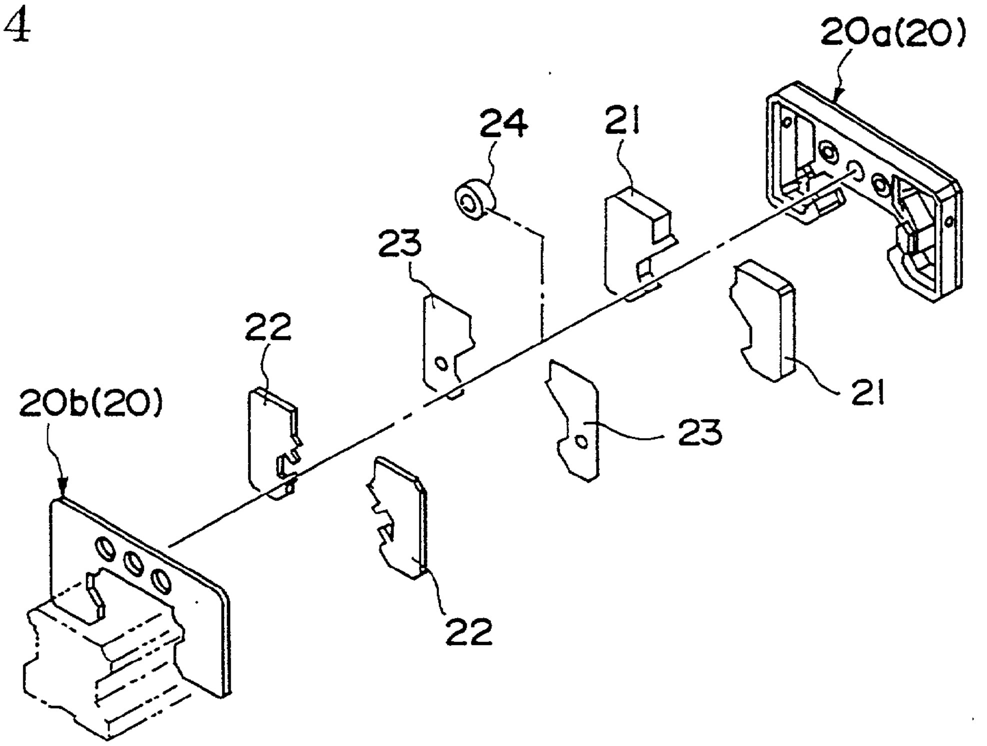


Fig.5

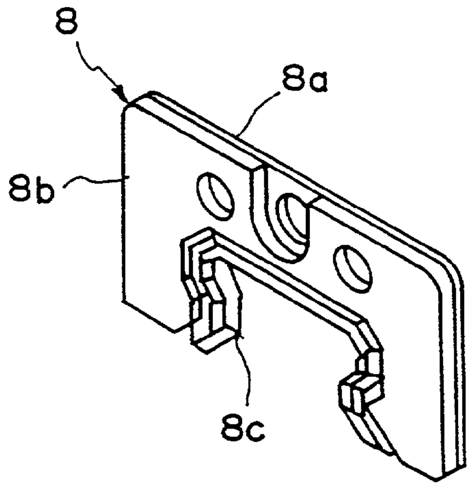


Fig.6

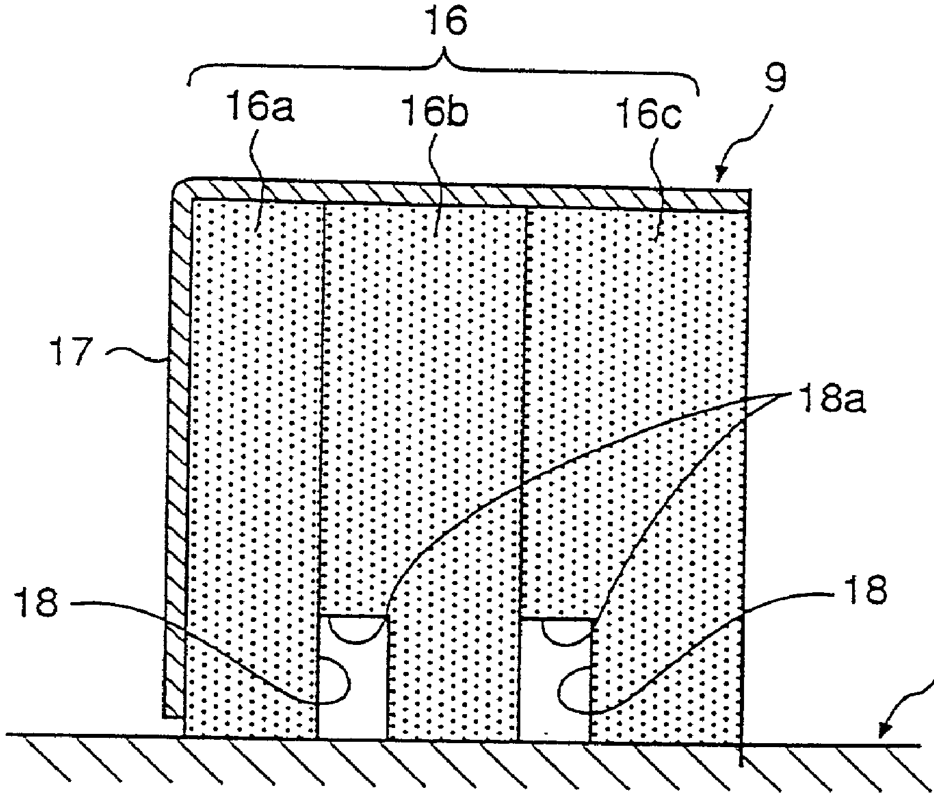


Fig.7

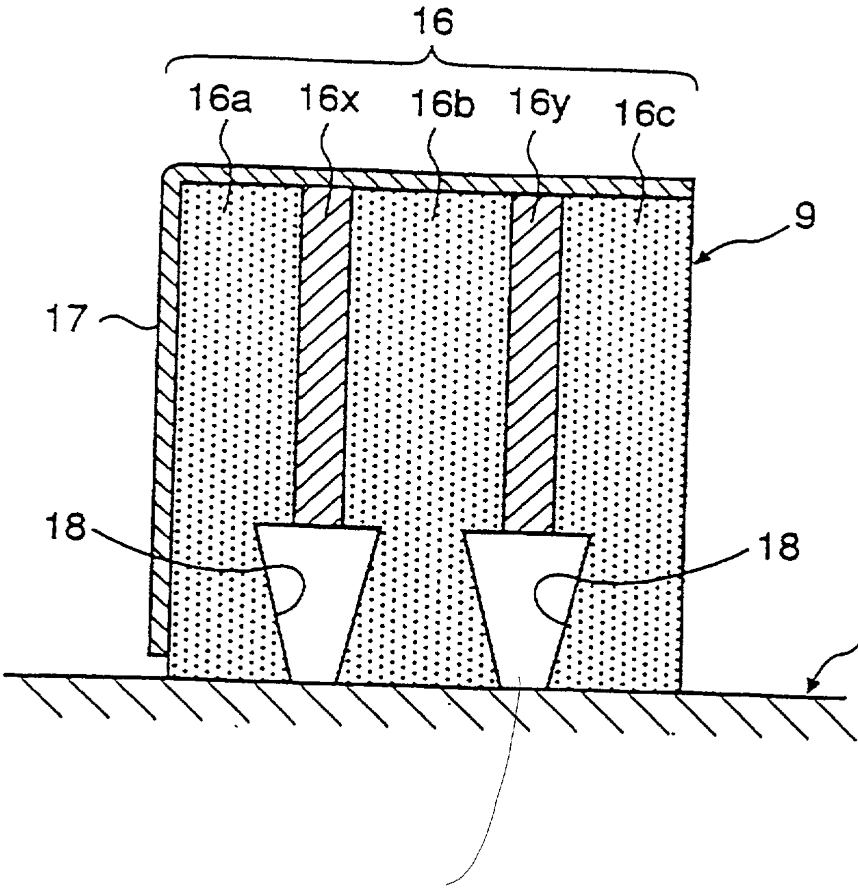
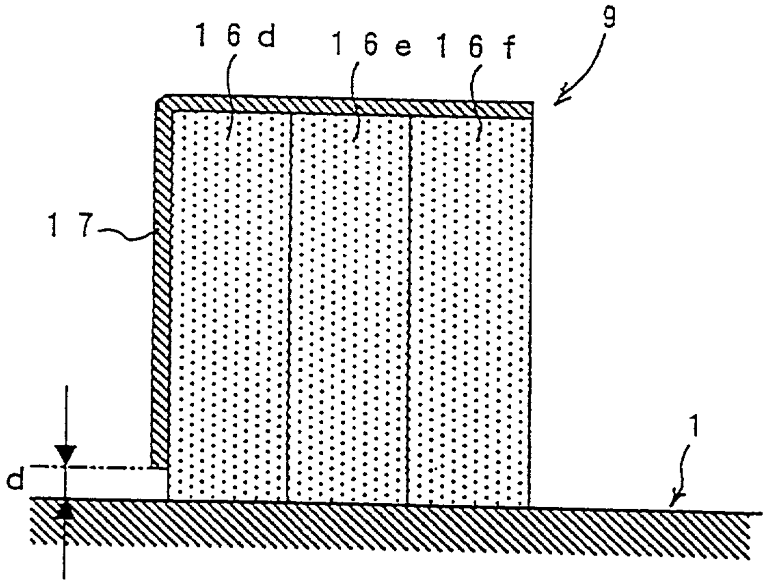


Fig.8



DUST PREVENTING STRUCTURE OF GUIDE UNIT

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a guide unit in which a track shaft and a sliding member are engaged with each other such that they are capable of relatively reciprocating via rolling bodies such as balls or rollers of ball bearing, ball bushing, ball screw, ball spline, roller bearing or the like for linear sliding and curved sliding, and more particularly to a dust preventing structure of a guide unit for removing foreign matter adhering to the surface of the track shaft and applying lubricating performance between the track shaft and sliding member.

[0002] This kind of the guide units are used in various fields requiring a linear motion, rotary motion, a curved motion and the like and their use conditions are diversified. For example, a guide unit of linear sliding type ball bearing for use in semiconductor manufacturing apparatus is used under a very clean environment, a guide unit of machine tool is used under an environment in which coolant is used and further, a guide unit of timber processing unit is used under a condition in which dust, dirt, wooden pieces, cutting powder and the like falls thereon.

[0003] In such a guide unit, if foreign matter such as coolant and dust invades into a gap between the track shaft and sliding member, the coolant repels lubricant or foreign matter absorbs lubricant, so that lubricity between the track shaft and sliding member drops considerably. As a result, rolling bodies such as balls or rollers bearing a load between the track shaft and sliding member or the track shaft in which the rolling bodies roll and the rolling groove in the sliding member side are worn abnormally thereby the service life of the unit dropping remarkably.

[0004] Thus, in a conventional linear sliding motion ball bearing comprising a track rail (track shaft) in which a ball rolling groove is formed in the length direction thereof and a sliding base (sliding member) in which a ball infinite circulation path constituted of a load rolling groove opposing the ball rolling groove in the aforementioned track rail via a plurality of balls, a direction changing path disposed at beginning and terminal ends of the load rolling groove and a ball return path connecting these direction changing paths is formed, sealing members made of rubber or the like are attached to both ends in the traveling direction of the sliding base so that they are in firm contact with the track rail, thereby removing coolant, dust and the like adhering to the surface of the track rail in the accordance the movement of the sliding base to prevent them from invading into the interior of the sliding base.

[0005] In case where, in this kind of the guide unit, foreign matter such as welding spatter or the like adheres to the track rail, if the aforementioned sealing member makes contact with the spatter, it may be caught thereby and damaged. To avoid such an inconvenience, according to another known structure of the guide unit, a scraper member made of metal or the like is attached outside of the sealing member of the sliding base with a slight gap with respect to the track rail, so that the foreign matter such as welding spatter adhering to the track rail is scraped out by this scraper member before the sealing member comes into contact with the spatter.

[0006] Because this kind of the sealing member keeps a firm contact with the track shaft (track rail in the previous example), lubricant such as lubricating oil and grease supplied inside the sliding member (sliding base in the previous example) and adhering to the surface of the track shaft is wiped off by a sealing member at the rear side of the sliding member in the advancement direction so as to prevent the lubricant from leaking out of the sliding member (lubricant leakage preventing function).

[0007] This lubricant leakage preventing function of this sealing member exerts an effect of using lubricant supplied inside the sliding member effectively. If an attention is paid to a sealing member located at the front side in the advancement direction when the sliding member reciprocates, it comes that this sealing member moves with a firm contact with the surface of the track shaft after lubricant is wiped off, so that friction resistance increases as compared to the sealing member located at the rear side in the advancement direction. As a result, a smooth reciprocation of the sliding member is prevented and if a reciprocating stroke is extremely long, the sealing member located at the front side in the advancement direction may be damaged by a friction caused between the sealing member and the track shaft or the service life of the sealing member may be shortened extremely.

[0008] This problem occurs like a case in which a scraper member made of metal, plastics or the like is used with the sealing member. Although the scraper member is capable of removing a large foreign matter such as spatter, because it cannot be mounted in a firm contact with the surface of the track shaft, it is not capable of removing small dust or dirt and when the sliding member reciprocates, the sealing member located at the front side in the advancement direction comes into contact with the small dust or dirt, so that friction resistance increases thereby the service life being reduced.

[0009] If the guide unit is used under a condition in which use of coolant is required or under an environment in which dust, dirt, wooden pieces, cutting powder or the like falls, this problem is very conceivable because after the sealing member wipes off, a slight amount of lubricant remaining on the surface of the track shaft is washed off by those foreign matters or absorbed. This problem needs to be solved to accelerate maintenance free about lubricant in a guide unit for use under such a severe condition.

OBJECT AND SUMMARY OF THE INVENTION

[0010] Accordingly, the inventor of the present invention considered a solution of this problem earnestly. As a result, the inventor of the present invention has completed a dust preventing structure of a guide unit capable of achieving a smooth reciprocation with less friction resistance of the sliding member with respect to the track shaft, preventing foreign matter from invading inside of the sliding member even if use of the sealing member is omitted if it is not used under a severe environment and further maintaining a smooth reciprocation of the sliding member with respect to the track shaft in a long period even under a severe condition in which use of coolant is required or dust, dirt, wooden pieces, cutting powder or the like falls on the guide unit, by using the sealing member at the same time.

[0011] Therefore, an object of the present invention is to provide a dust preventing structure of a guide unit capable of achieving a smooth reciprocation of the sliding member with respect to the track shaft with less friction resistance.

[0012] Further, another object of the present invention is to provide a dust preventing structure of a guide unit capable of maintaining a smooth reciprocation of the sliding member with respect to the track shaft in a long period even under a severe condition in which use of coolant is required or dust, dirt, wooden pieces, cutting powder or the like falls on the guide unit.

[0013] To achieve the above object, according to an aspect of the invention, there is provided a dust preventing structure of a guide unit comprising a track shaft and a sliding member engaging the track shaft via a plurality of rolling bodies so that it is capable of reciprocating in a length direction thereof, wherein elastic members in firm contact with the track shaft are overlaid in the length direction of the track shaft.

[0014] Further, according to another aspect of the invention, there is provided a dust preventing structure of a guide unit comprising a track shaft and a sliding member engaging the track shaft via a plurality of rolling bodies so that it is capable of reciprocating in a length direction thereof, the dust preventing structure further comprising a lubricant pocket forming member having a concave groove portion made of elastic material for forming a lubricant pocket filled with lubricant together with the surface of the track shaft.

[0015] Then, according to a preferred embodiment of the present invention, there is provided a dust preventing structure of a guide unit comprising a track shaft and a sliding member engaging the track shaft via a plurality of rolling bodies so that it is capable of reciprocating in a length direction thereof, the dust preventing structure further comprising a lubricant pocket forming member made of elastic material, including a lubricant supplying portion which is in firm contact with the track shaft holding lubricant for supplying lubricant to the surface of the track shaft upon use and a concave groove portion for forming a lubricant pocket filled with lubricant together with the surface of the track shaft.

[0016] According to the present invention, basically, the aforementioned lubricant pocket forming member is made of elastic material and includes the lubricant supplying portion which is in firm contact with the track shaft holding lubricant for supplying lubricant to the surface of the track shaft upon use and the concave groove portion for forming the lubricant pocket to be filled with lubricant together with the surface of the track shaft. If the lubricant supplying portion made of elastic material is capable of coating the surface of the track shaft with lubricant loaded in the lubricant pocket, with some extent of stiffness and holding a sufficient amount of lubricant, this lubricant pocket forming member can be formed with only the elastic material for forming the lubricant supplying portion. In this case, the lubricant pocket forming member may be formed with a single component member having a single or plural stripes of the concave groove portions or may be formed with plural component members when a single or plural stripes of the concave groove portions are formed when they are combined.

[0017] However, if as lubricant to be loaded in the lubricant pocket, for example, grease or solid lubricant is used, coating resistance which is generated when each of these lubricants is applied to the surface of the track shaft increases, so that an elastic material capable of holding a sufficient amount of lubricant considering a durable period of the dust preventing structure of the present invention may not be capable of bearing this coating resistance. Preferably, this lubricant pocket forming member comprises a plurality of elastic members constituting the lubricant supplying portion holding lubricant and spacer members which are made of stiff material and sandwiched between the plural elastic members so as to form a single or plural stripes of concave groove portions with the elastic members.

[0018] The size and quantity of the concave groove portion formed in the lubricant pocket forming member are not restricted to any particular ones, requirement for the lubricant pocket is satisfied if at least one stripe of the concave groove portion is formed and a sufficient amount of lubricant can be loaded in the lubricant pocket formed by this concave groove portion and the surface of the track shaft considering the durable period of the dust preventing structure of the present invention. Further, this concave groove portion needs to extend over an entire range in the direction of an outside periphery in which the sliding member covers the track shaft, so that lubricant can be applied to a substantially entire range in which the sliding member covers the track shaft.

[0019] The elastic material for forming at least the lubricant supplying portion of the aforementioned lubricant pocket forming member is continuously foamed body such as a continuously foamed polyurethanefoam and sintered resin or fiber entangled body such as wool felt, having physical properties including a tensile strength of 30-50 kg/cm^3, degree of elongation of 300-500%, and impact resilience of 30-60% and made to absorb and hold lubricant after it is formed to a predetermined shape. If the elastic member is formed of rubber or synthetic resin, lubricant is mixed with the rubber or synthetic resin preliminarily and formed to a predetermined shape. Alternatively, lubricant is mixed with monomer at a stage where monomer is polymerized so as to produce rubber or synthetic resin and an obtained rubber or synthetic resin containing lubricant is formed to a predetermined shape. Meanwhile, in case where the aforementioned polyurethanefoam is soaked with lubricant, preferably, the lubricant should be 30-50 weight % in terms of weight ratio.

[0020] The lubricant to be loaded in the aforementioned lubricant pocket may be in any condition of fluid, solid or gelatinous as long as it has a lubricating performance and can be loaded in the lubricant pocket. Although fluid lubricant having a relatively low viscosity can be used, the lubricant is preferred to have a high viscosity of more than 200 cst because such a lubricant is not likely to leak out of the lubricant pocket or in the form of paste, solid state or gelatinous state. More specifically, grease, high viscosity lubricant, solid lubricant, or gelatinous or solid state wax, or the like can be mentioned. Particularly, grease is preferred because it forms a lubricant coating film having an excellent durability (that is, lubricant coating film having an excellent anti-coolant performance) under a condition in which coolant is used.

[0021] In case where the lubricant pocket forming member is composed of a plurality of the elastic members and spacer members, the same elastic members as those for forming the lubricant supplying portion can be used and the spacer members may be formed of metallic plate or synthetic resin plate. Preferably, the spacer member is made of a metallic plate such as stainless plate because its mechanical characteristic value is excellent.

[0022] Further, according to the present invention, it is preferable to provide a scraper member which holds the aforementioned lubricant pocket forming member by sandwiching it between the scraper member and the sliding member. This scraper member needs to have such a strength that it is never deformed or damaged when it removes foreign matter adhering to the surface of the track shaft such as welding spatter and it is attached to the sliding member with a slight gap with respect to the surface of the track shaft, for example, a gap of 0.05-0.3 mm.

[0023] Preferably, this scraper member is formed into a shape capable of covering substantially entirely the lubricant pocket forming member with both ends of the sliding member in the advancement direction and the surface of the track shaft so as to protect the lubricant pocket forming member having the lubricant supplying portion formed of the elastic material from an impact given from outside, and foreign matter such as coolant, dust, cutting powder and the like.

[0024] The dust preventing structure of the present invention having the lubricant pocket forming member is accommodated in various guide units in diversified patterns.

[0025] The guide unit to which the dust preventing structure of the present invention is applied basically comprises the track shaft and the sliding member engaging this track shaft via a plurality of the rolling bodies such that it is capable of reciprocating in the length direction thereof and this dust preventing structure is mounted on each of both ends of the sliding member of the guide unit in the advancement direction thereof.

[0026] The guide unit to which the dust preventing structure of the present invention is applicable includes not only the linear sliding type ball bearing comprising the track rail (track shaft) having the ball rolling grooves and the sliding base (sliding member) engaging the track rail via a plurality of balls such that it is capable of reciprocating in the length direction thereof and having an infinite circulation path for the balls, but also a ball screw comprising a screw shaft (track shaft) having a spiral ball rolling groove and a nut member (sliding member) engaging the screw shaft via a plurality of balls such that it is capable of reciprocating and having an infinite circulation path for the balls, curved sliding type ball bearing, ball bushing, ball spline and roller bearings for linear sliding and curved sliding and the like.

[0027] The sliding member of the guide unit to which the dust preventing structure of the present invention is mounted may be or may not be provided with a sealing member for sealing between inside and outside of this sliding member at both end portions in the advancement direction and this is selectable depending on use condition of the guide unit.

[0028] Although the lubricant supplying member is disposed as required between the sliding member and sealing member, the dust preventing structure of the present invention may be or may not be provided with that lubricant supplying member. This is also selectable depending on use condition of the guide unit.

[0029] Regardless of it that the sliding member of the guide unit is provided with the sealing member and the lubricant supplying member, the dust preventing structure of the present invention is disposed most outside of both ends in the advancement direction of the sliding member and the lubricant supplying portion of the lubricant pocket forming member slides in firm contact with the surface of the track shaft to remove relatively small foreign matter and further lubricant loaded in the lubricant pocket formed by the lubricant pocket forming member is applied to the surface of the track shaft.

[0030] In case where the aforementioned scraper member is disposed outside of the lubricant pocket forming member, this scraper member exerts a function of scraping out a relatively large foreign matter adhering to the surface of the track shaft ahead of the lubricant pocket forming member.

[0031] Thus, according to the dust preventing structure of the present invention, it is used with, for example, the sealing member and lubricant supplying member, and even if the guide unit is used under a severe condition in which use of coolant is required or dust, dirt, wooden pieces, cutting powder or the like falls thereon, it can remove foreign matter on the surface of the track shaft securely and apply lubricant to the surface of the track shaft to form lubricant coating film before the sealing member comes into contact with the surface of the track shaft or lubricant is supplied to the surface of the track shaft by the lubricant supplying member. As a result, such an event that the sealing member is damaged or supplied lubricant is repelled by foreign matter remaining on the surface of the track shaft, particularly coolant so that it is not supplied uniformly to the entire surface of the track shaft never occurs, so that a smooth reciprocation of the sliding member with respect to the track shaft can be maintained in a long period.

[0032] Of course, if the guide unit is not used under such a severe condition, the dust preventing structure of the present invention may be mounted directly on both ends in the advancement direction of the sliding member without using the sealing member or lubricant supplying member, thereby achieving two roles of removing foreign matter from the surface of the track shaft and supplying lubricant to the surface of the track shaft at the same time.

[0033] According to the present invention, it is possible to provide a dust preventing structure of a guide unit capable of not only achieving a smooth reciprocation of the sliding member with respect to the track shaft with less friction resistance but also maintaining a smooth reciprocation of the sliding member with respect to the track shaft in a long period even under a severe condition in which use of coolant is required or dust, dirt, wooden pieces, cutting powder falls on the guide unit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] **FIG. 1** is a side view showing a linear sliding ball bearing incorporating a dust preventing structure according to the embodiment of the present invention;

[0035] **FIG. 2** is a disassembly perspective view of **FIG. 1**;

[0036] **FIG. 3** is a sectional explanatory view showing the dust preventing member of **FIGS. 1, 2**;

[0037] **FIG. 4** is a disassembly perspective view showing the lubricant supplying member of **FIGS. 1, 2**;

[0038] **FIG. 5** is a perspective view showing an end seal of FIGS. **1** or **2**;

[0039] **FIG. 6** is a sectional explanatory view showing a dust preventing structure (dust preventing member) according to a modification of the present invention;

[0040] **FIG. 7** is a sectional explanatory view showing a dust preventing structure (dust preventing member) according to other modification of the present invention; and

[0041] **FIG. 8** is a sectional explanatory view showing a dust preventing structure (dust preventing member) according to still other modification of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0042] Hereinafter, the preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[0043] **FIGS. 1, 2** show a ball bearing for linear sliding provided with a dust preventing structure according to the embodiment of the present invention.

[0044] This ball bearing for linear sliding comprises a track rail (track shaft) **1** in which a ball rolling groove **1***a* is formed in the length direction thereof and a sliding base (sliding member) **2** in which an infinite circulation path for balls **3** including a load rolling groove **5** opposing the ball rolling groove **1***a* in the aforementioned track rail **1** via a plurality of balls **3**, direction changing paths (not shown) disposed at beginning and terminal ends of the load rolling groove **5** and a ball return path **6** for connecting between these direction changing paths is formed. Lubricant supplying members **7**, end seal (sealing member) **8** and a dust preventing member **9** of the present invention are disposed on both end portions back and forth in the advancement direction of the sliding base **2**.

[0045] The sliding base **2** comprises sliding base main body **2***a* composing a main body thereof and end plates **2***b* attached to both ends portions back and forth in the advancement direction. The load rolling path **5** and ball return path **6** which constitute the infinite circulation path for the balls **3** are formed in the sliding base main body **2***a* and the direction changing path constituting the infinite circulation path for the balls **3** is formed in the end plates **2***b*.

[0046] Mounting holes **11***a*, **11***b*, **11***c* through which a pair of fixing bolts **10** are inserted are formed in each top portion of the aforementioned lubricant supplying member **7**, end seal **8** and dust preventing member **9**. The lubricant supplying member **7**, end seal **8** and dust preventing member **9** are mounted on each of both ends portions back and forth of the sliding base **2** in the advancement direction with the fixing bolts **10** which pass through the mounting holes **11***a*, **11***b*, **11***c* and engage the end plate **2***b* of the sliding base **2**.

[0047] Reference numeral **12** denotes a supplying nipple for supplying lubricant or grease to the infinite circulation path for the balls **3** formed in the sliding base **2**, the supplying nipple being inserted through holes **13** provided in the lubricant supplying member **7**, end seal **8** and dust preventing member **9** and engaging a mounting hole **14** in the end plate **2***b*. Reference numerals **15***a*, **15***b*, **15***c* denote collars each having a dimension corresponding to thickness of the lubricant supplying member **7**, end seal **8** and dust preventing member **9** so as to prevent the lubricant supplying member **7**, end seal **8** and dust preventing member **9** from being crushed when the fixing bolts **10** are tightened firmly.

[0048] The dust preventing member **9** of the present invention which is applied by this embodiment is made of continuously foamed urethanefoam as shown in FIGS. **2**, **3**, comprising lubricant pocket forming portion **16** including three elastic members **16***a*, **16***b*, **16***c* soaked cheld with lubricant for constituting the lubricant supplying portion and spacer members **16***x*, **16***y* made of metallic plates, which are interposed between the elastic members **16***a*, **16***b*, **16***c* for forming concave groove portion **18** with the elastic members **16***a*, **16***b*, **16***c* and a scraper member **17** made of metal plates, having a shape capable of covering a substantially entire lubricant pocket forming member **16** together with the both end portions back and forth (correspond to the end seal **8** mounted on both end portions back and forth in the advancement direction of the sliding base **2** in this embodiment) in the advancement direction of the sliding base **2** and the surface of the track rail **1**, in other words, a shape capable of covering all surface substantially completely except faces of the lubricant pocket forming member **16** which contact the end seal **8** and track rail **1**, the scraper member **17** being mounted on the sliding base **2** with a slight gapd (0.1 mm in this embodiment) relative to the track rail **1** while the lubricant pocket forming member **16** being sandwiched and held between the scraper member **17** and the sliding base **2** together with the lubricant supplying member **7** and end seal **8**.

[0049] Meanwhile, the aforementioned scraper **17** may be formed of resin in the form of a case. In this case, it is recommendable to attach a metallic scraper for removing foreign matter on the track rail **1** on an outside face thereof.

[0050] An inside size (dimension in a plane perpendicular to the length direction of the track rail **1**) of this case is set so as to be smaller than an outside size (size in the same plane) of each of the elastic members **16***a*, **16***b*, **16***c*. As a result, the respective elastic members **16***a*, **16***b*, **16***c* are fit within the case by tightening so that the outside peripheries of the elastic members **16***a*, **16***b*, **16***c* are fixed. By setting the inside size of the case appropriately, the tightening amount of the respective elastic members **16***a*, **16***b*, **16***c* can be adjusted. The size of the spacers **16***x*, **16***y* to be disposed between the elastic members **16***a*, **16***b*, **16***c* is set such that they are fit with the case with a gap because they are made of stiff material.

[0051] Although according to the above embodiment, the respective elastic members **16***a*, **16***b*, **16***c* are fit within the case by tightening, these elastic members **16***a*, **16***b*, **16***c* may be fit such that they are tightened by the track rail **1**. In this case, preferably the above case has no gap with respect to the elastic members **16***a*, **16***b*, **16***c*.

[0052] Further, by forming the case of resin, the collars **15***a*, **15***b*, **15***c* for preventing the lubricant supplying member **7**, end seal **8** and dust preventing member **9** from being crushed can be molded integrally with this case, thereby the number of parts being reduced.

[0053] Further, by extending this case such that it covers not only the respective elastic members **16***x*, **16***b*, **16***c* and spacers **16***a*, **16***y* but also the end seal **8** and lubricant supplying member **7** disposed backward thereof, the elastic members **16***a*, **16***b*, **16***c*, spacers **16***x*, **16***y*, end seal **8** and lubricant supplying member **7** can be molded integrally with the case, thereby assembly efficiency and appearance of the case being improved.

[0054] The sealed space lubricant pocket (corresponding to the concave groove portion **18**) formed by the concave groove portion **18** formed in the lubricant pocket forming member **16** with the surface of the track rail **1** is filled with paste like grease

[0055] According to this embodiment, the respective elastic members **16***a*, **16***b*, **16***c* made of continuously foamed urethanefoam have tensile strength of 43 kg/cm^3, elongation degree of 360%, density of 0.5 g/cm^3 and impact resilience of 53% and is soaked with lubricant of more than 50 weight %. Further, a supply possible period of the lubricant which is absorbed by these elastic members **16***a*, **16***b*, **16***c* and supplied to the track rail **1** is designed so as to be equal to a coating possible period of grease **19** which is loaded in the lubricant pocket (corresponds to the concave groove portion **18**) and applied to the track rail **1**.

[0056] As shown in **FIG. 4**, the lubricant supplying member **7** used in this embodiment comprises a casing **20** including a main body **20***a* and a lid portion **20***b*, an oil absorptive body **21** made of rayon mixed wool felt having a percentage of void of 81%, which is accommodated in the casing **20** and soaked with lubricant a coating body **22** made of wool felt having a percentage of void 54%, which receives lubricant from the oil absorptive body **21** for coating the ball rolling groove **1***a* the track rail **1** with lubricant and an oil amount adjusting plate **23** which partitions between the oil absorptive body **21** and coating body **22** for supplying lubricant of a predetermined amount from the oil absorptive body **21** to the coating body **22**. Reference numeral **24** denotes a collar.

[0057] As shown in **FIG. 5**, the end seal **8** used for this embodiment comprises a stiff main body **8***a* made of a metallic plate having a stiffness, an elastic main body **8***b* bonded to the surface of the main body **8***a* and made of a rubber plate having an elasticity, and a seal lip portion **8***c* formed integrally of the same material as the elastic main body **8***b* and to be in firm contact with the surface of the track rail **1**.

[0058] Thus, according to the dust preventing structure (dust preventing member **9**) of this embodiment, even if use of coolant is required or this is used under a severe condition in which dirt, dust, wooden pieces, cutting powder or the like falls thereon, before the end seal **8** comes into a contact with the surface of the track rail **1** or lubricant is supplied to the ball rolling groove **1***a* of the track rail **1** by the lubricant supplying member **7**, foreign matter such as coolant and dust adhering to the surface of the track rail **1** is removed securely by the scraper member **17** and the three elastic members **16***a*, **16***b*, **16***c* constituting the lubricant supplying portion. Further, grease **19** loaded in the lubricant pocket (corresponds to the concave groove portion **18**) is applied to the track rail **1** so as to form lubricant film having an excellent anti-coolant performance. As a result, a friction between the surface of the track rail **1** and the seal lip portion **8***c* of the end seal **8** can be reduced as much as possible. Thus, air tightness between the surface of the track rail **1** and seal lip portion **8***c* of the end seal **8** can be maintained in a long term. Consequently, a reduction of lubricity caused due to a shortage of lubricant supplied from the lubricant supplying member **7** to the ball rolling groove **1***a* of the track rail **1** or lubricant or grease supplied to the infinite circulation path for the balls **3** via the supply nipple **12** can be prevented in a long term.

[0059] About this point, durability test was performed under a condition in which coolant was used regarding the embodiment in which the lubricant pocket (corresponds to the concave groove portion **18**) was filled with grease **19** and a comparative example in which no grease **19** is loaded in the lubricant pocket (corresponds to the concave groove portion **18**). As a result, in this embodiment, at an end portion of each of three the elastic members **16***a*, **16***b*, **16***c* constituting the lubricant supplying portion while in firm contact with the surface of the track rail **1**, a durability seven times the comparative example was indicated and even if an impact applied to the seal lip portion **8***c* of the end seal **8** in firm contact with the surface of the track rail **1** exceeds seven times the comparative example, any damage was not noticed, thereby indicating that a durability seven times the comparative example was exerted.

[0060] **FIG. 6** shows a modification of the dust preventing structure (dust preventing member **9**) of the present invention. Different from the above embodiment, the lubricant pocket forming member **16** comprises three elastic members **16***a*, **16***b*, **16***c* made of continuously foamed polyurethanefoam and soaked with lubricant so as to form a lubricant supplying portion. A cutout portion **18***a* is formed in the two elastic members **16***b*, **16***c* of them and when three elastic members **16***a*, **16***b*, **16***c* are overlaid, a predetermined concave groove portion **18** is formed.

[0061] In this modification, the lubricant pocket forming member **16** is entirely formed of continuously foamed polyurethanefoam, so that the amount of lubricant which it can be soaked with increases thereby lubricant being supplied in a longer term.

[0062] **FIG. 7** shows other modification of the dust preventing structure (dust preventing member **9**) of the present invention. Different from the above embodiment, a cutout portion **18***a* having a triangular section is formed on a single side of a bottom of each of the two elastic members **16***a*, **16***b* located on both sides and a cutout portion **18***a* having a triangular section is formed on each of both sides of a bottom of the elastic member **16***b* located in the center. When the spacer members **16***x*, **16***y* are overlaid and sandwiched between the elastic members **16***a*, **16***b*, **16***c*, the concave groove portions **18** each having a section of inverse trapezoidal shape are formed with the elastic members **16***a*, **16***b*, **16***c* and the spacer members **16***x*, **16***y*.

[0063] In this modification, the formed concave groove portion **18** has a section of inverse trapezoidal shape and therefore the shape of a section of the lubricant pocket formed with the surface of the track rail **1** is inverse trapezoidal. As a result, the capacity of the lubricant pocket relative to the size of a coating surface (that is, opening portion of the concave groove portion **18**) of lubricant can be increased, so that the amount of lubricant which can be loaded in this lubricant pocket increases thereby making it possible to supply the lubricant in a longer period.

[0064] **FIG. 8** shows other modification of the dust preventing structure (dust preventing member **9**) of the present invention. In this modification, the dust preventing member **9** comprises three elastic members **16***d*, **16***e*, **16***f* made of elastic materials not soaked with lubricant unlike the aforementioned elastic members **16***a*, **16***b*, **16***c* soaked with lubricant and the scraper member **17** mounted on the sliding base **2** such that it holds these three elastic members **16***d*, **16***e*, **16***f* between the scraper member **17** and the sliding base **2** with the lubricant supplying member **7** and end seal **8** while maintaining a slight gap with respect to the track rail **1**.

[**0065**] In this modification also, the dust preventing member **9** prevents an invasion of dust or dirt into the sliding base **2** because the elastic members **16***d*, **16***e*, **16***f* are overlaid on the track shaft **1** in the length direction thereof such that they are in firm contact with the track shaft **1**, thereby achieving a smooth reciprocating motion of the sliding base **2** relative to the track rail **1**. Further, lubricant supplied to the track rail **1** by the aforementioned lubricant supplying member **7** or other means is held effectively, thereby maintaining a smooth reciprocating motion of the sliding base **2** with respect to the track rail **1** in a long period.

[**0066**] Although in the modification of **FIG. 8**, all the three elastic members **16***d*, **16***e*, **16***f* constituting the dust preventing member **9** are composed of elastic members not soaked with lubricant, it is permissible to replace one or two of them with the aforementioned elastic members **16***a*, **16***b*, **16***c* soaked with lubricant so that the elastic members soaked with lubricant and not soaked with lubricant are combined, considering a use environment of a guide unit to which the dust preventing structure of the present invention is applied.

What is claimed is:

1. A guide unit comprising:

a track shaft having a rolling groove of a rolling body,

a sliding member engaged with the track shaft via the rolling body and moved relative to the track shaft,

a pair of end seals mounted to both ends in traveling direction of the sliding member, having a seal lip portion being in firm contact with a surface of the track shaft, and

a pair of dust preventing members mounted to both ends in traveling direction of the sliding member and being on outer side of the end seals, for removing foreign matters adhering to the track shaft forwardly to the end seal,

wherein the dust preventing member comprises elastic members holding lubricant, in firm contact with a surface of said track shaft, said elastic members are overlaid in the length direction of said track shaft, and a spacer member interposed between the elastic members, and the spacer member is in no contact with the surface of the track shaft.

2. A guide unit according to claim 1, wherein the elastic members are made of continuously foamed urethane foam.

3. A guide unit according to claim 1, wherein the spacer member is made of a metallic plate.

4. A guide unit according to claim 1, wherein a scraper member is mounted on the sliding member with a predetermined gap relative to the track shaft for scraping off foreign matters adhering to the track shaft in accordance with a relative movement between the sliding member and the track shaft, and the elastic members are sandwiched and held between the scraper member and the sliding member.

5. A guide unit according to claim 2, wherein a scraper member is mounted on the sliding member with a predetermined gap relative to the track shaft for scraping off foreign matters adhering to the track shaft in accordance with a relative movement between the sliding member and the track shaft, and the elastic members are sandwiched and held between the scraper member and the sliding member.

* * * * *

US 20020090152A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2002/0090152 A1**

Shirai et al. (43) **Pub. Date: Jul. 11, 2002**

(54) **BALL CHAIN**

(75) Inventors: **Takeki Shirai**, Tokyo (JP); **Shigeru Ebina**, Tokyo (JP); **Mitsuaki Honma**, Tokyo (JP); **Tomozumi Murata**, Tokyo (JP)

Correspondence Address:
ARENT FOX KINTNER PLOTKIN & KAHN
1050 CONNECTICUT AVENUE, N.W.
SUITE 400
WASHINGTON, DC 20036 (US)

(73) Assignee: **THK Co., Ltd.**

(21) Appl. No.: **10/090,734**

(22) Filed: **Mar. 6, 2002**

Related U.S. Application Data

(62) Division of application No. 09/390,628, filed on Sep. 7, 1999, now abandoned, which is a division of application No. 09/142,139, filed on Sep. 2, 1998, now Pat. No. 6,116,783.

(30) **Foreign Application Priority Data**

Jan. 17, 1997 (JP) 9/006760
Feb. 28, 1997 (JP) 9/046179

Publication Classification

(51) **Int. Cl.**[7] **F16C 29/06**
(52) **U.S. Cl.** **384/45**

(57) **ABSTRACT**

The present invention relates to a ball chain used by being integrated to, for example, a ball endless track of a linear guide device for endless sliding in which a number of balls are arranged in one row and rollably held, particularly to a ball chain which is most pertinent to a linear guide device having a ball rolling groove in a shape of a Gothic arch. According to the ball chain, the number of balls are arranged in one row and the balls are held rollably, each of the balls is pinched by a pair of spherical seats and the spherical seats are connected to each other by flange portions to thereby constitute a ball holding unit and a plurality of the ball holding units are connected in a shape of a rosary by a flexible connecting portion. Further, the spherical seats and the flange portions are molded by a resin material whereas the connecting portion is formed by a material having a tensile strength larger than that of the resin material.

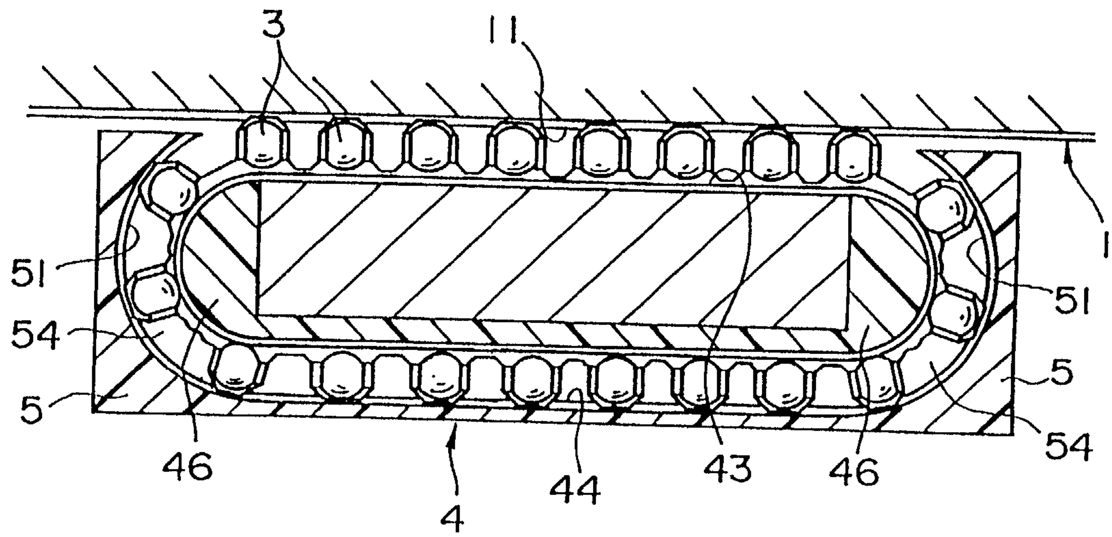


Fig. 1

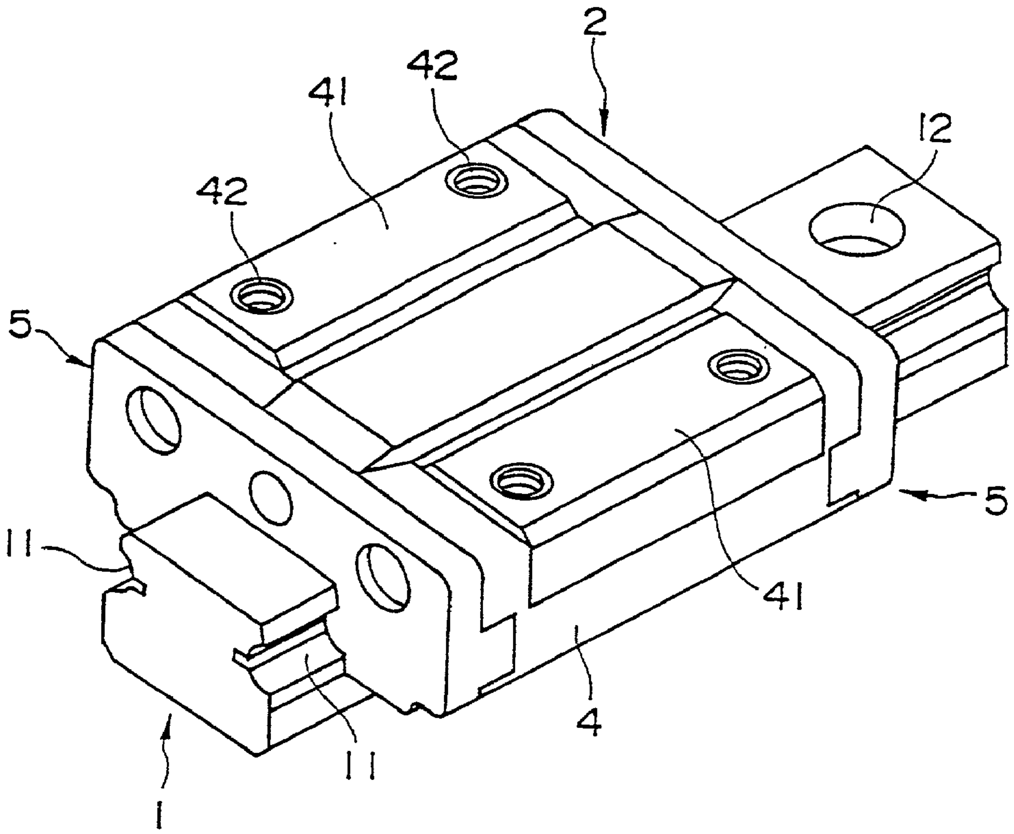


Fig. 2

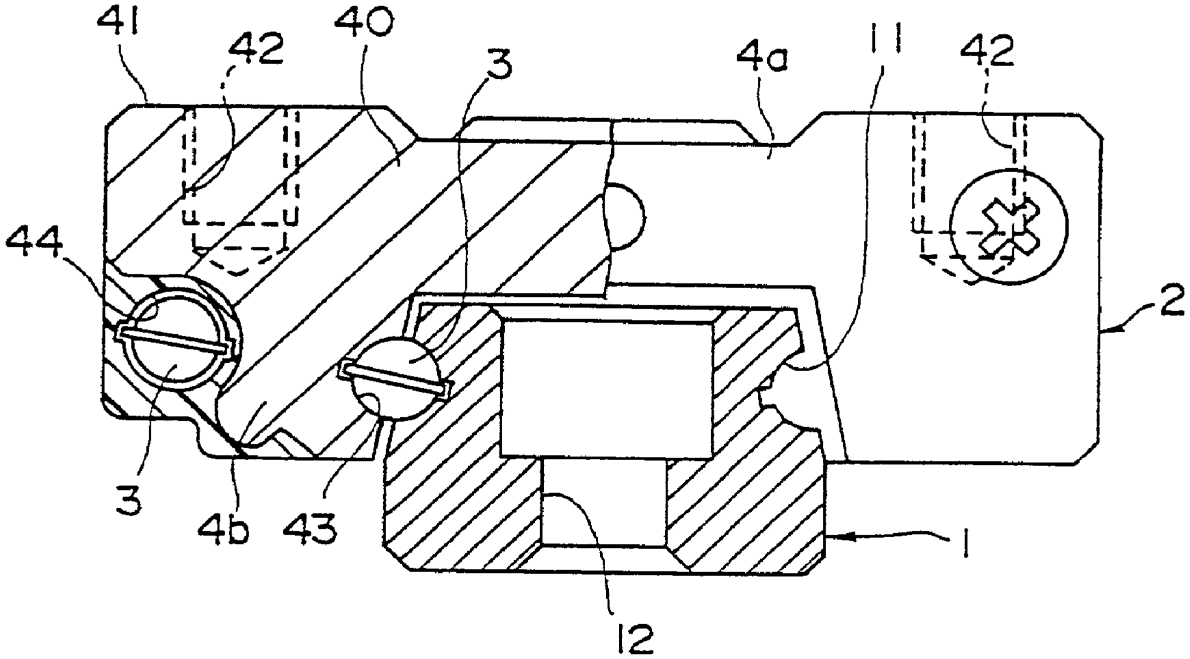


Fig. 3

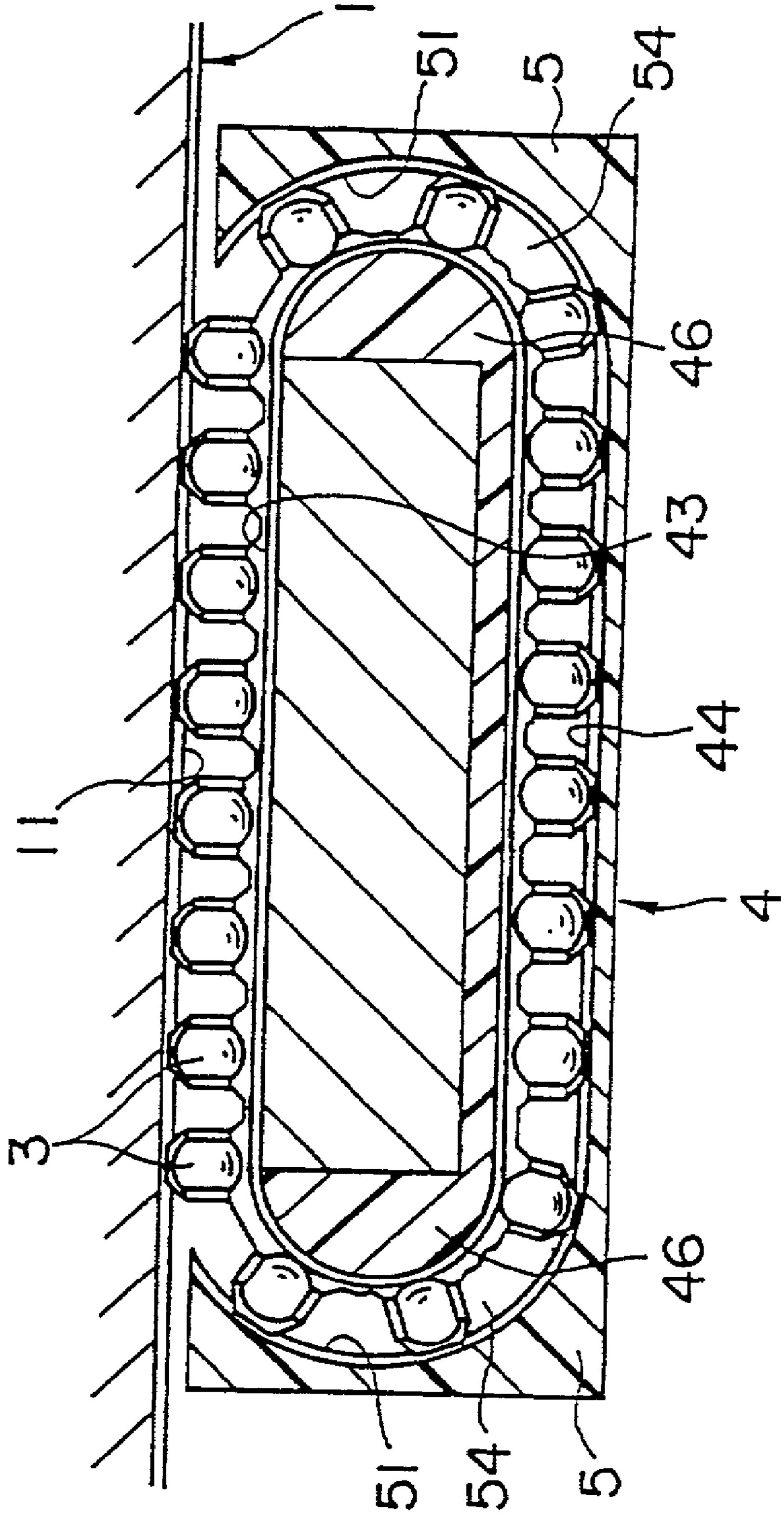


Fig. 4

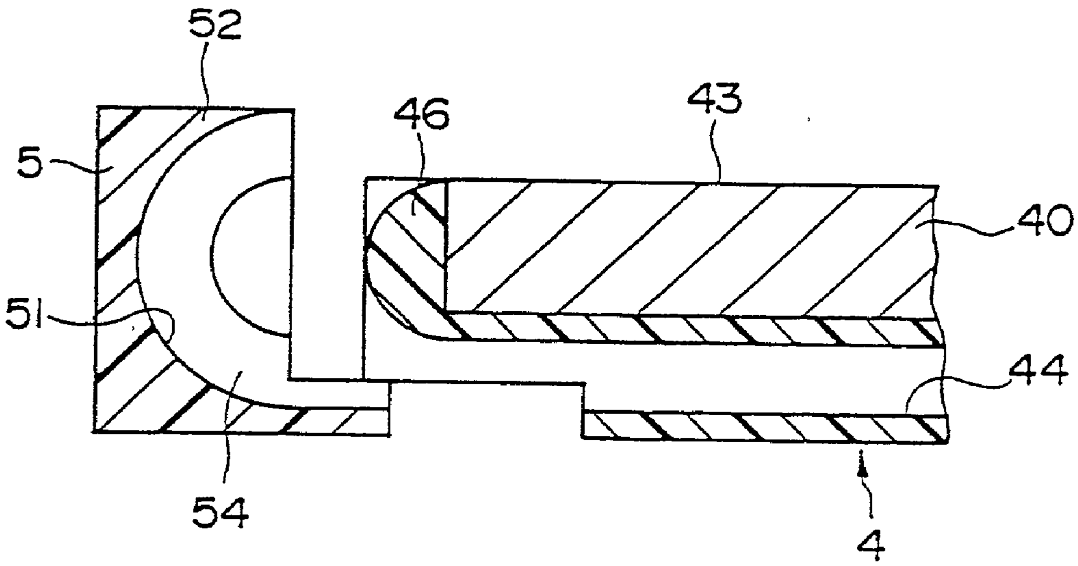


Fig. 5

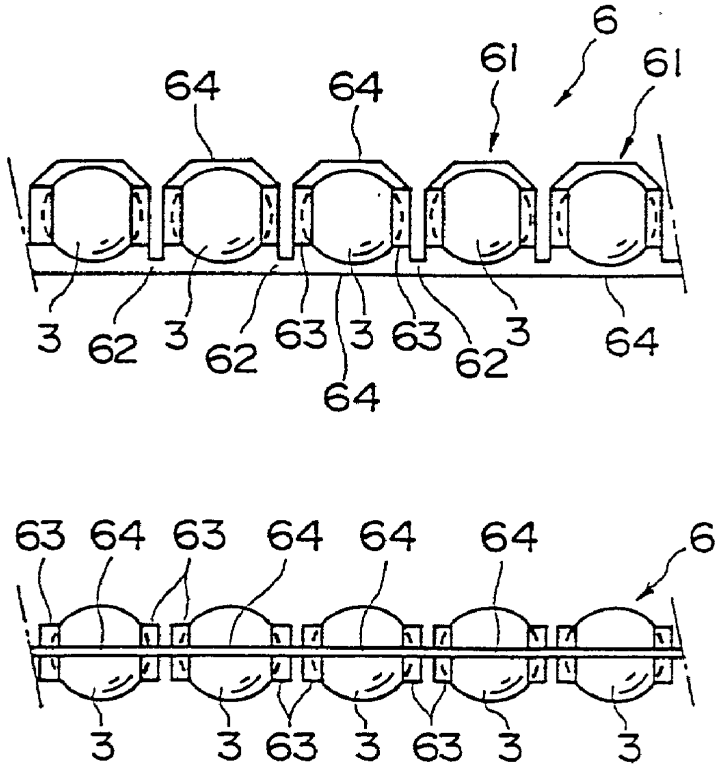

6
61
61
64
64
3
62
3
62
63
3
63
62
3
64
64
63
64
63
64
64
64
6
3
3
63
3
63
3
3

Fig. 6

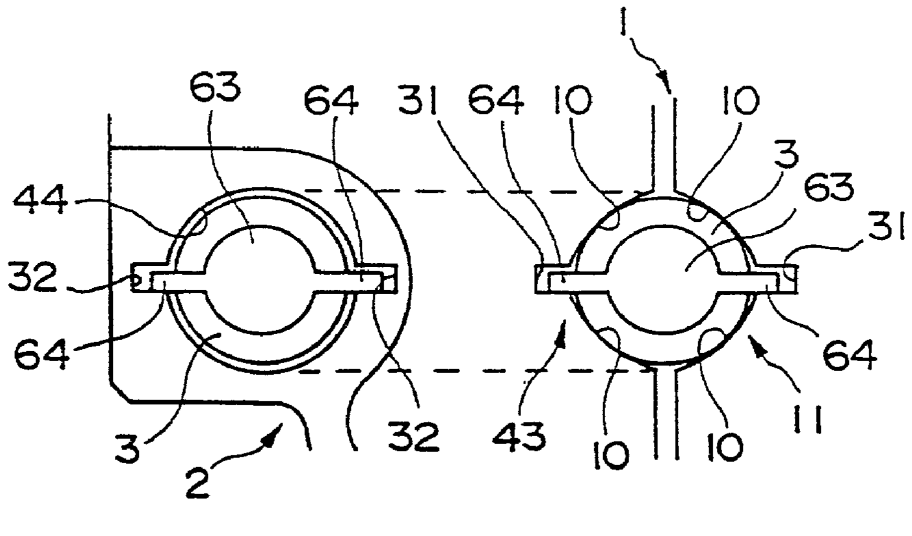

1
63
64
31
64
10
10
3
63
44
31
32
64
64
3
32
43
10
10
11
2

Fig. 7

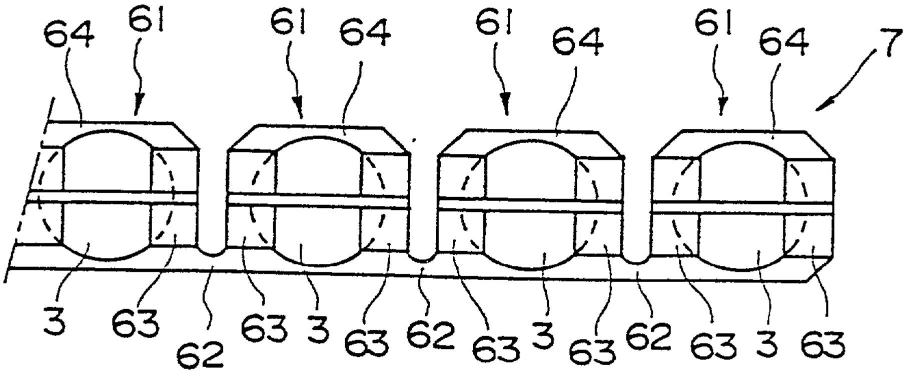


Fig. 8

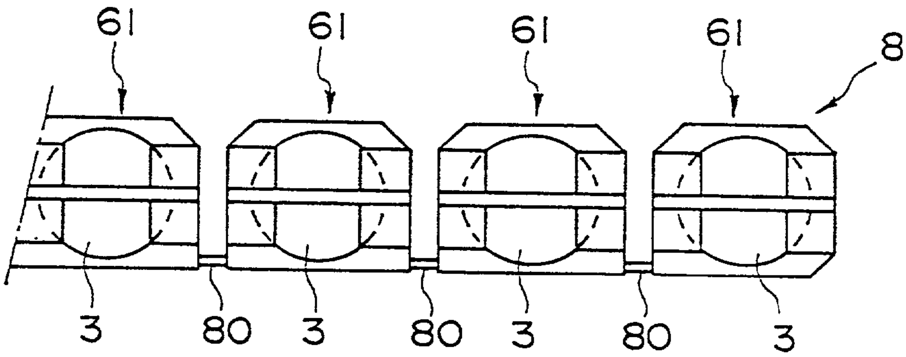


Fig. 9

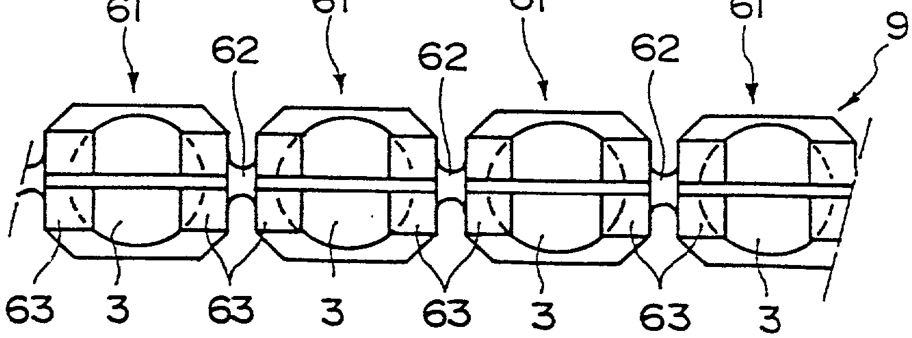


Fig. 10

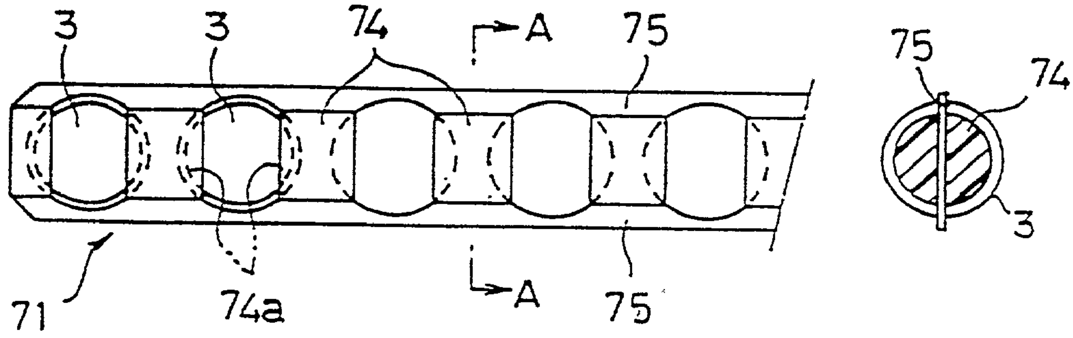

3
3
74
A
75
71
74a
A
75
75
74
3

Fig. 11

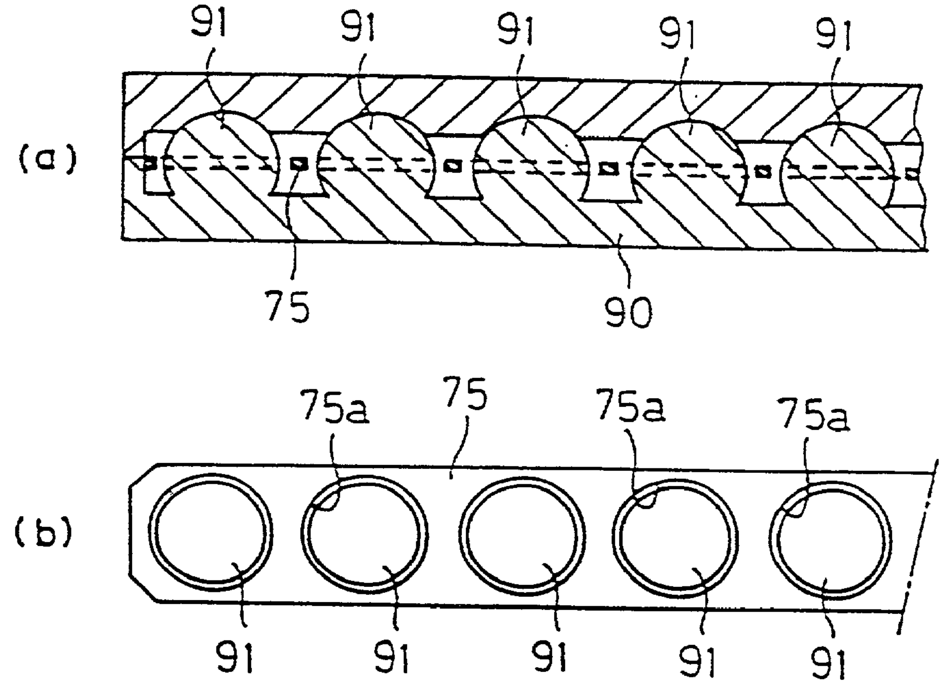

91
91
91
91
91
(a)
75
90
75a
75
75a
75a
(b)
91
91
91
91
91

Fig. 12

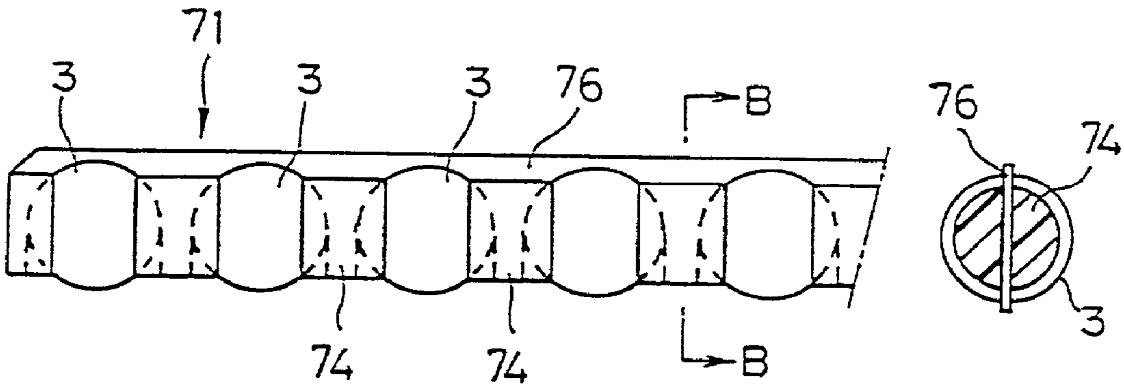


Fig. 13

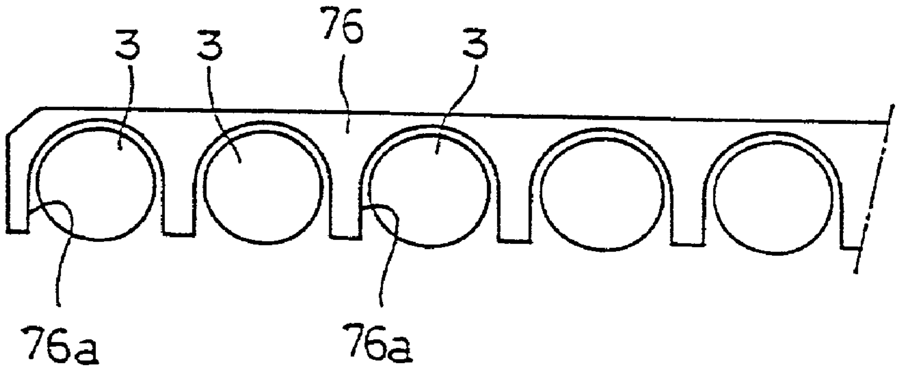


Fig. 14

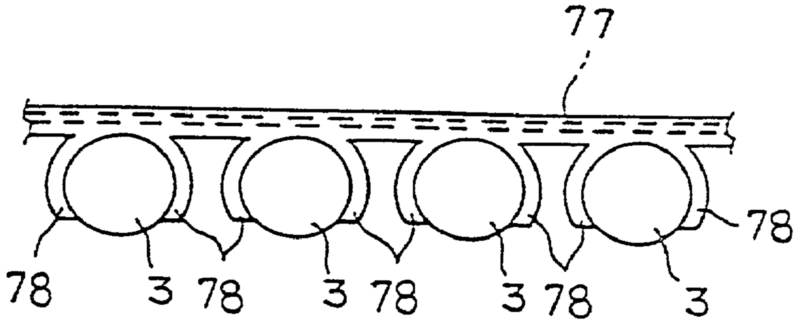


Fig. 15

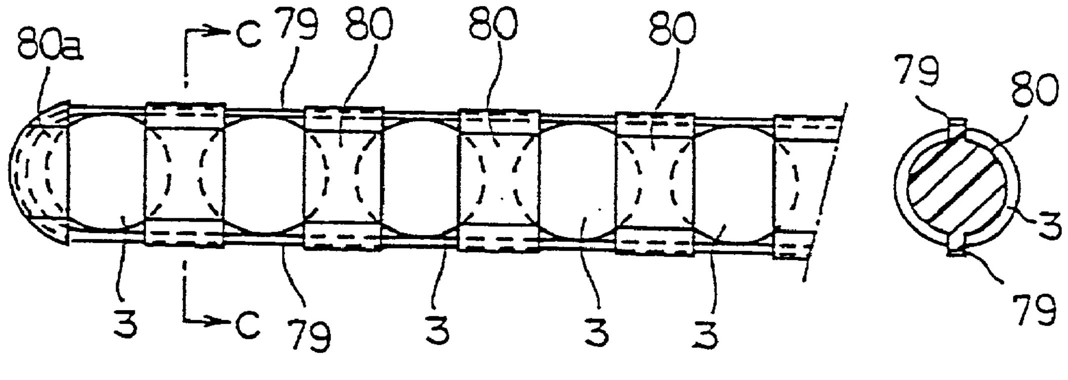


Fig. 16

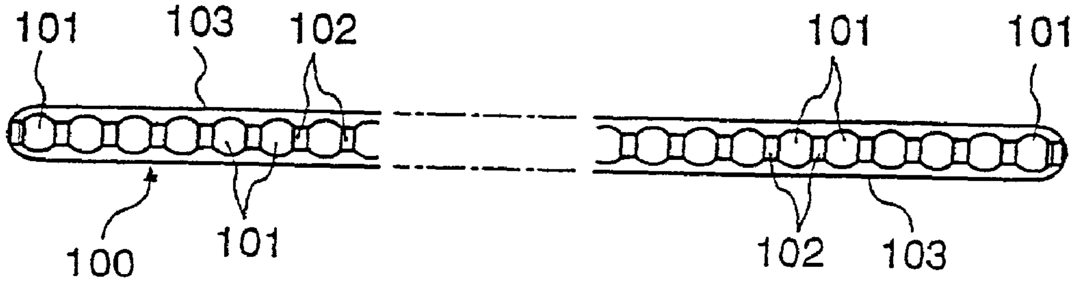

101
103
102
101
101
100
101
102
103

Fig. 17

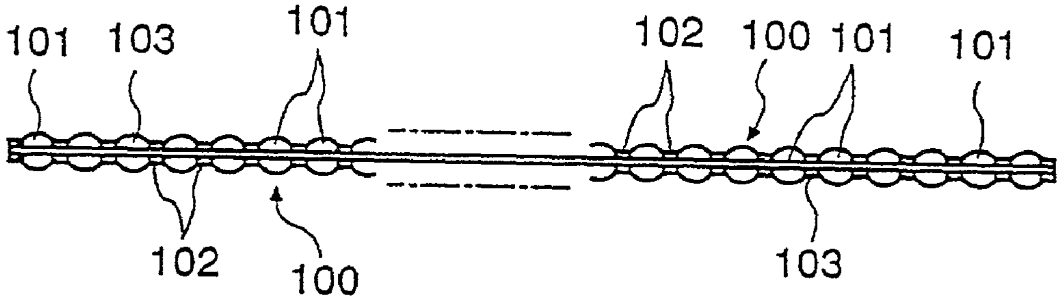

101
103
101
102
100
101
101
102
100
103

Fig. 18

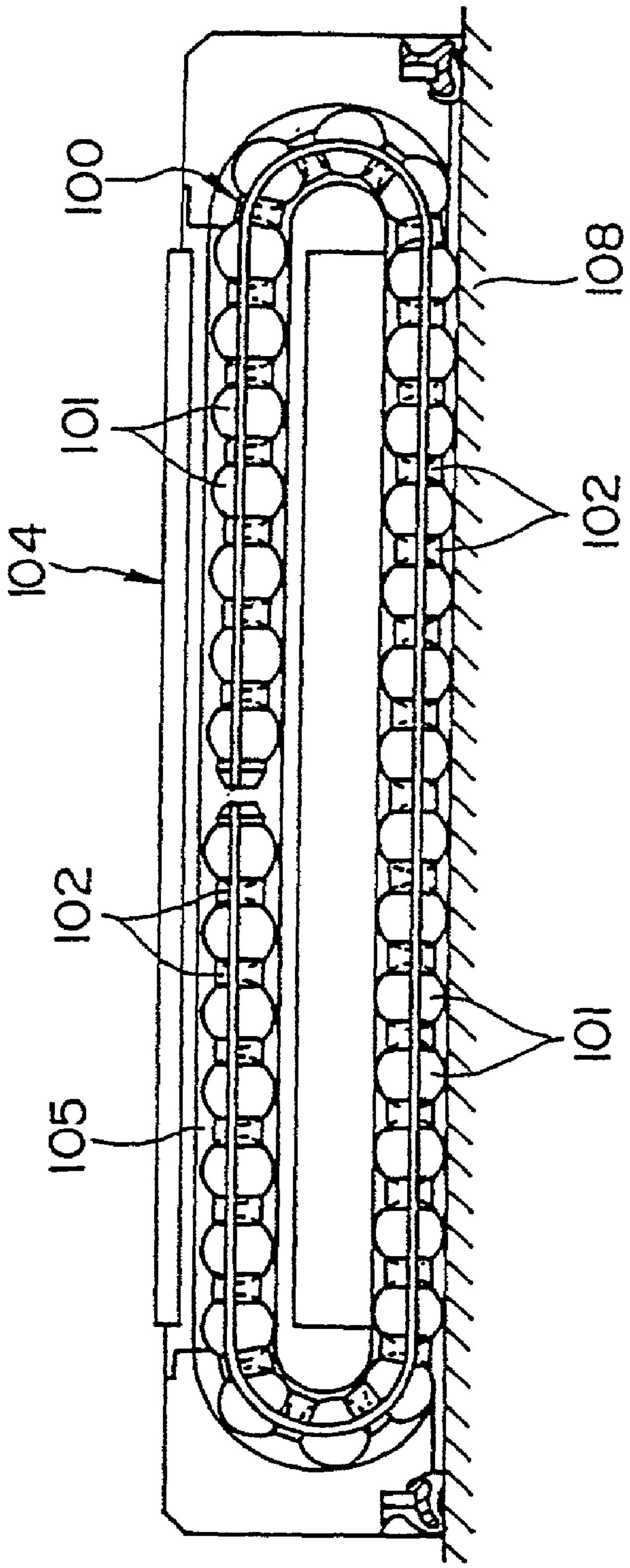


Fig. 19

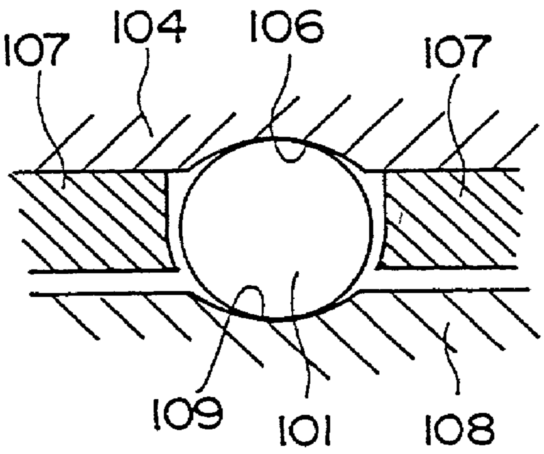
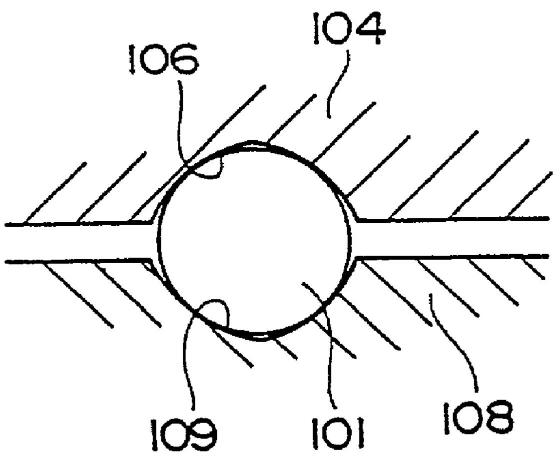


Fig. 20



BALL CHAIN

TECHNICAL FIELD

[0001] The present invention relates to a ball chain used by being integrated, for example, to a ball endless track of a linear guide device for endless sliding in which a number of balls are arranged in one row and are held rollably, particularly to a ball chain which is most pertinent in a linear guide device having a ball rolling groove in a shape of a Gothic arch.

BACKGROUND ART

[0002] There has conventionally been known a linear guide device for guiding a movable body of a table or the like along a fixed unit of a bed or the like, which is constituted by a track rail having a ball rolling groove, a slider having a load rolling groove opposed to the ball rolling groove, having a no load rolling path for circulating balls from one end to other end of the load rolling groove and moved along the track rail and a number of the balls rolling between the slider and the track rail while carrying a load and circulating an endless track constituted by the load rolling groove of the slider and the no load rolling path.

[0003] According to the conventional linear guide device constituted in this way, the endless track of the slider is filled with the balls and accordingly, when the slider is moved along the track rail, the balls contiguous to each other are circulated in the endless track while colliding or sliding with each other by which there poses a problem in which the balls are worn at an early stage and the life of the device is shortened.

[0004] Hence, in order to resolve such a problem, there has been proposed a linear guide device in which a ball chain aligning and holding a number of balls is integrated to the endless track (Japanese Unexamined Patent Publication No. JP-A-5-52217). As shown by **FIG. 16** and **FIG. 17**, according to such a ball chain **100**, spacers **102** are interposed among respective balls **101** contiguous to each other, the balls **101** are connected in a shape of a rosary by connecting the respective spacers **102** by connecting portions **103** in a strip-like shape and the balls **101** are fabricated by injection molding of flexible resin where balls **101** are arranged in a mold as cores.

[0005] The conventional ball chain **100** constituted in this way, is integrated in an endless track **105** of a slider **104** and circulated in the endless track as shown by **FIG. 18**, in this case, the spacers **102** are interposed among the balls **101** contiguous to each other and therefore, mutual friction or collision among the balls is prevented and wear of the balls **101** can be prevented as less as possible.

[0006] However, according to such a conventional ball chain **100**, one of the spacers **102** supports two of the balls **101** disposed on both sides thereof and therefore, when an angle of contact of the spacer **102** in respect of the ball **101** is changed by bending or twisting the ball chain **100**, there poses a problem in which the balls **101** drop off among the spacers **102**.

[0007] Accordingly, although the conventional ball chain sufficiently achieves a function as a ball retainer for preventing mutual contact of balls, a function thereof as a so-called ball case for preventing detachment of balls is not sufficient. Therefore, according to a conventional linear guide device integrated with such a ball chain, in order to completely prevent accident of detachment of balls when a slider is removed from a track rail, as shown by **FIG. 19**, ball retainers **107** are installed on both sides of a load rolling groove **106** of a slider **104**.

[0008] However, when a ball rolling groove **109** of a track rail **108** and the load rolling groove **106** of the slider **104** are formed in a shape of a so-called circular arc comprising a single ball rolling face, depths of the rolling grooves **106** and **109** are comparatively small relative to the radius of the ball **101** and therefore, although as shown by **FIG. 19**, the ball retainers **107** can be formed on the both sides of the load rolling groove **106** of the slider **104**, when the ball rolling groove **109** and the load rolling groove **106** are formed in a shape of a Gothic arch, that is, in a shape where a pair of ball rolling faces are intersected with each other, as shown by **FIG. 20**, the depths of the rolling grooves **106** and **109** are near to the radius of the ball **101** and accordingly, it is almost impossible to install the ball retainers **107** on the both sides of the load rolling groove **106**.

[0009] Therefore, in integrating a ball chain to a linear guide device having ball rolling grooves in a shape of a Gothic arch, it is necessary to ensure sufficiently the function of the ball chain for retaining the balls and it is problematic to integrate a conventional ball chain having a such a weak function as it is.

[0010] Meanwhile, such a ball chain **100** is used by being circulated in an endless track and accordingly, it is preferable to make the connecting portion **103** for connecting the respective spacers **102** as thin as possible and make a sectional area thereof as small as possible to flexibly bend the ball chain **100** in the endless track.

[0011] Meanwhile, considering that the respective spacers **102** are brought into sliding contact with the balls **101**, the resin material used in molding the ball chain **100** needs to be provided with lubrication performance, wear resistance and the like in respect of rolling of the balls **101** and therefore, there is a constant restriction in selecting resin for molding the ball chain **100** and mechanical strength of the mold resin per se is difficult to provide.

[0012] Therefore, according to the conventional ball chain **100**, the tensile strength of the connecting portion **103** is obliged to lower and there caused a trouble in which the connecting portion **103** is broken between the respective spacers **102** when the ball chain is being used in an endless circulating path.

DISCLOSURE OF THE INVENTION

[0013] The present invention has been carried out in view of such a problem and it is a first object thereof to provide a ball chain capable of firmly holding balls even when the ball chain is bent or twisted or the like and which is most pertinent to a linear guide device having a ball rolling groove in a shape of a Gothic arch.

[0014] Further, it is a second object of the present invention to provide a ball chain in which lubrication performance and wear resistance in respect of rolling of balls are excellent, arranged balls are rolled excellently and which is provided with sufficient tensile strength and capable of preventing accident of breaking the ball chain while it is being used.

[0015] According to an aspect of the present invention achieving the first object, there is provided a ball chain arranged with a number of balls in one row and rollably holding the balls wherein each of the balls are pinched by a pair of spherical seats and the spherical seats are connected to each other by flange portions to thereby constitute a ball holding unit and a plurality of the ball holding units are connected in a shape of a rosary by a flexible connecting portion.

[0016] According to such a technical means, each of the balls is pinched by the pair of spherical seats connected by the flange portions, the ball holding unit is constituted for each of the balls and the ball chain is constituted by connecting the ball holding units in a shape of a rosary by the flexible connecting portion and accordingly, even when the ball chain is bent or twisted or the like, an angle of contact of the spherical seat in respect of the ball remains unchanged and the ball can be held at each of the ball holding unit with certainty.

[0017] In this case, the ball chain according to the present invention can be fabricated by injection molding of synthetic resin in which the balls are inserted into a mold as cores and in view of reducing a minimum radius in bending the ball chain in a shape of a circular arc, it is preferable that the connecting portion is softer and the sectional area is preferably small.

[0018] Further, according to another aspect of the present invention achieving the second object mentioned above, there is provided a ball chain comprising a number of balls arranged in one row, a plurality of ball holding members arranged among the balls contiguous to each other for rotatably holding the balls and a connecting portion for connecting the ball holding members wherein a tensile strength of the connecting portions is larger than a tensile strength of the ball holding members.

[0019] According to such a technical means, the ball holding members for rotatably holding the balls are interposed among the balls contiguous to each other, the ball holding members are connected to each other by the connecting portion having a tensile strength larger than a tensile strength of the ball holding member and accordingly, even when a material for molding the ball holding member which is provided with a low mechanical strength is used, a sufficient tensile strength can be ensured for the ball chain as a whole. Further, the mechanical strength of the material per se for molding the ball holding member does not pose any problem and the tensile strength of the ball chain as a whole can be ensured and accordingly, such a molding material can be selected only in view of lubrication performance, wear resistance or the like in respect of rolling of the balls and excellent rolling of the arranged balls can be expected.

[0020] In this case, although the ball chain according to the present invention can be integrated by penetrating the connecting portion such as wire or the like through the ball holding members molded by resin, the integrating operation is troublesome when the ball holding members are penetrated one by one by the connecting portion and in view of reducing time and labor of integration, it is preferable to pad the ball holding members to the connecting portion by injection molding of synthetic resin.

[0021] Further, in padding the ball holding members by such an injection molding, it is preferable to form recesses and protrusions at the connecting portion in correspondence with portions for padding the ball holding members such that the ball holding members do not drop off the connecting portion after molding.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] **FIG. 1** is a perspective view showing a first embodiment of a linear guide device using a ball chain according to the present invention;

[0023] **FIG. 2** illustrates a front view and a sectional view showing the first embodiment of the linear guide device according to the present invention;

[0024] **FIG. 3** is a sectional view showing an endless track of balls provided to a slider according to the first embodiment;

[0025] **FIG. 4** is a view disassembling a moving block and a lid constituting the endless track of balls;

[0026] **FIG. 5** illustrates a plane view and a front view showing the first embodiment of the ball chain according to the present invention;

[0027] **FIG. 6** is an enlarged view showing a section of the endless track of balls according to the first embodiment of a linear guide device;

[0028] **FIG. 7** is a plane view showing a second embodiment of a ball chain according to the present invention;

[0029] **FIG. 8** is a plane view showing a third embodiment of a ball chain according to the present invention;

[0030] **FIG. 9** is a plane view showing a fourth embodiment of a ball chain according to the present invention;

[0031] **FIG. 10** illustrates a front view and a sectional view showing a fifth embodiment of a ball chain according to the present invention;

[0032] **FIGS. 11***a* and *b* are front views showing connecting portions according to the fifth embodiment; formed in a shape of a Gothic arch.

[0033] [Description of Notation]

[0034] **1** . . . Track rail **2** . . . slider **3** . . . ball b . . . ball chain **11** . . . ball rolling groove **31** . . . escape groove **43** . . . load rolling groove **61** . . . ball holding unit **62** . . . connecting portion **63** . . . spherical seat **64** . . . flange portion

BEST MODE FOR CARRYING OUT THE INVENTION

[0035] A detailed explanation will be given of a ball chain according to the present invention in reference to attached drawings as follows.

⊙ First Embodiment

[0036] **FIG. 1** and **FIG. 2** show an embodiment of a linear guide device integrated with a ball chain according to the present invention.

[0037] In the drawings, notation **1** designates a track rail arranged at a fixed unit of a bed of a machine tool or the like, notation **2** designates a slider for guiding a movable body of a table or the like along the track rail **1**, notation **3** designates a ball rolling between the track rail **1** and the slider **2** while carrying a load and is endlessly circulated in the slider **2**.

[0038] First, a section of the track rail **1** is formed substantially in a rectangular shape and a total of two streaks of ball rolling grooves **11** where the balls **3** roll are formed on both side faces thereof along a longitudinal direction (direction orthogonal to paper face of **FIG. 2**). The track rail **1** is formed with bolt attaching holes **12** at pertinent intervals in the longitudinal direction and the track rail **1** is fixed to the fixed unit by fixing bolts, not illustrated, which are inserted into the bolt attaching holes **12**.

[0039] Further, the slider **2** is constituted by a moving block **4** having attaching faces **41** for a movable body of a table or the like and tap holes **42** into which fixing bolts of the movable body are screwed and a pair of lids **5** which are fixed to both front and rear end faces of the moving block **4** and endless tracks of the balls **3** are provided in the slider by fixing the lids **5** to the moving block **4**.

[0040] A section of the moving block **4** is formed substantially in a shape of a saddle having a horizontal portion **4***a* formed with the attaching faces **41** and a pair of skirt portions **4***b* hung from the horizontal portion **4***a* and a load rolling groove **43** opposed to the ball rolling groove **11** of the track rail **1** is formed on an inner face side of each of the skirt portions **4***b*. Further, a ball return hole **44** in correspondence with each of the load rolling groove **43** is formed at each of the skirt portions **4***b* in which the balls **3** finished with rolling on the load rolling groove **43** and relieved of the load are rolled in a direction reverse to a direction of rolling on the load rolling groove **43**.

[0041] The moving block **4** is fabricated by utilizing injection molding of synthetic resin. That is, the moving block **4** is formed by padding synthetic resin by injection molding to a block main body **40** made of metal and formed by machining, portions requiring mechanical strength such as the movable body attaching face **41**, the load rolling face **43** of the ball **3** and the like mentioned above, are formed at the block main body **40** and in the meantime, portions where mechanical strength is not important such as the ball return hole **44** an the like are formed by synthetic resin and light weight formation of the moving block **4** is achieved as light as possible.

[0042] **FIG. 3** is a sectional view showing an endless track of the balls **3** provided to the slider **2** and as shown by **FIG. 4**, the endless track is completed by fixing the lids **5** to end faces of the moving block **4**. That is, when the lid **5** is fixed to the moving block **4**, a ball guide portion **46** on the side of the moving block **4** is fitted into a U-shape groove **51** on the side of the lid **5** by which a direction change path **54** in a U-like shape is completed and the load rolling face **43** of the moving block **4** is connected to the ball return hole **44** by the direction change path **54**.

[0043] Thereby, when the balls **3** carrying a load between the ball rolling groove **11** of the track rail **1** and a load rolling groove **43** of the moving block **4**, finishes rolling on the load rolling groove **43** in accordance with movement of the slider **2**, the balls are relieved of the load, enter the direction change path **54** of one of the lids **5** and are rolled in the ball return hole **44** of the moving block **4** in a no load state as they are in a direction reverse to a direction of rolling on the load rolling groove **43**. Further, the balls **3** which have finished rolling in the ball return hole **44**, enter again between the track rail **1** and the moving block **4** via the direction change path **54** of other of the lids **5** and roll on the load rolling groove **43** while carrying the load.

[0044] Meanwhile, the balls **3** are integrated to the endless track of the slider **2** in a state where they are held in one row by the ball chain **6** and the ball chain **6** is circulated in the endless track in accordance with rolling of the balls **3**. As shown by **FIG. 5**, the ball chain **6** is formed by connecting a plurality of ball holding units **61** each holding a single piece of the ball **3** in a shape of a rosary by a flexible connecting portion **62** and each of the ball holding units **61** is constituted by a pair of spherical seats **63** pinching the ball **3** from left and from right and flange portions **64** connecting the spherical seats **63** to each other.

[0045] The connecting portion **62** connects only side ends on one side of the ball holding units **61** arranged in one row to each other and when the connecting portion **62** is flexed as shown by **FIG. 3**, slit-like spaces among the ball holding units **61** contiguous to each other are expanded and the ball chain **6** per se can be bent in a ring-like shape in a state where the flange portions **64** are disposed on an inner peripheral side or an outer peripheral side.

[0046] Further, the ball chain **6** is formed by injection molding of synthetic resin inserted with the balls **3** as cores in a mold and the connecting portions **62**, the spherical seats **63** and the flange portions **64** are integrally molded by such an injection molding and the balls **3** are incorporated by the spherical seats **63**.

[0047] **FIG. 6** is an enlarged sectional view showing a state of rolling the balls **3** in the endless track.

[0048] The load rolling groove **43** of the slider **2** and the ball rolling groove **11** of the track rail **1** are formed in a shape of a Gothic arch formed by intersecting two of ball rolling faces **10** to each other and each of the balls **3** is brought into contact with two points of each of the load rolling groove **43** and the ball rolling groove **11**. Further, escape grooves **31** are respectively formed at deepest portions of the ball rolling groove **11** and the load rolling groove **43** which are formed in a shape of a Gothic arch, that is, positions in each of which the two ball rolling faces **10** are intersected with each other and the flange portions **64** of the ball chain **6** are contained in the escape grooves **31** while the balls **3** are rolling in the rolling grooves **43** and **11**.

[0049] Further, guide grooves **32** are formed in the ball return hole **44** of the slider **2** along the longitudinal direction, the flange portions **64** of the ball chain **6** under a no load state are guided by the guide grooves **32** and the ball chain **6** is prevented from meandering in the ball return hole **44**.

[0050] Further, according to the linear guide device of the embodiment constituted as described above, when the slider **2** is moved on the track rail **1**, the balls **3** roll on the load rolling groove **43** of the slider **2** and the ball rolling groove **11** of the track rail **1** and the ball chain **6** is circulated at inside of the endless track formed in the slider **2**. In this case, according to the respective ball holding units **61** constituting the ball chain **6**, regardless of a state of flexing or extending the ball chain **6**, pairs of the spherical seats **63** always pinch the balls **3** with certainty and therefore, the balls **3** can be prevented from dropping off the ball chain **6** as less as possible.

[0051] Further, the ball chain **6** in the endless track is circulated while disposing the flange portions **64** on the outer peripheral side or the inner peripheral side and accordingly, for example, even when the slider **2** is drawn from the track rail **1** (state where track rail **1** is removed in **FIG. 6**), the balls **3** are brought into a state where they are pinched from three directions by the load rolling groove **43** of the slider **2** and the flange portions **64** of the ball chain **6** and the balls **3** can be prevented from dropping off the endless track of the slider **2** with certainty.

◎ Second Embodiment

[0052] **FIG. 7** shows a second embodiment of a ball chain according to the present invention. Although the ball chain **7** is provided with a constitution substantially similar to that of the ball chain **6** of the first embodiment shown by **FIG. 5**, the constitution is different therefrom only in that the flange portions **64** connecting pairs of the spherical seats **63** are arranged to divide in four the surroundings of the balls **3**. Therefore, according to the ball chain **7** of the second embodiment, the balls **3** are completely constrained at insides of the ball holding units **61** and the balls **3** can be completely prevented from dropping off the ball chain **7**.

◎ Third Embodiment

[0053] **FIG. 8** shows a third embodiment of a ball chain according to the present invention.

[0054] According to the ball chain **6** of the first embodiment, the connecting portion **62** for connecting the respective ball holding units **61** are also molded by resin and therefore, when the ball chain **6** is circulated in the endless track and flexing and extending thereof are repeated, there is a concern that the ball chain **6** is cut at the connecting portion **62**.

[0055] Hence, according to a ball chain **8** of the embodiment, a wire **80** penetrating the respective ball holding units **61** is installed and the connecting portion **62** is constituted by the wire **80**. Although a method of fabricating such a ball chain **8** is substantially the same as that of the ball chain **6** according to the first embodiment, a single piece of the wire **80** is inserted in a mold along with the balls **3** and the respective ball holding units **61** are padded to the wire **80** at an equal interval by injection molding of synthetic resin.

[0056] Further, according to the ball chain **8** of the embodiment where the connecting portion **62** is reinforced by the wire **80**, the connecting portion **62** is not broken even by repeated flexing and extending and trouble of breaking the ball chain **8** in the midst of use can be avoided.

◎ Fourth Embodiment

[0057] **FIG. 9** shows a fourth embodiment of a ball chain according to the present invention.

[0058] A ball chain **9** of the embodiment of constituted such that the connecting portion **62** for coupling the respective ball holding units **61** is formed at centers of the spherical seats **63** and a contiguous pair of the ball holding units **61** can be flexed in any direction centering on the connecting portion **62**. Therefore, different from the ball chains described above, there is no specific flexing direction in the ball chain **9** and the ball chain **9** can be integrated to the endless track without taking any special consideration in the flexing direction in the endless track of the slider **2**.

[0059] Further, although according to the linear guide devices mentioned above, the slider is provided with a total of two streaks of the ball endless tracks in which respective streaks are in correspondence with both left and right side faces of the track rail, the linear guide device according to the present invention is not limited thereto but the slider **2** may be provided with a total of four streaks of the ball endless tracks in which respective two streaks are in correspondence with each of both left and right side faces of the track rail **1**.

◎ Fifth Embodiment

[0060] **FIG. 10** shows a fifth embodiment of a ball chain according to the present invention.

[0061] According to a ball chain **71**, the plurality of balls **3** are arranged in a connector belt **72** in one row at a predetermined interval and the balls **3** are rotatable in a state where they are held by the connector belt **72**.

[0062] The connector belt **72** is constituted by a plurality of ball holding members **74** interposed among the respective balls **3** and a strip-like connecting portion **75** for connecting contiguous ones of the ball holding members **74** to each other and spherical seats **74***a* for embracing the spherical face of the ball **3** are formed at each of the ball holding members **74**. Thereby, the respective balls **3** are brought into a state where they are embraced from left and from right by the contiguous ball holding members **74** and are held by such a connector belt **72**.

[0063] As shown by FIGS. **11**(*a*) and **11**(*b*), according to the connecting portion **75**, through holes **75***a* each having a diameter more or less larger than the diameter of the ball, are formed in a stainless steel sheet (SUS **304** or the like) having a thickness of 0.05 through 0.2 mm which is formed in a strip-like shape and the balls **3** are contained in such through holes **75***a*. Meanwhile, the ball holding member **74** is molded by synthetic resin of polyamide-base elastomer, polyester-base elastomer or the like and is padded to the connecting portion **75** by injection molding. That is, as shown by **FIG. 11**(*a*), ball dies **91** each having a diameter larger than the diameter or the ball **3** are projected at a predetermined interval in a forming mold **90** and as shown by **FIG. 11**(*b*), the ball dies **91** are contained in the through holes **75***a* of the connecting portion **75** and under the state, the ball holding members **74** are padded to the connecting portion **75** by injection molding. Thereafter, the ball dies **91** are forcibly detached from among the ball holding members **74** and the balls **3** are pushed in portions detached of the ball dies **91** by which the ball chain **71** in which the balls **3** are contained in the through holes **75***a* of the connecting portion **75** by the ball holding members **74** is completed.

[0064] Further, the ball chain **71** of the embodiment constituted as described above, is used by being integrated to an endless track of a slider constituting a linear guide device or the like, the tensile strength of the connecting portion **75** formed by a stainless steel sheet is considerably larger than that of the ball holding member **74** made of synthetic resin and accordingly, even when large tensile force is exerted on the ball chain **71** during circulation in the endless track, the ball chain **71** is not broken between the ball holding members **74** contiguous to each other and smooth circulation of the ball chain **71** can always be expected.

[0065] Further, the tensile strength of the ball chain **71** per se is dependent on that of the connecting portion **75** and accordingly, it is not necessary to expect mechanical strength such as tensile strength or the like in resin material molding the ball holding members **74** and resin material used in injection molding can be selected only in view of lubrication performance, wear resistance or the like in respect of rolling of the balls **3**. Accordingly, smooth rolling of the balls **3** can also be expected.

◎ Sixth Embodiment

[0066] **FIG. 12** shows a sixth embodiment of a ball chain according to the present invention.

[0067] Although according to the above-described fifth embodiment, the connecting portion **75** is installed along both sides of a row of the balls which are arranged in one row, according to the embodiment, a connecting portion **76** is installed only on one side of the ball row. The other points as well as the constitution and the method of fabrication are the same as those in the fifth embodiment.

[0068] Accordingly, as shown in **FIG. 13**, according to the connecting portion **76** of the embodiment, notched portions **76***a* each in a shape of an arch are arranged in the longitudinal direction at a predetermined interval and the balls **3** are contained in the notched portions **76***a*.

◎ Seventh Embodiment

[0069] **FIG. 14** shows a seventh embodiment of a ball chain according to the present invention.

[0070] Although according to the above-described fifth and sixth embodiments, a stainless steel sheet in a strip-like shape is used as the connecting portion, according to the embodiment, wires **77** each having a slender wire diameter are used as a connecting portion and ball holding members **78** are padded to the wires **77** by using injection molding of synthetic resin.

[0071] Each of the ball holding members **78** is arranged to be brought into contact with a single one of the ball and an independent ball holding unit is constituted by a pair of the ball holding members disposed on both sides of the ball. Therefore, even in the case where such a ball chain is used by being flexed extremely, according to each of the ball holding units, a pair of the ball holding members **78** hold the balls **3** with certainly and prevention of detachment of the ball **3** is achieved.

◎ Eighth Embodiment

[0072] **FIG. 15** shows an eighth embodiment of a ball chain according to the present invention.

[0073] Although according to the above-described ball chains of the respective embodiments, the ball holding members **74** interposed among the respective balls **3** are integrated with the connecting portion **75** (or **76**) in a strip-like shape by utilizing injection molding of synthetic resin, according to the embodiment, the connecting portion is constituted by a wire **79** having a slender wire diameter and ball holding members **80** previously formed by injection molding of synthetic resin which are penetrated by the wire **79** at a later stage.

[0074] That is, the ball holding members **80** are formed with through holes for inserting the wire **79** and by passing the wire **79** through the through holes, the respective ball holding members **80** are connected to each other. Such a wire **79** is folded back by a ball holding member **80***a* disposed at an end portion of the ball chain and is inserted through the respective ball holding members **80** at both sides of the ball row. Further, a stopper plate for fixedly engaging both end portions of the wire **79** is installed at an end portion of the ball chain, not illustrated, and a detachment preventive processing is carried out on the both end portions of the wire **79** which has passed through all of the ball holding members **80** after they are passed through the stopper plate.

[0075] Further, also in the ball chain of the eighth embodiment, the ball holding members **80** made of synthetic resin are connected by the wire **79** having large tensile strength by which the balls **3** are rotatably held and accordingly, even when large tensile force is exerted on the ball chain, the ball chain is not broken between the ball holding members **80** contiguous to each other and by using a resin material excellent in lubrication of the balls **3** for the ball holding members **80**, smooth formation of rolling of the balls **3** can be expected.

Industrial Applicability

[0076] As has been explained, according to a ball chain of the present invention, a ball holding unit pinching a ball is formed by a pair of spherical seats, the ball chain is constituted by connecting a plurality of the ball holding units and accordingly, even when the ball chain is bent or twisted while it is being used, the balls do not drop off among the spherical seats and the balls can be held by the ball chain with certainty.

[0077] Further, according to a ball chain of the present invention, ball holding members interposed among balls contiguous to each other are connected to each other by a connecting portion having a tensile strength higher than that of the ball holding member and accordingly, even when a material for molding the ball holding member which is provided with a low mechanical strength is used, a sufficient tensile strength can be ensured for the ball chain as a whole and accordingly, occurrence of accident of breaking the ball chain while it is being used can be prevented beforehand.

[0078] Further, even in the case where the material for molding the ball holding member which is provided with low mechanical strength is used, the tensile strength of the ball chain can be ensured and occurrence of breaking the ball chain can be prevented and accordingly, in selecting a material for molding the ball holding member, consideration is given only in view of lubrication performance, wear resistance or the like in respect of rolling of the balls by which excellent rolling of the balls arranged thereby can be expected.

1. A ball chain arranged with a number of balls in one row and rollably holding the balls:

wherein each of the balls are pinched by a pair of spherical seats and the spherical seats are connected to each other by flange portions to thereby constitute a ball holding unit and a plurality of the ball holding units are connected in a shape of a rosary by a flexible connecting portion.

2. The ball chain according to claim **1**:

wherein the spherical seats and the flange portions are molded by a resin material and the connecting portion is formed by a material having a tensile strength larger than a tensile strength of the resin material.

3. A linear guide device comprising a track rail having ball rolling grooves each in a shape of a Gothic arch formed by intersecting a pair of ball rolling faces with each other, a slider having load rolling grooves each in a similar shape of a Gothic arch opposed to the ball rolling grooves and no load rolling paths for circulating the balls from one end to other end of each of the load rolling grooves for moving along the track rail and a number of balls rolling between the slider and the track rail while carrying a load and circulating endless tracks constituted by the load rolling grooves and the no load rolling paths of the slider:

wherein the ball chain according to claim 1 are integrated to each of the endless tracks of the slider such that the flange portions of the ball chain are disposed on an inner peripheral side or an outer peripheral side thereof and escape grooves by which the flange portions of the ball chains are contained and guided are formed at deepest portions of the ball rolling grooves of the track rail and the load rolling grooves of the slider both formed in the shape of the Gothic arch.

4. A ball chain comprising a number of balls arranged in one row, a plurality of ball holding members arranged among the balls contiguous to each other for rotatably holding the balls and a connecting portion for connecting the ball holding members:

wherein a tensile strength of the connecting portion is larger than a tensile strength of the ball holding members.

5. The ball chain according to claim **4**:

wherein the connecting portion is made of a metal material whereas the ball holding members are made of a resin material.

6. The ball chain according to claim **4**:

wherein the connecting portion and the ball holding members are made of a resin material.

7. The ball chain according to claim 5 or **6**:

wherein the ball holding members are padded to the connecting portion by injection molding.

8. The ball chain according to claim **7**:

wherein the connecting portion is formed with recesses and protrusions in correspondence with portions thereof for padding the ball holding members.

* * * * *

US 20020028030A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2002/0028030 A1**

(43) **Pub. Date: Mar. 7, 2002**

Michioka et al.

(54) **UNIVERSAL GUIDE DEVICE AND MOVING TABLE DEVICE USING SAME**

(75) Inventors: **Hidekazu Michioka**, Tokyo (JP); **Hiroaki Mochizuki**, Yamanashi-ken (JP); **Kaoru Hoshide**, Tokyo (JP); **Minoru Kouchi**, Tokyo (JP)

Correspondence Address:
ARENT FOX KINTNER PLOTKIN & KAHN
1050 CONNECTICUT AVENUE, N.W.
SUITE 600
WASHINGTON, DC 20036 (US)

(73) Assignee: **THK Co., Ltd.**

(21) Appl. No.: **09/988,282**

(22) Filed: **Nov. 19, 2001**

Related U.S. Application Data

(62) Division of application No. 09/589,129, filed on Jun. 8, 2000.

(30) **Foreign Application Priority Data**

Jun. 9, 1999 (JP) 11/162557
Sep. 29, 1999 (JP) 11/276807

Publication Classification

(51) **Int. Cl.**[7] **F16C 29/06**
(52) **U.S. Cl.** **384/45**

(57) **ABSTRACT**

The present invention offers a universal guide device capable of using the sliders of conventional straight guide devices intact. The universal guide device does not need a different slider for each different radius of track rail. The universal guide device can be manufactured at lower cost than heretofore. This universal guide device in accordance with the invention comprises a track rail and sliders mounted to the rail via balls circulating through endless circular paths. The rail has at least one straight region and at least one curved region shaped in an arc with a given radius of curvature. Each of the sliders is of saddlelike cross section. The sliders span the rail. The sliders have ball-rolling surfaces shaped linearly. The curved region of the rail is set narrower than the straight region of the rail.

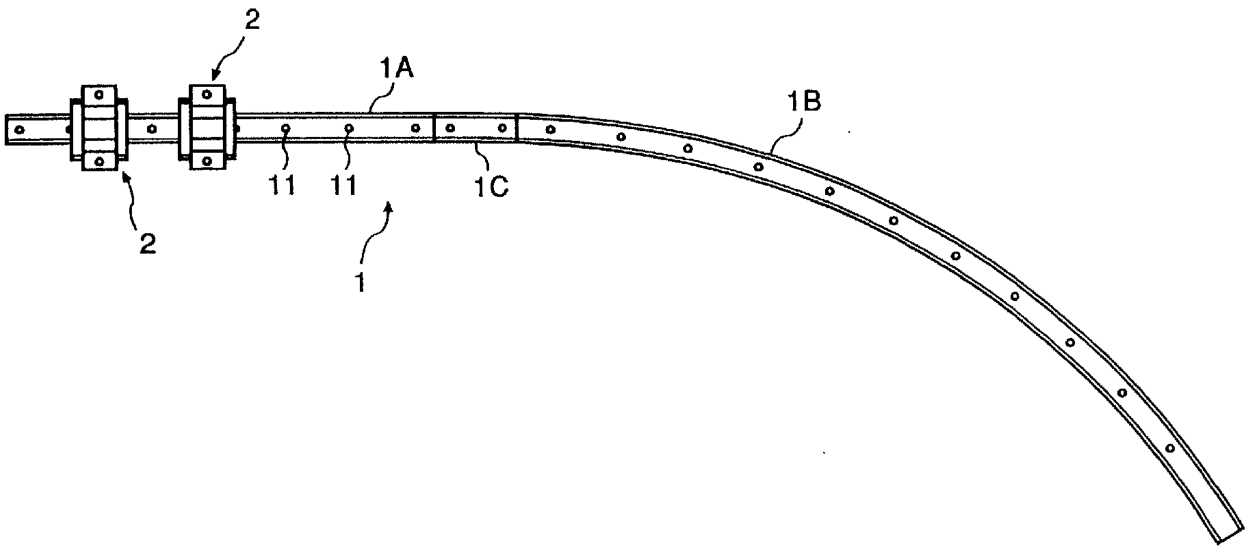
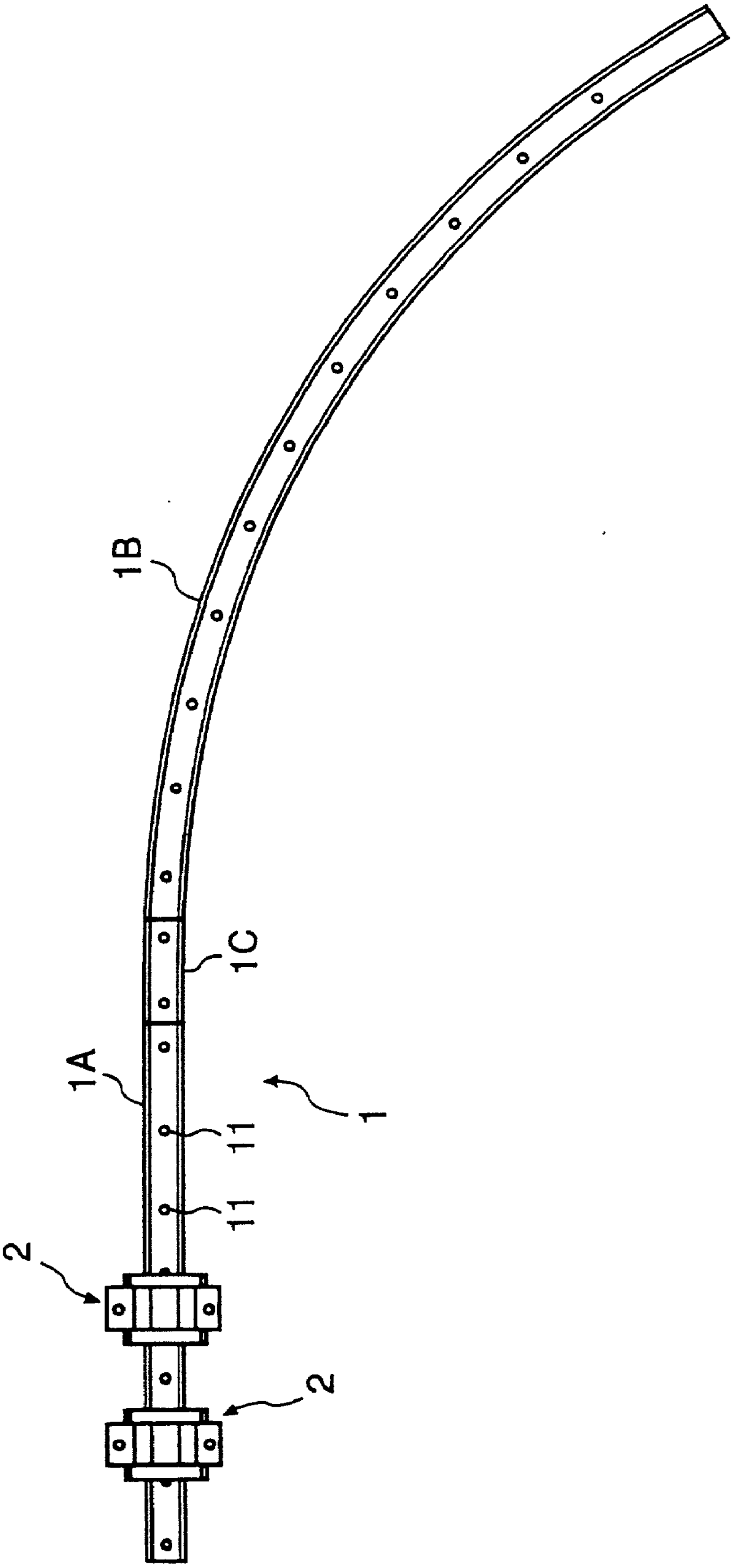


Fig 1



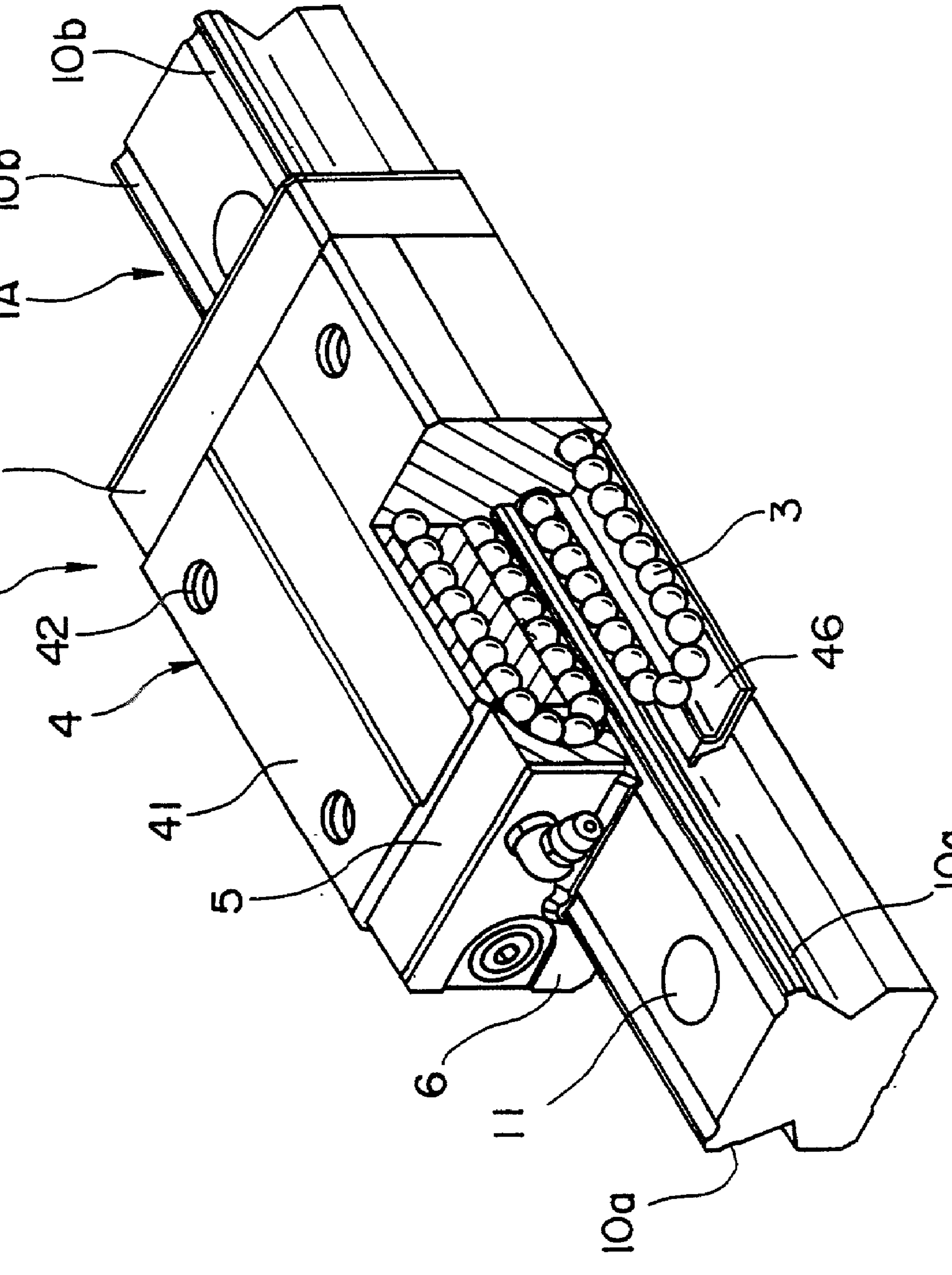


Fig 2

Fig 3

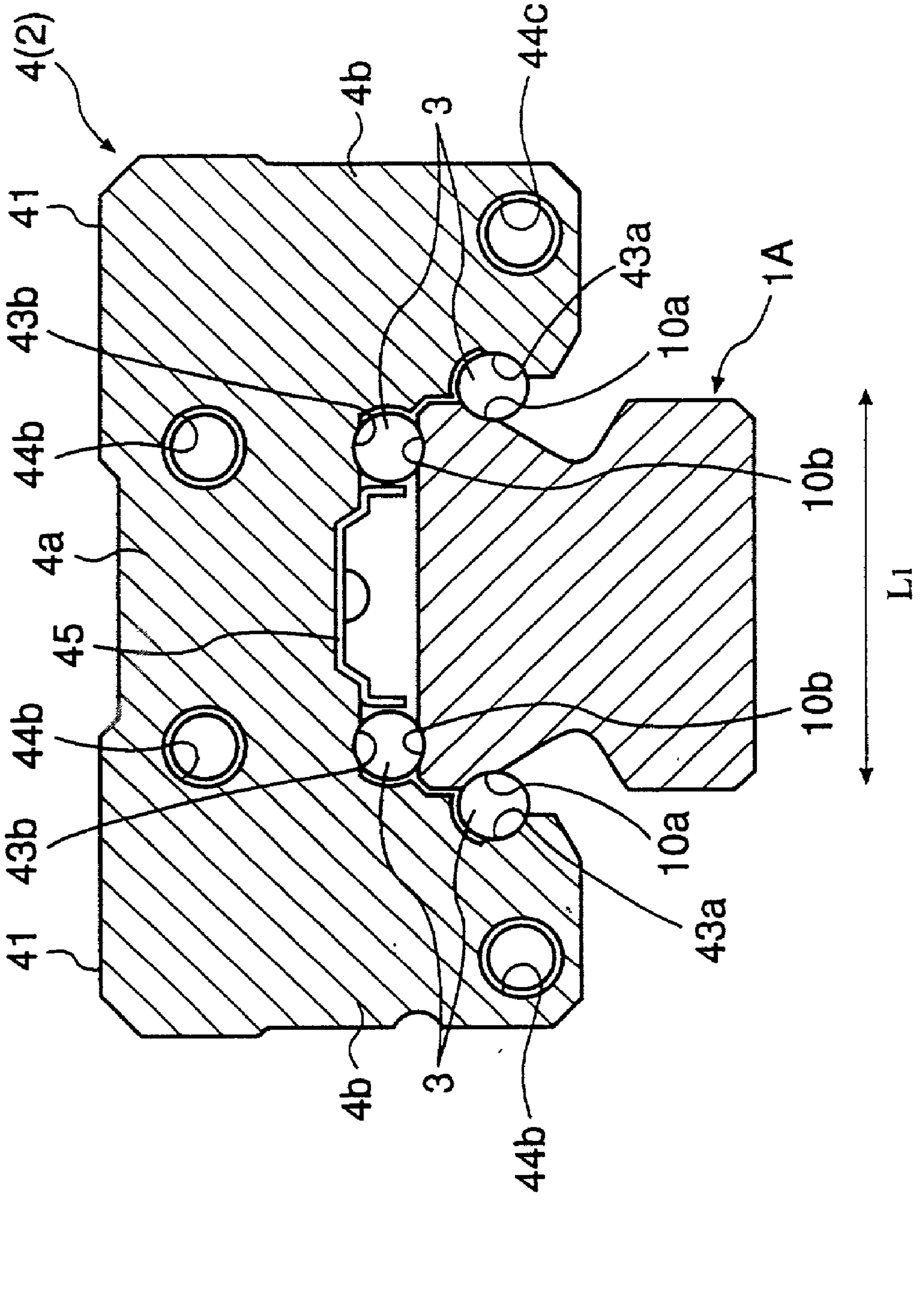

4(2)
41
43b
44b
4a
45
44b
43b
41
4b
3
44c
43a
10a
1A
10b
10b
10a
43a
3
4b
44b
L1

Fig 4

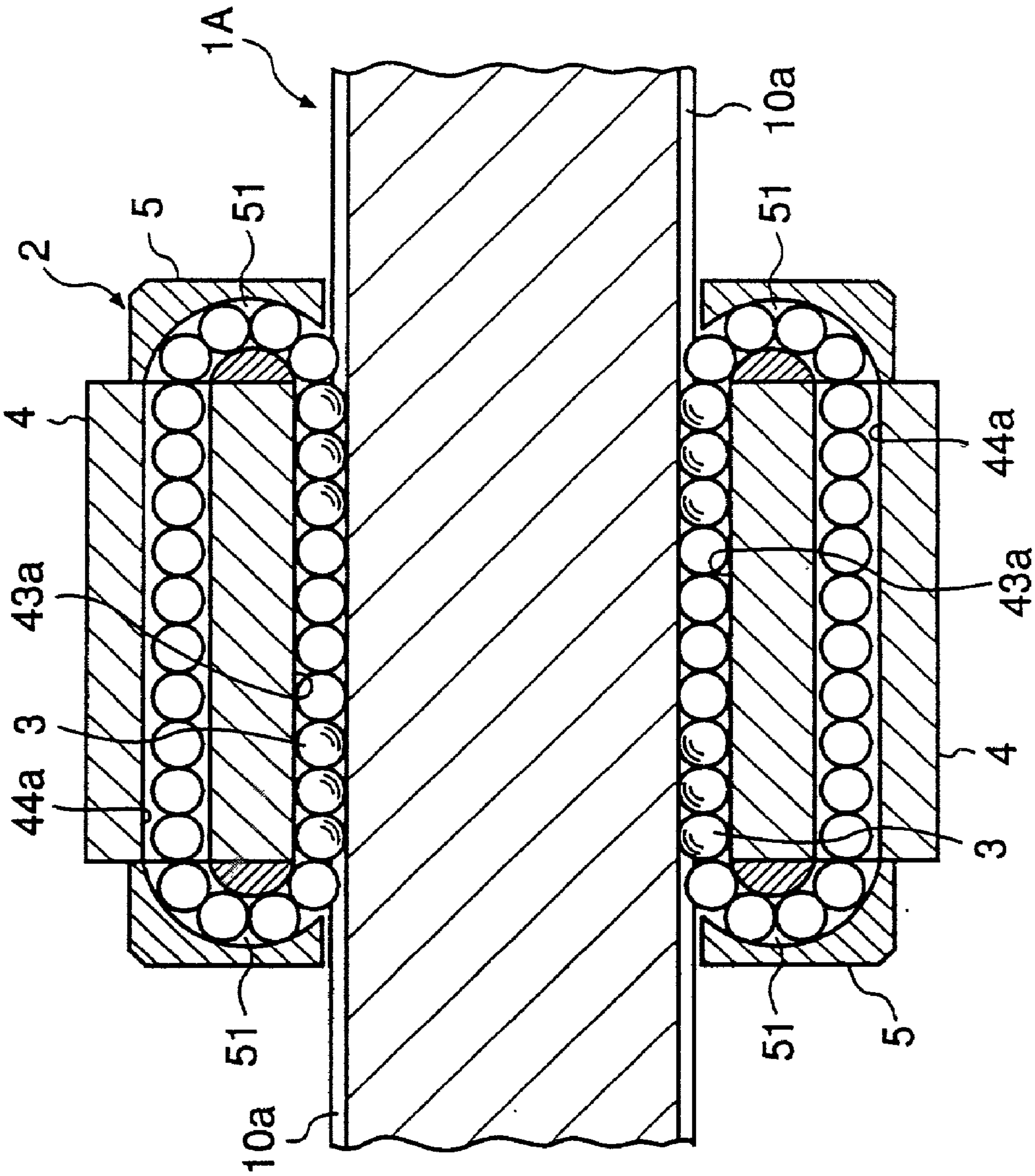
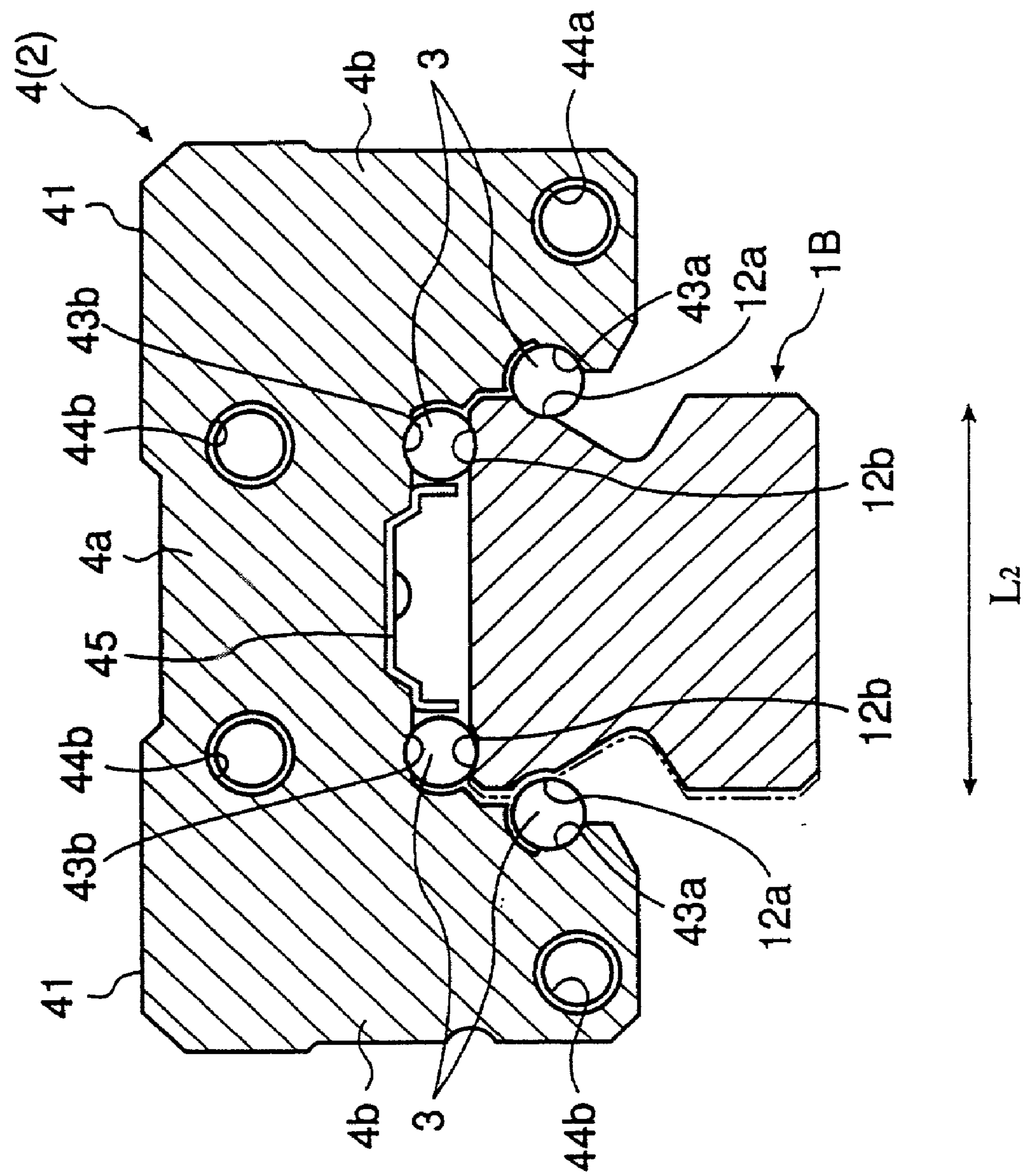


Fig 5



4(2)
4b
3
44a
41
43b
43a
12a
1B
44b
12b
4a
45
L2
12b
44b
43b
43a
12a
41
4b
3
44b

Fig 6

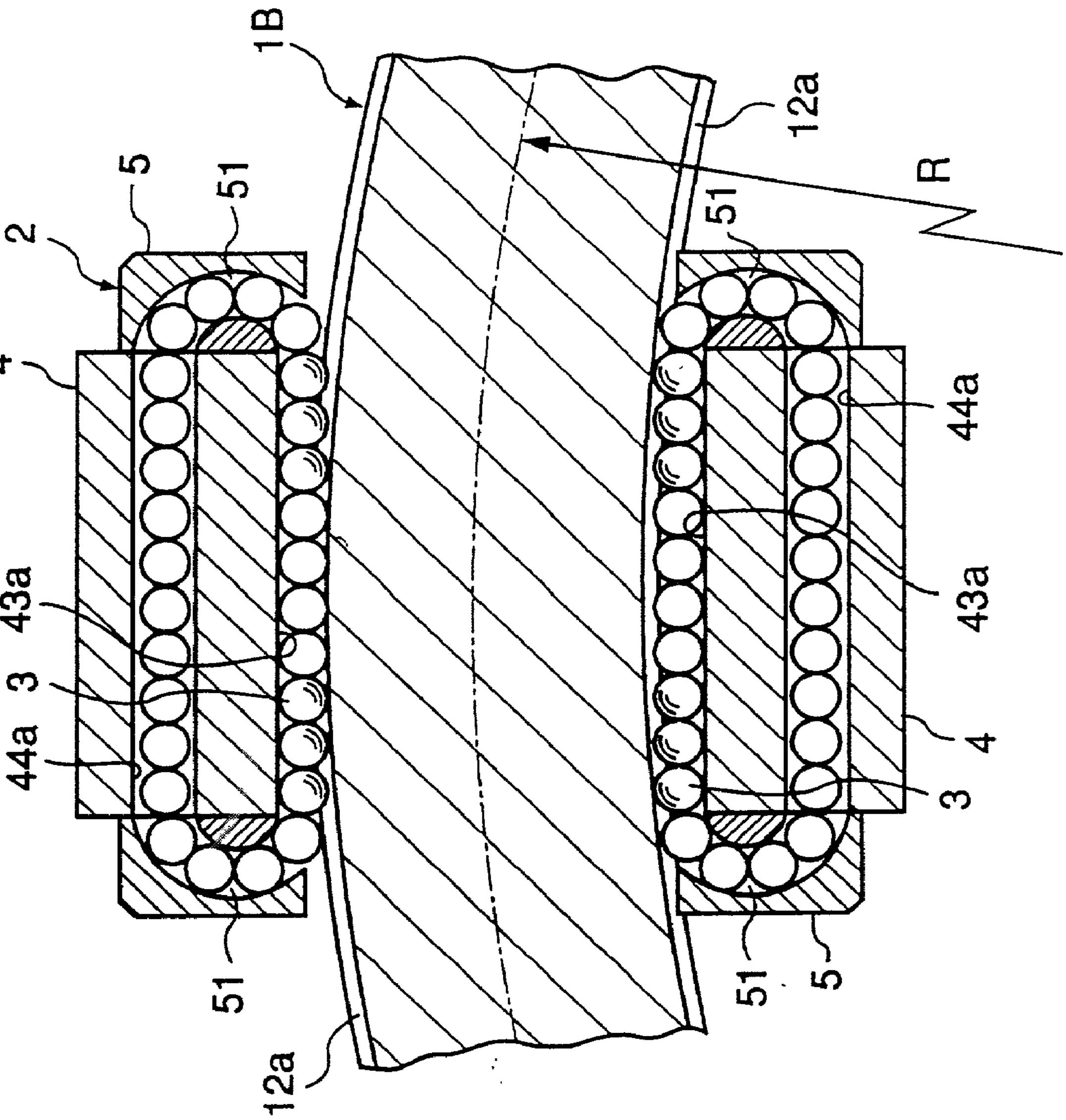


Fig 7

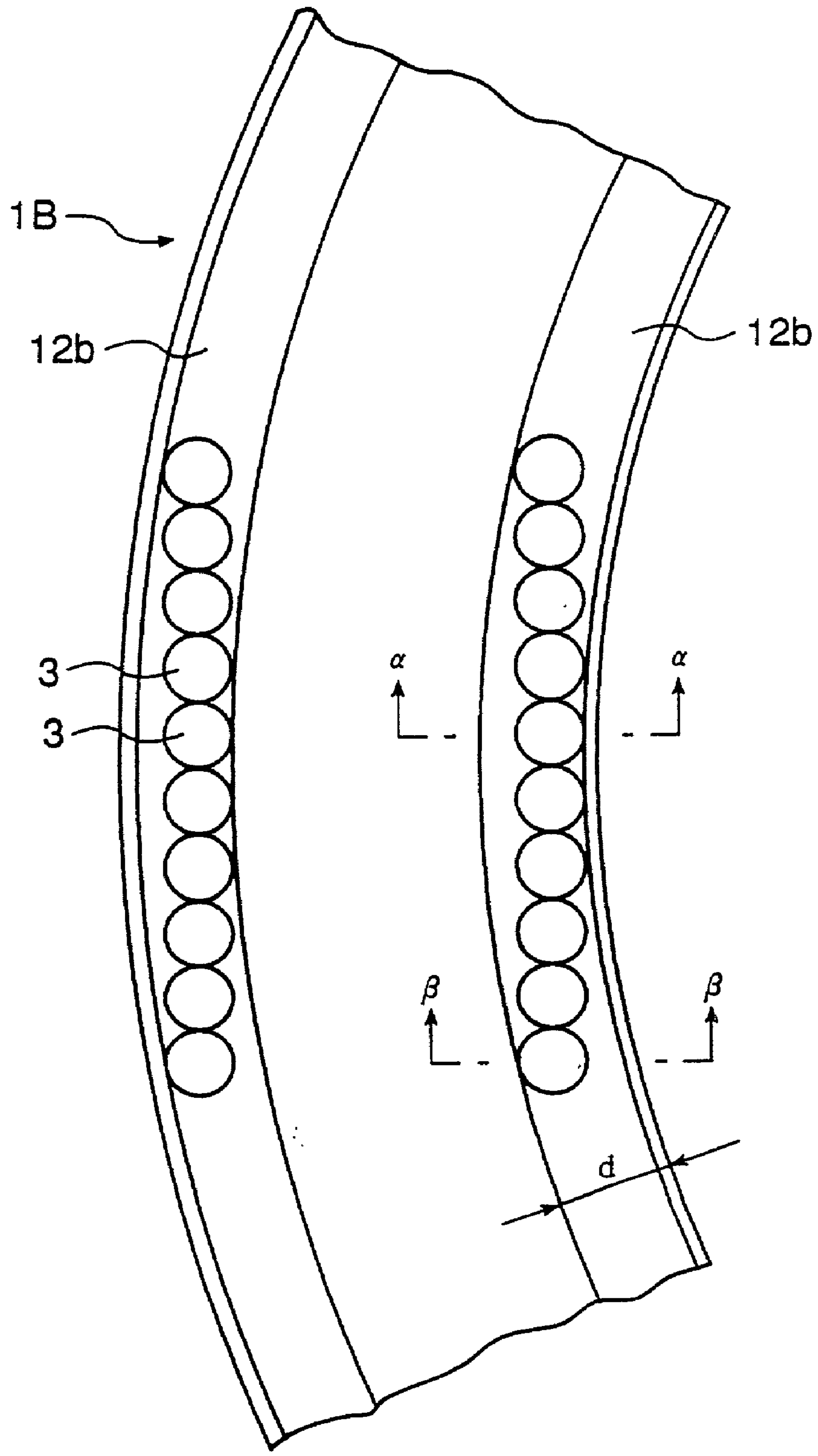


Fig 8

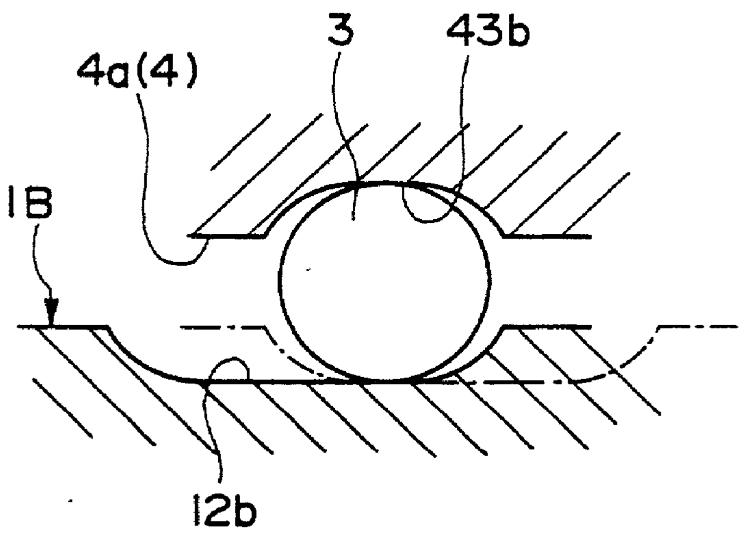
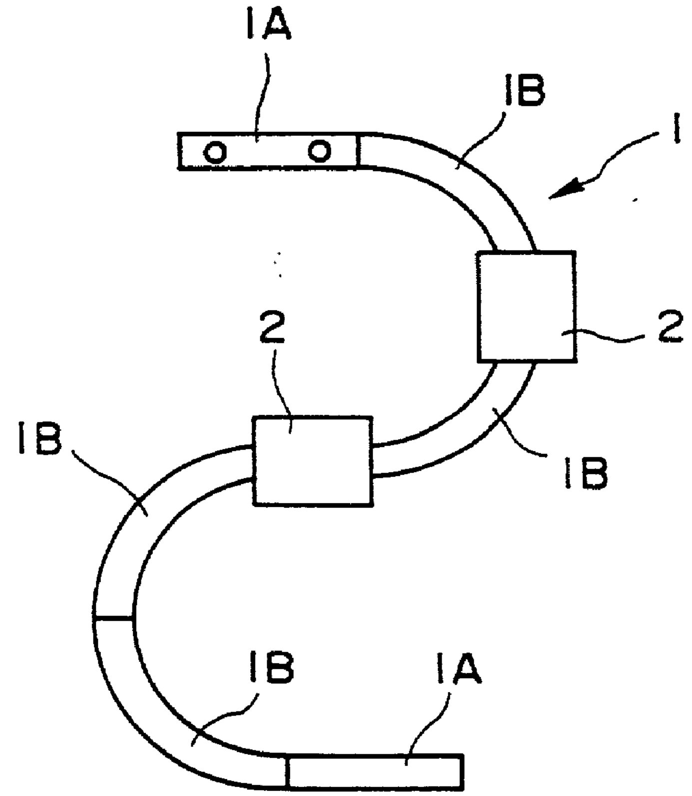


Fig 9



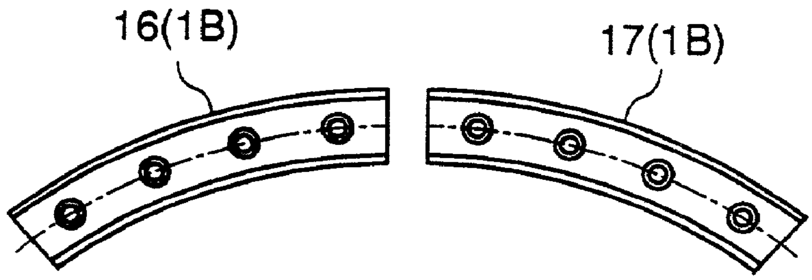


Fig 10(a)

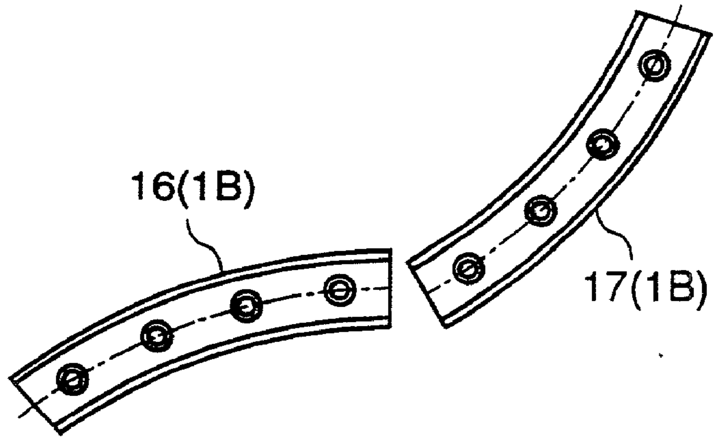


Fig 10(b)

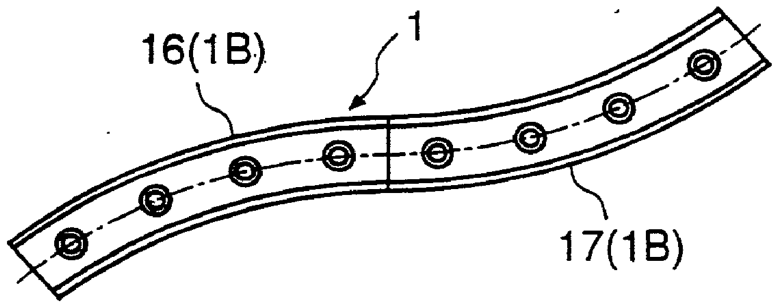


Fig 10(c)

Fig 11

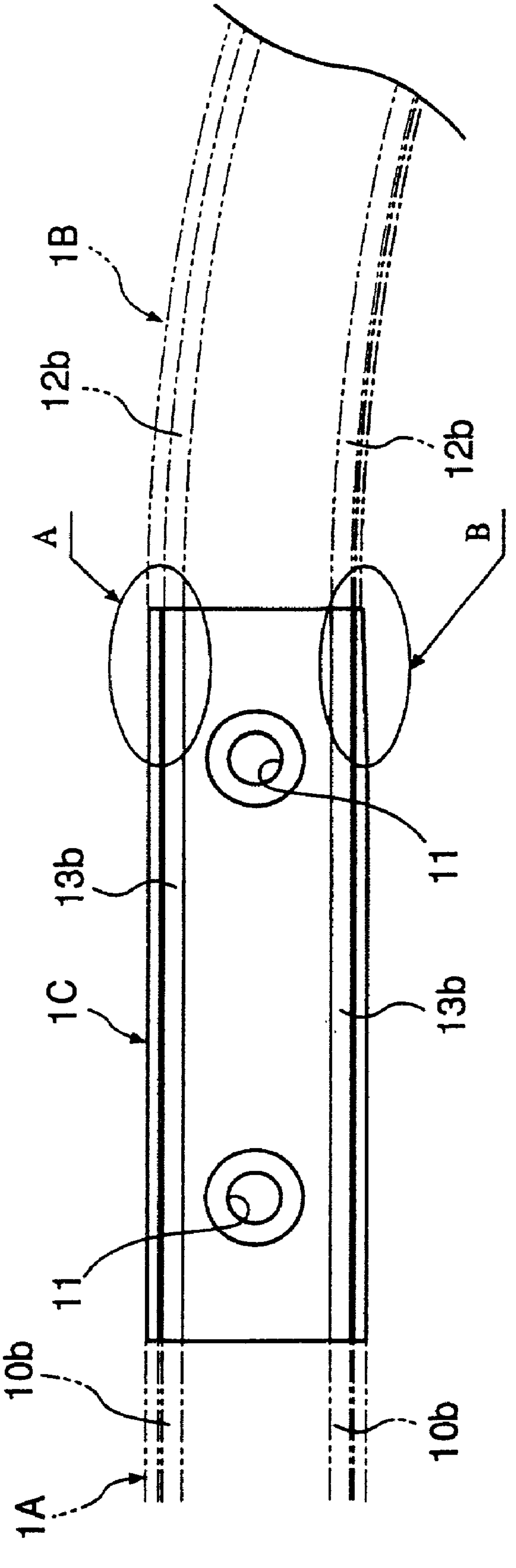


Fig 12

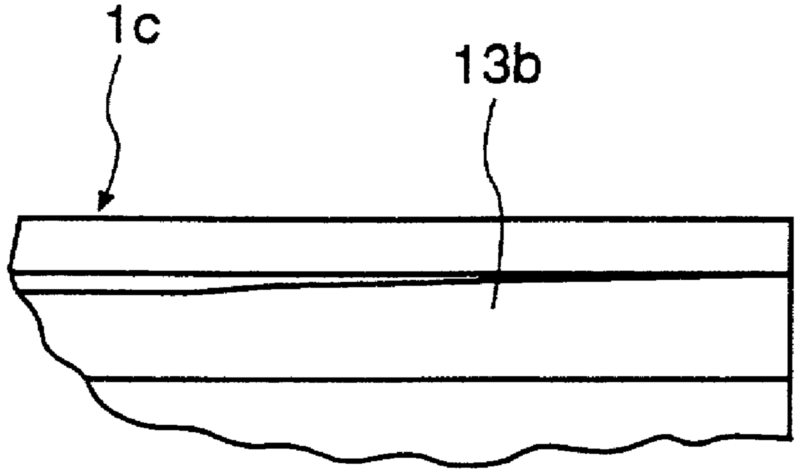


Fig 13

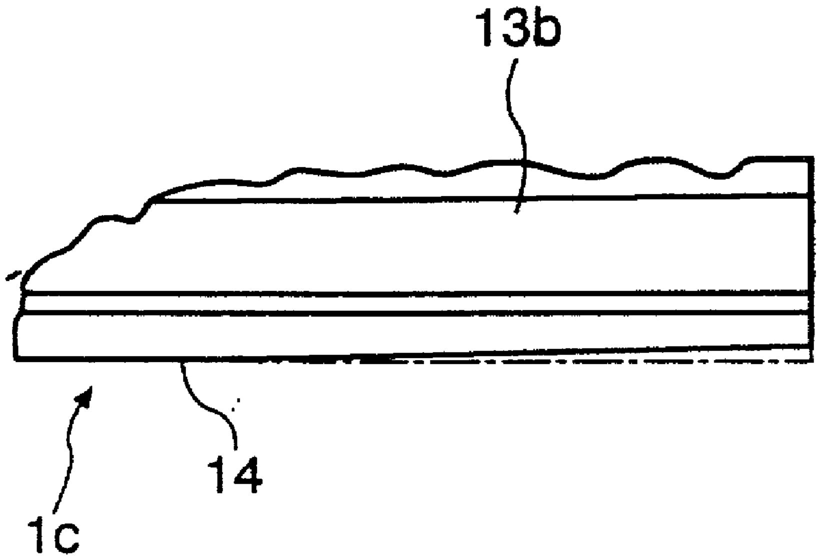


Fig 14

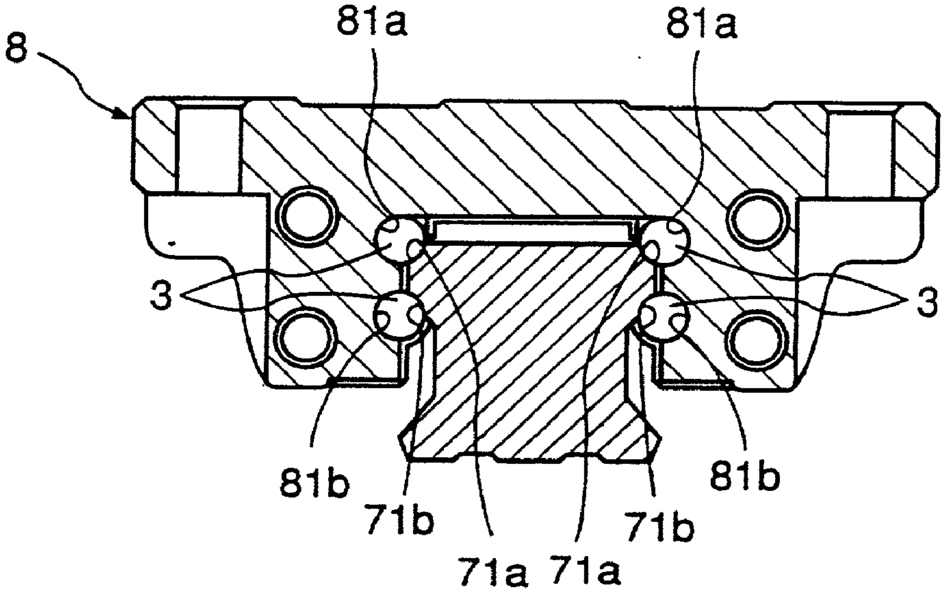


Fig 15

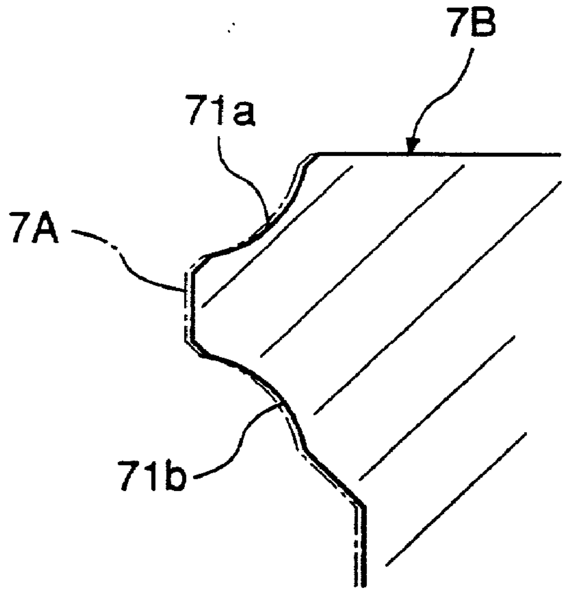
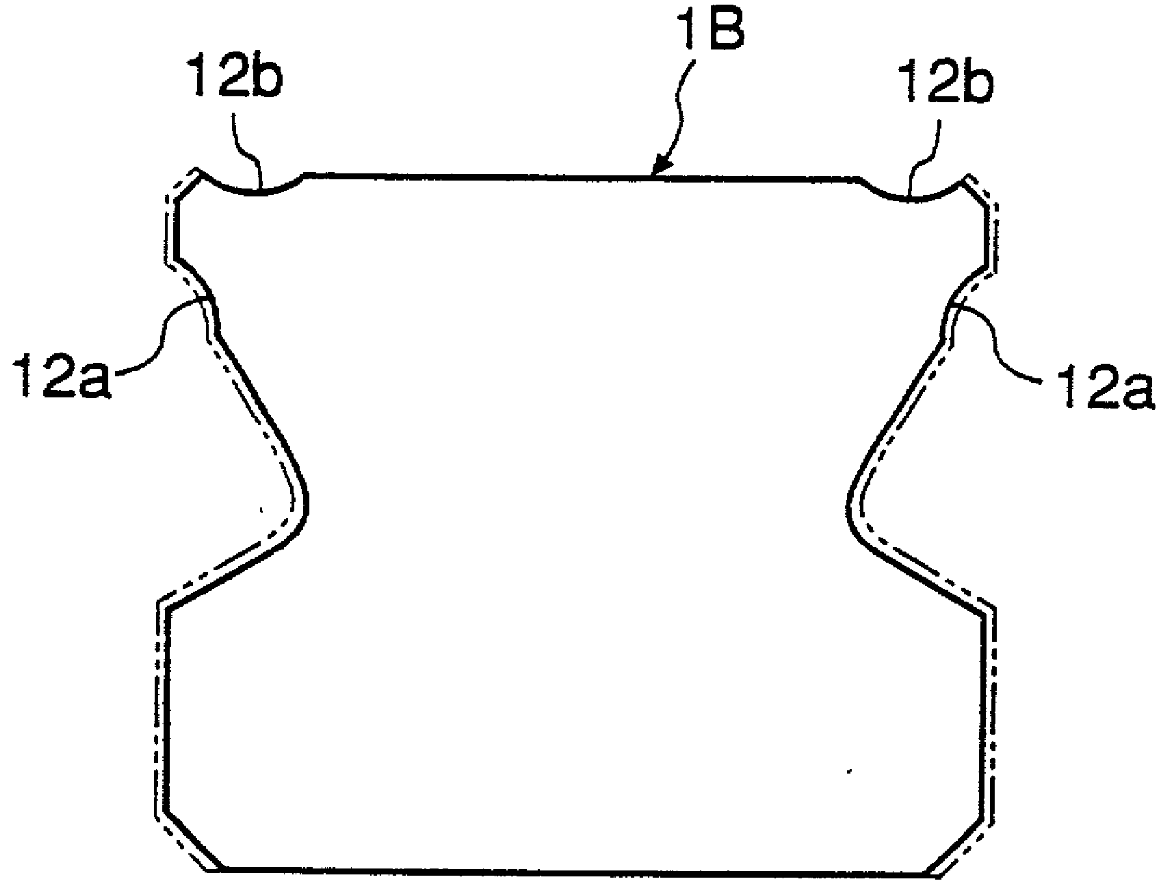


Fig 16



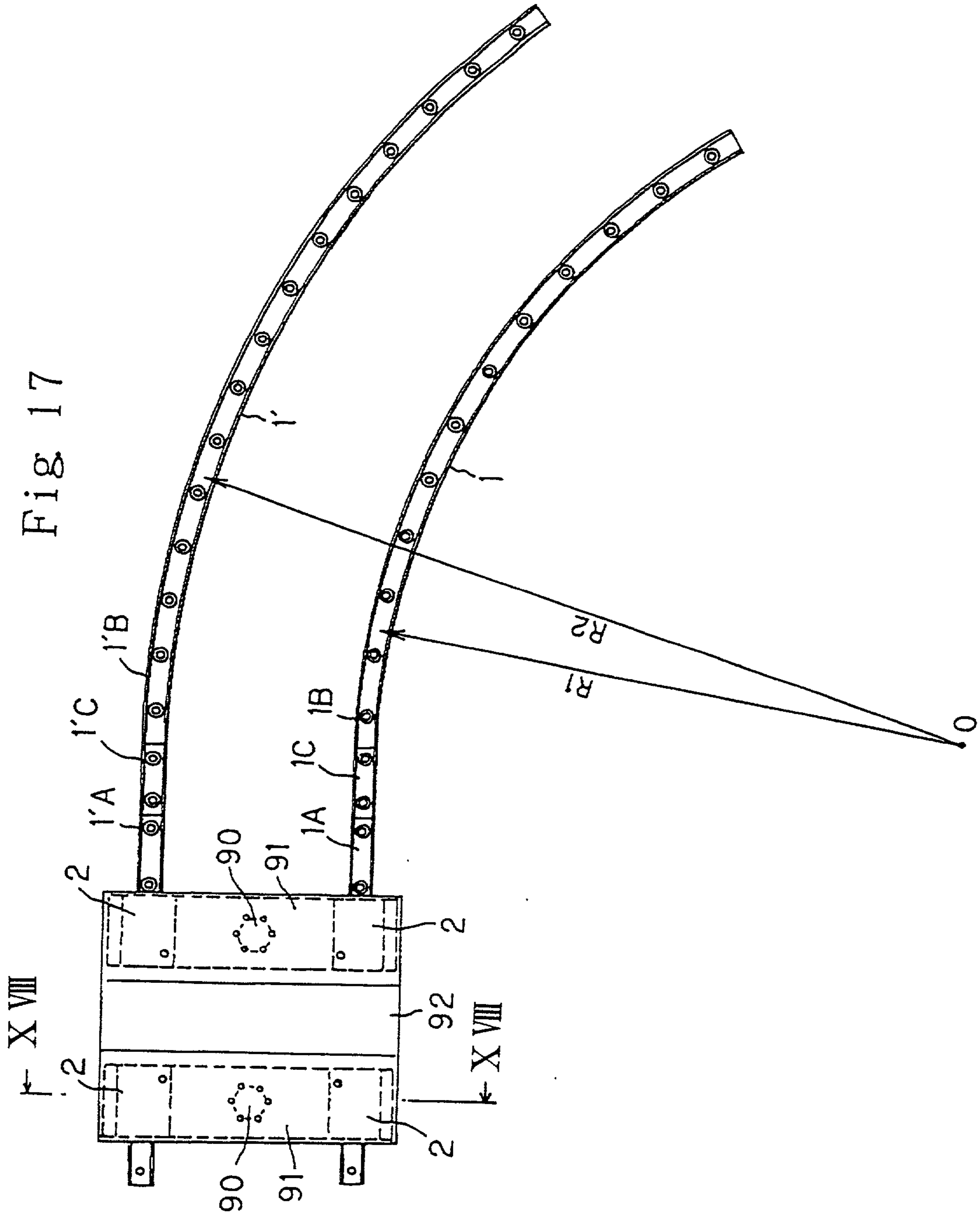


Fig 17

Fig 18

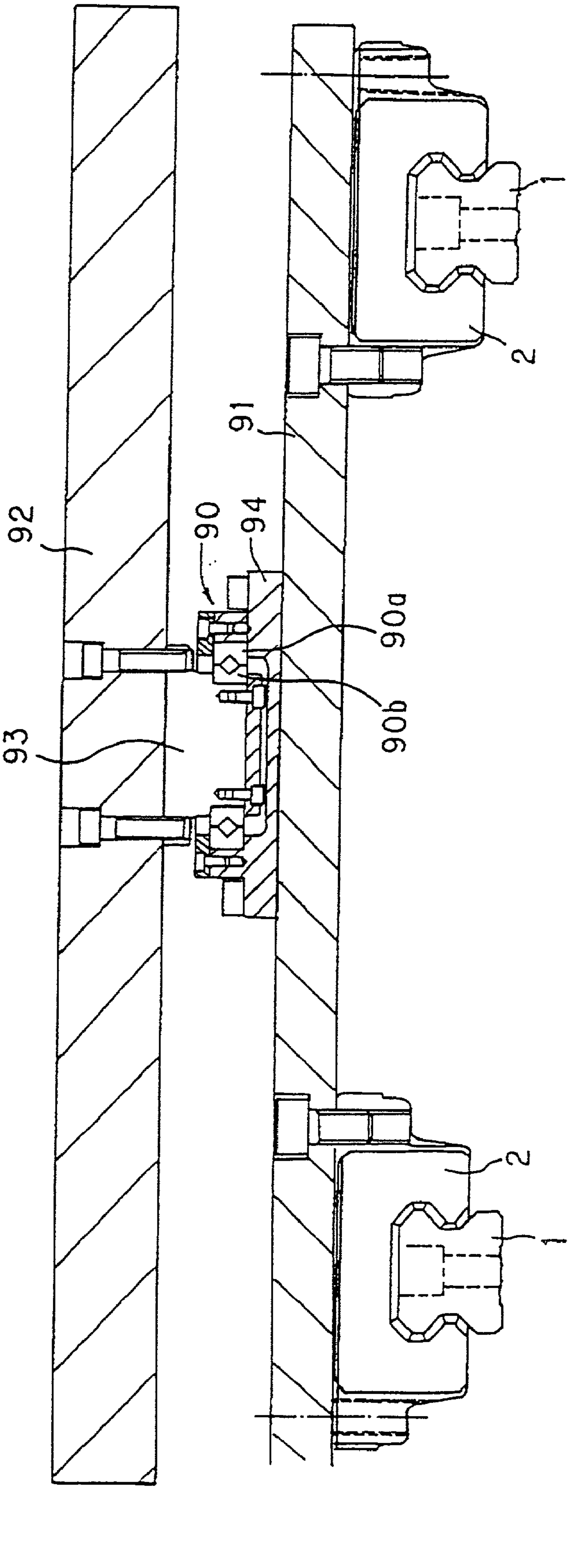


Fig. 19

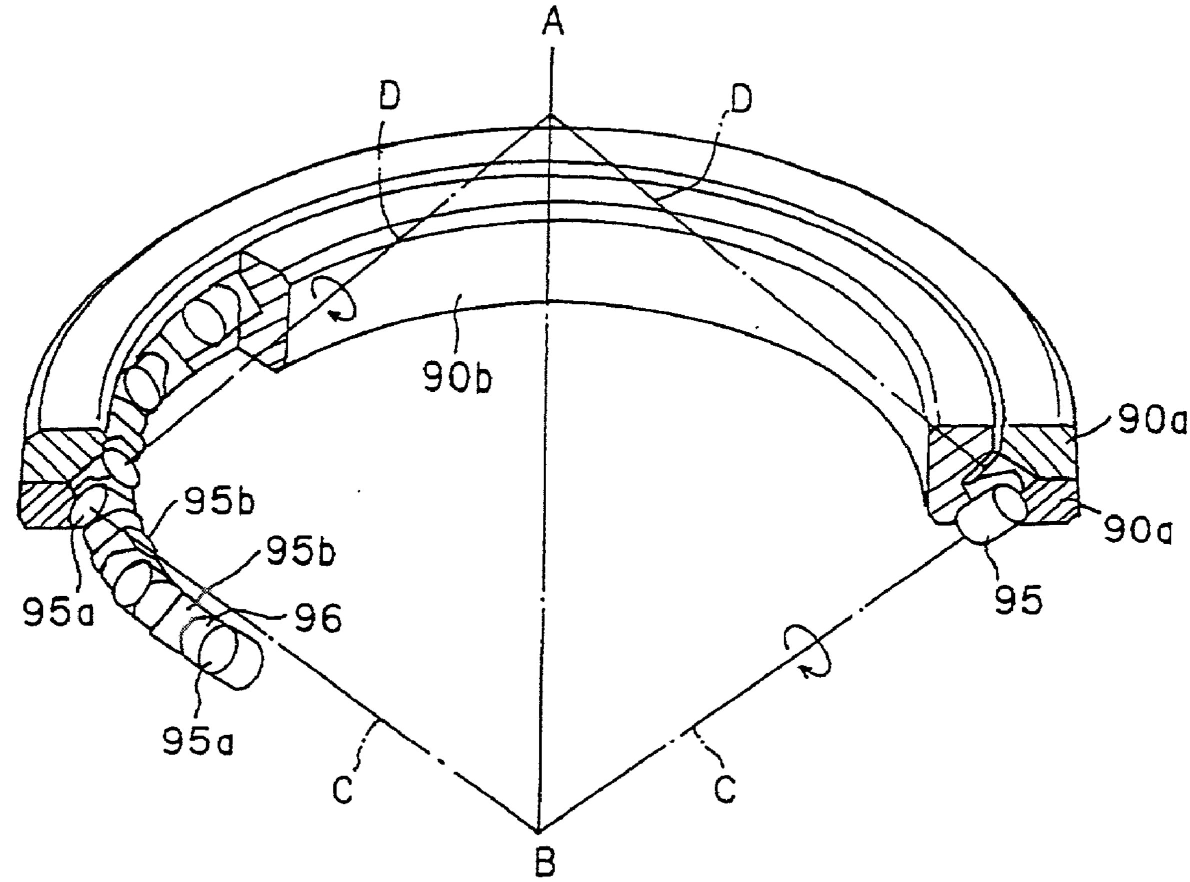


Fig 20

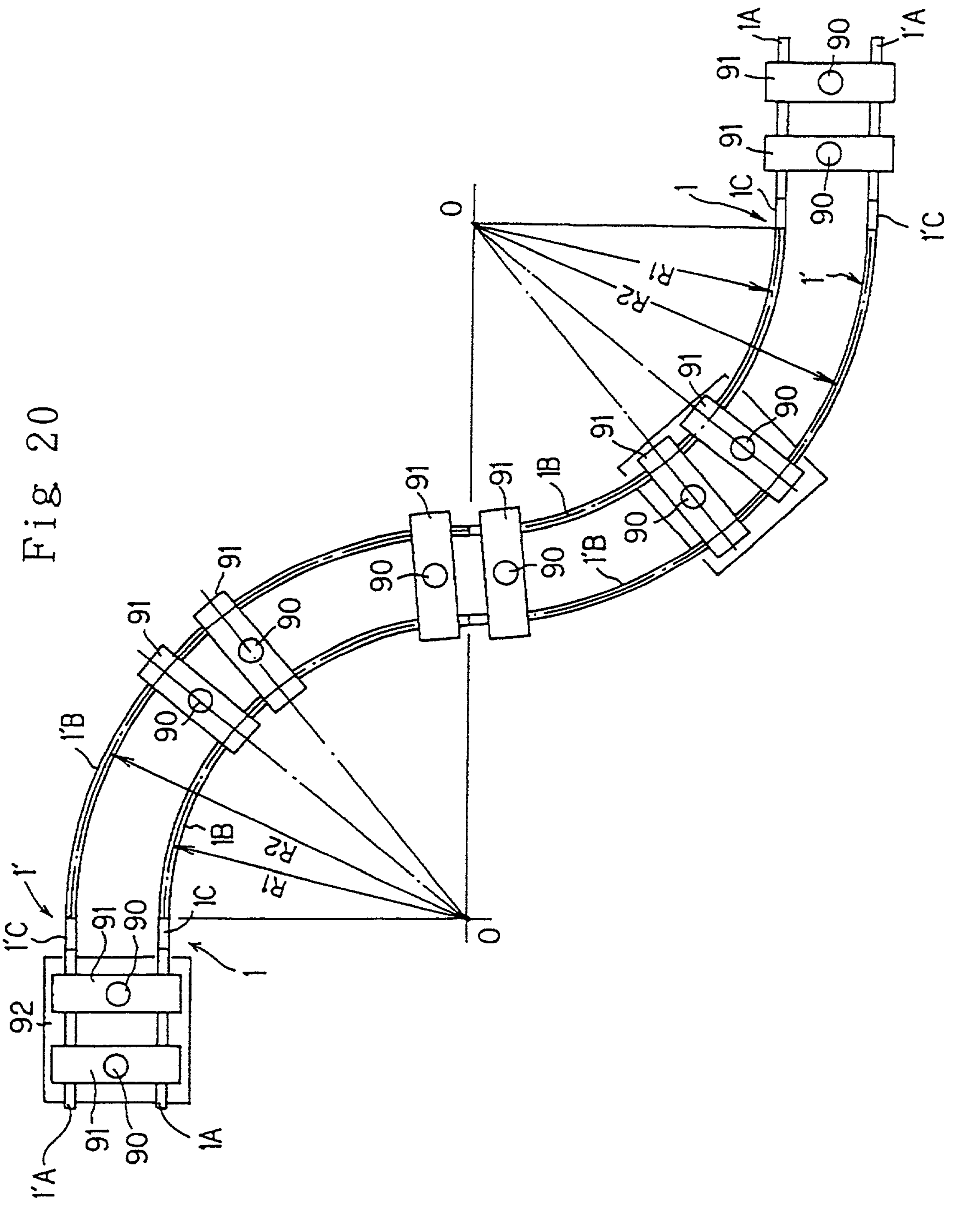


Fig 21

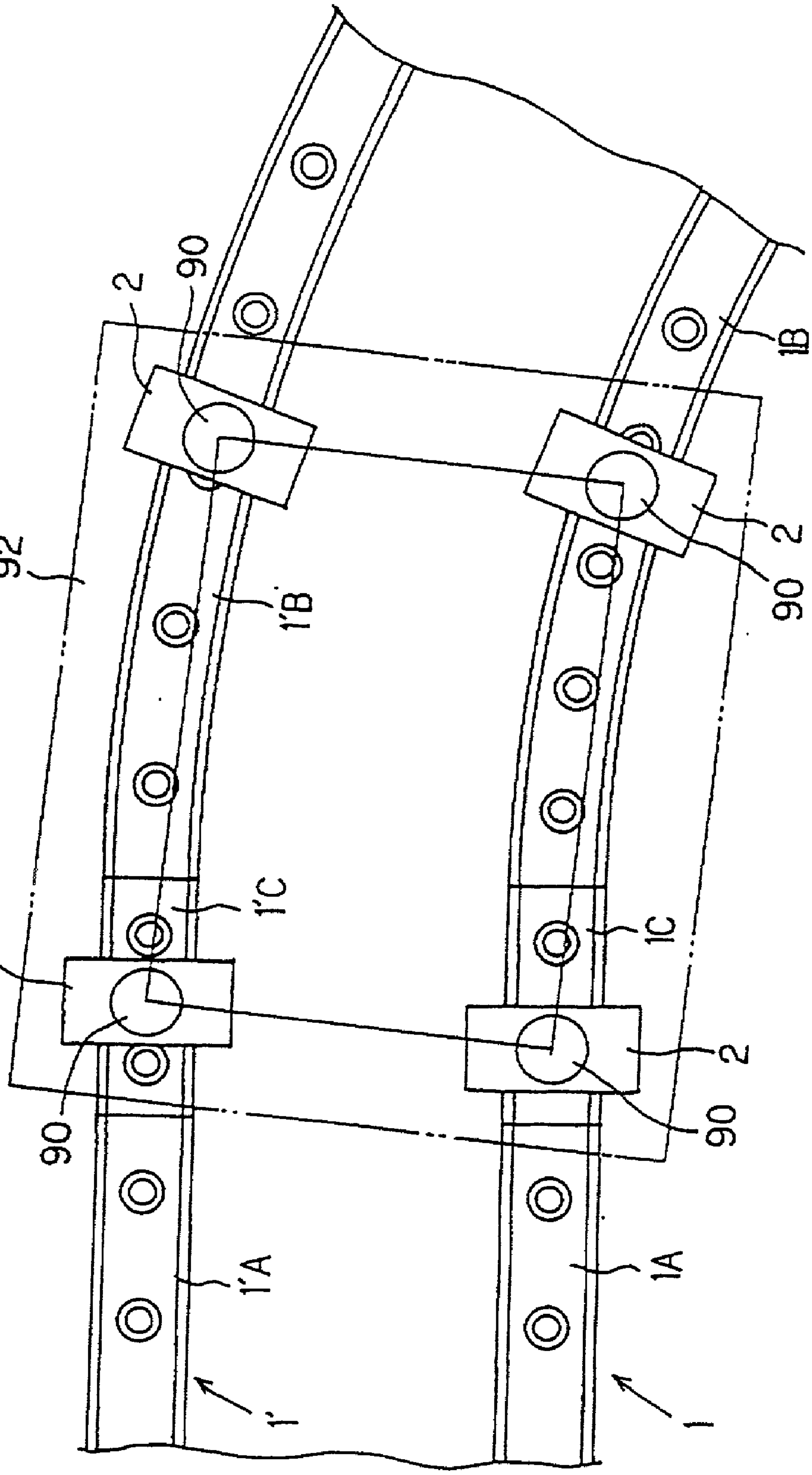
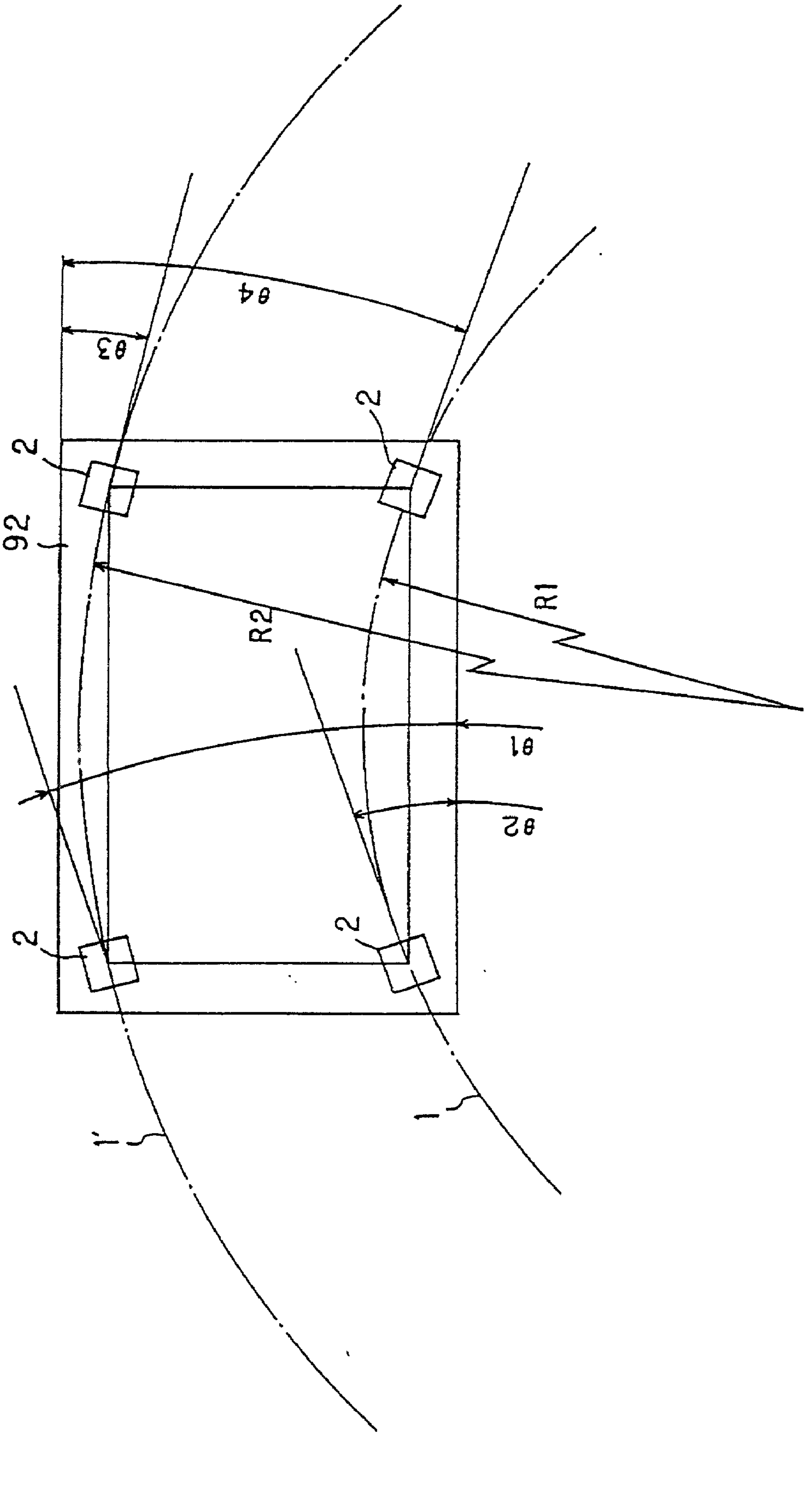


Fig 22



UNIVERSAL GUIDE DEVICE AND MOVING TABLE DEVICE USING SAME

FIELD OF THE INVENTION AND RELATED ART STATEMENT

[0001] 1. Field of the Invention

[0002] The present invention relates to a universal guide device that is used in sliding portions of various machine tools, part-conveying systems, and so on and is capable of guiding a movable object or material over a conveyance path containing both straight and curved regions.

[0003] 2. Related Art

[0004] For example, on a product line or the like in a plant, if all processing stations are arranged linearly, then no problems will take place. However, depending on the space of the plant in which a machine is installed or on the contents of the processing performed in processing stations, it may be necessary to change the direction of conveyance of materials to be processed between two adjacent processing stations. In this case, it is customary to use a pallet changer or the like to achieve a change in the direction of conveyance. Unfortunately, additional space and cost for installing the pallet changer or the like are necessary.

[0005] Known means for modifying the direction of conveyance of materials or objects without using a pallet changer include universal guide devices (as described in Laid-open, unexamined Japanese patent application Nos. 293319/1988 and 50333/1994) capable of guiding materials continuously along a path including both straight and curved lines and curved guide devices (as described in Laid-open, unexamined Japanese patent application No. 186028/1988) capable of guiding materials continuously along an annular path.

[0006] These universal guide devices and curved guide devices each comprise a track rail, a slider, and a number of balls. The rail forms longitudinally extending surfaces on which the balls roll. The slider is mounted to span the rail. Load-rolling surfaces opposite to the rolling surfaces of the rail and an endless circular path for the balls are formed on and in the slider. The endless circular path includes the load-rolling surfaces. The balls roll in the endless circular path of the slider and between the rolling surfaces of the rail and the load-rolling surfaces of the slider carry a load. The slider moves along the rail in response to rolling movement of the balls.

[0007] In the former universal guide device, each load-rolling surface of the slider is partitioned into straight load regions formed linearly and curved load regions shaped into an arc in conformity with the curvature of the rail. In each straight load region of the rail, the load acting on the slider is carried by the balls rolling in the straight load region. In each curved region, the load is carried by the balls rolling in the curved region. As a result, even if straight and curved regions are intermingled on the track rail, the slider can move along the rail through the straight and curved regions continuously.

[0008] In the latter curved guide device, the track rail is shaped into an arc having a given curvature. The load-rolling surface of the slider is shaped into an arc in conformity with the curvature of the rail. All the balls interposed between the load-rolling surface of the slider and the rolling surface of the rail roll on while carrying the load acting on the slider. In consequence, the slider can make a curved motion along the rail.

[0009] In these conventional universal guide devices and curved guide devices, the load-rolling groove or race in the slider is shaped into an arc in conformity with the curvature of the track rail to permit movement of the slider through the curved region of the rail. Therefore, it has been necessary to machine the load-rolling surface in conformity with the curvature of the rail. Consequently, it has been impossible to directly use the sliders of conventional mass-produced linear guide devices that are available in the market. Hence, the production cost is increased. Furthermore, a different slider is necessary for each different curvature of track rail. Therefore, it is laborious to machine the sliders and to manage finished products.

[0010] Where the load-rolling surface of a slider is machined into an arc, the direction of bending of the curved region of a track rail is limited to one direction, left or right. Although it is possible to transport materials and objects annularly, it is impossible to convey materials along a track including two curved regions bent in different directions such as an S-shaped track.

[0011] On the other hand, in a path between two adjacent machining stations on a product line, if materials can be transported, no problems take place. It is considered that capability to carry very large loads is not necessary in curved regions of the rail. However, during a machining process, a machining force acting on a material needs to be sustained reliably by a guide device. Straight regions of the rail are required to have ability to carry a larger load than curved regions. In the aforementioned conventional universal guide device, the load-rolling surface formed on the slider is divided into straight and curved load regions. Therefore, the straight regions of the rail have decreased ability to sustain loads. Consequently, a machining force acting on materials cannot be sufficiently sustained.

[0012] Where materials are actually transported using such universal guide devices, it is necessary to construct a moving table device from two or more universal guide devices in order to transport such materials stably. In particular, two track rails are placed parallel to each other. Plural sliders are mounted to each track rail. A table is mounted so as to span all of these sliders. The materials to be transported are placed on this table.

[0013] Where the table is moved only through a linear region or only through a curved region, if all the sliders are mounted directly to the table, no problems take place. The table can be smoothly moved. However, where the table is moved from a curved region to a straight region or vice versa continuously, if all the sliders are directly mounted to the same table, the configuration of one slider relative to the track rail is restricted by other sliders. This makes it difficult to move the table smoothly. Accordingly, where plural universal guide devices of the construction described above are used to construct the moving table device, it has been impossible to mount the sliders directly to the table.

OBJECTS AND SUMMARY OF THE INVENTION

[0014] In view of the foregoing problem, the present invention has been made. It is an object of the present invention to provide a universal guide device which can directly use sliders heretofore employed in linear guide devices and which do not need different sliders for each different radius of track rail and thus can be fabricated at lower cost than conventionally.

[0015] It is another object of the invention to provide a universal guide device in which sliders can move through two curved regions of a track rail continuously along the rail even if the two curved regions are bent in different directions and in which the sliders can move from a straight region to a curved region or vice versa continuously without sacrificing the ability of the rail to sustain a load in the straight region even if the rail contains both straight and curved regions.

[0016] It is a further object of the invention to provide a moving table device comprising plural parallel track rails and plural sliders mounted to each track rail, the moving table device being characterized in that smooth movement of the sliders is assured even if a table is supported by the sliders that are four or more in number.

[0017] To achieve the objects described above, a universal guide device in accordance with the present invention comprises: a track rail including a straight region and a curved region shaped into an arc with a given radius of curvature and having ball-rolling surfaces on both its side surfaces, the ball-rolling surfaces extending longitudinally; a slider having a saddlelike cross section and mounted to span the track rail; load-rolling surfaces formed on the slider and located opposite to the rolling surfaces, respectively, of the rail; and an endless circular path for a number of balls. The circular path is formed on the slider and includes the load-rolling surfaces. The numerous balls sustain a load between each rolling surface of the track rail and each load-rolling surface of the slider. The load-rolling surfaces formed on the slider are formed linearly. The width of the curved region of the track rail is set narrower than the straight region of the rail.

[0018] In this universal guide device in accordance with the present invention, the load-rolling surfaces formed on the slider are not shaped into an arc corresponding to the curvature of the curved region of the track rail. Rather, the load-rolling surfaces are formed linearly in conformity with the rolling surfaces of the straight region of the track rail. In the present invention, however, the curved region of the rail is set narrower than the straight region of the rail. Therefore, if the rolling surfaces of the rail assume the form of an arc, and if the load-rolling surfaces of the slider are linear, the slider can engage the curved region of the rail and can move along the curved region without trouble.

[0019] When the slider is moving through the curved region of the track rail, the balls are squeezed in between the arc-shaped rolling surfaces formed longitudinally of the rail and the linear load-rolling surfaces formed on the slider and roll along the load-rolling surfaces while carrying the load. Therefore, with respect to the numerous balls rolling on the load-rolling surfaces, only some of the balls carry the load between the rolling surfaces of the rail and the load-rolling surfaces of the slider.

[0020] In this universal guide device in accordance with the present invention, the load-rolling surfaces formed on the slider are shaped linearly rather than into an arc. Therefore, the sliders of linear guide devices can be used intact. Furthermore, an operation for machining the load-rolling surface into an arc in conformity with the curvature of the track rail is dispensed with. Therefore, it is possible to fabricate a universal guide device at quite low cost. Furthermore, the linearly formed load-rolling surfaces have no directivity. Consequently, even if two curved regions bent in different directions are contained in the rail, the slider can move through these curved regions continuously.

[0021] In addition, in the universal guide device in accordance with the present invention as described above, all the balls rolling on the load-rolling surfaces of the slider bear against the rolling surfaces of the track rail within the straight region of the rail. Therefore, the ability of the slider to sustain a load is not impaired, unlike the case in which only some balls bear against the rolling surfaces in a curved region. If large loads act on the slider, the loads can be sufficiently sustained.

[0022] In the present invention, as long as the ball-rolling surfaces on the track rail side are formed on the surfaces of the rail, balls forming a row and rolling on the load-rolling surface of the slider do not simultaneously touch the arc-shaped rolling surface on the rail side. Therefore, this rolling surface may be shaped in the same way as the rolling surface of the prior art curved guide device without needing any special machining operation. Furthermore, this track rail can be easily fabricated, because one surface of the rail and the arc-shaped rolling surface formed on it can be simultaneously ground. However, where an upward facing rolling surface is formed on the top surface of a track rail, this rolling surface needs to be machined in a special manner. In particular, a downward facing load-rolling surface is linearly formed on the slider in an opposite orientation to the upward facing rolling surface of the track rail. Consequently, this upward facing rolling surface needs to have such a width that balls forming a row and rolling on the downward facing rolling surface of the slider simultaneously touch the upward facing surface.

[0023] In the universal guide device in accordance with the present invention, the slider can move through both straight and curved regions of the track rail freely. Therefore, if this rail is composed of only curved regions, the slider can move along the annular rail. That is, where attention is paid to only the curved region of the rail, the universal guide device in accordance with the invention can be regarded as a curved guide device.

[0024] As mentioned previously, in the universal guide device in accordance with the present invention, the straight and curved regions of the track rail differ in width. Therefore, it is desired to provide an intermediate rail portion connecting the straight and curved regions of the rail such that the width of the rail varies continuously in this intermediate rail portion.

[0025] Moreover, a moving table device can be built using universal guide devices of the construction in accordance with the invention as described above. Specifically, plural track rails are mounted parallel to each other on a fixed portion such as a pedestal or a base. A table is mounted to span sliders that move on these rails. However, if two or more sliders are mounted to each rail, and if all of the sliders are directly mounted to the same table, it will be difficult to move the table smoothly between the straight and curved regions of the rail, as mentioned previously.

[0026] In view of this, first and second track rails are mounted parallel to each other. Plural sliders are mounted to each of these rails. A fixed plate is made to span one slider mounted to the first rail and one slider mounted to the second rail such that these two sliders are coupled. Another fixed plate is bridged across another slider mounted to the first rail and another slider mounted to the second rail, and so on. Preferably, the table is mounted so as to be rotatable relative to the fixed plates. Where the moving table device is constructed in this way, even if the table is supported by the sliders that are four in number, the first fixed plate bridged over the first row of sliders that is the forerunner in the direction of movement and the second fixed plate bridged over the second row of sliders rotate in such a way that the sliders are oriented in the tangential direction of the rails. The distance between the sliders on the rails is made variable. Hence, the sliders can move smoothly.

[0027] Additionally, the table can be smoothly moved between the straight and curved regions of the rail by mounting the first and second rails parallel to each other, mounting plural sliders to each of the rails, and mounting the table so as to be rotatable relative to the sliders. That is, in this structure, when the sliders move through the curved region of the rail, they rotate to arbitrary directions so as to orient themselves to the tangential direction of the rails. This permits smooth movement of the sliders.

[0028] As described thus far, in the universal guide device in accordance with the present invention, the load-rolling surfaces formed on the sliders are only required to be shaped linearly rather than into an arc. Therefore, the sliders of numerous linear guide devices available on the market can be used intact. Moreover, it is not necessary to machine the load-rolling surfaces in conformity with the curvature of the rails. In consequence, the sliders can be manufactured easily and inexpensively.

[0029] Since the load-rolling surfaces formed on the sliders have no directivity, if each track rail has two curved regions bent in different directions, the sliders can move through the curved regions continuously along the rail. For example, materials can be guided freely along a track having a high degree of freedom (e.g., consisting of a combination of straight lines and curved lines such as an S-shaped track).

[0030] Because the load-rolling surfaces formed on the sliders are linear, all the balls rolling on the load-rolling surfaces of the sliders bear against the rail in the straight regions and sustain the load. Therefore, the sliders can exhibit sufficient ability to sustain the load within these straight regions. If straight and curved lines are intermingled on the rail, the sliders can move through the straight and curved regions continuously without sacrificing the ability of the rail in the straight regions to sustain the load.

[0031] Other objects and features of the invention will appear in the course of the description thereof, which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] **FIG. 1** is a plan view of a universal guide device in accordance with a first embodiment of the present invention;

[0033] **FIG. 2** is a perspective view of one slider and the straight guide rail portion shown in **FIG. 1**;

[0034] **FIG. 3** is a front elevation in cross section of the slider and straight guide rail portion shown in **FIG. 2**, and in which the slider is mounted on the rail;

[0035] **FIG. 4** is a plan view in cross section of the slider and straight guide rail shown in **FIGS. 2 and 3**, showing the manner in which balls are rolling and circulating through a circular path when the slider is moving along the rail;

[0036] **FIG. 5** is a front elevation in cross section similar to **FIG. 3**, but in which the slider is mounted on a curved guide rail portion;

[0037] **FIG. 6** is a plan view in cross section of the slider and curved guide rail portion shown in **FIG. 5**, showing the manner in which balls are rolling through circular paths when the slider is moving along the rail;

[0038] **FIG. 7** is a fragmentary plan view of a rolling surface formed on the top surface of a curved guide rail portion, showing the manner in which balls are rolling on the rolling surface;

[0039] **FIG. 8** is an enlarged cross section of a rolling surface formed on the top surface of a curved guide rail portion and a load-rolling surface of a slider, showing the manner in which balls are rolling between the rolling surface on the rail and the load-rolling surface of the slider;

[0040] **FIG. 9** is a plan view of a universal guide device that can be fabricated by making use of a combination of straight guide rail portions and curved guide rail portions in accordance with the first embodiment;

[0041] FIGS. **10**(*a*)-**10**(*b*) are plan views of S-shaped rails each consisting of two split guide rail portions;

[0042] **FIG. 11** is a fragmentary plan view of an intermediate rail portion in accordance with the first embodiment of the invention;

[0043] **FIG. 12** is a fragmentary enlarged plan view of portion A of **FIG. 11**;

[0044] **FIG. 13** is an enlarged plan view of portion B of **FIG. 11**;

[0045] **FIG. 14** is a front view in cross section of a universal guide device in accordance with a second embodiment of the invention;

[0046] **FIG. 15** is an enlarged cross section of main portions of the curved guide rail portions shown in **FIG. 14**;

[0047] **FIG. 16** is a cross-sectional view of the curved guide rail portion shown in **FIGS. 14 and 15**, but in which the rail portion has been ground at both side surfaces and finished to a given width;

[0048] **FIG. 17** is a fragmentary plan view of a moving table device forming a third embodiment of the invention, the moving table device using a universal guide device in accordance with the invention;

[0049] **FIG. 18** is a cross-sectional view taken along line XVIII-XVIII of **FIG. 17**;

[0050] **FIG. 19** is a perspective view of a rotary bearing used for the moving table device shown in **FIGS. 17 and 18**;

[0051] **FIG. 20** is a plan view of this moving table device, showing the manner in which a table is moved;

[0052] FIG. 21 is a plan view of a fragmentary plan view of a moving table device built forming a fourth embodiment of the invention and using a universal guide device in accordance with the invention;

[0053] FIG. 22 is a diagram illustrating the disposition of the slider of the moving table device shown in FIG. 21 in a curved region;

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0054] Referring to FIG. 1, there is shown a universal guide device in accordance with a first embodiment of the present invention. A track rail 1 is mounted to a fixed portion such as a pedestal or a base. Sliders 2 can move along the rail 1. This rail 1 is composed of a straight guide rail portion 1A, a curved guide rail portion 1B shaped into an arc with a given radius, and an intermediate rail portion 1C connecting these rail portions 1A and 1B. The sliders 2 can move on these rail portions 1A, 1B, and 1C freely.

[0055] FIG. 2 is a perspective view of the straight guide rail portion 1A and one slider 2 mounted on this rail portion 1A. FIG. 3 is a front view in cross section taken axially of the straight guide rail portion 1A. The straight rail portion 1A has a substantially rectangular cross section. Two side ball-rolling surfaces 10*a* and two top ball-rolling surfaces 10*b* extend longitudinally. Balls 3 roll on these four rolling surfaces 10*a*, 10*b*. The two side ball-rolling surfaces 10*a* are formed on the opposite side surfaces of the straight guide rail portion 1A, while the two top ball-rolling surfaces 10*b* are formed around the opposite edges, respectively, of the top surface of the guide rail portion 1A. The side ball-rolling surfaces 10*a* are tilted at an angle of 30° downwardly from the horizontal in the paper. The top ball-rolling surfaces 10*b* face vertically upward. Bolt-mounting holes 11 are formed in the straight guide rail portion 1A and spaced regularly from each other longitudinally along the rail portion 1A. Anchoring bolts (not shown) are inserted in the bolt-mounting holes 11 to mount the rail portion 1A fixedly to the fixed portion.

[0056] Referring particularly to FIGS. 2 and 3, each of the sliders 2 described above comprises a movable block 4 and two covers 5 mounted to the front and rear end surfaces, respectively, of the block 4. The movable block 4 is provided with tapped holes 42 into which the anchoring bolts are screwed. The movable block 4 has a mounting surface 41 on which a movable body such as a table is mounted. An endless circular path for the balls 3 is formed inside the slider by mounting the covers 5 to the movable block 4. Seal members 6 that make a sliding contact with the track rail 1 are mounted to the covers 5, respectively, to prevent dust adhering to the rail 1 from entering the slider 2 during movement of the slider.

[0057] Referring particularly to FIG. 3, the aforementioned movable block 4 has a horizontal portion 4*a* and a pair of skirt portions 4*b* descending from the horizontal portion 4*a*. The block 4 has a saddlelike cross section. The above-described mounting portion 41 is formed in the horizontal portion 4*a*. Two straight load-rolling surfaces 43*a* are formed on the inner surfaces of the skirt portions 4*b* of the horizontal portion 4*a* and located opposite to side ball-rolling surfaces 10*a* of the straight guide rail portion 1A. Two straight load-rolling surfaces 43*b* are formed on the bottom surface of the horizontal portion 4*a* and located opposite to the top ball-rolling surfaces lob of the straight guide rail portion 1A. Ball return holes 44*a* corresponding to the load-rolling surfaces 43*a* are formed in the skirt portions 4*b*, respectively. Ball return holes 44*b* corresponding to the load-rolling surfaces 43*b* are formed in the horizontal portion 4*a*. U-shaped direction change paths 51 (FIG. 4) are formed in the covers 5, respectively, to connect the load-rolling surfaces 43*a* and 43*b* with the ball return holes 44*a* and 44*b*, respectively, thus forming an endless circular path for balls.

[0058] Some of the balls 3 sustain a load between the ball-rolling surface 10*a* of the straight guide rail portion 1A and the load-rolling surface 43*a* of the movable block 4. The other balls 3 sustain a load between the top ball-rolling surface 10*b* of the straight guide rail portion 1A and the load-rolling surface 43*b* of the movable block 4. As each slider 2 moves, the balls 3 finish rolling over the load-rolling surfaces 43*a* and 43*b*. Then, the balls 3 are relieved of the load and enter the direction change path 51 in one cover 5. The balls then roll through the ball return holes 44*a* and 44*b* in the movable block 4 in a direction opposite to the direction of rolling motion on the load-rolling surfaces 43*a* and 43*b* while maintained in an unloaded state. After finishing rolling through the ball return holes 44*a* and 44*b*, the balls 3 enter again into the gap between the straight guide rail 1A and the movable block 4 through the direction change path 51 in the other cover 5, and roll on the load-rolling surfaces 43*a* and 43*b* while sustaining a load.

[0059] Ball-holding plates 45 and 46 are mounted to the bottom ends of the skirt portions 4*b* and the horizontal portion 4*a*, respectively, of the movable block 4. The ball-holding plates 45 and 46 are stamped from a metal plate or formed from a hard synthetic resin by injection molding or other method. The ball-holding plates 45 and 46 prevent the balls 3 rolling on the ball-rolling surfaces 10*a*, 10*b* from coming off the slider 2 when the slider 2 is removed from the track rail 1.

[0060] FIG. 4 shows the manner in which the balls 3 are rolling on the side rolling surfaces 10*a* formed on the side surfaces of the straight guide rail portion 1A and circulating through the path when each slider 2 is moving along the straight guide rail portion 1A. The balls 3 rolling on the top ball-rolling surfaces lob formed on the top surface of the straight guide rail portion 1A make similar rolling and circulating motion.

[0061] As mentioned previously, the direction change paths 51 corresponding to the load-rolling surfaces 43*a* and 43*b* are formed in the two covers 5 mounted to the opposite end surfaces, respectively, of the movable block 4. By mounting the covers 5 to the movable block 4, the slider 2 forms an endless circular path for the balls 3 as shown. The rolling surfaces 10*a* and 10*b* extend linearly and longitudinally along the straight guide rail portion 1A. Also, the load-rolling surfaces 43*a* and 43*b* of the slider 2 opposite to the rolling surfaces 10*a* and 10*b*, respectively, are formed linearly. Therefore, all the balls 3 simultaneously rolling on the load-rolling surfaces 43*a* and 43*b* are in contact with the rolling surfaces 10*a* and 10*b*, respectively, of the straight guide rail portion 1A, as shown in FIG. 4. That is, when the slider 2 is moving along the straight guide rail portion 1A, none of the balls 3 are idling without sustaining a load between the rolling surface **10**a or **10**b on the side of the track rail **1** and the load-rolling surface **43**a or **43**b on the side of the slider **4**. If a large load is applied to the slider **2**, the load is sustained reliably, and the slider **2** can be moved smoothly.

[0062] **FIG. 5** is a front view in cross section of the curved guide rail portion **1**B and one slider **2** mounted on it. This curved guide rail portion **1**B is shaped into a cross-sectional shape similar to that of the above-described straight guide rail portion. This curved guide rail portion **1**B is shaped into an arc having a given curvature R in the longitudinal direction. Side rolling surfaces **12**a continuous with the side rolling surfaces **10**a, respectively, formed on the opposite side surfaces of the straight guide rail portion **1**A are formed on the opposite side surfaces of the curved guide rail portion **1**B. Top rolling surfaces **12**b continuous with the top rolling surfaces **10**b, respectively, formed on the top surface of the straight guide rail portion **1**A are formed on the top surface of the curved guide rail portion **1**B.

[0063] Since the curved guide rail portion **1**B is formed to have a given curvature, if the width L_2 of the curved guide rail portion **1**B is set equal to the width L_1 of the straight guide rail portion **1**A, then the inner side surface of the curved guide rail portion **1**B may be hindered by the skirt portions **4**b or with the covers **5**. Therefore, the width L_2 of the curved guide rail portion **1**B is set smaller than the width L_1 of the straight guide rail portion **1**A. For comparison, the cross section of the straight guide rail portion **1**A is indicated by the dot-and-dash line. When the width L_2 of the curved guide rail portion **1**B is set smaller than the width L_1 of the straight guide rail portion **1**A, only the inner side surface of the curved guide rail portion **1**B needs to be ground, as shown in **FIG. 5**. Alternatively, both inner and outer side surfaces may be ground, as shown in **FIG. 16**.

[0064] **FIG. 6** shows the manner in which the balls **3** are rolling and circulating through a circular path when the slider **2** is moving along the curved guide rail portion **1**B. The balls **3** are shown to roll on the rolling surfaces **12**a formed on the opposite side surfaces of the curved guide rail portion **1**B. The rolling surfaces **12**a are shaped into arcs longitudinally of the curved guide rail portion **1**B. On the other hand, the load-rolling surfaces **43**a of the slider **2** opposite to the rolling surfaces **12**a are shaped linearly. Thus, as shown in **FIG. 6**, inside of the curved guide rail portion **1**B, only those of the balls **3** which are rolling close to both ends of the load-rolling surfaces **43**a bear against the rolling surfaces **12**a. Outside of the curved guide rail portion **1**B, only those of the balls **3** which roll across the centers of the load-rolling surfaces **43**a bear against the rolling surfaces **12**a. That is, when the slider **2** is moving along the curved guide rail portion **1**B, only parts of the balls **3** rolling on the load-rolling surfaces **43**a of the slider **2** sustain a load, whereas the other balls **3** idle without sustaining a load. It may be considered that all the balls **3** rolling on the load-rolling surfaces **43**a bear against the rolling surfaces **12**a of the curved guide rail portion **1**B, depending on the curvature of the curved guide rail portion **1**B. Even in this case, some of the balls **3** hardly sustain a load and idle. Even if some of the balls **3** idle without bearing against the rolling surfaces **12**a of the curved guide rail portion **1**B in this way, these balls **3** do not disengage from between the load-rolling surfaces **43**a and the rolling surfaces **12**, because the ball-holding plate **46** is mounted to the slider **2**.

[0065] **FIG. 7** shows the manner in which the balls **3** are rolling on the load-rolling surfaces **43**b formed on the horizontal portion **4**a of the slider **2**. That is, **FIG. 7** is a perspective of the slider **2** as taken from above the curved guide rail portion **1**B. Since the load-rolling surface **43**b of the slider **2** is straight while the opposite rolling surface **12**b of the curved guide rail portion **1**B is shaped into an arc, if the width of the rolling surfaces **12**b is set equal to the width of the side rolling surfaces **12**a on the curved guide rail portion and the width of the load-rolling surfaces **43**b, some of the balls **3** rolling on the load-rolling surface **43**b on the side of the slider **2** bear against the inner surface of the rolling surface **12**b. The others come off the rolling surface **12**b and bear against the top surface of the curved guide rail portion **1**B. Consequently, the balls **3** cannot smoothly circulate through the endless circular path in the slider **2**.

[0066] Therefore, the rolling surface **12**b formed on the top surface of the curved guide rail portion **1**B is shaped to have a larger groove width d than the load-rolling surfaces **43**b such that all the balls **3** which roll on the load-rolling surfaces **43**b can simultaneously bear against the rolling surface **12**b, as shown in **FIG. 7**. **FIG. 8** is an enlarged view showing the manner in which the balls **3** touch rolling surfaces between the load-rolling surface **43**b on the side of the slider **2** and the rolling surface **12**b on the side of the curved guide rail portion **1**B. The solid line indicates the manner in which the balls touch the rolling surfaces in cross section α-α of **FIG. 7**. The dot-and-dash line indicates the manner in which the balls touch the rolling surfaces in cross section B-B. The rolling surfaces **12**b are set wider than the load-rolling surfaces **43**b. Furthermore, the rolling surfaces **12**b are shaped into an arc having a curvature in the horizontal direction in the plane of **FIG. 8**. Therefore, as the balls **3** roll on the straight load-rolling surfaces **43**b, the positions at which the balls touch the rolling surfaces **12**b move right and left. The balls roll on the load-rolling surfaces **43**b while sustaining a load between the slider and the curved guide rail portion at all times.

[0067] In the universal guide device in the present invention in this way, the curved guide rail portion **1**B is set narrower than the straight guide rail portion **1**A. Where the top surface of the track rail **1** needs a rolling surface for the balls **3**, only the rolling surface **12**b on the top surface of the curved guide rail portion **1**B is set wider than the load-rolling surface **43**b on the side of the slider **2**. Hence, the slider **2** can be moved freely between the straight guide rail portion **1**A and the curved guide rail portion **1**B, though the slider **2** is the same as the prior art linear guide device structure.

[0068] However, when the slider **2** moves along the curved guide rail portion **1**B, the number of the balls **3** bearing against the side rolling surfaces **12**a of the curved guide rail portion **1**B is fewer than the number of the balls **3** bearing against the side rolling surfaces **10**a of the straight guide rail portion **1**A. Therefore, it cannot be denied that the ability of the slider **2** to sustain a load in the curved region of the track rail **1** decreases. However, the ability of the straight region to sustain a load is not sacrificed for the sake of the curved region. If a large load acts on the slider **2** in the straight region, the load can be sufficiently sustained.

[0069] In the universal guide device in accordance with the present invention as described above, the load-rolling surfaces **43**_a_ and **43**_b_ of the slider **2** are shaped linearly and have no directivity. Therefore, the slider **2** can move along the curved guide rail portion **1**B without trouble, irrespective of whether the curved guide rail portion **1**B is bent right or left. For this reason, as shown in **FIG. 9**, the slider **2** can be moved along an S-shaped track rail **1** built by combining two curved guide rail portions **1**B bent in different directions. Furthermore, it is not always necessary that all the successive curved guide rail portions **1**B within the continuous track rail **1** be shaped into arcs with uniform radius. The slider can be moved freely even if curved rail portions having different radii are combined.

[0070] As shown in **FIG. 10**, the curved guide rail portion **1**B formed at uniform curvature is cut into two rail pieces **16** and **17**. Then, one rail piece **17** is rotated through 180° and combined with the other rail piece **16**, thus forming an S-shaped track rail **1**. Even in this case, the slider **2** can be moved along the track rail **1** freely.

[0071] Referring next to **FIG. 11**, there is shown the intermediate rail portion **1**C connecting the straight guide rail portion **1**A and the curved guide rail portion **1**B. It may be possible to construct the track rail **1** by connecting the straight guide rail portion **1**A and curved guide rail portion **1**B without using the intermediate rail portion **1**C. As mentioned previously, the curved guide rail portion **1**B is set narrower than the straight guide rail portion **1**A. In addition, the rolling surface **12**_b_ of the curved guide rail portion **1**B is set wider than the top rolling surface **10**_b_ of the straight guide rail portion **1**A. Therefore, if the straight guide rail portion **1**A and curved guide rail portion **1**B are connected directly, then smooth movement of the slider **2** may be somewhat hindered. Consequently, in the present invention, the intermediate rail portion **1**C is interposed between the straight guide rail portion **1**A and the curved guide rail portion **1**B to transport the slider **2** from the straight guide rail portion **1**A to the curved guide rail portion **1**B and vice versa smoothly.

[0072] This intermediate rail portion **1**C assumes a cross-sectional shape similar to that of the straight guide rail portion **1**A, and extends linearly. The intermediate rail portion **1**C has ball-rolling surfaces that continuously connect with the rolling surfaces **10**_a_ and **10**_b_ of the straight guide rail portion **1**A and with the rolling surfaces **12**_a_ and **12**_b_ of the curved guide rail portion **1**B. Since the curved guide rail portion **1**B is set narrower than the straight guide rail portion **1**A, the side surface **14** of the intermediate rail portion **1**C that is continuous with the inner side surface of the curved guide rail portion **1**B is cut out obliquely on the side at the end of the curved guide rail portion **1**B as indicated by the dot-and-dash line of **FIG. 13**. The width decreases gradually from the straight guide rail portion **1**A toward the curved guide rail portion **1**B. Thus, the side rolling surface **10**_a_ formed on the side of the straight guide rail portion **1**A is continuous with the rolling surface **12**_a_ formed on the side surface of the curved guide rail portion **1**B, without step-wise changes. The balls can roll smoothly between the rolling surfaces **10**_a_ and **12**_a_.

[0073] As shown in **FIG. 11, a** ball-rolling surface **13**_b_ that is continuous with the rolling surface **10**_b_ of the straight guide rail portion **1**A and with the rolling surface **12**_b_ of the curved guide rail portion **1**B is formed on the top surface of the intermediate rail portion **1**C. As shown in **FIGS. 12 and 13**, the width of the ball-rolling surface **13**_b_ gradually increases on the side at the end of the curved guide rail portion **1**B. This connects the rolling surfaces **10**_b_ and **12**_b_ having different widths without any step-wise changes. Consequently, balls that have rolled on the rolling surface **12**_b_ of the curved guide rail portion roll into the top rolling surface **10**_b_ of the straight guide rail portion that is narrower than the rolling surface **12**_b_ without being caught. In this way, the slider can be smoothly moved from the curved region to the straight region of the track rail.

[0074] Referring next to **FIG. 14**, there is shown a universal guide device in accordance with a second embodiment of the present invention. A track rail **7** and a slider **8** are similar in fundamental structure with their respective counterparts of the first embodiment described above. However, the rail **7** has two ball-rolling surfaces **71**_a_ and two ball rolling surfaces **71**_b_ on opposite sides, one pair above the other. The upper rolling surfaces **71**_a_ are tilted at an angle of 45° upwardly. The lower rolling surfaces **71**_b_ are tilted at an angle of 45° downwardly. The slider **8** has load-rolling surfaces **81**_a_ and **81**_b_ that are tilted at angles corresponding to the ball rolling surfaces **71**_a_ and **71**_b_, respectively.

[0075] This **FIG. 14** shows the manner in which the slider **8** is mounted to the straight region of the track rail **7**, i.e., the straight guide rail portion **7**A. A curved guide rail portion **7**B continuous with this straight guide rail portion **7**A is set narrower than the straight guide rail portion **7**A, in the same way as in the first embodiment. **FIG. 15** is a front view in cross section of the curved guide rail portion **7**B, and in which the contour of the straight guide rail portion **7**A is also indicated by the dot-and-dash line.

[0076] In the universal guide device in accordance with the second embodiment constructed in this manner, the curved guide rail portion **7**B is set narrower than the straight guide rail portion **7**A in the same way as in the first embodiment. In consequence, the slider **8** can freely move between the straight guide rail portion **7**A and the curved guide rail portion **7**B.

[0077] In the embodiments given above, the present invention is applied to universal guide devices. If an annular track rail is composed by combining plural curved guide rail portions of the structure described above, the slider can be moved along this rail. A curved guide device can be easily constructed.

[0078] In the present invention, the load-rolling surfaces **43**_a_ and **43**_b_ formed on the slider **2** are shaped linearly. Therefore, a universal guide device can be fabricated by making direct use of sliders of the existing linear guide devices. Accordingly, in the embodiments described above, the curved guide rail portion **1**B is set narrower than the straight guide rail portion **1**A to permit the slider of the straight guide device to move along the curved guide rail portion **1**B as it is. However, due to the degree of curvature of the curved guide rail portion **1**B, it may be impossible to adapt the structure sufficiently only with a decrease in the width of the curved guide rail portion **1**B. The curved guide rail portion **1**B may be hindered in its movement by the skirt portions **4**_b_ of the slider **2** or with the covers **5**. Accordingly, in this case, the length of the slider **2** taken longitudinally with regard to the track rail **1** is reduced, thus preventing interference between the curved guide rail portion **1**B and the slider **2**.

[0079] Referring to **FIGS. 17 and 18**, there is shown a moving table device using a universal guide device in accordance with the present invention, the moving table device forming a third embodiment of the invention. Track rails **1** and **1'** are mounted to a fixed portion such as a pedestal or a base. Sliders **2** can move along the rails **1** and **1'**. A table **92** is mounted to the sliders.

[0080] The track rails **1** and **1'** are composed of the first rail **1** and the second rail **1'** that extend in parallel and are uniformly spaced from each other. The rail **1** comprises a straight guide rail portion **1A**, a curved guide rail portion **1B** shaped into an arc with a given curvature, and an intermediate rail portion **1C** connecting the straight guide rail portion **1A** and the curved guide rail portion **1B**. Similarly, the rail **1'** comprises a straight guide rail portion **1'A**, a curved guide rail portion **1'B** shaped into an arc with a given curvature, and an intermediate rail portion **1'C** connecting the straight guide rail portion **1'A** and the curved guide rail portion **1'B**. The radii of curvature of the curved guide rail portions **1B** and **1'B** are set to R1 and R2, respectively. The centers O of their radii of curvature are coincident.

[0081] Plural (e.g., 2) sliders **2** are mounted to each of the rails **1** and **1'**. Four sliders in total support the table. The sliders **2** can move freely on the first rail **1** (1A, 1B, 1C) and on the second rail **1'** (1'A, 1'B, 1'C). A pair of fixed plates **91** is mounted across the first and second rows of the sliders **2** as viewed in the direction of motion on the rails **1** and **1'**. The fixed plates **91** assume an elongated rectangular form and are mounted to the top surfaces of the sliders **2** with fixing means such as screws. That is, the fixed plates **91** are bridged across the sliders **2** that are adjacent to each other looking down the longitudinal direction of the rails **1** and **1'** (i.e., in the direction of the array of the rail portions).

[0082] The table **92** is mounted so as to be rotatable relative to the fixed plates. A shaft **93** is mounted to the bottom surface of the table **92**. Rotary bearings **90** for rotatably holding the shaft **93** are mounted to the top surfaces of the fixed plates **91**. The rotary bearings **90** permit the table **92** to rotate relative to the fixed plates while the bearings receive a load from the table **92**. The rotary bearings **90** are mounted in housings **94**, which in turn are mounted to the fixed plates **91**. Each of the rotary bearings **90** has an outer race **90*a*** mounted to the housing and an inner race **90*b*** mounted to the shaft **93**.

[0083] **FIG. 19** shows one of the rotary bearings **90**. A V-shaped rolling surface is formed in both the outer race **90*a*** and inner race **90*b***. A roller-rolling path of substantially rectangular cross section is formed between these rolling surfaces. Plural rollers **95** are arranged in the roller-rolling path and tilted alternately in directions at right angles to each other. The rollers **95** roll in the roller-rolling path while receiving a load. Spacers **96** are interposed between adjacent rollers **95** to maintain the rollers **95** in a given disposition.

[0084] In the roller-rolling path, the two rollers **95** horizontally adjacent to the same spacer **96** have axes that are perpendicular to each other. These rollers **95** are classified as outward facing rollers **95*a*** and inward facing rollers **95*b***. The spacers **96** maintain the outward facing rollers **95*a*** in such a disposition that their axes C face toward the center of rotation B lying at the center of rotation of the outer race **90*a*** and the inner race **90*b***.

[0085] **FIG. 20** shows the manner in which the track rails **1** and **1'** consisting of the rail portions **1A**, **1B**, **1C** and rail portions **1'A**, **1'B**, **1'C**, respectively, are combined into an S-shaped form. The fixed plates **91** and the table **92** move on this S-shaped rail. When moving on the curved rail portions **1B** and **1'B**, the sliders **2** are directed in the tangential direction of the curved rail portions **1B** and **1'B**. Therefore, the fixed plates **91** mounted to the sliders **2** rotate about the center O of the radius of curvature. As a result, the distance between the sliders **2** moving on the inner track rail **1** decreases, while the distance between the sliders **2** moving on the outer track rail **1'** increases. Since the fixed plates **91** are rotatably mounted to the table **92**, the plates permit such variations in the distances between the sliders **2** and enable smooth motion of the sliders **2**.

[0086] **FIGS. 21 and 22** show a moving table device using a universal guide device in accordance with the present invention, the moving table device forming a fourth embodiment of the present invention. In this fourth embodiment, the first track rail **1** and the second track rail **1'** are mounted in parallel, and two sliders **2** are mounted to both of the rails **1** and **1'**. These four sliders **2** support the table **92**, in the same way as in the third embodiment described above. However, the moving table device in accordance with the fourth embodiment differs from the moving table device in accordance with the third embodiment in that the four sliders **2** have their respective rotary bearings **90** and that the table **92** is rotatably held by the rotary bearings **90**. The rotary bearings **90** are similar in structure to the rotary bearings used in the third embodiment. Shafts mounted at the four corners of the table **92** are rotatably held.

[0087] In the moving table device in accordance with this embodiment, the sliders **2** support the four corners of the table **92** and so the table **92** can be held more stably than in the third embodiment. Since the four sliders **2** are rotatably held to the table, the sliders **2** moving on the curved guide rail portions **1B** and **1'B** rotate arbitrarily and independently and are directed in tangential directions $\theta 1$, $\theta 2$, $\theta 3$, and $\theta 4$ of the curved guide rail portions **1B**, **1'B**, as shown in **FIG. 22**. This permits smooth motion of the sliders **2**.

[0088] When the table **92** moves between the track rails **1** and **1'** having different radii of curvature as encountered when moving from the straight regions **1A**, **1'A** of the rails **1**, **1'** to the curved regions **1B**, **1'B**, if the distance between the sliders **2** is kept constant, the sliders **2** will be hindered in their movement by the rails **1** and **1'**, hindering smooth movement of the table **92**. However, gaps are provided between the sliders **2** and the rails **1**, **1'** by setting the width of rails **1** and **1'** narrower as mentioned above. The gaps eliminate the interference between the sliders **2** and the rails **1**, **1'**, assuring smooth movement of the sliders **2**.

What is claimed is:

1. A universal guide device comprising:

a track rail including a straight region and at least one curved region shaped into an arc having a given radius of curvature, and having ball-rolling surfaces formed on the two opposite side surfaces along a longitudinally direction of said track rail;

a slider formed a saddlelike shape and mounted on said track rail, having load-rolling surfaces which located opposite to said ball-rolling surfaces of said track rail, and having endless circular paths which including said load-rolling surfaces;

a number of balls rolling in said endless circular path formed in said slider, sustaining a load between said ball-rolling surfaces of said track rail and said load-rolling surfaces of said slider; and

wherein said load-rolling surfaces are shaped linearly and said curved region of said track rail is set narrower than said straight region of said track rail.

2. The universal guide device of claim 1, wherein the balls sustain a load between the arc-shaped ball-rolling surfaces along a longitudinally direction of said track rail and the straight load-rolling surfaces formed on said slider, when said slider moves through the curved region of said track rail.

3. The universal guide device of claim 1, wherein some of said balls rolling on said load-rolling surfaces on said slider sustain a load between the ball-rolling surfaces on said track rail and the load-rolling surfaces on said slider, when said slider moves through the curved region of said track rail.

4. The universal guide device of claim 1, wherein said track rail has a upward ball-rolling surface which formed on a top surface of said track rail, said slider has a downward load-rolling surface opposite to said upward ball-rolling surface of said track rail, and said upward ball-rolling surface in said curved region of said track rail is set to such a width that all the balls rolling on the downward load-rolling surface of said slider simultaneously touch said upward ball-rolling surface.

5. The universal guide device of claim 1, wherein said track rail has two curved regions bent in different directions, right and left.

6. The universal guide device of claim 1, wherein said track rail is constructed by combining a straight guide rail and a curved guide rail.

7. The universal guide device of claim 6, wherein said track rail has a intermediate rail that connects said straight guide rail with said curved guide rail, and wherein said intermediate rail has a width that continuously varies from the end of said straight guide rail to the end of said curved guide rail.

8. A moving table device comprising plural universal guide devices mounted parallel to each other and a table guided said universal guide devices, each of said universal guide devices comprising:

a track rail including a straight region and at least one curved region shaped into an arc having a given radius of curvature, and having ball-rolling surfaces formed on the two opposite side surfaces along a longitudinally direction of said track rail;

a slider formed a saddlelike shape and mounted on said track rail, having load-rolling surfaces which located opposite to said ball-rolling surfaces of said track rail, and having endless circular paths which including said load-rolling surfaces;

a number of balls rolling in said endless circular path formed in said slider, sustaining a load between said ball-rolling surfaces of said track rail and said load-rolling surfaces of said slider; and

wherein said load-rolling surfaces are shaped linearly and said curved region of said track rail is set narrower than said straight region of said track rail.

9. The moving table device of claim 8, wherein plurality of said track rails are mounted parallel to each other, plurality of said sliders are mounted to each of said track rails, the sliders adjacent each other on different said rails are connected by fixed plates, and said table is mounted so as to be rotatable relative to said fixed plates.

10. The moving table device of claim 8, wherein plurality of said track rails are mounted parallel to each other, plurality of said sliders are mounted to each of said track rails, said table is mounted so as to be rotatable relative to said sliders.

11. A moving table device comprising plural universal guide devices mounted parallel to each other and a table guided said universal guide devices, each of said universal guide devices comprising:

a track rail including a straight region and at least one curved region shaped into an arc having a given radius of curvature, and having ball-rolling surfaces formed on the two opposite side surfaces along a longitudinally direction of said track rail;

a slider formed a saddlelike shape and mounted on said track rail, having load-rolling surfaces which located opposite to said ball-rolling surfaces of said track rail, and having endless circular paths which including said load-rolling surfaces;

a number of balls rolling in said endless circular path formed in said slider, sustaining a load between said ball-rolling surfaces of said track rail and said load-rolling surfaces of said slider; and

wherein plurality of said track rails are mounted parallel to each other, plurality of said sliders are mounted to each of said track rails, the sliders adjacent each other on different said rails are connected by fixed plates, and said table is mounted so as to be rotatable relative to said fixed plates.

* * * * *

US 20010048776A1

(19) United States
(12) Patent Application Publication (10) Pub. No.: US 2001/0048776 A1
Kawaguchi et al. (43) Pub. Date: Dec. 6, 2001

(54) **ROLLER RETAINER, ROLLER SCREW USING ROLLER RETAINER AND ROLLING GUIDE APPARATUS USING ROLLER RETAINER**

(75) Inventors: **Takahiro Kawaguchi**, Tokyo (JP); **Tadashi Hirokawa**, Tokyo (JP); **Kentarou Nishimura**, Tokyo (JP); **Osamu Maruyama**, Tokyo (JP); **Shino Kimura**, Tokyo (JP)

Correspondence Address:
MORGAN, LEWIS & BOCKIUS
1800 M STREET NW
WASHINGTON, DC 20036-5869 (US)

(73) Assignee: **THK CO., LTD.**

(21) Appl. No.: **09/826,008**

(22) Filed: **Apr. 5, 2001**

(30) **Foreign Application Priority Data**

Apr. 12, 2000 (JP) P.2000-110600

Publication Classification

(51) **Int. Cl.**[7] **F16C 29/06**
(52) **U.S. Cl.** **384/51**; 384/44

(57) **ABSTRACT**

A roller retainer **11** encloses an outer periphery of the roller **9** situated on a diagonal **20** when the roller **9** is viewed from the side surface thereof. Whether the rollers **9** are arranged in a parallel manner or in a cross manner, the roller retainer **11** is able to keep a constant position and thus the disposition of the roller retainer **11** is free from the influence of the direction the roller **9**. Also, since the roller retainer **11** restricts a corner portion **9***a* of the roller **9**, the roller **9** is difficult to slip off the roller retainer **11** and thus the roller **9** can be restricted positively, thereby being able to control the skew of the roller **9**.

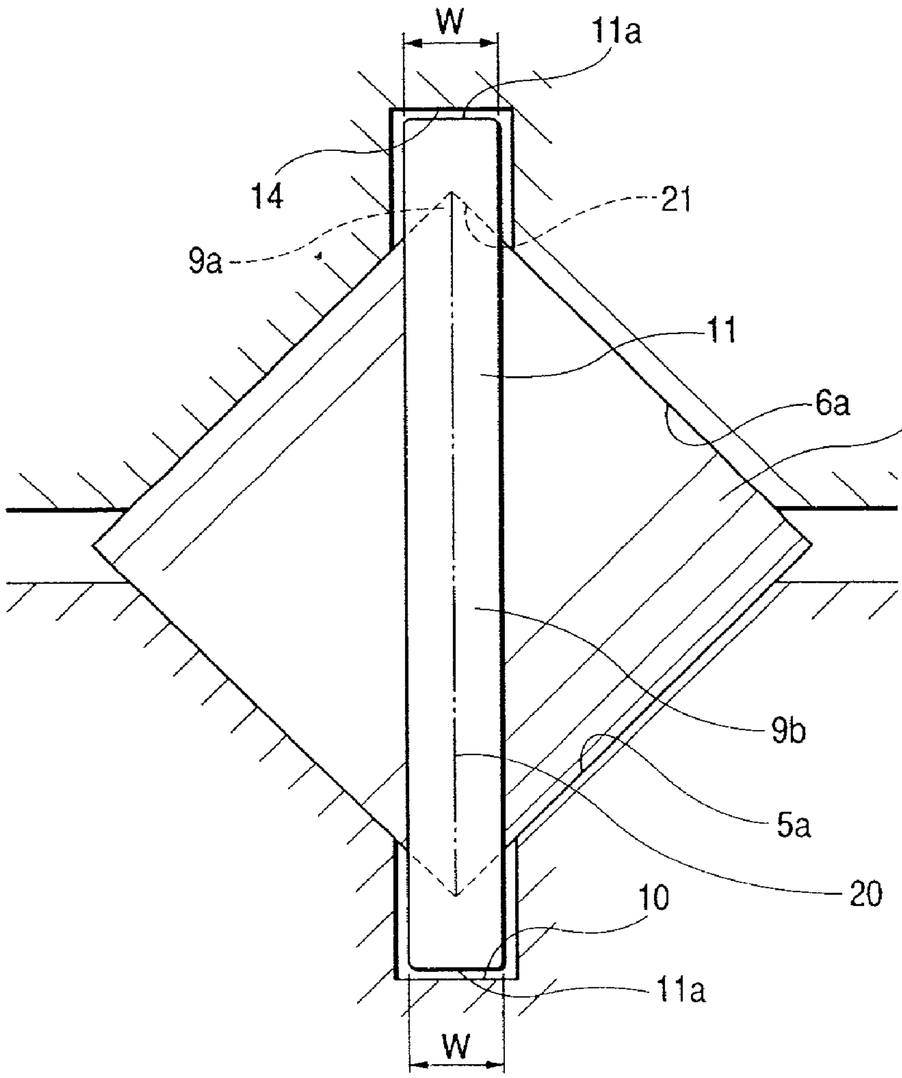


FIG. 1

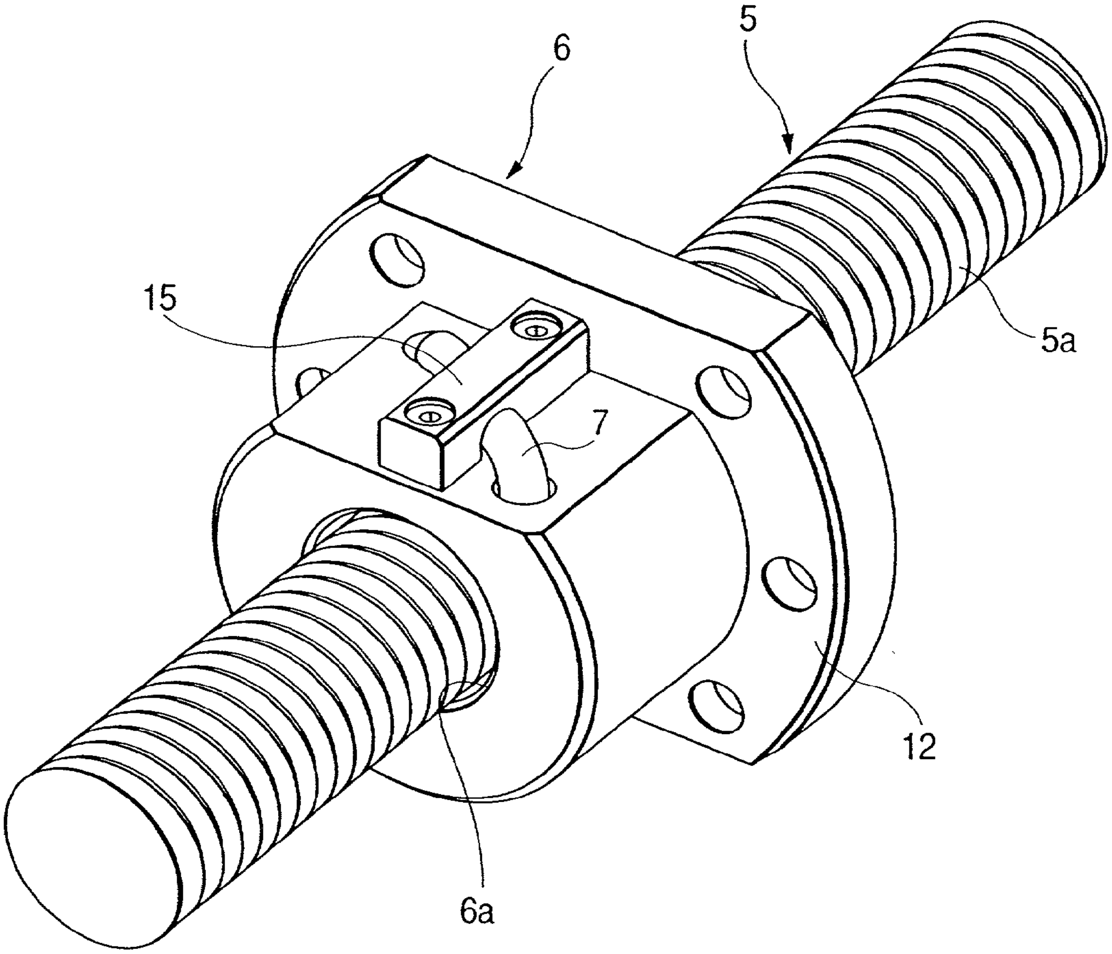


FIG. 2

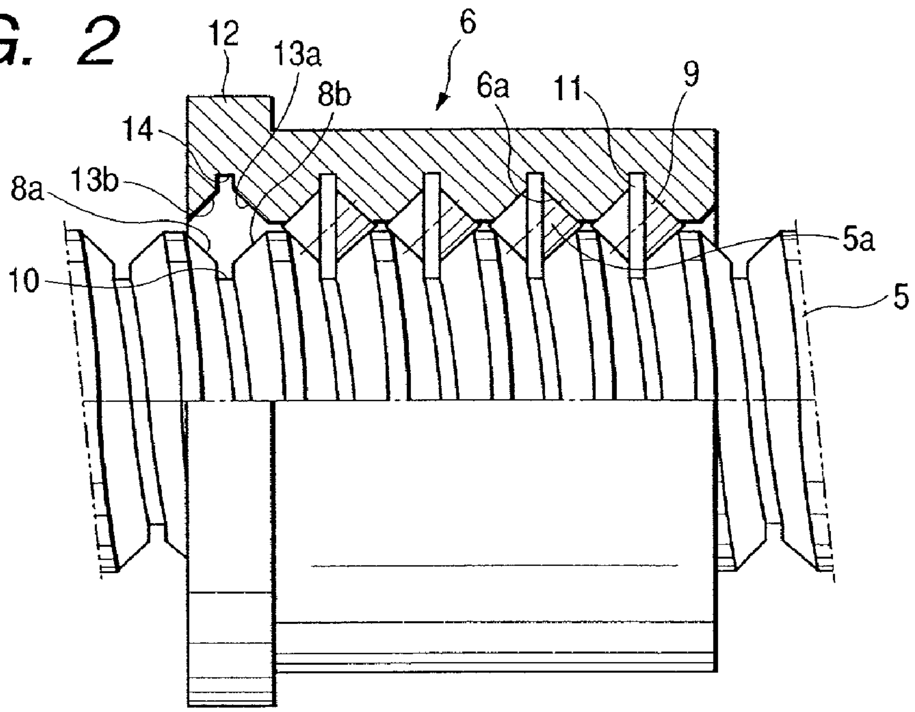

12
13a
6
8b
6a
11
9
14
8a
13b
5a
10
5

FIG. 3

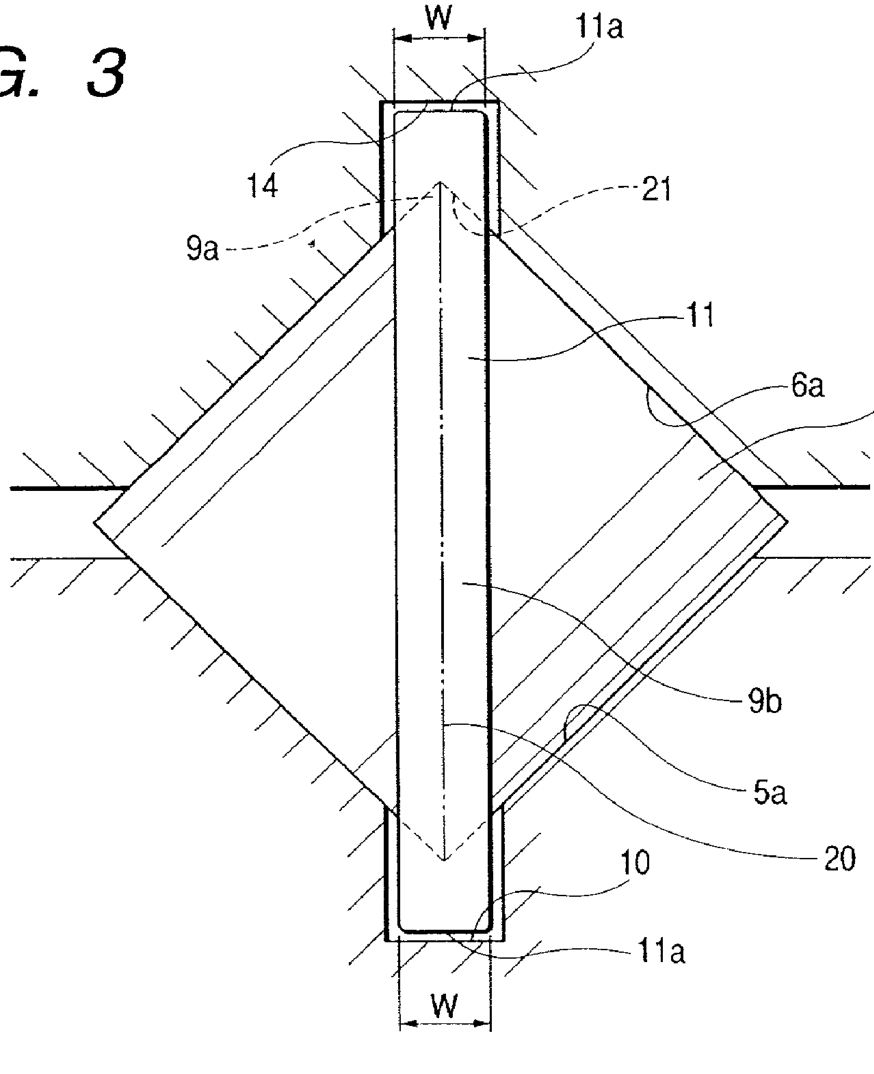

W
11a
14
21
9a
11
6a
9
9b
5a
20
10
11a
W

FIG. 4

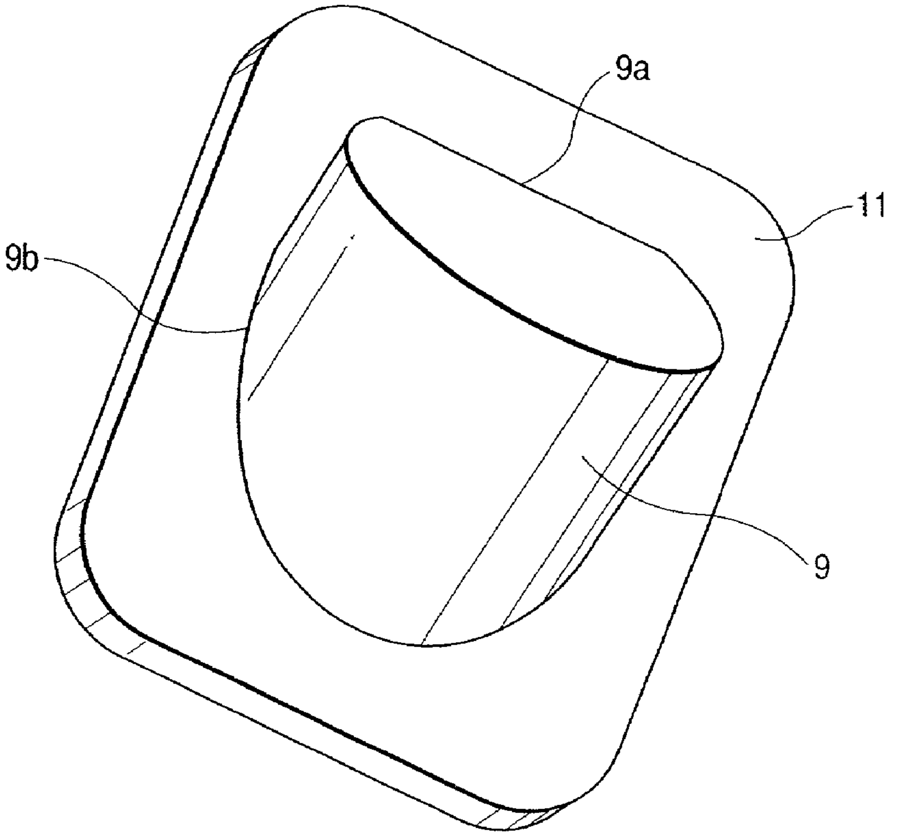


FIG. 5A

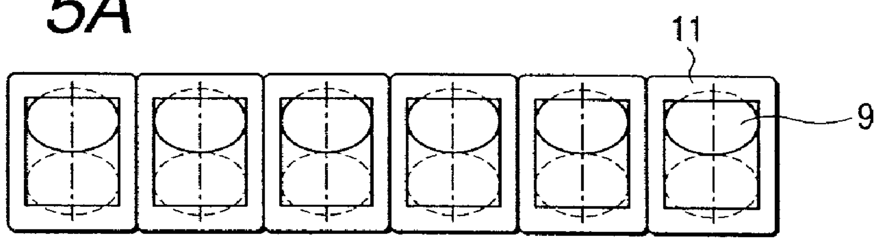


FIG. 5B

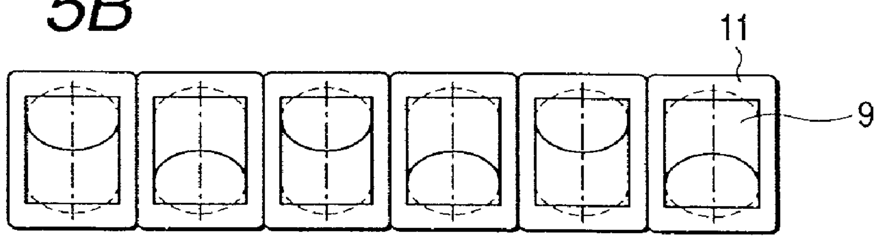


FIG. 6

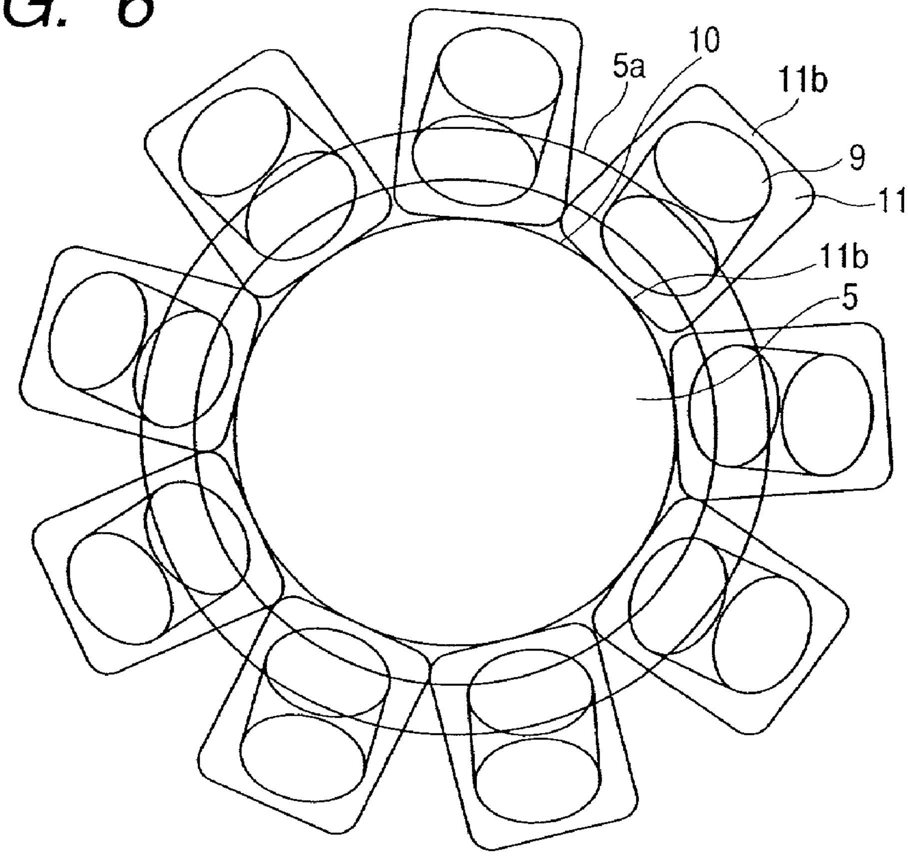


FIG. 7

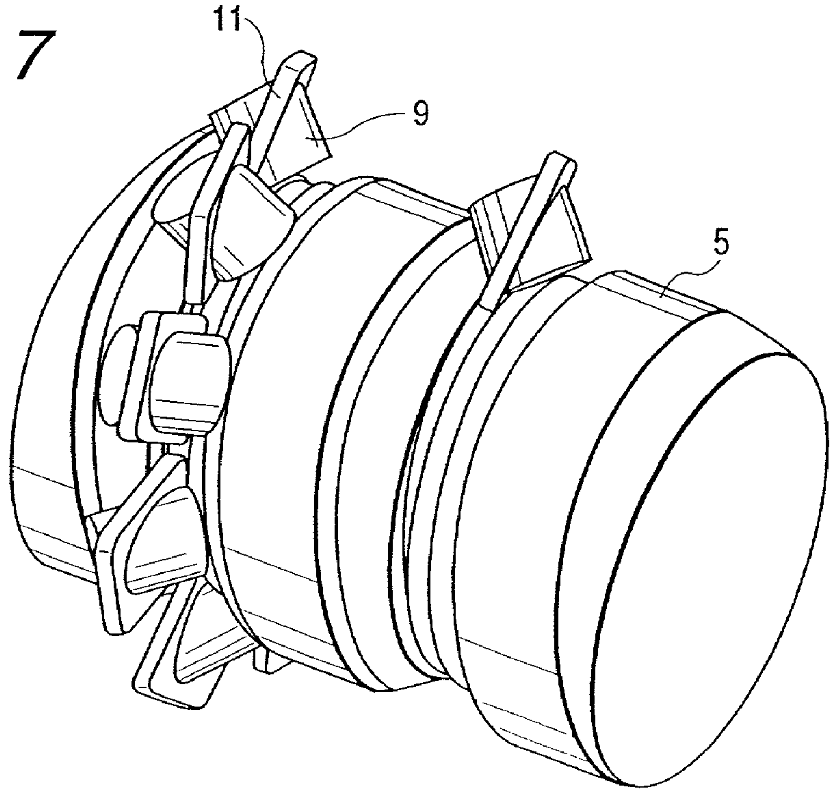


FIG. 8

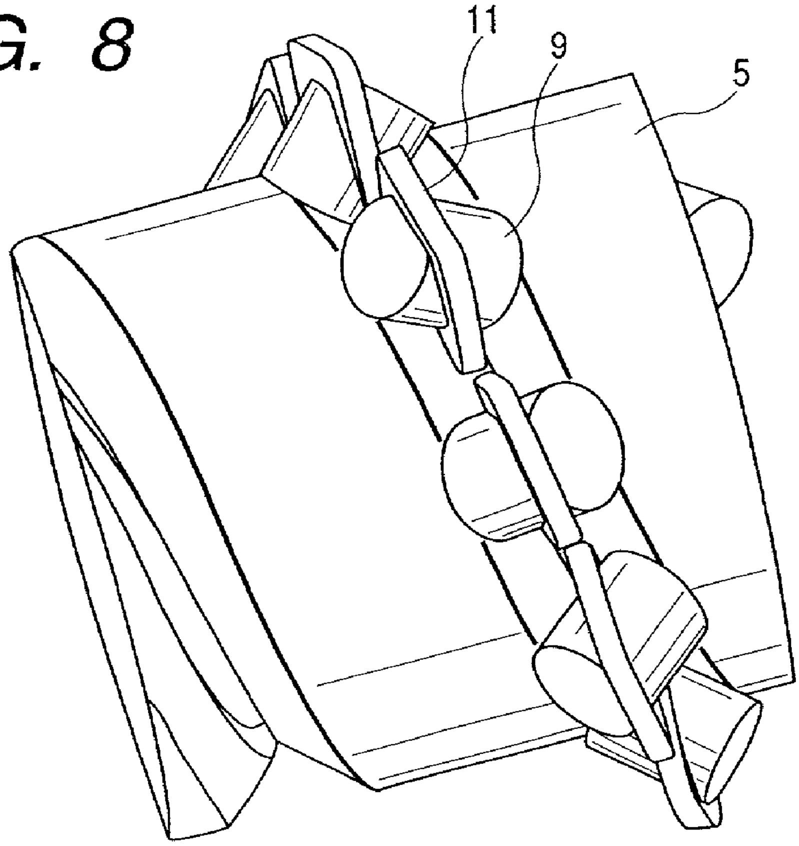


FIG. 9

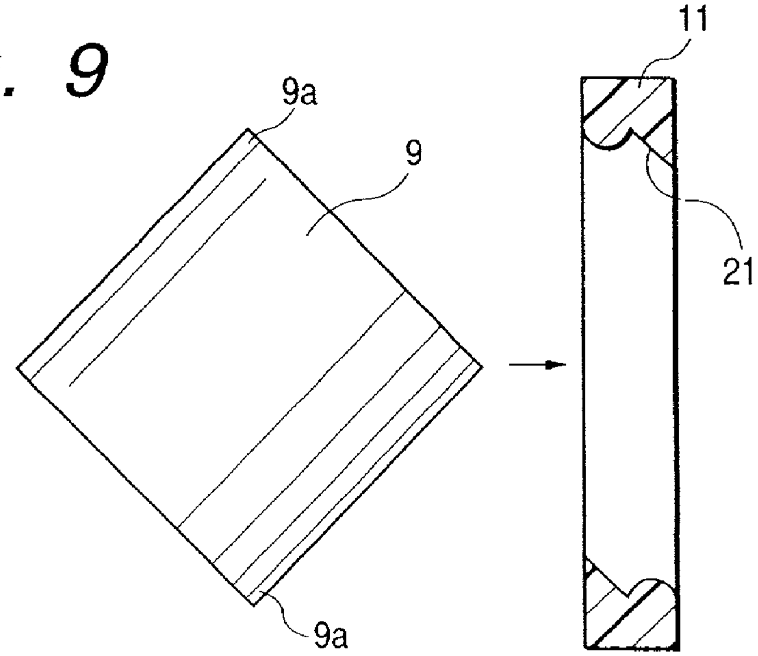


FIG. 10

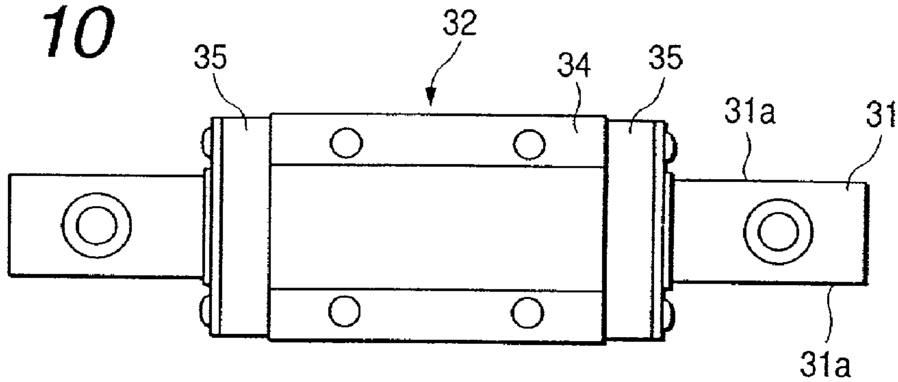


FIG. 11

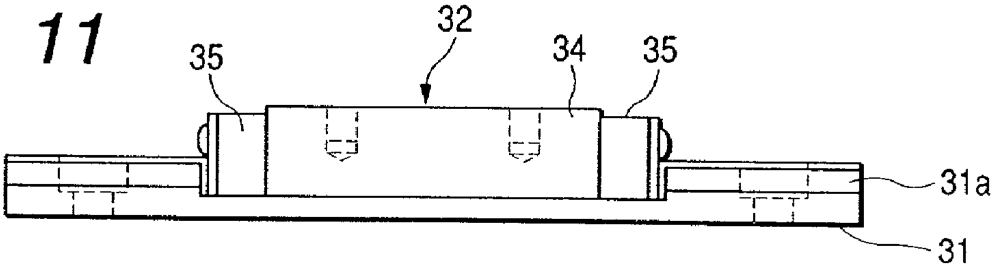


FIG. 12

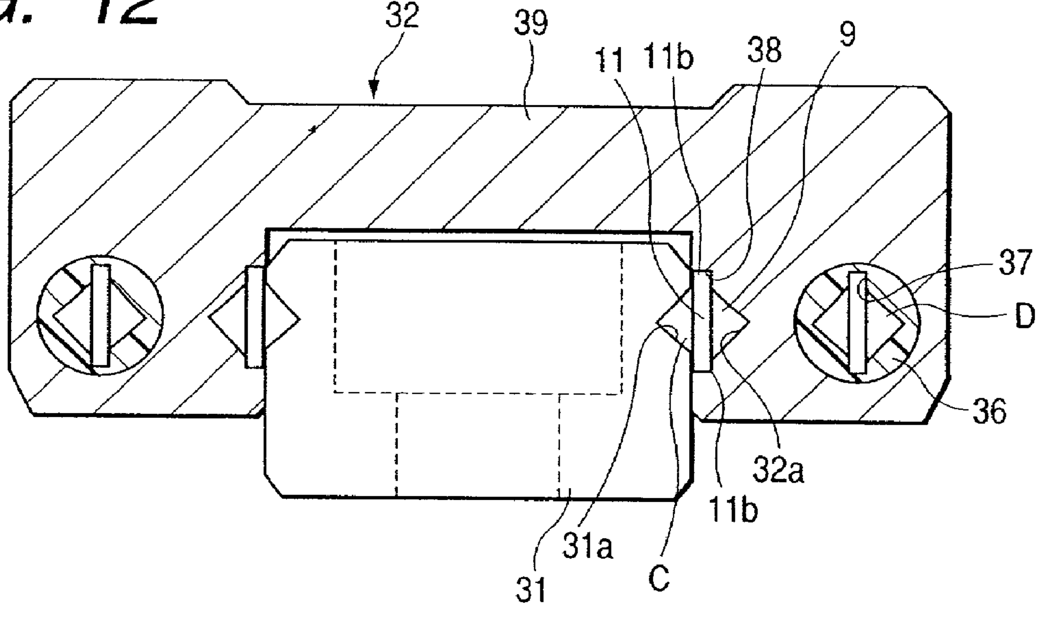
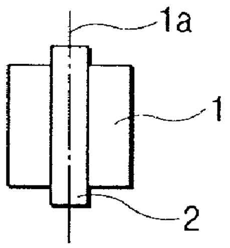


FIG. 13



ROLLER RETAINER, ROLLER SCREW USING ROLLER RETAINER AND ROLLING GUIDE APPARATUS USING ROLLER RETAINER

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a roller retainer which is used in a rolling guide apparatus and a roller screw and also which is used to hold rollers rolling through a circulation passage in such a manner that the rollers can be freely rotated and slid.

[0003] 2. Description of the Related Art

[0004] Conventionally, there is known a roller screw structured such that a plurality of rollers are interposed between a screw shaft and a nut member. In case where the screw shaft is rotated with respect to the nut member, the nut member is moved linearly in the axial direction of the screw shaft. In the screw shaft, there is formed a spiral-shaped roller rolling groove. On the other hand, in the nut member, there is formed a roller circulation passage including a spiral-shaped load rolling groove which is so formed as to correspond to the roller rolling groove of the screw shaft. The rollers roll in such a manner that they move along the outer periphery of a screw groove between the screw shaft and nut member, thereby circulating through the roller circulation passage. In such roller screw, the plurality of rollers are, in some cases, arranged parallel in the roller circulation passage in order that the axes of the mutually adjoining rollers can be held almost parallel to each other; and, in other cases, they are cross arranged in such a manner that the axes of the mutually adjoining rollers cross each other.

[0005] Generally, in a roller screw in which only the rollers are arranged in the roller circulation passage, the movements of the respective rollers can vary from one another, and the rollers can fall down in a plane including the axes of the rollers and the advancing direction of the rollers to thereby cause a so called skew. Such skew interferes with the lined-up circulation of the rollers. To prevent the skews of the rollers, there is proposed use of a roller retainer which can hold the rollers in such a manner that the rollers can be freely rotated and slid. As shown in **FIG. 13**, the roller retainer **2** encloses the outer periphery of a roller **1** that is situated on the center line **1***a* of the roller **1** when the roller **1** is viewed from the side surface thereof, and thus restricts the roller **1** to thereby prevent the roller **1** against skew.

[0006] However, in the conventional roller retainers **2**, when the rollers **1** are arranged in a crossing manner, the roller retainers **2** are also arranged in a crossing manner that the roller retainers **2** cross each other, which makes it impossible to obtain a large contact area between the roller retainers **2**. For this reason, the conventional roller retainers **2** cannot be applied to the rollers **1** which are cross arranged.

[0007] Also, since the conventional roller retainer **2** encloses the outer periphery of the roller **1** that is situated on the center line **1***a* of the roller **1** when the roller **1** is viewed from the side surface thereof, the roller **1** is easy to slip off the roller retainer **2** and the roller retainer **2** is not be able to provide a sufficient force to hold the roller **1**, thereby raising a fear that the skew of the roller cannot be controlled.

SUMMARY OF THE INVENTION

[0008] The present invention aims at eliminating the above drawbacks found in the conventional roller retainer, and therefore an object of the invention is to provide a roller retainer which can be applied to both of cross arranged rollers and parallel arranged rollers and can restrict the rollers more positively in such a manner the skews of the rollers can be controlled, as well as a linear guide apparatus and a roller screw respectively using such roller retainers.

[0009] Now, description will be given below of the invention. By the way, for easy understanding of the invention, reference numerals shown in the accompanying drawings are stated herein while putting them in parentheses; however, the invention is not limited to the illustrated embodiments thereof. In attaining the above object, according to the invention, the outer periphery of a roller situated on a diagonal when the roller is viewed from the side surface thereof is enclosed by a roller retainer, and the corner portion and cylindrical portion of the roller are restricted.

[0010] In other words, according to a first aspect of the invention, there is provided a roller retainer (**11**) for holding a roller (**9**) circulating through a roller circulation passage, wherein the roller retainer (**11**) encloses the outer periphery of the roller (**9**) situated on a diagonal (**20**) when the roller (**9**) is viewed from the side surface thereof. Here, the roller retainer may hold a plurality of rollers, which respectively circulate through the roller circulation passage, in a series manner, or the roller retainer may hold the plurality of rollers individually.

[0011] According to the first aspect of the invention, since the roller retainer encloses the outer periphery of the roller that is situated on the diagonal when the roller is viewed from the side surface thereof, the roller retainer is allowed to keep a constant position whether the rollers are arranged in a parallel manner or in a cross manner and thus the disposition of the roller retainer is free from the influence of the direction of the roller. Therefore, there can be obtained a roller retainer which can be applied not only to a structure in which rollers are parallel arranged but also to a structure in which rollers are cross arranged. Also, because the roller retainer restricts the corner portion of the roller, the roller is difficult to slip off the roller retainer, thereby being able to restrict the roller positively, so that the skew of the roller can be controlled.

[0012] Also, according to a second aspect of the invention, in a roller retainer according to the first aspect of the invention, the roller retainer (**11**) holds individually a plurality of rollers (**9**) which are respectively allowed to circulate through the roller circulation passage.

[0013] In the case of a roller screw, the circulation path of a roller draws a spiral shape. In case where a roller retainer is formed in a band shape so that it can hold a plurality of rollers in a series manner, the roller retainer is spirally twisted and a load is thereby applied to the roller retainer, which raises a fear that the roller retainer can be damaged or broken. However, according to the second aspect of the invention, since the roller retainer holds the plurality of rollers individually, even in case where the circulation path of the roller is formed in a spiral shape, the roller retainer can be prevented against damage or breakage.

[0014] Further, according to a third aspect of the invention, in a roller retainer according to the first or second aspect of the invention, the roller retainer (**11**) is molded with the roller (**9**) inserted therein. As the molding method, for example, there can be employed a method in which molten resin is injection molded into a metal mold in which the roller has been installed.

[0015] According to the third aspect of the invention, a clearance between the roller retainer and roller can be made small to thereby be able to restrict the roller positively.

[0016] Also, according to a fourth aspect of the invention, there is provided a roller screw comprising: a track shaft (**5**) including a spiral-shaped roller rolling groove (**5*a***) having a V-shaped section; a slide member (**6**) comprising a roller circulation passage including a spiral-shaped load rolling groove (**6*a***) having a V-shaped section and assembled to the track shaft (**5**) in such a manner that it can be moved with respect to the track shaft (**5**), the load rolling groove (**6*a***) being so formed as to correspond to the roller rolling groove (**5*a***); a plurality of rollers (**9**) respectively arranged and stored in the roller circulation passage and allowed to circulate through the roller circulation passage in linking with the relative motion of the slide member (**6**) with respect to the track shaft (**5**); and a plurality of retainers (**11**) for holding the plurality of rollers (**9**) individually in such a manner that the rollers (**9**) can be rotated and slid, wherein each of the roller retainers (**11**) encloses the outer periphery of its associated one of the rollers (**9**) that is situated on a diagonal (**20**) when the roller (**9**) is viewed from the side surface thereof, and also wherein, in at least one of the roller rolling groove (**5*a***) and load rolling groove (**6*a***), there is formed a guide groove (**10, 14**) for guiding the roller retainer (**11**).

[0017] According to the fourth aspect of the invention, not only there can be obtained the above-mentioned operation effects, but also, since the roller retainer is guided by the guide groove, the fall-down of the roller retainer as well as the skew of the roller can be controlled.

[0018] Further, according to a fifth aspect of the invention, there is provided a rolling guide apparatus comprising: a track shaft (**31**) including a roller rolling groove (**31*a***) having a V-shaped section; a slide member (**32**) comprising a roller circulation passage including a load rolling groove (**32*a***) having a V-shaped section and assembled to the track shaft (**31**) in such a manner that it can be moved with respect to the track shaft (**31**), the load rolling groove (**32*a***) being so formed as to correspond to the roller rolling groove (**31*a***); a plurality of rollers (**9**) respectively arranged and stored in the roller circulation passage and allowed to circulate through the roller circulation passage in linking with the relative motion of the slide member (**32**) with respect to the track shaft (**31**); and, a plurality of retainers (**11**) for holding the plurality of rollers (**9**) individually in such a manner that the rollers can be rotated and slid, wherein each of the roller retainers (**11**) encloses the outer periphery of its associated one of the rollers (**9**) that is situated on a diagonal (**20**) when the roller (**9**) is viewed from the side surface thereof, and also wherein, in at least one of the roller rolling groove (**31*a***) and load rolling groove (**32*a***), there is formed a guide groove (**38**) for guiding the roller retainer (**11**).

[0019] According to the fifth aspect of the invention, not only there can be obtained the above-mentioned operation effects, but also, since the roller retainer is guided by the guide groove, the fall-down of the roller retainer as well as the skew of the roller can be controlled.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] **FIG. 1** is a perspective view of a roller screw incorporating therein a roller retainer according to a first embodiment of the invention;

[0021] **FIG. 2** is a section view of the above roller screw in the axial direction thereof;

[0022] **FIG. 3** is a side view of a roller retainer and a roller;

[0023] **FIG. 4** is a perspective view of the roller retainer and roller;

[0024] **FIGS. 5A and 5B** are views of roller retainers and rollers, showing a state thereof in which they are respectively arranged in line; specifically, **FIG. 5A** shows a state thereof in which they are parallel arranged and **FIG. 5B** shows a state thereof in which they are cross arranged;

[0025] **FIG. 6** is atypical view of rollers and roller retainers rolling on the periphery of a screw shaft (that is, **FIG. 6** is a section view of the rollers and roller retainers in a direction crossing the screw shaft at right angles);

[0026] **FIG. 7** is a perspective view of rollers and roller retainers which are parallel arranged in a roller screw;

[0027] **FIG. 8** is a perspective view of rollers and roller retainers which are cross arranged in a roller screw;

[0028] **FIG. 9** is a section view of another example of a roller retainer;

[0029] **FIG. 10** is a plan view of a linear guide incorporating a roller retainer according to the first embodiment of the invention;

[0030] **FIG. 11** is a side view of the above linear guide;

[0031] **FIG. 12** is a section view of the linear guide, taken along the direction thereof to cross the axial direction thereof; and

[0032] **FIG. 13** is a side view of a roller retainer and a roller according to the prior art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0033] Hereinafter, a description will be given in more detail of preferred embodiments of the invention with reference to the accompanying drawings.

[0034] Now, **FIG. 1** shows a roller screw into which a roller retainer according to a first embodiment of the invention is incorporated. This roller screw comprises a screw shaft **5** with a spiral-shaped roller rolling groove **5*a*** formed on the outer peripheral surface thereof, a nut member **6** (slide member), in which a roller circulation passage (rolling body circulation passage) including a spiral-shaped load rolling groove **6*a*** formed on the inner peripheral surface thereof in such a manner to correspond to the spiral-shaped roller rolling groove **5*a*** is formed and which is assembled to the screw shaft **5** in such a manner that it can be moved with respect to the screw shaft **5**, and a plurality of rollers which are arranged and stored in the roller circulation passage and are allowed to circulate in linking with the relative movement of the nut member **6** with respect to the screw shaft **5**. A load rolling passage of the roller circulation passage is formed by and between the roller rolling groove **5*a*** of the screw shaft **5** and the load rolling groove **6***a* of the nut member **6**. The nut member **6** includes a return pipe **7**. A no-load return passage, which allows one end of the load rolling passage to communicate with the other end thereof, is formed by the return pipe **7**. With the relative rotation of the screw shaft **5** with respect to the nut member **6**, the roller is allowed to roll between the roller rolling groove **5***a* of the screw shaft **5** and the load rolling groove **6***a* of the nut member **6**, while the nut member **6** is moved linearly with respect to the screw shaft **5**.

[0035] Now, **FIG. 2** shows the section of the above roller screw in the axial direction thereof. On the outer peripheral surface of the screw shaft **5**, there is formed a roller rolling groove **5***a* having a given lead. The roller rolling groove **5***a* has a V-shaped section and the angle of the inclined wall surface of the V-shaped roller rolling groove **5***a* is set substantially at 90°.. A roller **9** is allowed to roll on the wall surface **8***a* or **8***b* of the roller rolling groove **5***a*. In the bottom portion of the roller rolling groove **5***a*, there is formed a guide groove **10** which is used to guide a roller retainer **11** along the roller rolling groove **5***a*. This guide groove **10** is formed slightly wider than the width W of the roller retainer **11** and slightly deeper than the end face **11***a* of the roller retainer **11**, in order to be able to avoid interference with the roller retainer **11** (see **FIG. 3**).

[0036] The nut member **6** is fitted with the screw shaft **5** with a clearance between them. The nut member **6** is formed substantially in a cylindrical shape and includes, in the end portion thereof, a flange **12** which is used to connect the nut member **6** to a member to be guided. On the inner peripheral surface of the nut member **6**, there is formed a spiral-shaped load rolling groove **6***a* having a lead equal to the lead of the screw shaft **5**. The load rolling groove **6***a* also has a V-shaped section and the angle of the inclined wall surface of the V-shaped load rolling groove **6***a* is set substantially at 90°. The roller **9** is allowed to roll on the wall surface **13***a* or **13***b* of the roller rolling groove **6***a*. Between the load rolling groove **6***a* and roller rolling groove **5***a* that adjoin each other, there is formed a substantially square-shaped load rolling passage. In the bottom portion of the load rolling groove **6***a*, there is formed a spiral-shaped guide groove **14** which extends along the load rolling groove **6***a*. This guide groove **14** is also formed slightly wider than the width W of the roller retainer **11** and slightly deeper than the end face **11***a* of the roller retainer **11**, in order to be able to avoid interference with the roller retainer **11** (see **FIG. 3**). As shown in **FIG. 1**, in the nut member **6**, there are opened up return pipe fit holes into which the two side portions of a return pipe **7** can be inserted. The return pipe fit holes are so formed as to extend into the load rolling groove **6***a*. The return pipe **7** is fixed to the nut member **6** by a pipe holder **15**.

[0037] As shown in **FIG. 2**, between the load rolling groove **6***a* of the nut member **6** and the roller rolling groove **5***a* of the screw shaft **5**, there are arranged and stored a plurality of rollers **9**. The plurality of rollers **9**, in some cases, are parallel arranged such that the axes of the mutually adjoining rollers **9** are kept almost parallel to each other and, in other cases, they are cross arranged such that the axes of the mutually adjoining rollers **9** cross each other almost at right angles. The manner of arrangement of the rollers **9** is decided according to a ratio of axial-direction loads applied to the roller screw during the reciprocating motion thereof.

[0038] **FIGS. 3 and 4** respectively show the roller retainer **11** and roller **9** which are incorporated into the above-mentioned roller screw. Specifically, **FIG. 3** is a view of the roller **9** and roller retainer **11** when they are viewed from the side surfaces thereof; and, **FIG. 4** is a perspective view of the roller **9** and roller retainer **11**.

[0039] The roller **9** is formed in a cylindrical shape and the side surface thereof has a substantially square shape. The roller **9** is allowed to roll between the wall surfaces **8***a* and **13***a* or between the wall surface **8***b* and **13***b* which respectively provide the mutually opposing sides of the load running passage (see **FIG. 2**). The outside diameter of the roller **9** is set almost the same as the distance between the wall surfaces, while the axial-direction length of the roller **9** is set slightly smaller than the distance between the wall surfaces. By the way, a pre-load may be given to the roller **9** or may not.

[0040] The roller retainers **11** are disposed in the same number as that of the rollers **9** in order that they are able to hold the plurality number of rollers **9** individually. Also, the roller retainer **11** is formed in a frame shape so that it can enclose the outer periphery of the roller **9** situated on the diagonal **20** when it is viewed from the side surface thereof. And, the corner portion **9***a* of the roller **9** is fitted into a fit groove **21** which is formed in the interior portion of the frame-shaped roller retainer **11** and has a V-shaped section. The roller retainer **11** restricts the corner portion **9***a* and cylindrical portion **9***b* of the roller **9**. The roller retainer **11** is formed of synthetic resin and is manufactured by injection molding with the roller **9** inserted therein.

[0041] Now, **FIGS. 5A and 5B** show examples where the rollers **9** and roller retainers **11** are arranged linearly in a line. Specifically, **FIG. 5A** shows an example where the mutually adjoining rollers are arranged in such a manner that their axes are kept substantially parallel to each other, whereas **FIG. 5B** shows an example where the mutually adjoining rollers are arranged in such a manner that their axes cross each other substantially at right angles. In the case of the roller screw, within the return pipe **7**, the rollers **9** and roller retainers **11** are arranged linearly in this manner. Also, in the case of a rolling guide apparatus which will be discussed later, within a load rolling passage and a no-load return passage, rollers **9** and roller retainers **11** are arranged linearly.

[0042] Now, **FIG. 6** is a typical view of a roller allowed to roll along the outer periphery of the screw shaft and a roller retainer for holding this roller. In case where, the screw shaft **5** is rotated, the rollers **9** and roller retainers **11** are respectively allowed to roll in the peripheral direction of the screw shaft **5** within the load rolling passage while receiving loads. In this rolling operation, there is produced a speed difference between the inner and outer peripheral sides of the screw shaft **5** and thus the roller **9** is going to fall down in a plane including the axis of the roller **9** and advancing direction thereof, thereby causing a skew in the roller **9**. However, since the roller retainer **11** restricts the corner portion **9***a* and cylindrical portion **9***b* of the roller **9**, the roller **9** can be restricted positively and the skew of the roller **9** can be thereby controlled. Also, because the two end portions **11***b* and **11***b* of the roller retainer **11** are guided to the guide groove **10** formed in the bottom portion of the roller rolling groove **5***a* and to the guide groove **14** formed in the bottom portion of the load rolling groove **6***a*, the smooth circulation of the roller retainer **11** and roller **9** can be assured. Also, as shown in **FIG. 6**, the two end portions **11***b* and **11***b* of the roller retainer **11** are contacted with the guide grooves **10** and **14**. That is, the roller retainer **11** itself is also restricted by the guide grooves **10** and **14**. This can prevent the roller retainer **11** from falling down and thus the roller **9** from falling down.

[0043] The roller **9** and roller retainer **11** rolling on the outer periphery of the screw shaft **5** are picked up by the return pipe **7**. The thus picked-up roller **9** and roller retainer **11** are then allowed to pass through the interior portion of the return pipe **7**. And, the roller **9** and roller retainer **11** are returned again to the load rolling passage at intervals of several pitches. In case where the direction of rotation of the screw shaft **5** is reversed, the roller **9** and roller retainer **11** are allowed to circulate reversely along the above passage. By the way, in case where the screw shaft **5** is fixed and the nut member **6** can be rotated, the roller **9** and roller retainer **11** are also allowed to circulate similarly.

[0044] Now, **FIG. 7** shows an example where a plurality of rollers **9** are parallel arranged in the roller circulation passage in such a manner that the axes of the mutually adjoining rollers **9** are kept substantially parallel to each other; and, **FIG. 8** shows an example where a plurality of rollers **9** are cross arranged in such a manner that the axes of the mutually adjoining rollers **9** are made to cross each other substantially at right angles. As shown in these figures, whether the rollers **9** are parallel arranged or cross arranged, the roller retainers **11** are always allowed to keep a constant position, that is, the disposition of the roller retainers **11** is free from the influence of the directions of the rollers **9**. Also, since the disposition of the roller retainers **11** is free from the influence of the directions of the rollers **9**, the guide grooves **10** and **14** may be formed only in the bottom portions of the roller rolling groove **5***a* and load rolling groove **6***a*, so that the guide grooves **10** and **14** can be formed easily.

[0045] Now, **FIG. 9** shows another example of a roller retainer according to the invention. The present roller retainer **11** is not molded with the roller **9** inserted therein but the roller retainer **11** is formed as a single body. And, after molded as a single body, the roller **9** is fitted into the roller retainer **11**. The corner portions **9***a* of the roller **9** are inserted into a fit groove **21** formed in the roller retainer **11**. Between the roller **9** and roller retainer **11**, there is provided an interference and thus the roller **9** and roller retainer **11** are interference fitted with each other. Even in case where the roller retainer **11** is formed in this manner, the clearance between the roller **9** and roller retainer **11** can be made small.

[0046] By the way, in the present roller screw, the roller **9** rolling on the roller rolling groove **5***a* of the screw shaft **5** is picked up by the return pipe **7** and is returned by an amount equivalent to several windings. However, alternatively, there can also be employed a structure in which a deflector for picking up the roller **9** is disposed in the nut member **6**. That is, the roller **9** rolling on the roller rolling groove **5***a* of the screw shaft **5** may be removed from the roller rolling groove **5***a* by this deflector and may be then returned beyond the outside diameter portion of the screw shaft **5** to the roller rolling groove **5***a* that is situated by one lead ahead. Also, although not shown, there can also be employed a roller screw of a so called side cover type in which a nut member **6** is composed of a nut main body with a load rolling groove formed therein and two side covers respectively mounted on the two ends of the nut main body, in the nut main body, there is formed a roller return passage, and, in the two side covers, there are formed communication passages allowing the load rolling groove and return passage to communicate with each other.

[0047] Now, **FIGS. 10 and 12** respectively show a linear guide serving as a rolling guide apparatus incorporating therein the roller retainer **11** according to the first embodiment of the invention. This is a known linear guide which is used to guide a movable body such as a table set on a fixed portion such as a bed or a saddle. And, this linear guide comprises a guide rail **31** (a track shaft) which is disposed on the fixed portion and includes roller rolling grooves **31***a* formed along the longitudinal direction of the guide rail **31** and serving as rolling body rolling surfaces, a moving block (a slide member) **32** in which there is formed a roller circulation passage (rolling body circulation passage) including load rolling grooves serving as load rolling surfaces corresponding to the roller rolling grooves **31***a* of the guide rail **31** and also which is assembled to the guide rail **31** in such a manner that it can be freely moved with respect to the guide rail **31**, and a plurality of rollers **9** which are respectively arranged and stored in the roller circulation passage and are allowed to circulate through the roller circulation passage in linking with the relative movement of the moving block **32** with respect to the guide rail **31**. The plurality of rollers **9** are held by the roller retainers **11** individually (see **FIG. 12**). The rollers **9** are arranged and stored in the roller circulation passage in such a manner that the axes thereof are kept substantially parallel to each other. With the endless circulation of the plurality of rollers **9**, the moving block **32** supporting the movable body is allowed to move linearly along the guide rail **31**. By the way, the roller retainer **11** may also be formed in a band shape so that the plurality of rollers **9** circulating through the roller circulation passage can be held in a series manner.

[0048] The guide rail **31** is long and narrow and has a substantially square-shaped section. On the two right and left side surfaces of the guide rail **31**, there are formed the roller rolling grooves **31***a* having a V-shaped section, which respectively extend along the whole length of the guide rail **31** in the longitudinal direction and provide a track when the rollers **9** roll. By the way, although the shown guide rail is linear, in some cases, a curved rail is also used as the guide rail. Also, while the number of the roller rolling grooves **31***a* is two in the illustrated embodiment, the number of the roller rolling grooves can also be changed according to the uses of the linear guide.

[0049] The moving block **32** can be substantially structured in such a manner that a moving block main body **34** and a pair of side covers **35** respectively disposed on the two ends of the main body **34** are combined together. In the moving block main body **34**, there are formed two load rolling grooves **32***a* with a V-shaped section which are respectively opposed to the roller rolling grooves **31***a* (see **FIG. 12**). Due to the combinations of the load rolling grooves **32***a* and roller rolling grooves **31***a*, between the guide rail **31** and moving block **32**, there are formed two load rolling passages C. Further, in the moving block main body **34**, there are formed two return passages D which respectively extend in parallel to their associated load rolling passages C, and a pair of direction switch passages which respectively connect the respective return passages D to their associated load rolling passages C. Combination of the return passages D and load rolling passages C with the pair of direction switch passages connecting them together forms a roller circulation passage.

[0050] As shown in **FIG. 12**, the moving block main body **34** includes a main body block **39** and a molded body **36**. The main body block **39** is a high-rigidity structure body which is made of steel in such a manner that it can stand a load to be applied to the moving block **32** and, in the upper surface of the main body block **39**, there is formed a screw hole for fixing a member to be guided by the present linear guide. The molded body **36** is molded integrally with the main body block **39** according to a so called insert molding method in which molten resin is injected into a metal mold storing the main body block **39** therein. By the way, in some cases, the molded body **36** is die-cast molded using metal such as aluminum instead of the resin. Also, the invention is not limited to the above-mentioned insert molding method. For example, the main body block **39** and molded body may be formed separately and, after then, they may be combined together. Also, the main body block **39** and molded body **36** may be molded integrally according to an MIM (Metal Injection Mold) method.

[0051] The above-mentioned load rolling grooves **32***a* are respectively formed in the main body block **39**. And, on the other hand, the return passages D are respectively formed in the molded body **36**. In the main body block **39**, there are formed two through holes which respectively extend in parallel to their associated load rolling grooves **32***a*, and the pipe-shaped portion of the molded body **36** is molded integrally with the through holes of the main body block **39**. And, in the interior portion of the pipe-shaped portion of the molded body **36**, there are formed the return passages D for return of the rollers as well as guide grooves **37** which are used to guide the roller retainer **11** in their associated return passages D. Also, in the main body block **39**, there are formed guide grooves **38** respectively extending along their associated load rolling grooves **32***a*. These guide grooves **37** and **38** are respectively formed slightly wider than the width of the roller retainer **11** and slightly deeper than the end face of the roller retainer **11**, in order to be able to avoid interference with the roller retainer **11**. These guide grooves **37** and **38** guide the roller retainer **11** as well as, when the moving block **32** is pulled out from the guide rail **31**, prevent the rollers **9** from slipping off the load rolling passages C. By the way, the guide grooves **38** may not be formed in the main body block **39** but guide grooves may be formed in the molded body that is formed integrally with the main body block **39**.

[0052] As the moving block **32** is moved along the guide rail **31**, the roller **9** rolls from one end of the load rolling passage C to the other end thereof while receiving a load from the moving block **32**, after then, the roller **9** is picked up into one direction switch passage and is then guided to the return passage D and, further, the roller **9** is returned to one end of the load rolling passage C through the other direction switch passage. During circulation of the roller **9**, the roller **9** is going to fall down in a plane including the axis of the roller **9** and the advancing direction thereof, thereby causing a skew in the roller **9**. However, since the roller retainer **11** restricts the corner portion **9***a* of the roller **9**, the roller **9** can be restricted positively to thereby be able to control the skew of the roller **9**. Also, because the end portions **11***b* and **11***b* of the roller retainer **11** are guided by the guide grooves **38** respectively formed in their associated load rolling grooves **32***a*, the smooth circulation of the roller retainer **11** and roller **9** can be assured. Further, since the roller retainer **11** according to the present embodiment encloses the outer periphery of the roller **9** that is situated on the diagonal thereof when the roller **9** is viewed from the side surface thereof, whether the rollers **9** are parallel arranged or cross arranged, the roller retainer **11** is able to always keep a constant position and thus the disposition of the roller retainer **11** is free from the influence of the direction of the roller **9**. Therefore, the guide grooves **37** and **38** may be formed only at the diagonal positions of the roller **9**, which can facilitate the formation of the guide grooves **37** and **38**.

[0053] By the way, in the present embodiment, the relative motion of the moving block **32** and guide rail **31** is linear; however, the invention can also apply suitably to a guide apparatus in which the relative motion is curved.

[0054] Also, the roller retainer according to the invention can also apply to a roller spline which is used as a rolling guide apparatus and further can apply to a bearing such as a swing bearing, provided it uses rollers.

[0055] As has been described heretofore, according to the invention, since each roller retainer encloses the outer periphery of its associated roller that is situated on the diagonal when the roller is viewed from the side surface thereof, the roller retainer is allowed to keep a constant position whether the rollers are arranged in a parallel manner or in a cross manner and thus the disposition of the roller retainer is free from the influence of the direction of the roller. Therefore, there can be obtained a roller retainer which can be applied not only to a structure in which rollers are parallel arranged but also to a structure in which rollers are cross arranged. Also, because the roller retainer restricts the corner portion of the roller, the roller is difficult to slip off the roller retainer, thereby being able to restrict the roller positively, so that the skew of the roller can be controlled.

What is claimed is:

1. A roller retainer for holding a roller circulating through a roller circulation passage,

wherein said roller retainer encloses the outer periphery of said roller situated on a diagonal when said roller is viewed from the side surface thereof.

2. A roller retainer as set forth in claim 1, wherein said roller retainer holds a plurality of rollers circulating through said roller circulation passage, individually.

3. A roller retainer as set forth in claim 1, wherein said roller retainer is molded with said roller inserted therein.

4. A roller screw comprising:

a track shaft including a spiral-shaped roller rolling groove having a V-shaped section;

a slide member including a roller circulation passage including a spiral-shaped load rolling groove having a V-shaped section and assembled to said track shaft so as to move with respect to said track shaft, said load rolling groove corresponding to said roller rolling groove;

a plurality of rollers arranged and stored in said roller circulation passage and allowed to circulate through said roller circulation passage in linking with the relative motion of said slide member with respect to said track shaft; and

a plurality of retainers for holding said plurality of rollers individually so that said rollers are rotated and slid;

wherein each of said roller retainers encloses the outer periphery of its associated one of said rollers that is situated on a diagonal when said roller is viewed from the side surface thereof, and also wherein, in at least one of said roller rolling groove and said load rolling groove, there is formed a guide groove for guiding said roller retainer.

5. A rolling guide apparatus comprising:

a track shaft including a roller rolling groove having a V-shaped section;

a slide member including a roller circulation passage with a load rolling groove having a V-shaped section and assembled to said track shaft so as to move with respect to said track shaft, said load rolling groove corresponding to said roller rolling groove;

a plurality of rollers arranged and stored in said roller circulation passage and allowed to circulate through said roller circulation passage in linking with the relative motion of said slide member with respect to said track shaft; and

a plurality of retainers for holding said plurality of rollers individually so that said rollers are rotated and slid;

wherein each of said roller retainers encloses the outer periphery of its associated one of said rollers that is situated on a diagonal when said roller is viewed from the side surface thereof, and also wherein, in at least one of said roller rolling groove and said load rolling groove, there is formed a guide groove for guiding said roller retainer.

* * * * *

US 20010048775A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2001/0048775 A1**

Michioka et al. (43) **Pub. Date: Dec. 6, 2001**

(54) **LINEAR MOTION GUIDING APPARATUS**

(75) Inventors: **Hidekazu Michioka**, Tokyo-To (JP); **Katsuya Iida**, Tokyo-To (JP); **Masahiro Yoshihashi**, Tokyo-To (JP); **Hiroaki Mochizuki**, Tokyo-To (JP); **Tadashi Hirokawa**, Tokyo-To (TW)

Correspondence Address:
YOUNG & THOMPSON
745 SOUTH 23RD STREET 2ND FLOOR
ARLINGTON, VA 22202

(73) Assignee: **THK Co., Ltd.**, Tokyo-To (JP)

(21) Appl. No.: **09/906,854**

(22) Filed: **Jul. 18, 2001**

Related U.S. Application Data

(62) Division of application No. 09/639,340, filed on Aug. 16, 2000, now Pat. No. 6,305,846, which is a division of application No. 09/088,491, filed on Jun. 2, 1998, now Pat. No. 6,132,093.

(30) **Foreign Application Priority Data**

Jun. 16, 1997 (JP) P09-175336
Apr. 30, 1998 (JP) P10-136062

Publication Classification

(51) **Int. Cl.**[7] **F16C 29/06**
(52) **U.S. Cl.** **384/45**

(57) **ABSTRACT**

A linear motion guiding apparatus comprises a guide rail provided with a ball running groove, and a movable block movably arranged along the guide rail through balls. The movable block is provided with a ball running counter-groove, a ball returning passage arranged away from the ball running counter-groove and direction changing passages for connecting these members. A resin-formed body for forming a ball circulation passage comprises a pair of ball passage forming portions, a returning passage forming portion and a pail of direction changing passage-inner guide forming portions. The resin-formed body is separately formed from a body of the movable block. At least two portions of (a) the ball passage forming portions, (b) the returning passage forming portion, (c) one of the direction changing passage-inner guide forming portions and (d) another of the of direction changing passage-inner guide forming portions are connected with each other through integral forming so that the resin-formed body can be built in the body of the movable block.

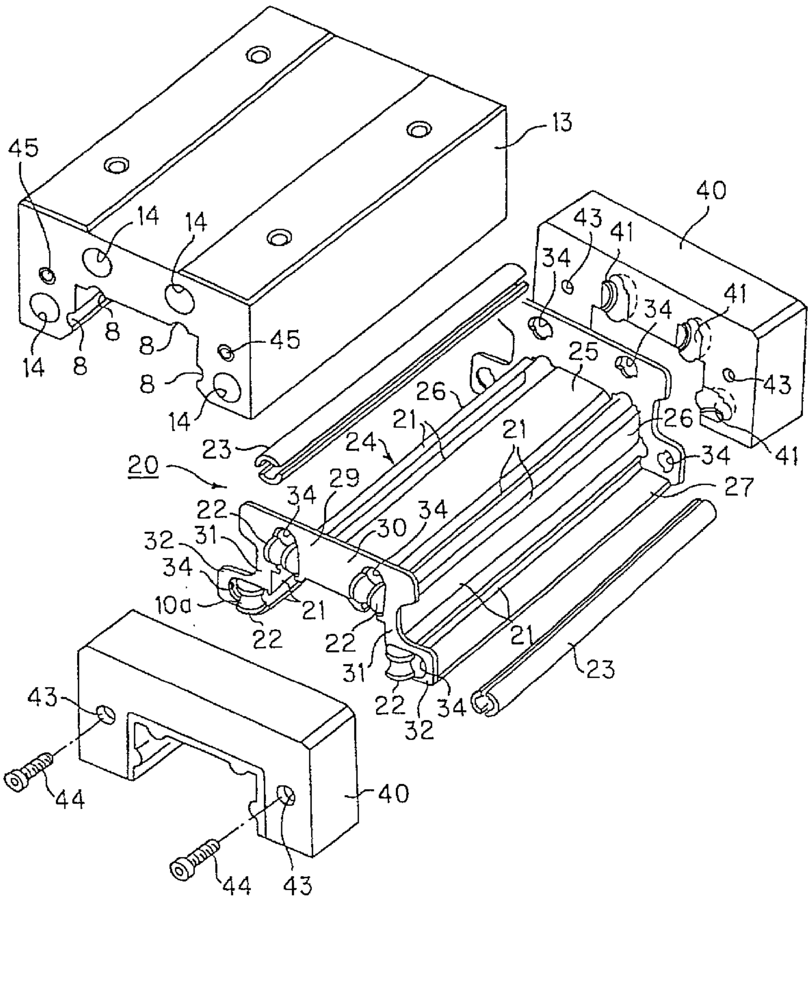
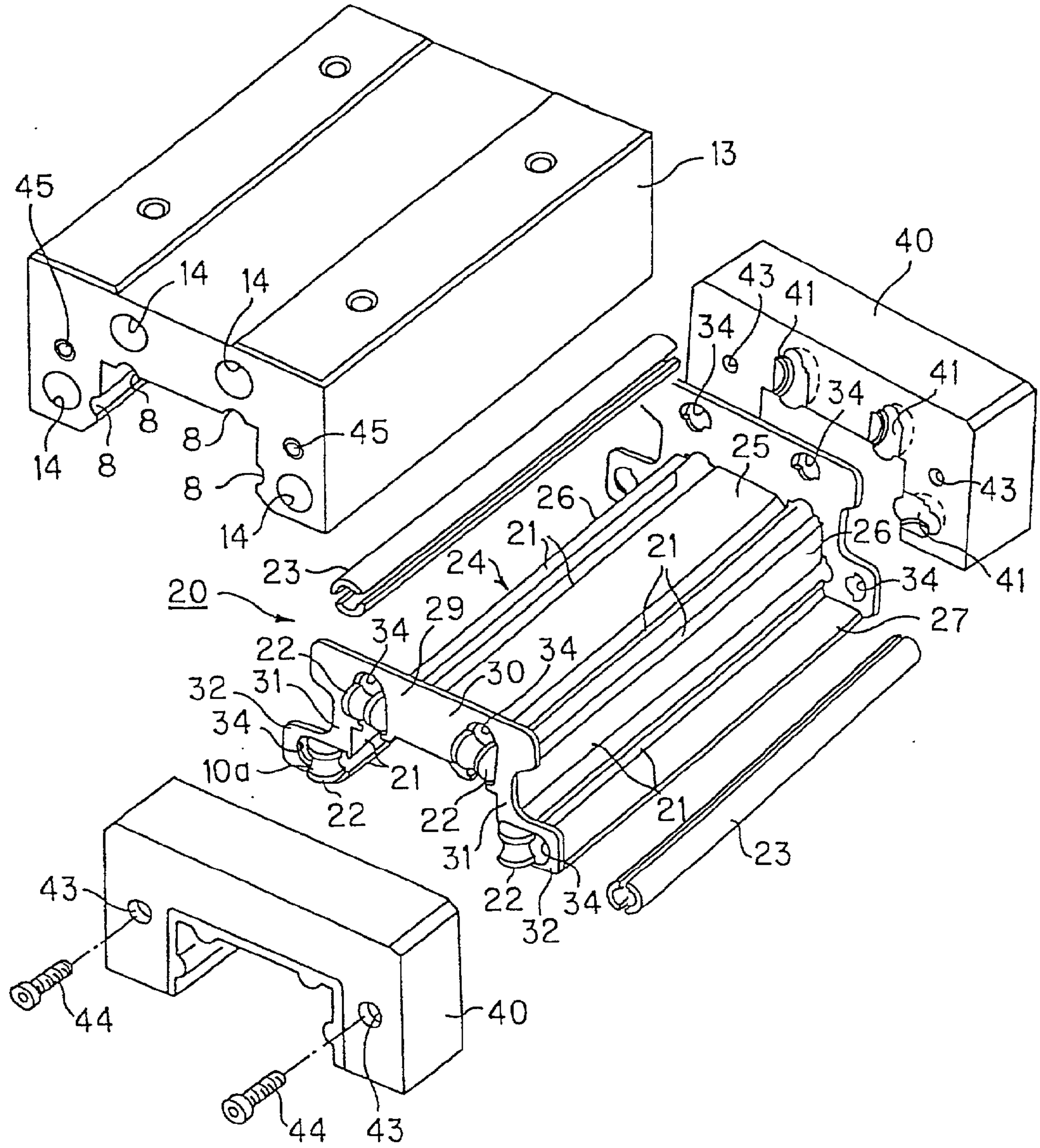


FIG. 1



13
45
14
14
14
8
8
8
8
45
14
14
40
43
41
34
41
34
43
25
26
26
21
21
24
23
20
34
41
27
29
22
34
32
31
30
34
34
10a
21
22
22
21
31
23
22
32
34
43
44
40
44
43

FIG. 2(a)

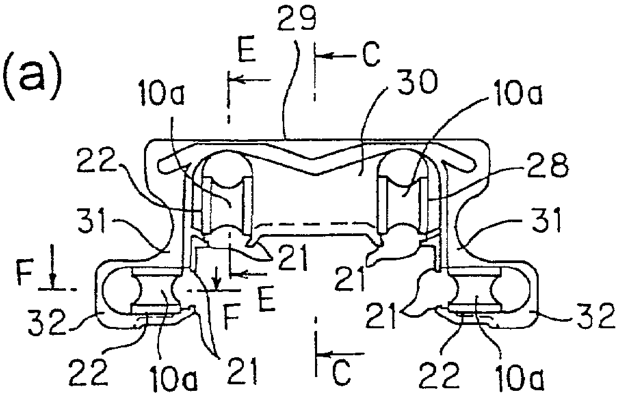


FIG. 2(b)

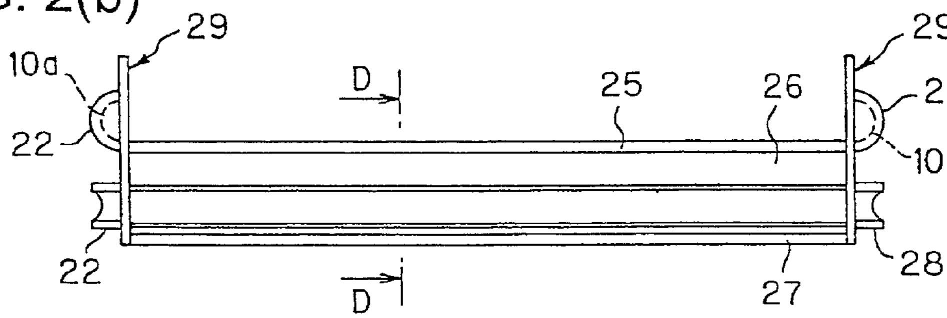


FIG. 2(c)

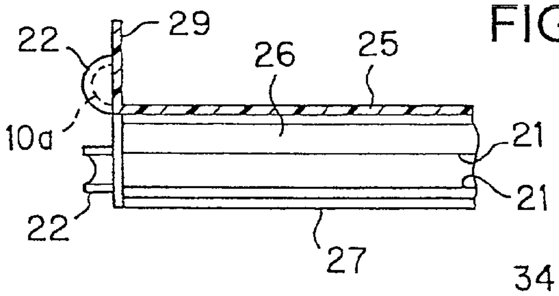


FIG. 2(d)

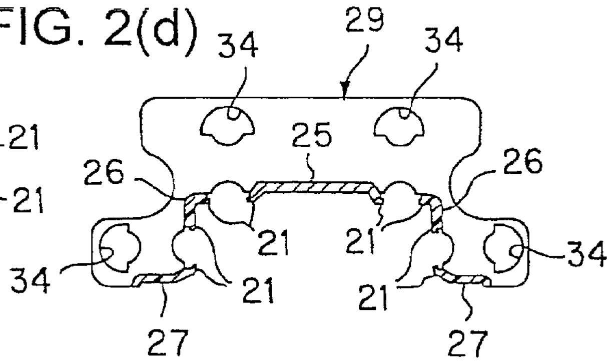


FIG. 2(e)

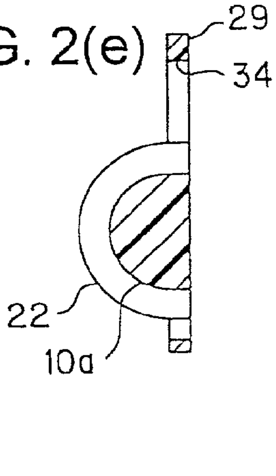


FIG. 2(f)

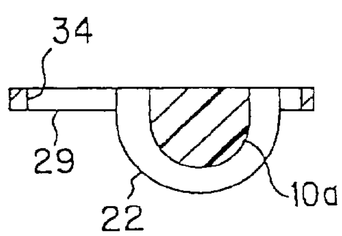


FIG. 3(a)

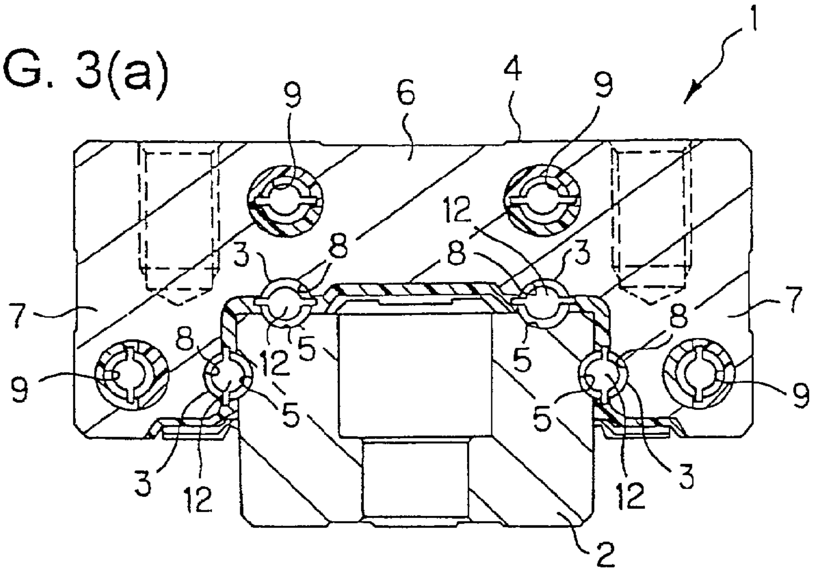


FIG. 3(b)

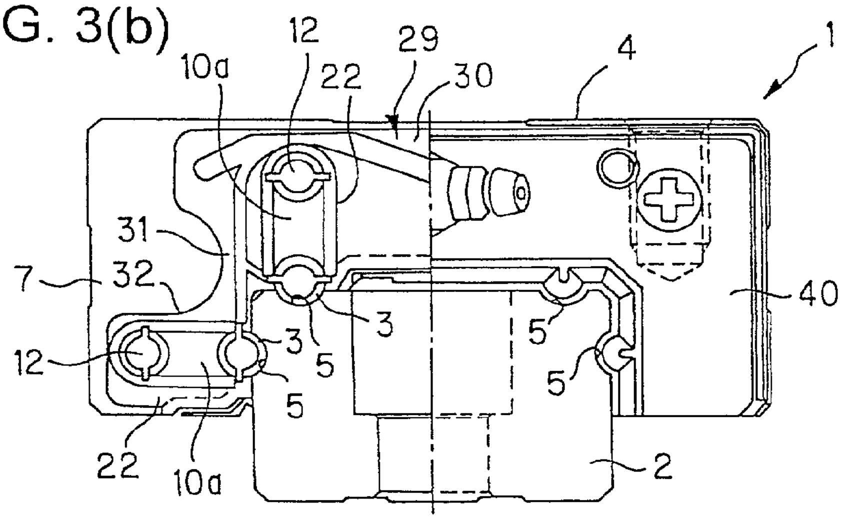


FIG. 3(c)

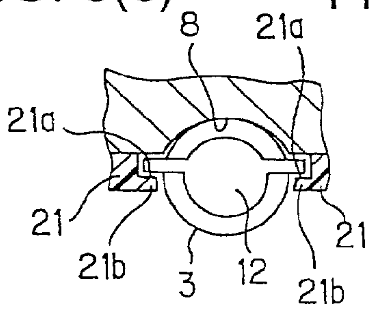


FIG. 3(d)

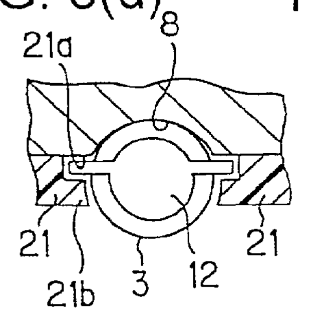


FIG. 3(e)

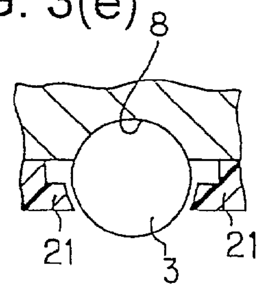


FIG. 3(f)

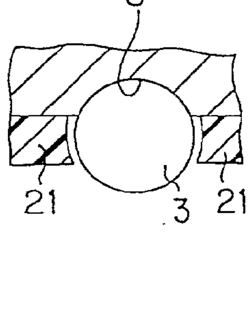


FIG. 4(a)

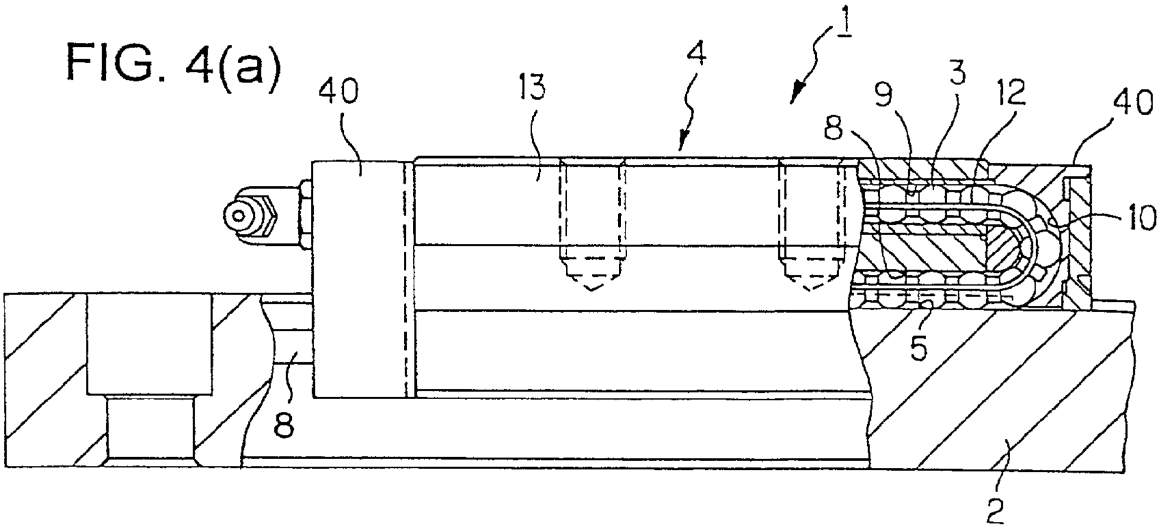


FIG. 4(b)

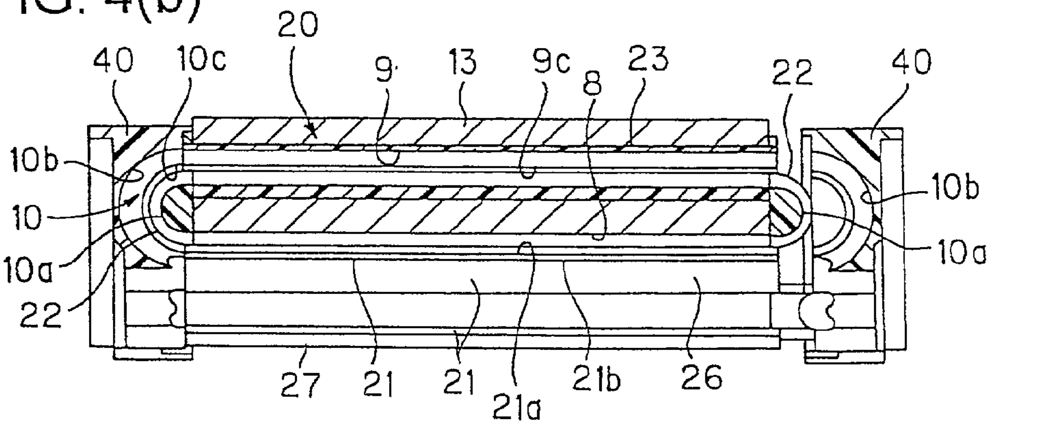


FIG. 4(c)

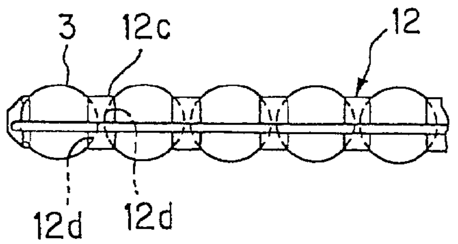


FIG. 4(d)

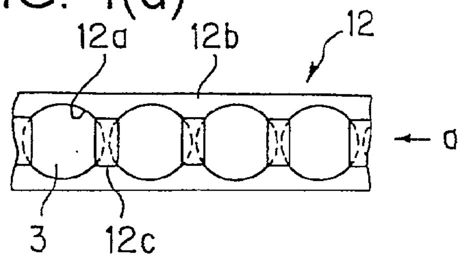


FIG. 4(e)

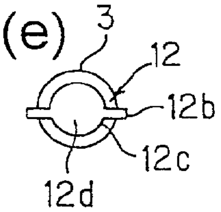


FIG. 5(a)

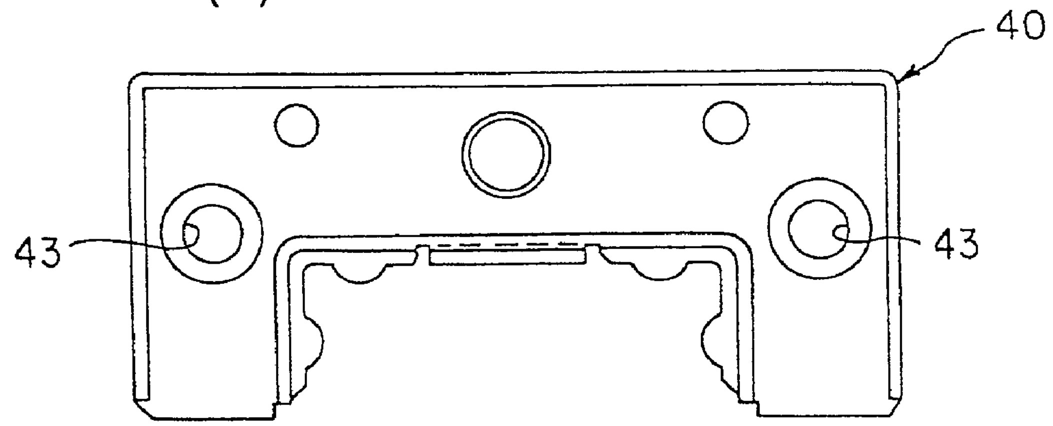


FIG. 5(b)

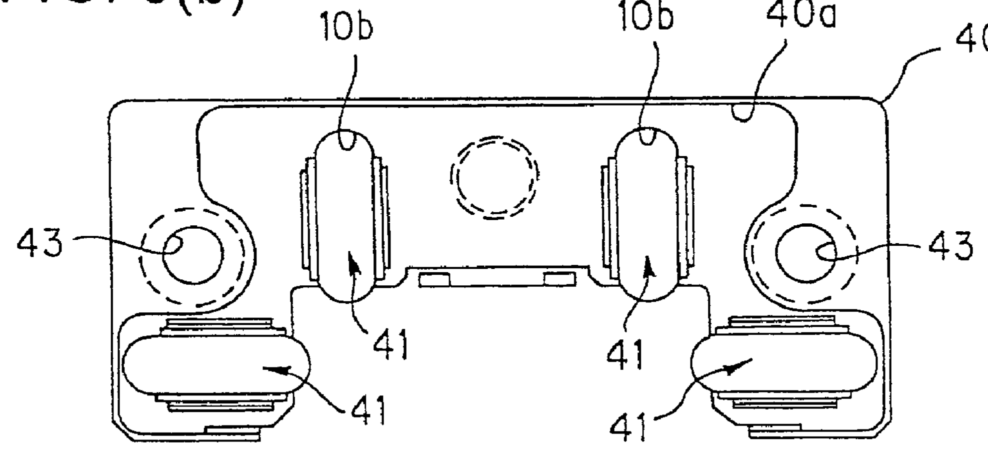


FIG. 5(c)

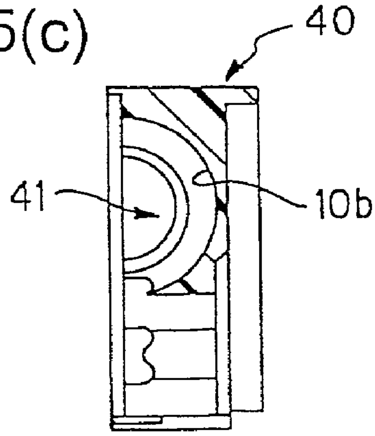


FIG. 6(a)

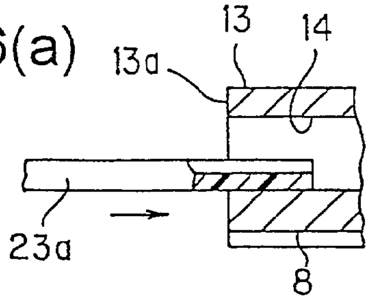


FIG. 6(b)

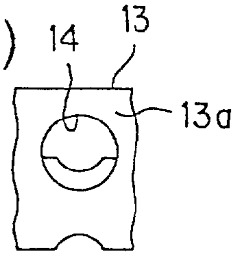


FIG. 6(c)

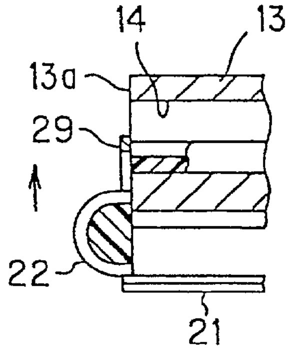


FIG. 6(d)

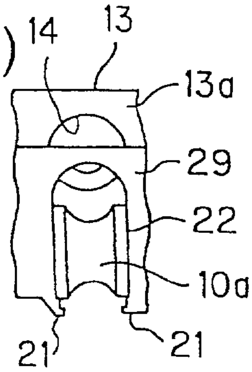


FIG. 6(e)

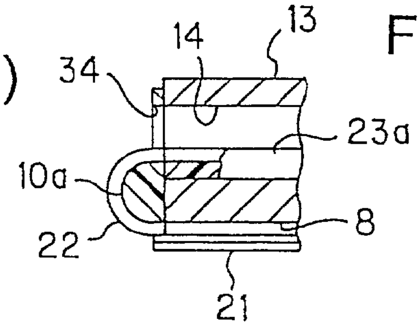


FIG. 6(f)

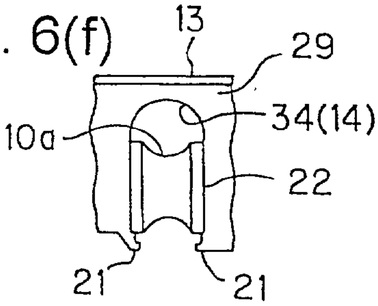


FIG. 6(g)

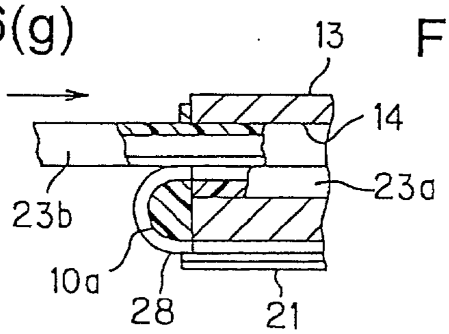


FIG. 6(h)

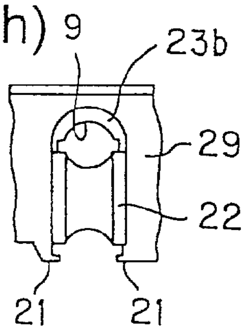


FIG. 6(i)

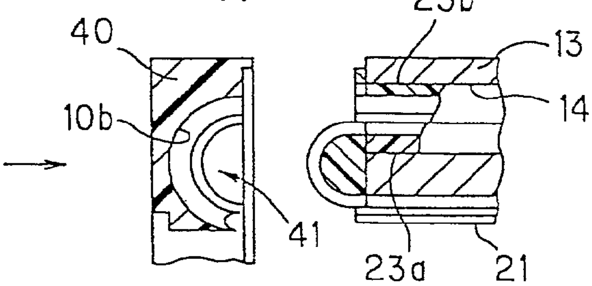


FIG. 7(a)

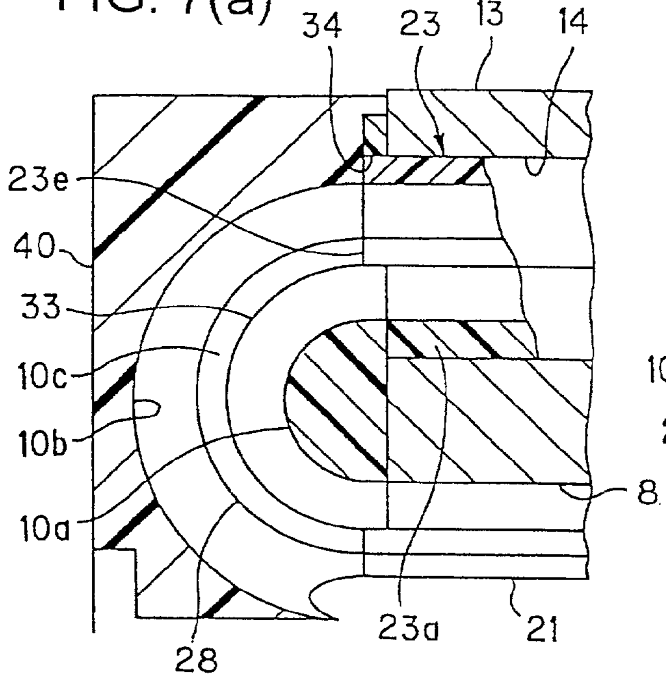


FIG. 7(b)

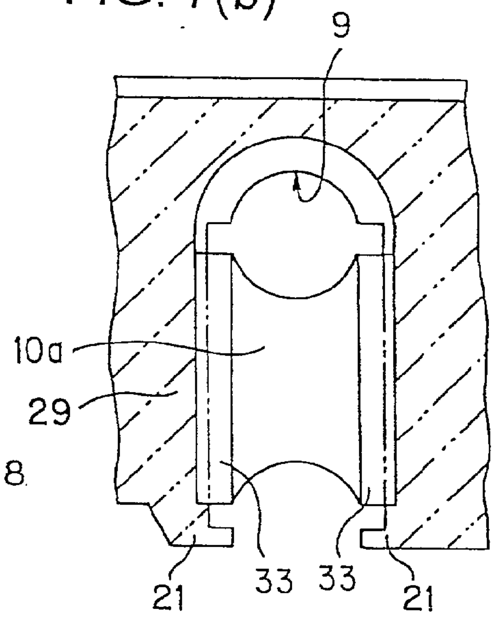


FIG. 7(c)

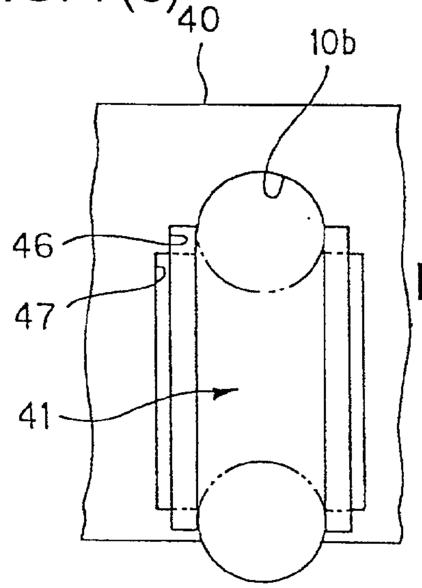


FIG. 7(e)

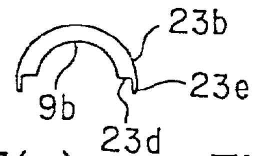


FIG. 7(d)

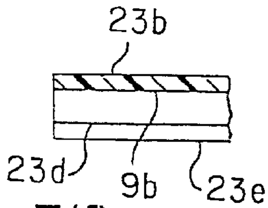


FIG. 7(g)

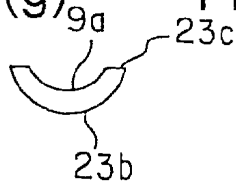
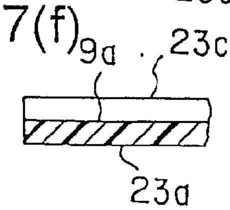


FIG. 7(f)



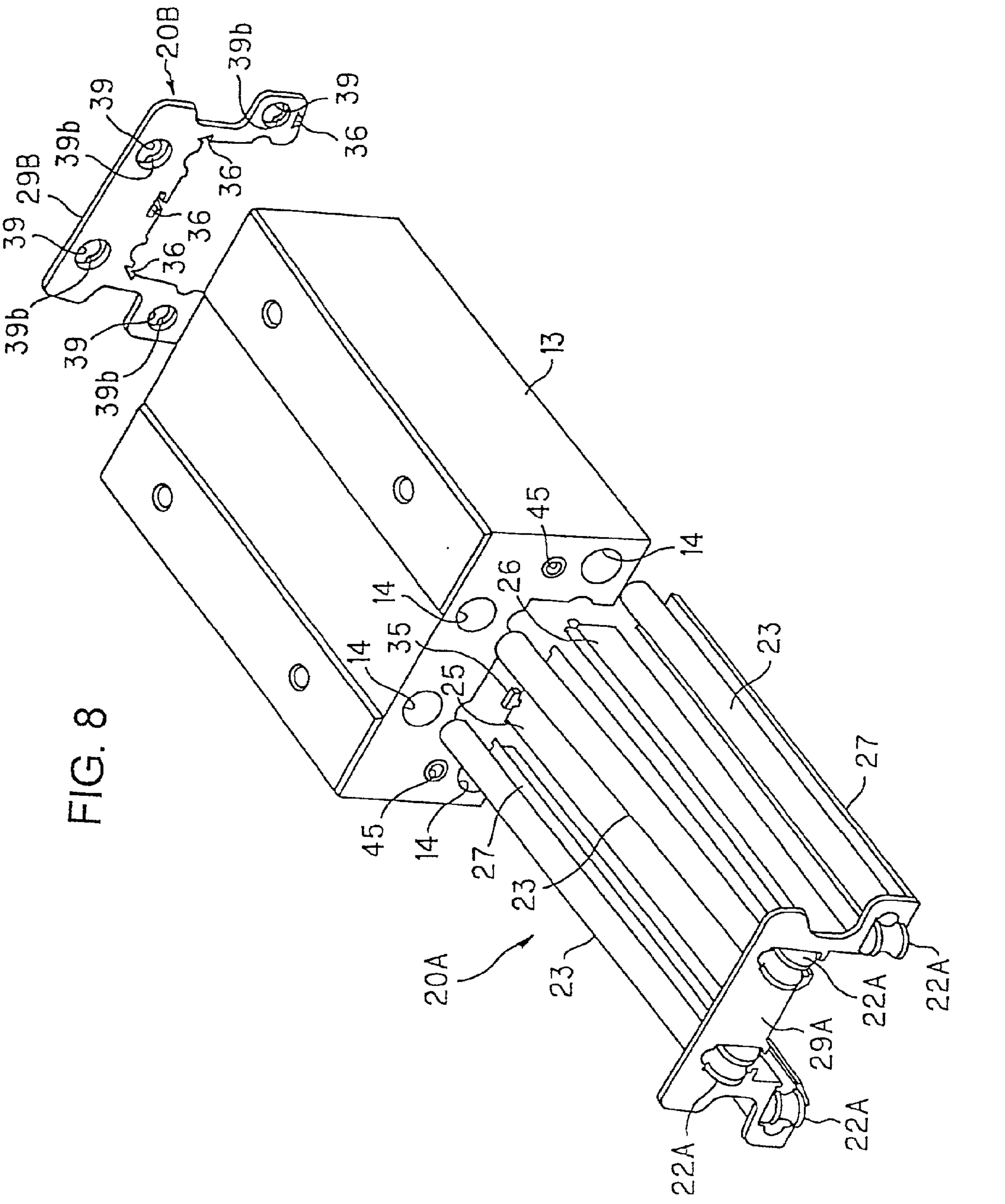

20B
39b
39
36
39
39b
29B
36
36
39
36
36
39b
39
39b
13
45
14
26
14
35
14
25
23
27
45
14
27
23
20A
23
22A
22A
29A
22A
22A

FIG. 8

FIG. 9(a)

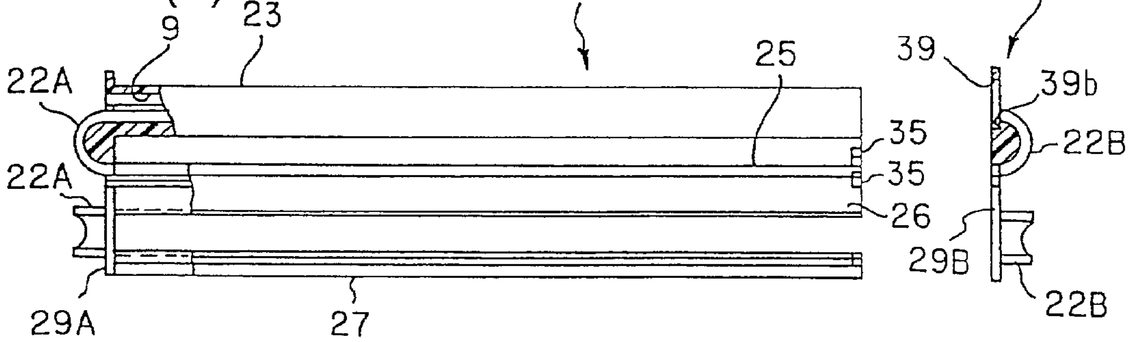


FIG. 9(b)

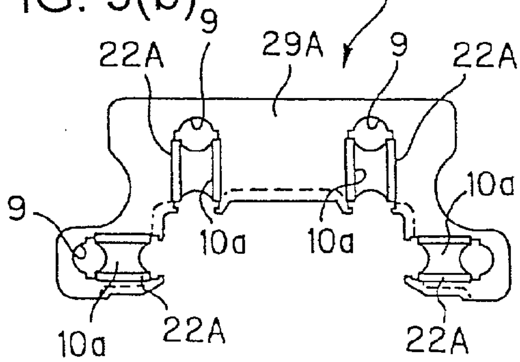


FIG. 9(c)

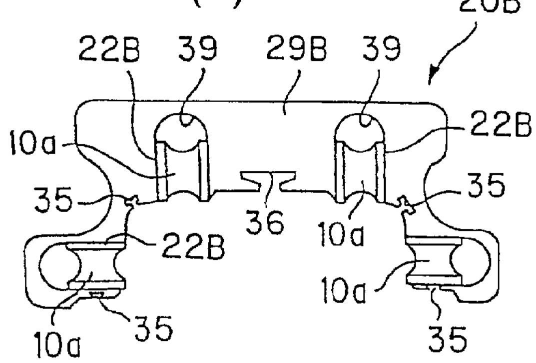


FIG. 9(d)

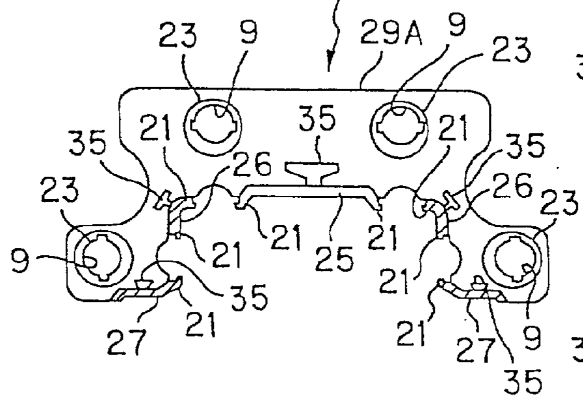
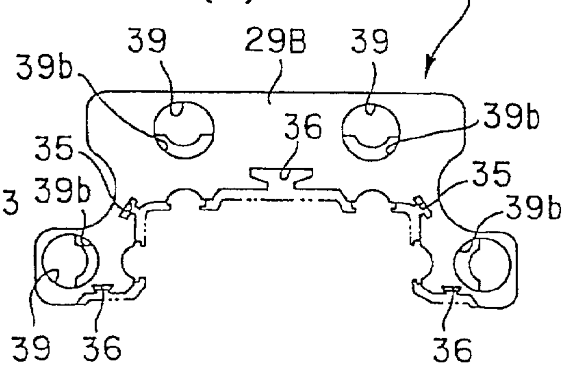


FIG. 9(e)



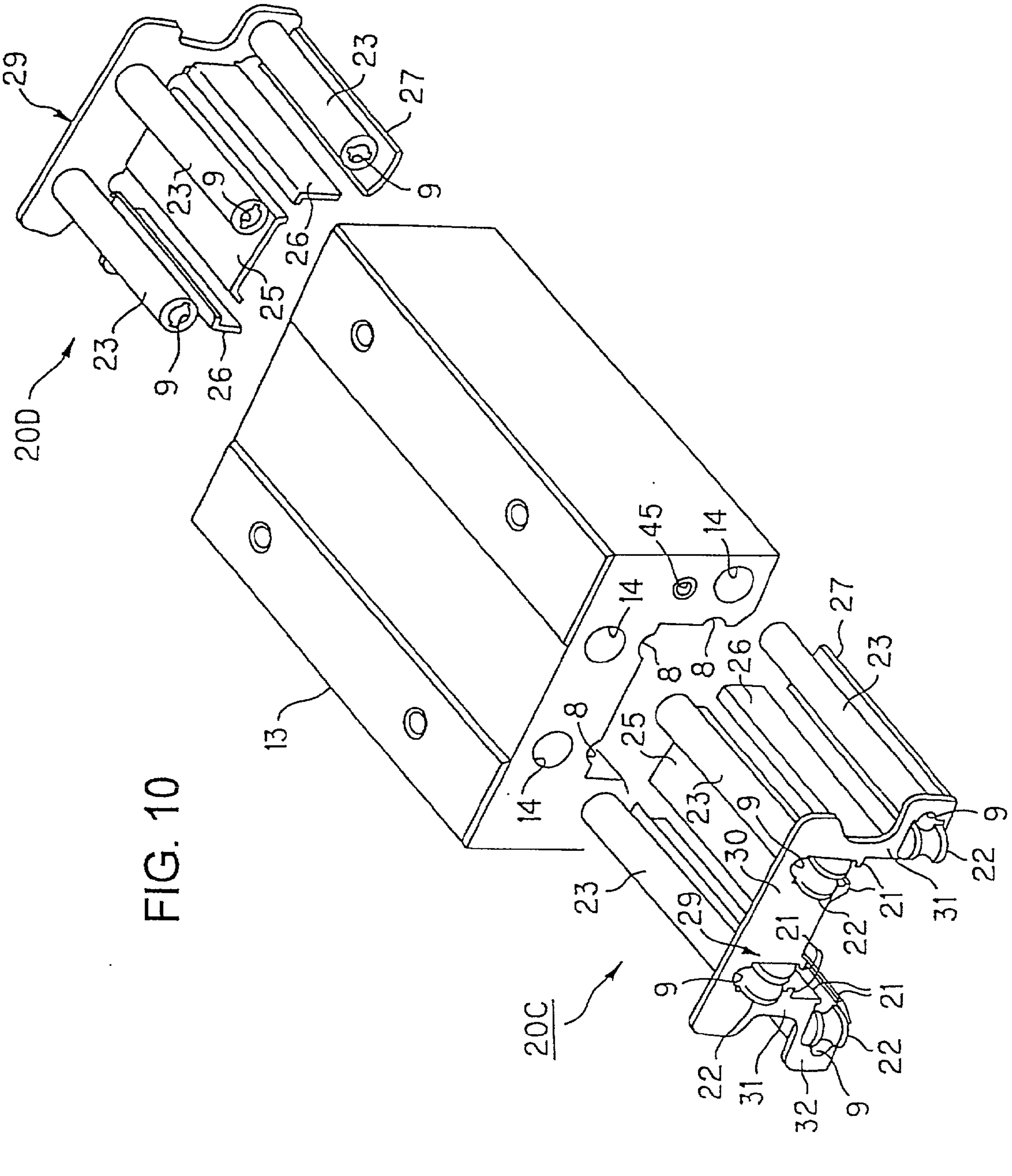


FIG. 10

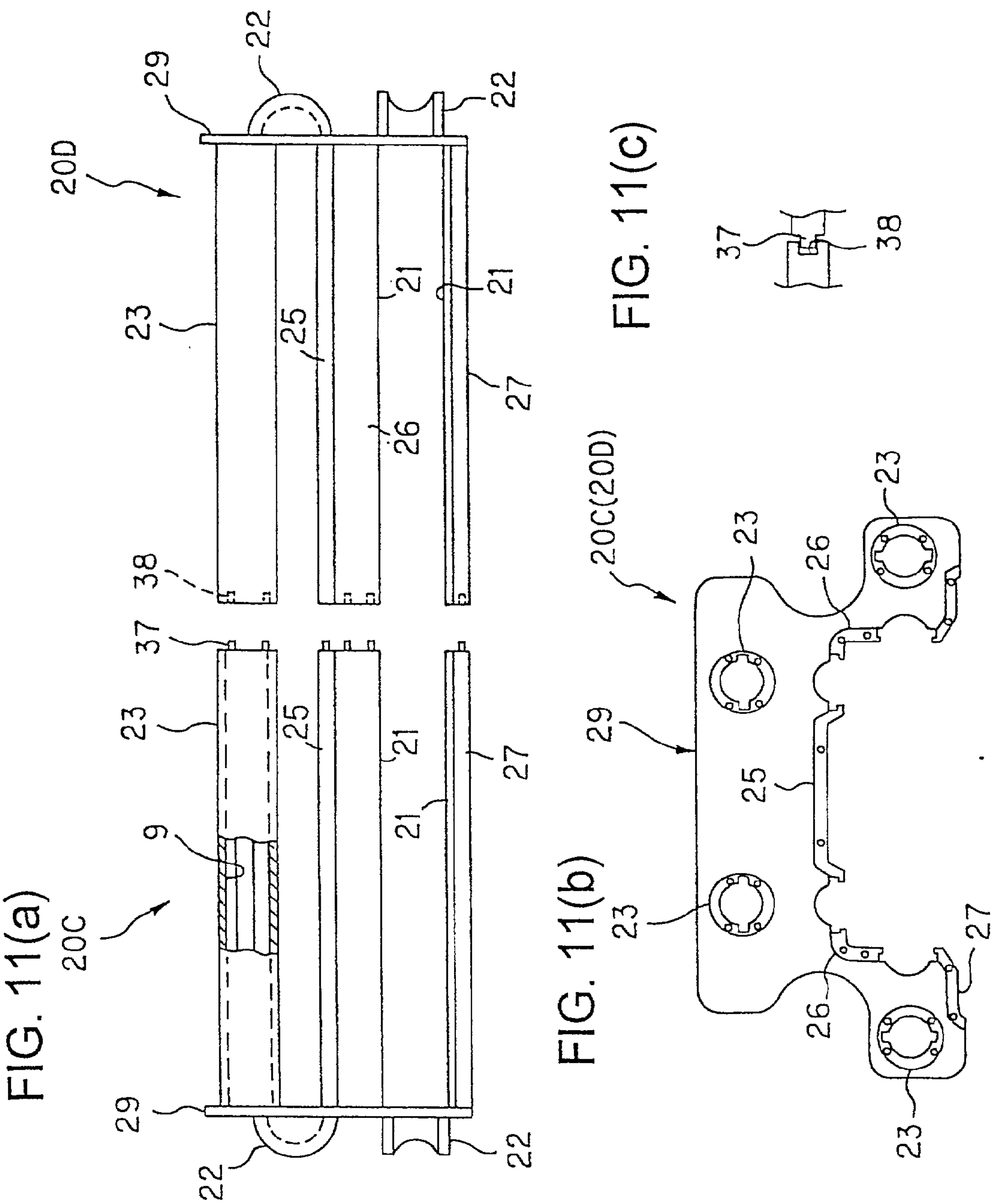


FIG. 11(a)

FIG. 11(b)

FIG. 11(c)

FIG. 12

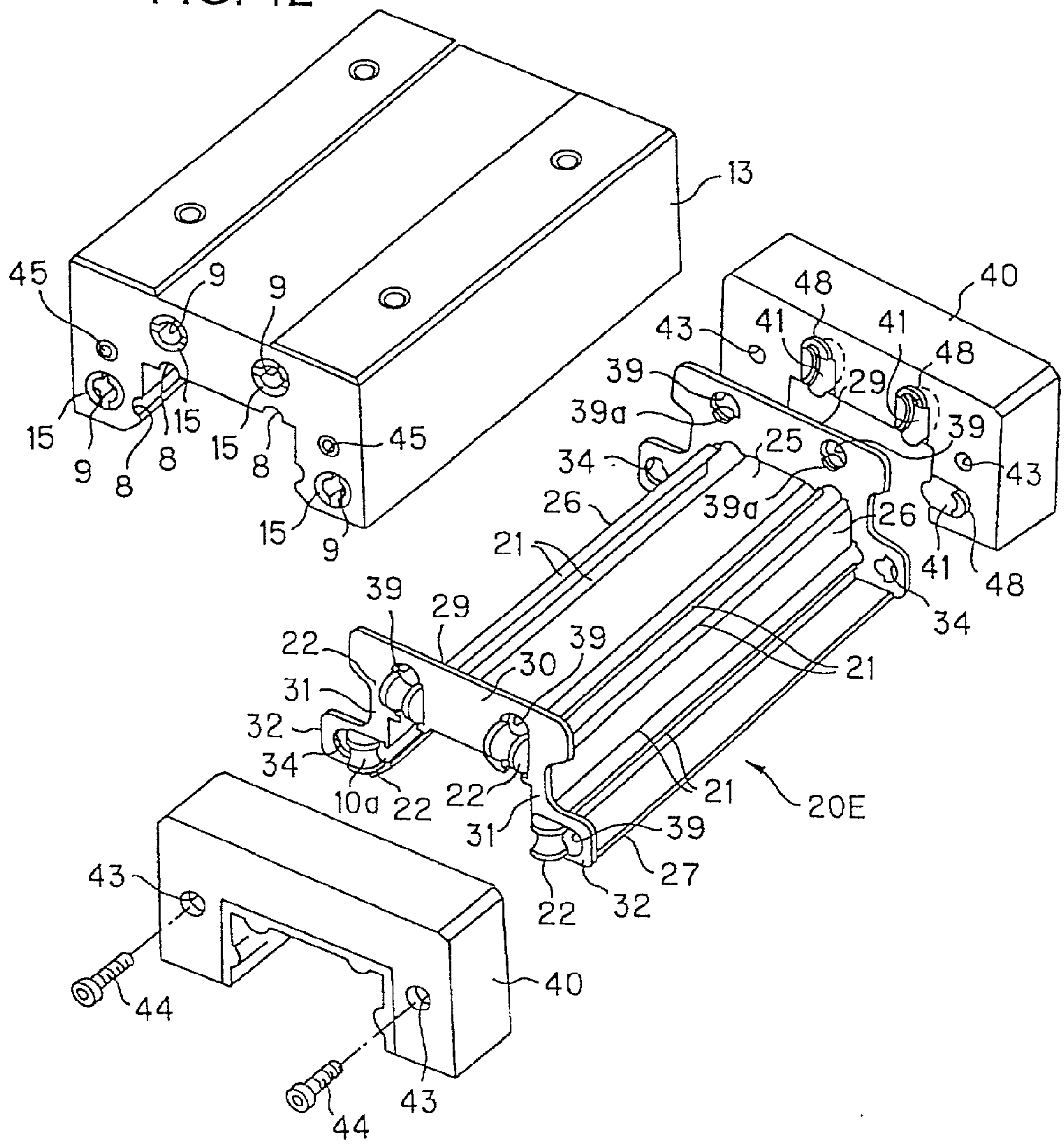

13
45
9
9
15
9
8
15
8
15
8
45
15
9
40
48
43
41
41
48
39
29
39a
39
34
25
43
39a
26
26
41
48
21
34
21
39
29
22
39
30
31
32
34
10a
22
22
21
20E
31
39
27
22
32
43
40
44
43
44

FIG. 13(a)

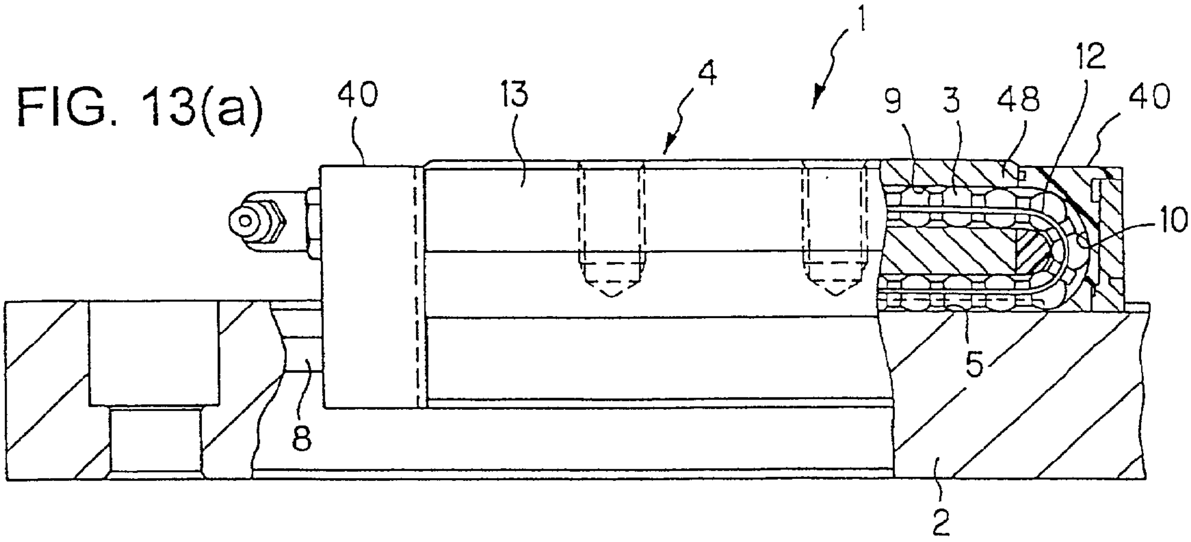


FIG. 13(b)

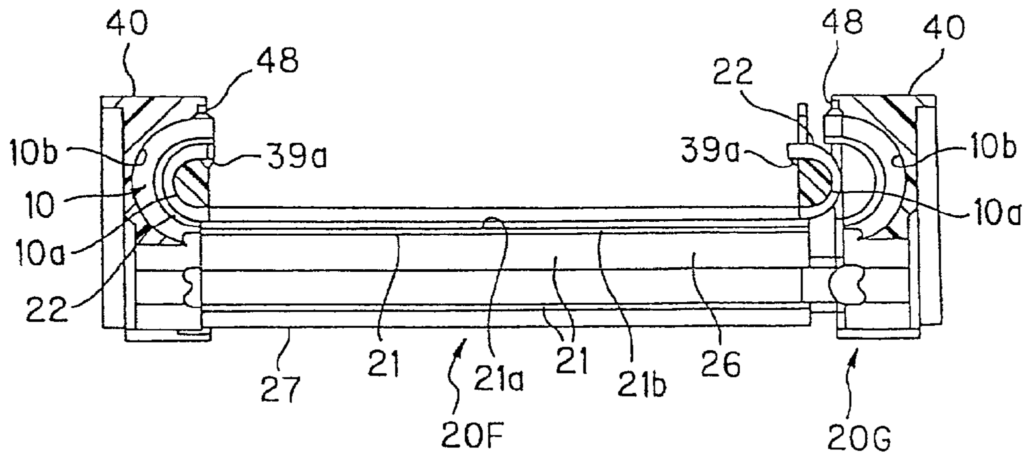


FIG. 14(a)

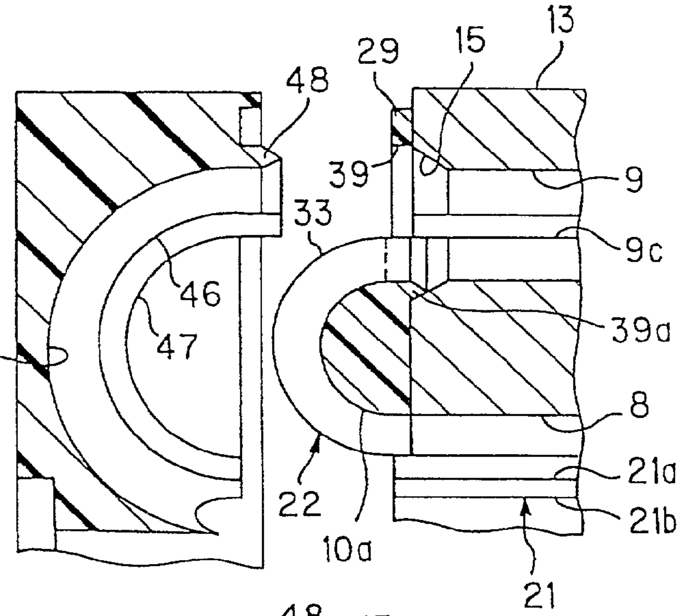


FIG. 14(b)

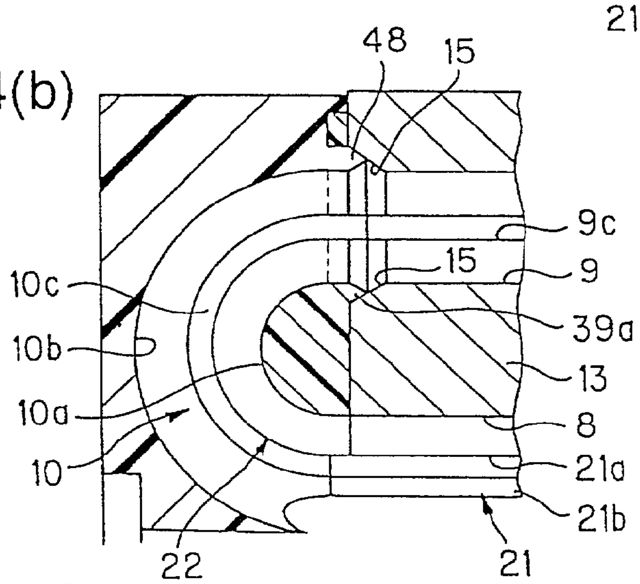


FIG. 14(c)

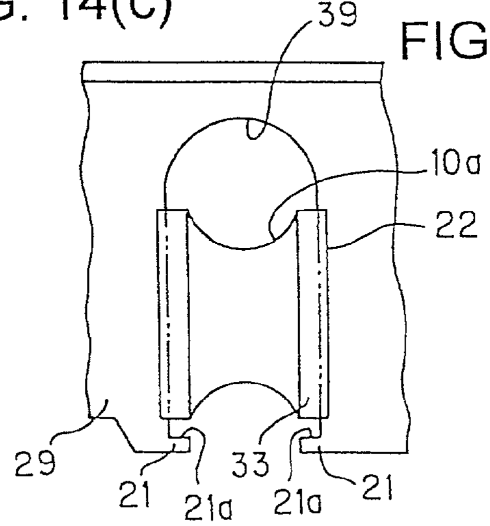


FIG. 14(d)

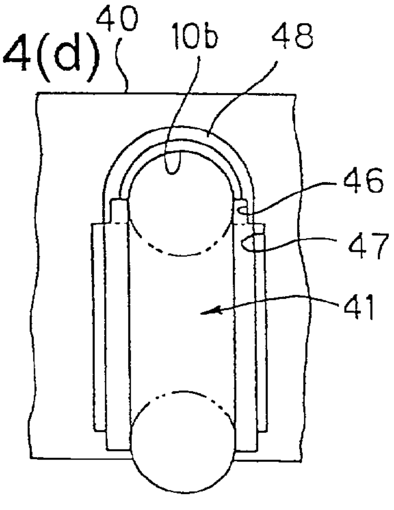


FIG. 15

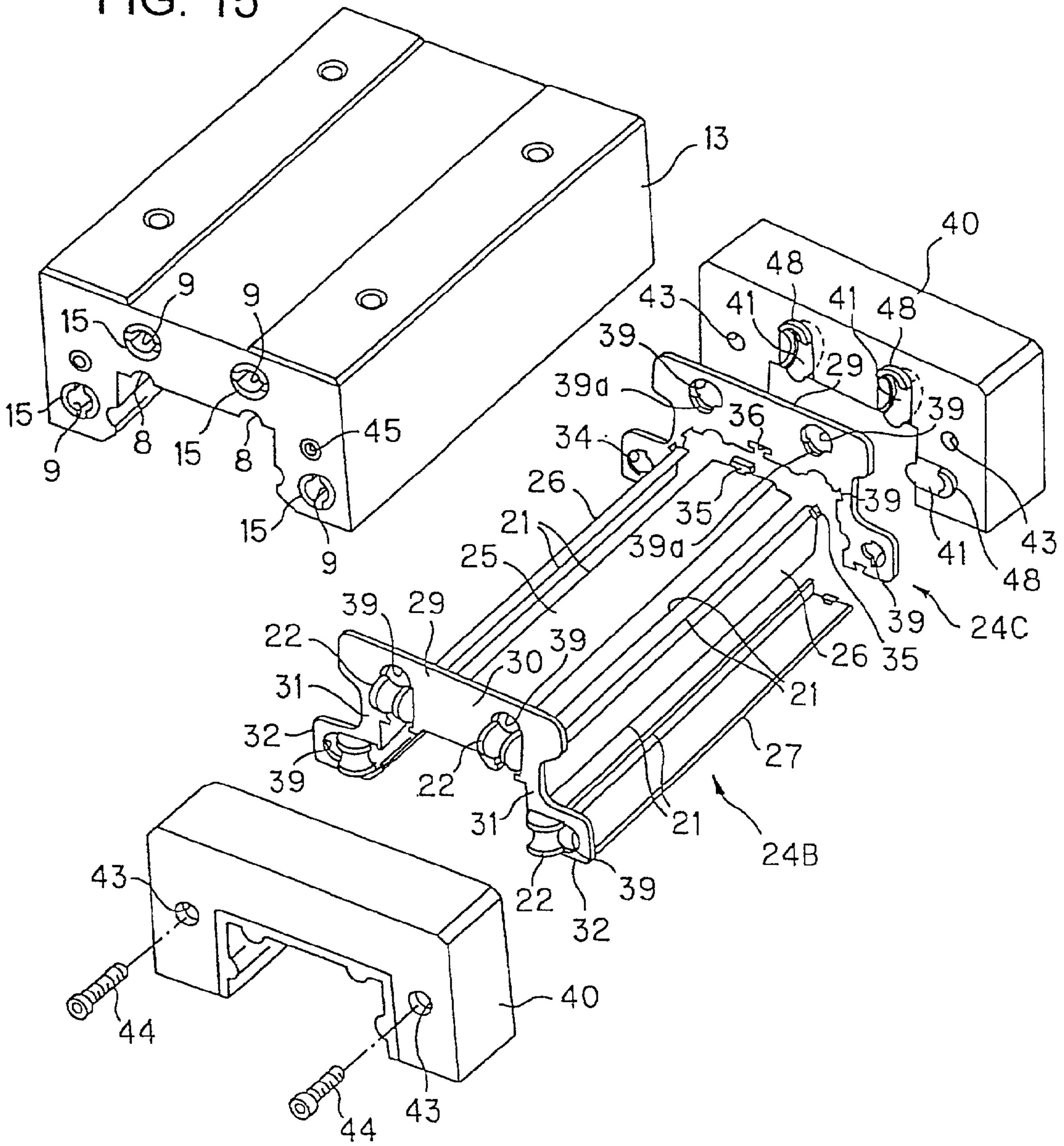

13
40
48
41
41
48
43
39
29
39a
36
39
34
15
9
9
15
15
9
8
15
8
45
15
9
26
35
39
21
39a
25
39
43
41
48
39
24C
22
39
29
30
39
31
32
39
22
26
35
21
27
31
21
24B
22
39
32
43
44
40
44
43

FIG. 16(a)

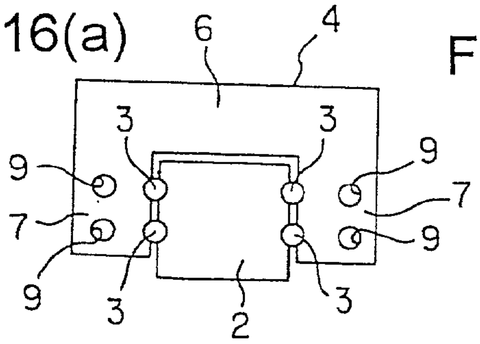


FIG. 16(b)

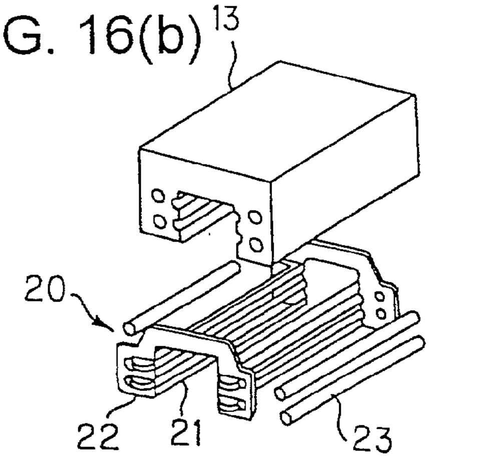


FIG. 16(c)

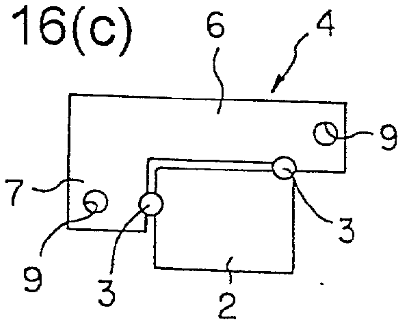


FIG. 16(d)

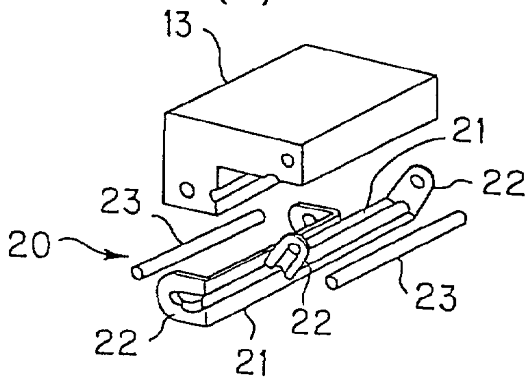


FIG. 16(e)

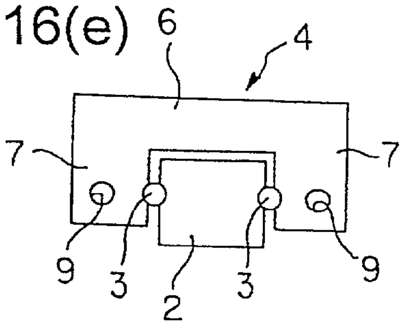


FIG. 16(f)

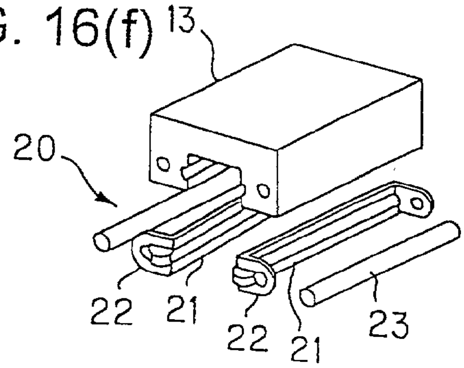


FIG. 16(g)

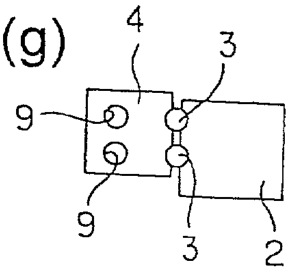


FIG. 16(h)

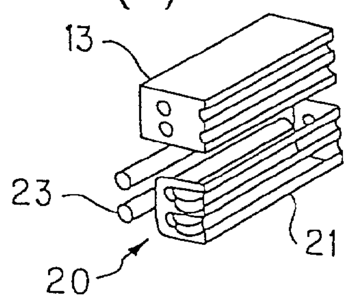


FIG. 17

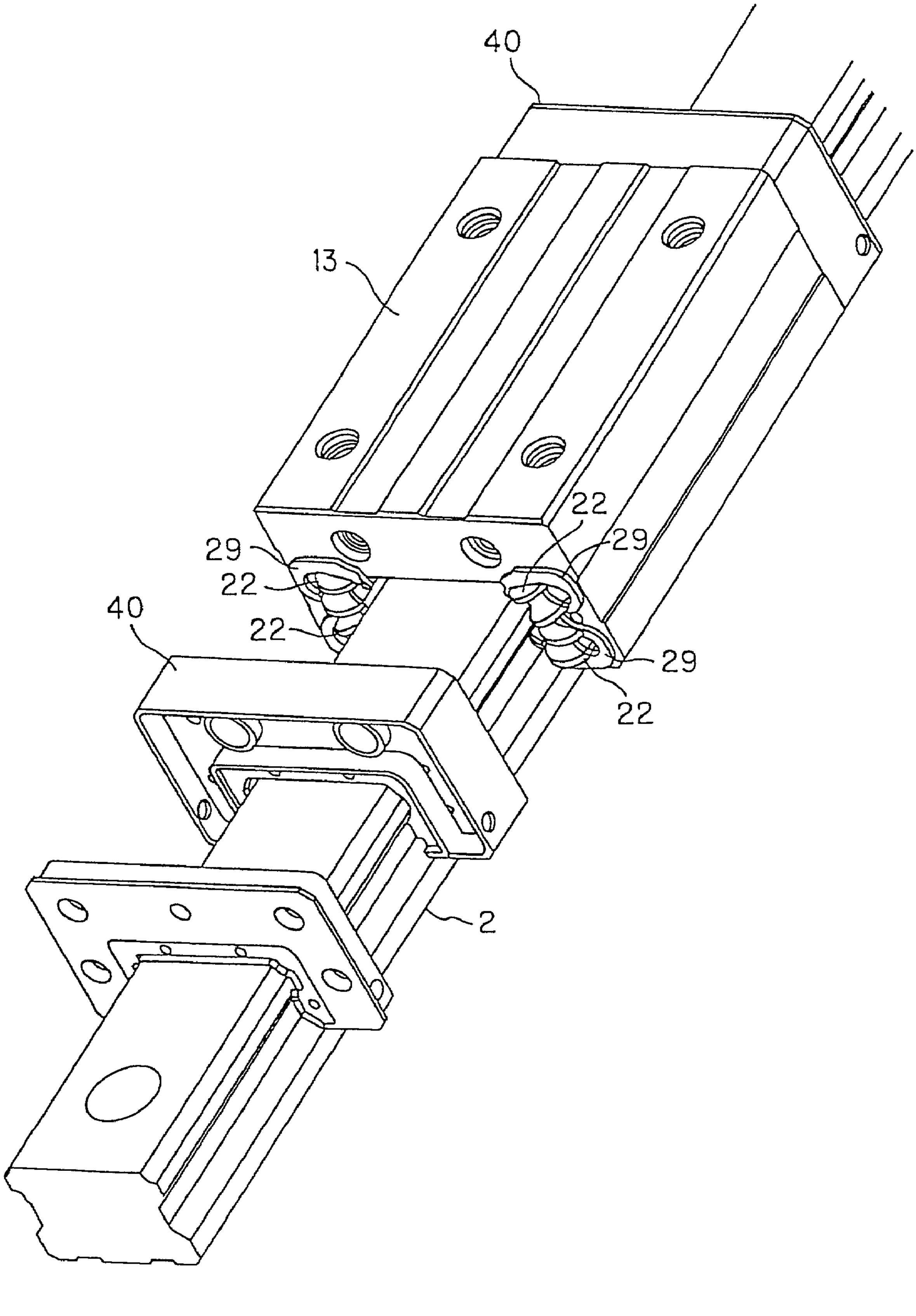


FIG. 18

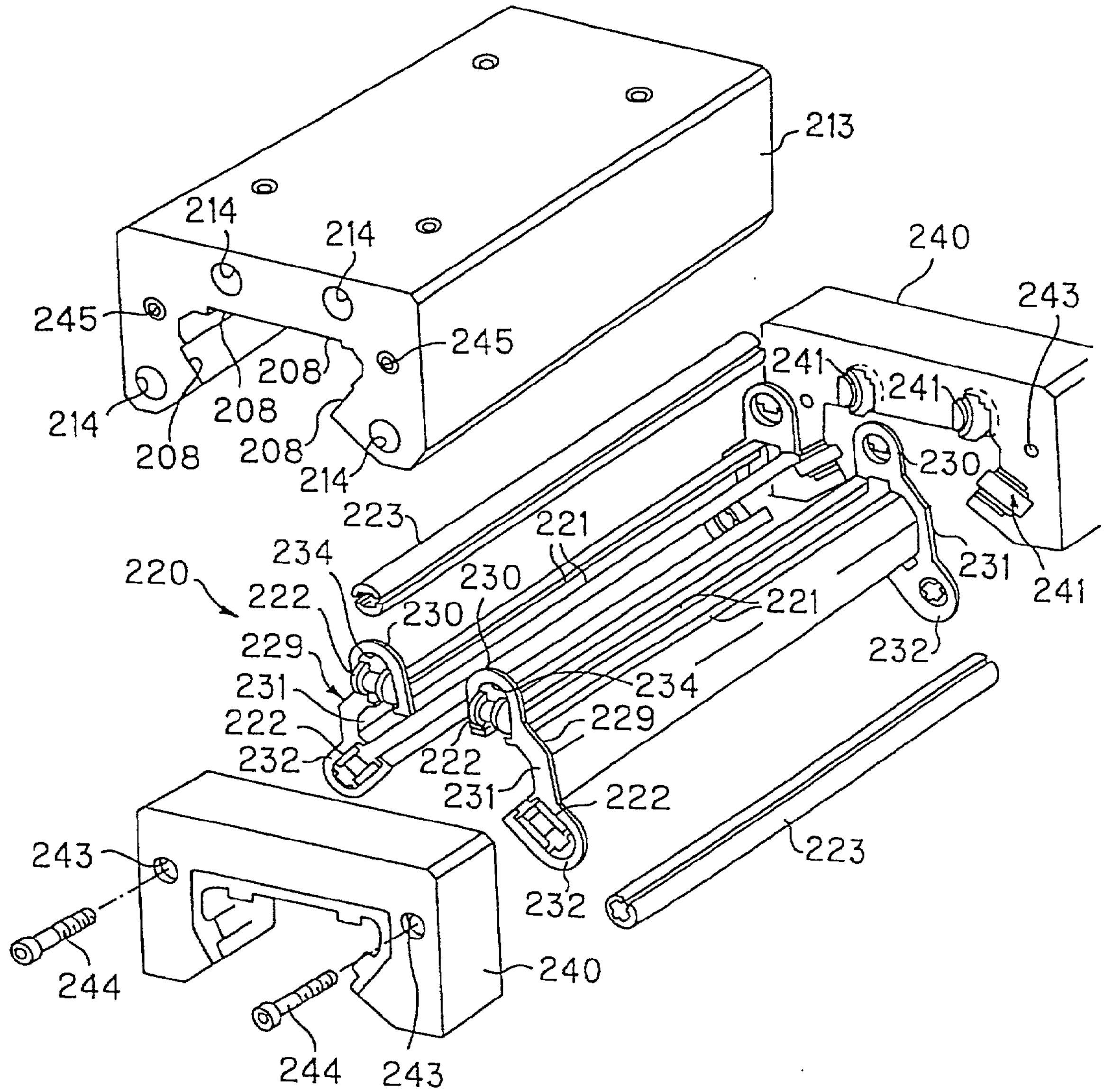

213
214
214
214
214
245
245
208
208
208
208
240
243
241
241
241
230
223
221
221
231
232
220
234
222
230
229
231
222
232
230
234
229
222
231
222
232
223
243
244
240
244
243

FIG. 19(a)

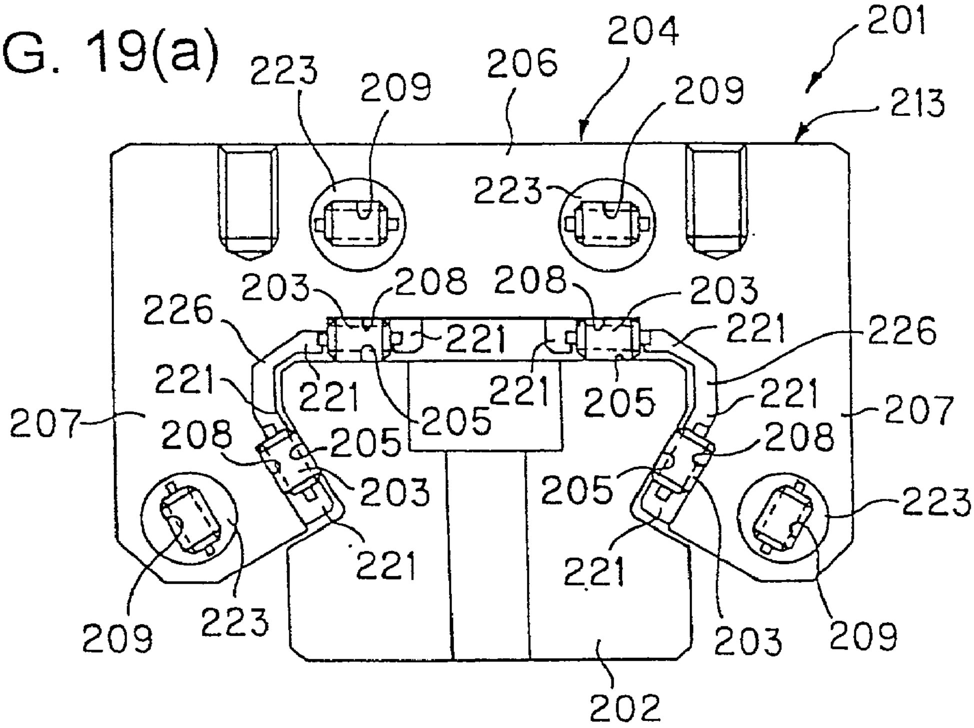


FIG. 19(b)

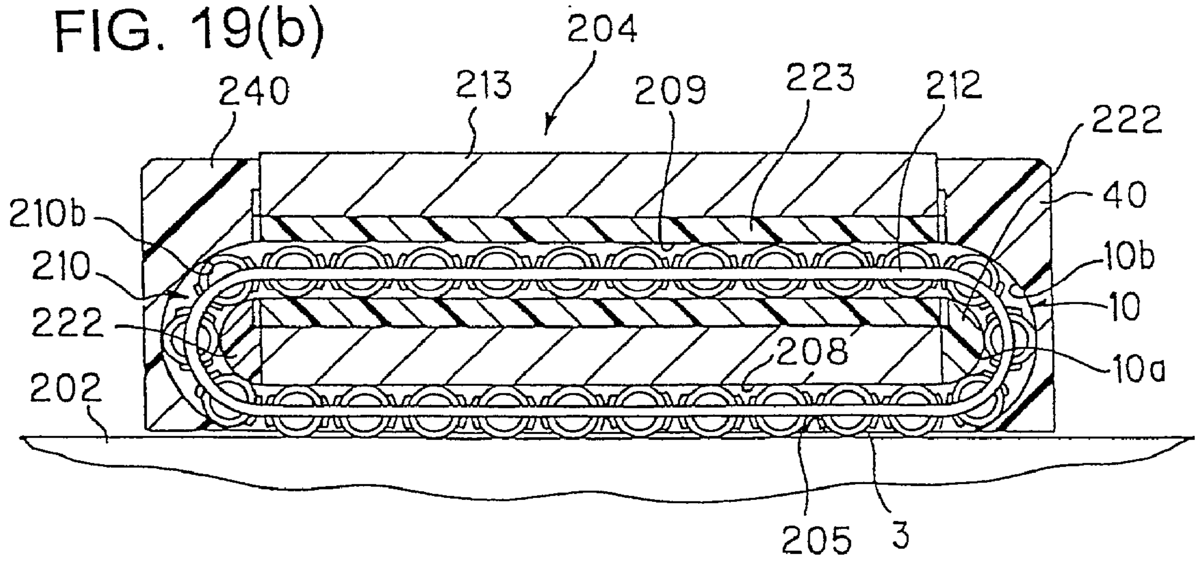


FIG. 19(c)

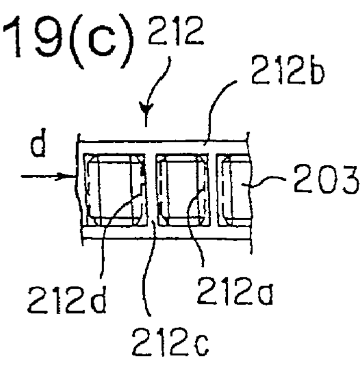
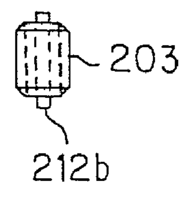


FIG. 19(d)



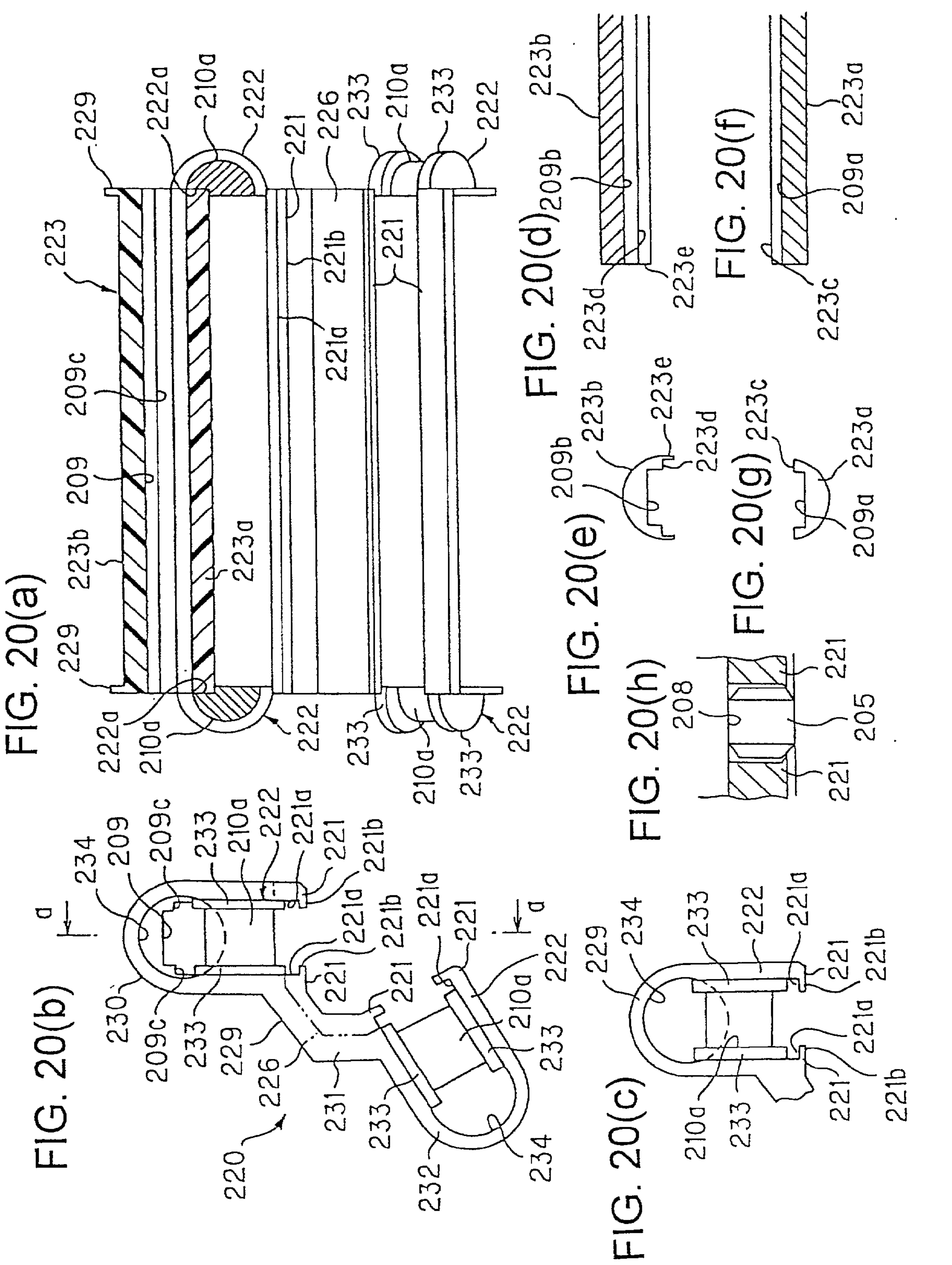


FIG. 20(a)

FIG. 20(b)

FIG. 20(c)

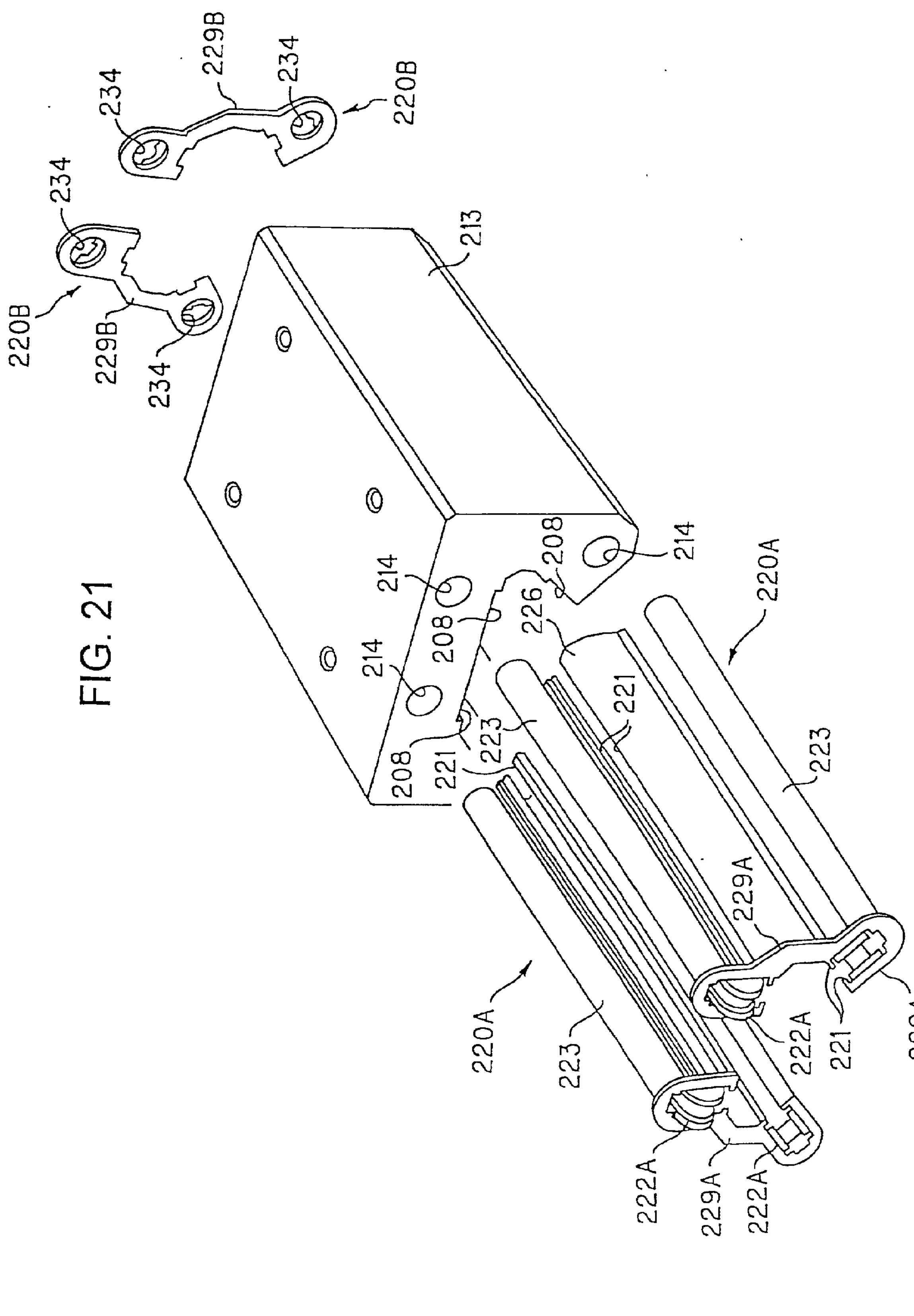
FIG. 20(d)

FIG. 20(e)

FIG. 20(f)

FIG. 20(g)

FIG. 20(h)



220B
229B
234
234
229B
234
220B
234
213
214
208
214
208
214
208
226
223
221
221
223
220A
220A
223
229A
222A
221
222A
222A
229A
222A

FIG. 21

FIG. 22(a)

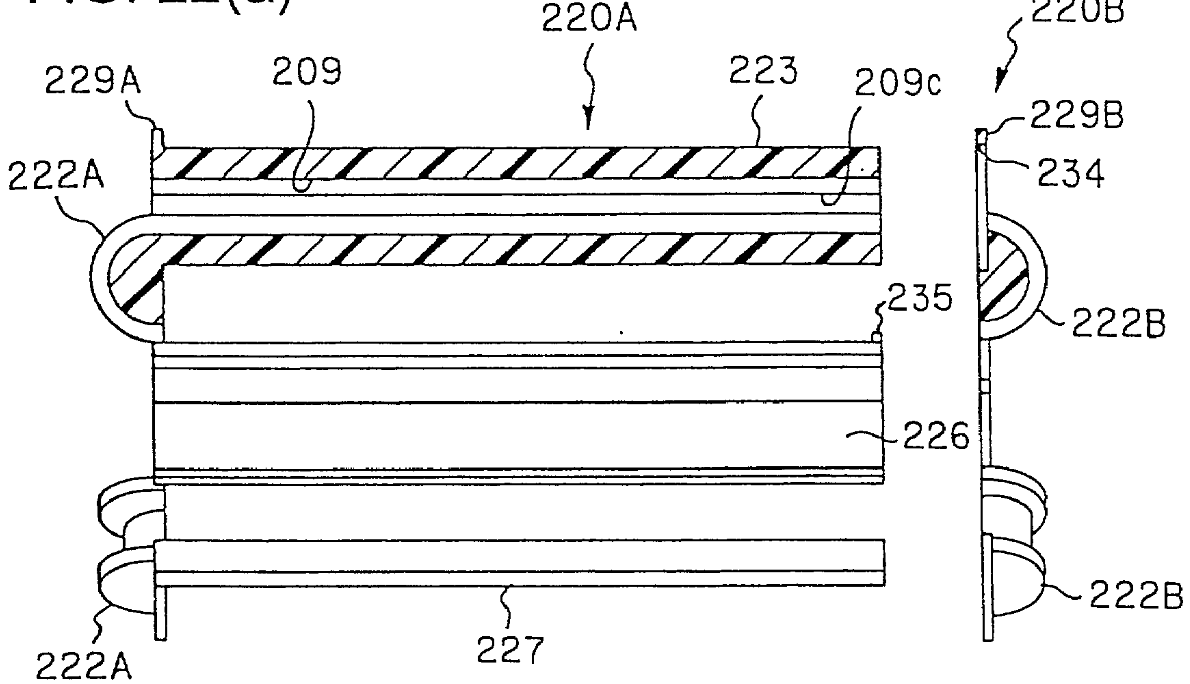


FIG. 22(b)

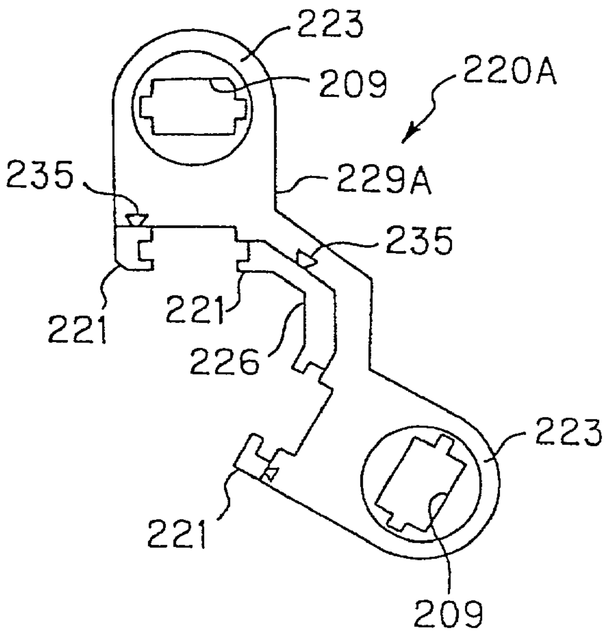
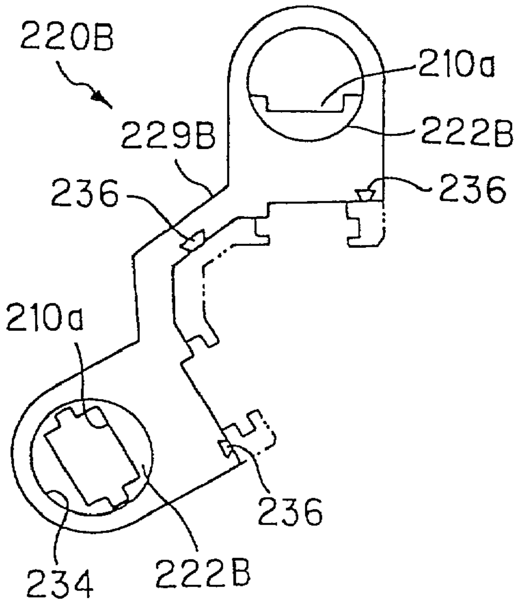


FIG. 22(c)



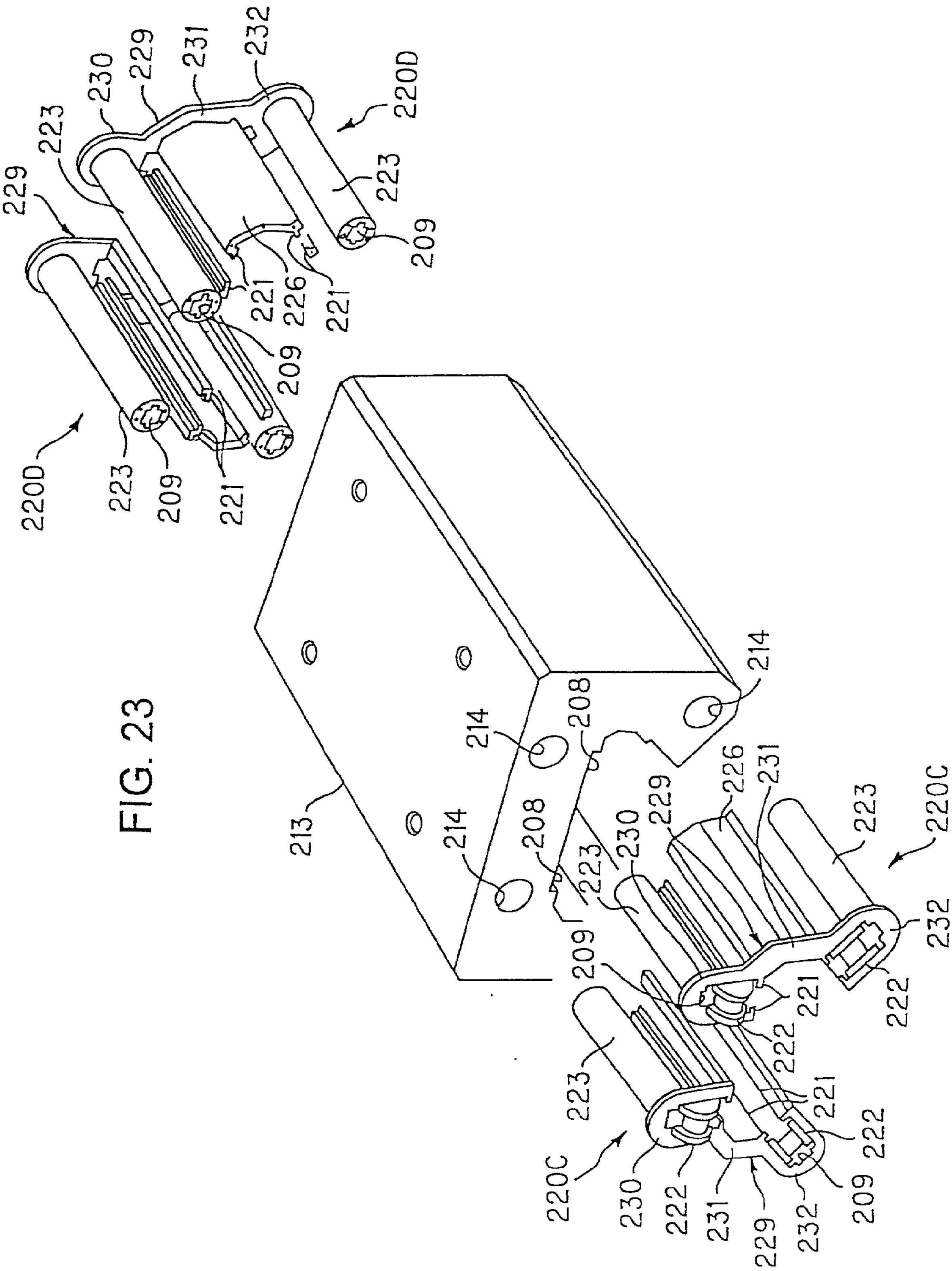

229
223
230
229
231
232
220D
223
209
221
226
221
209
220D
223
209
221
213
214
208
214
208
214
223
230
229
226
231
223
220C
232
222
221
209
222
223
221
222
220C
230
222
231
229
232
209

FIG. 23

FIG. 24(a)

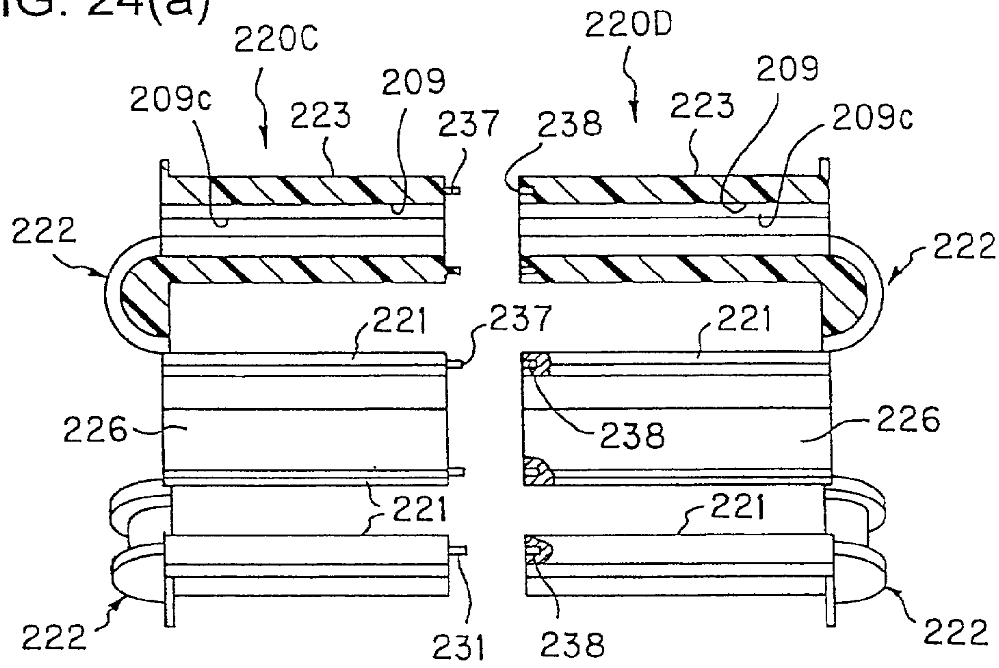


FIG. 24(b)

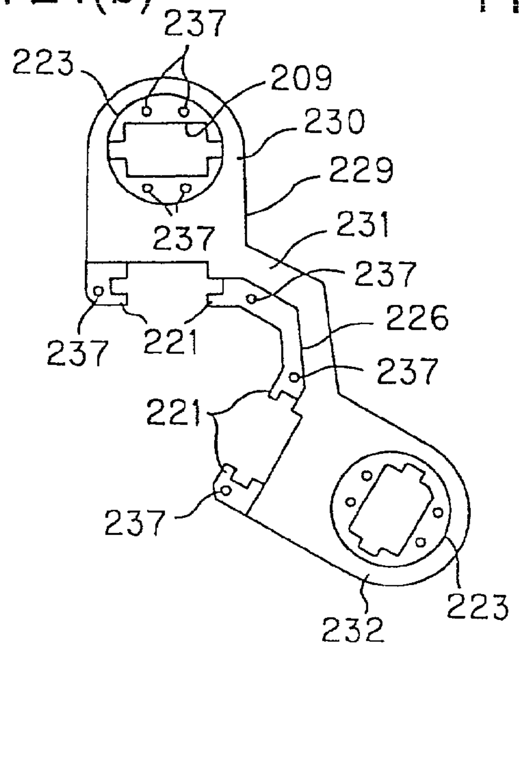


FIG. 24(c)

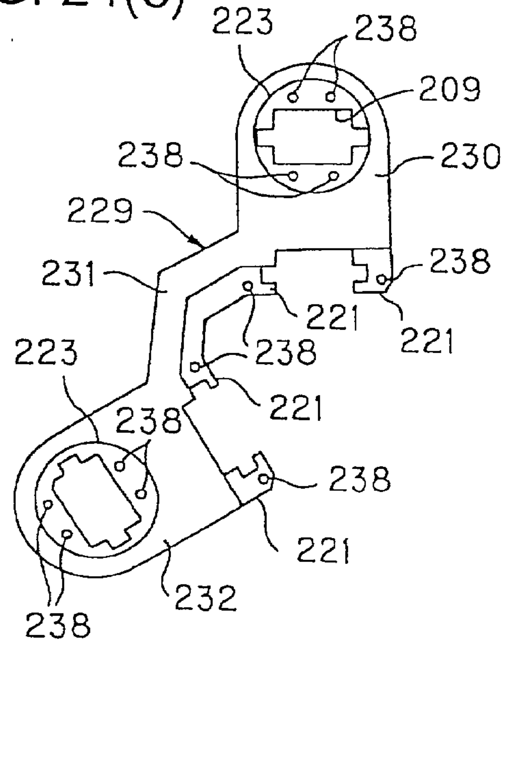


FIG. 25

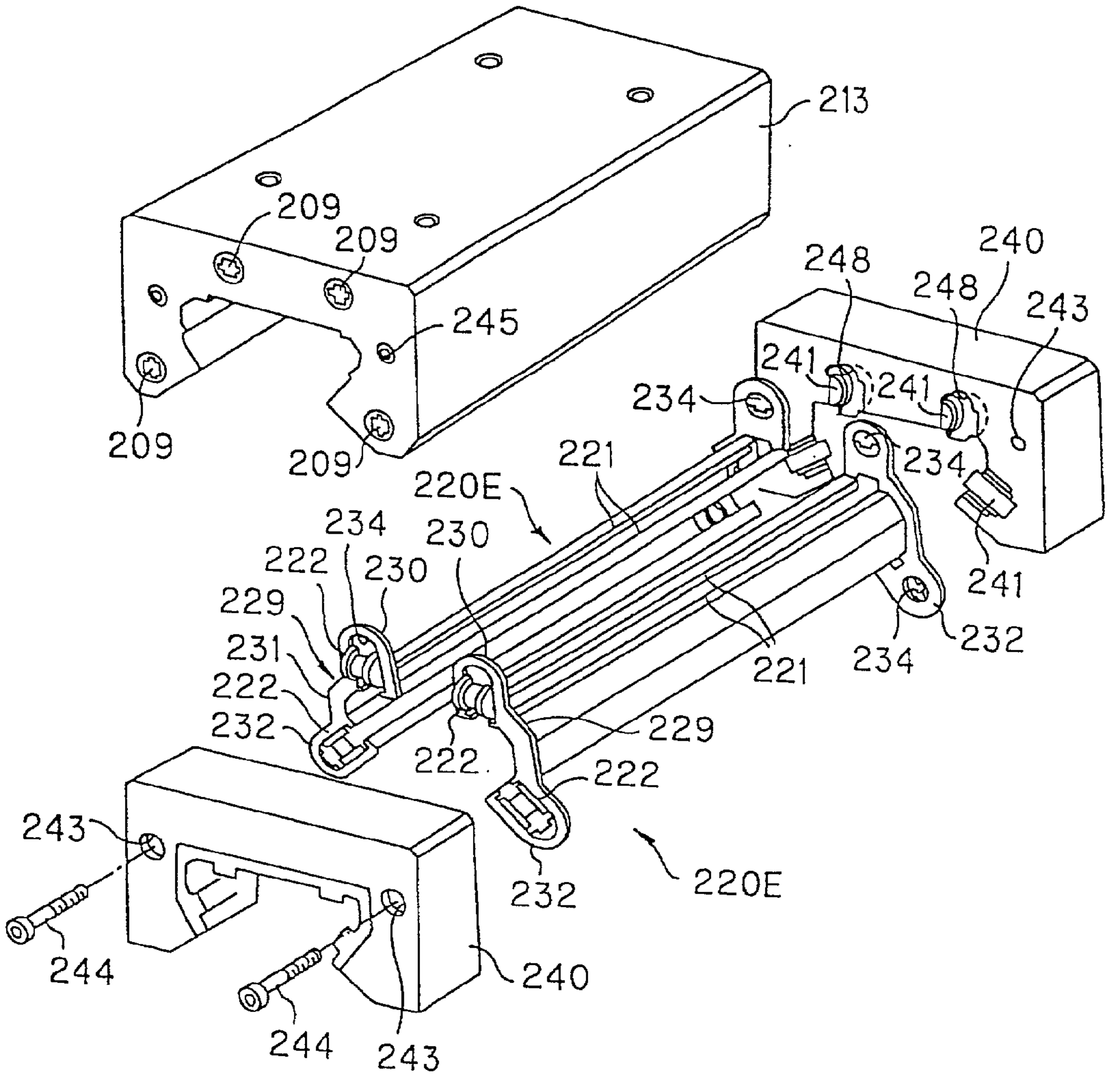

213
209
209
245
209
209
240
248
248
243
241
241
234
234
221
220E
241
234
230
222
230
229
231
222
232
221
234
232
229
222
222
243
232
220E
244
240
244
243

FIG. 26

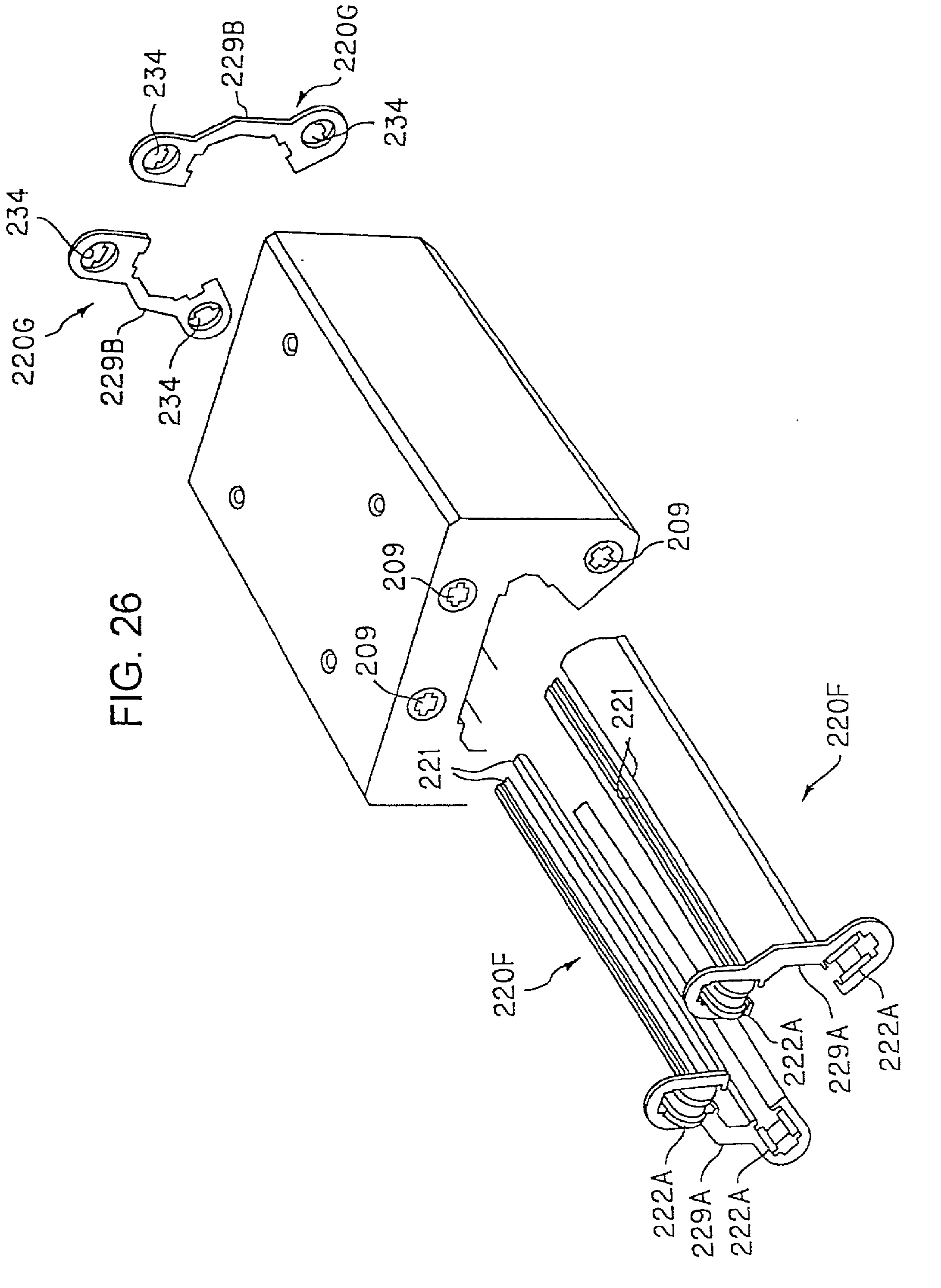
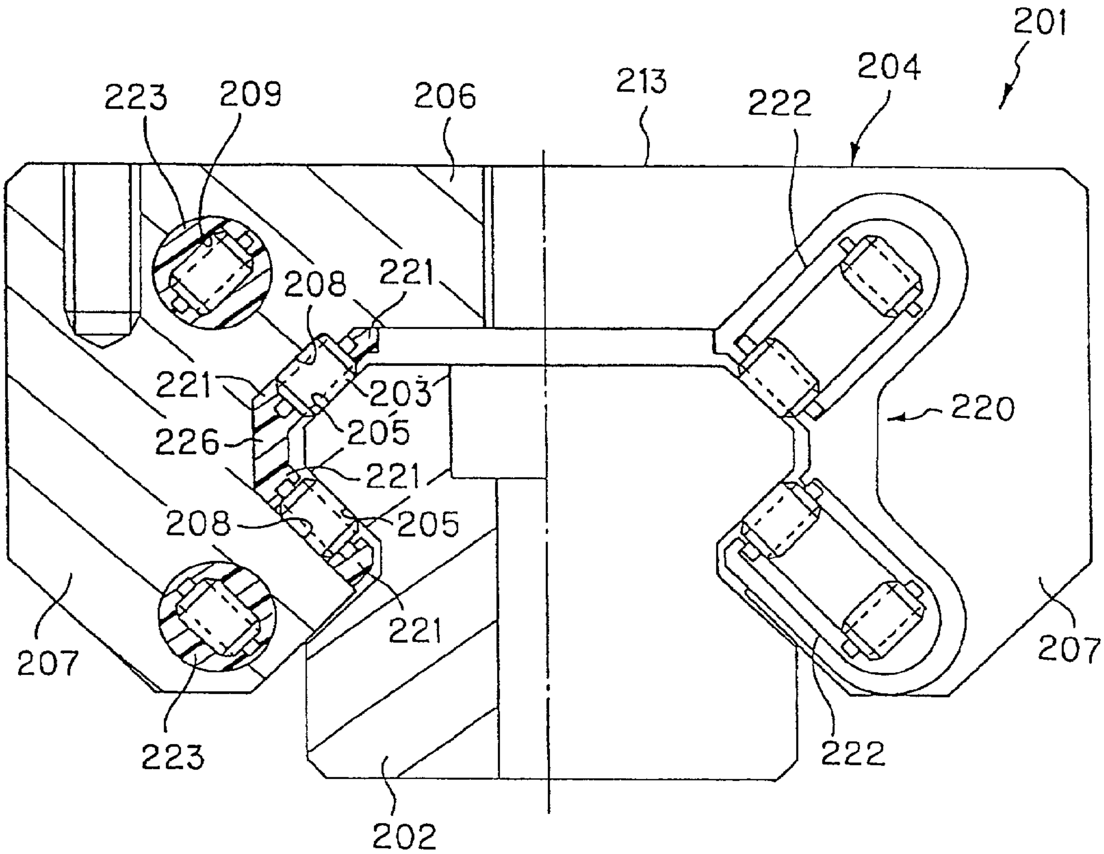

220G
229B
234
234
234
234
229B
220G
209
209
209
221
221
220F
220F
222A
229A
222A
222A
229A
222A

FIG. 27



201
204
222
213
206
209
223
208
221
221
203
226
205
221
208
205
221
220
207
207
223
222
202

FIG. 28

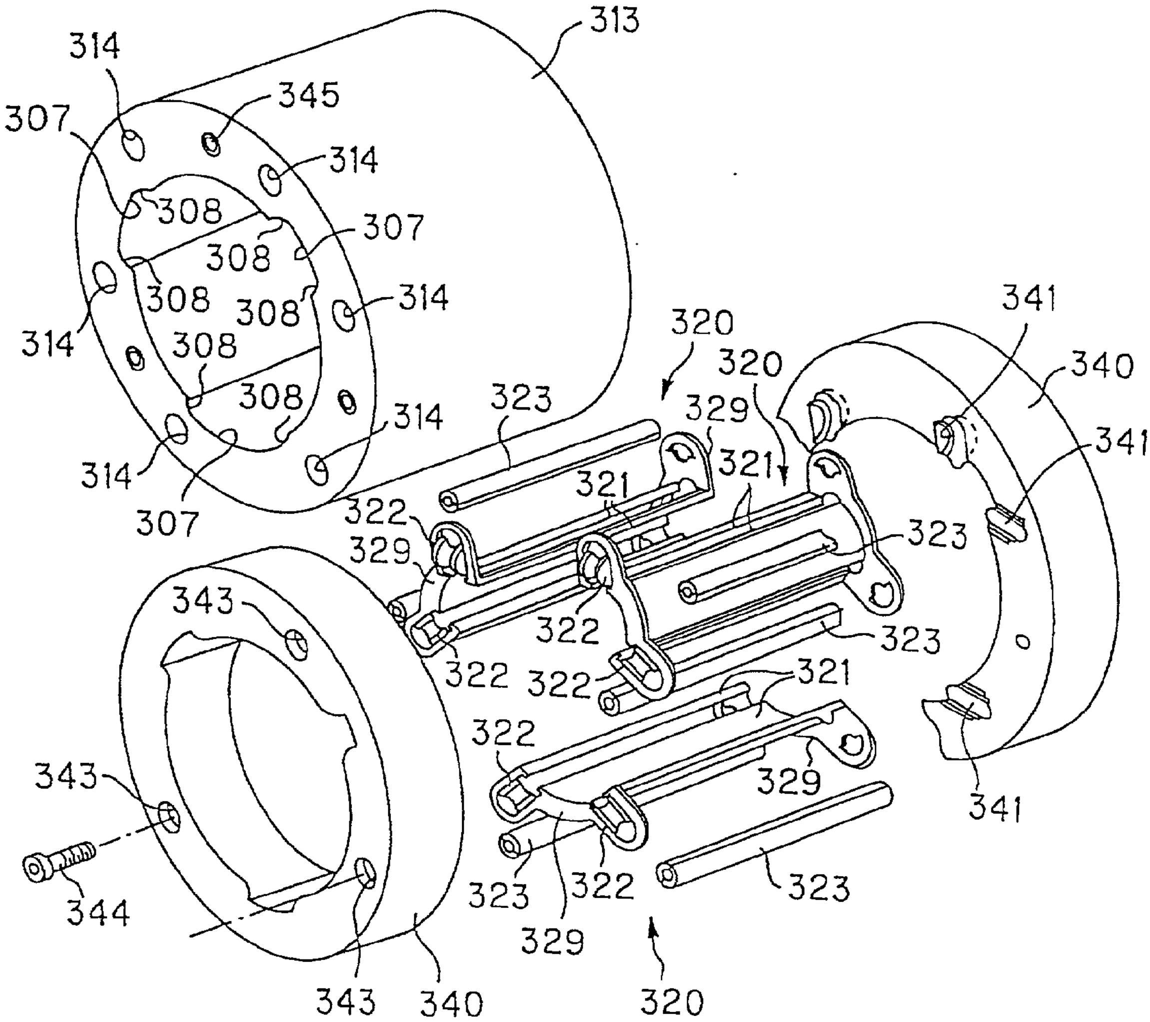

313
314
345
307
314
308
307
308
314
308
308
314
308
308
314
314
307
320
320
341
340
341
323
329
321
321
323
322
329
343
322
323
322
322
321
343
322
329
341
323
322
323
344
323
329
343
340
320

FIG. 29(a)

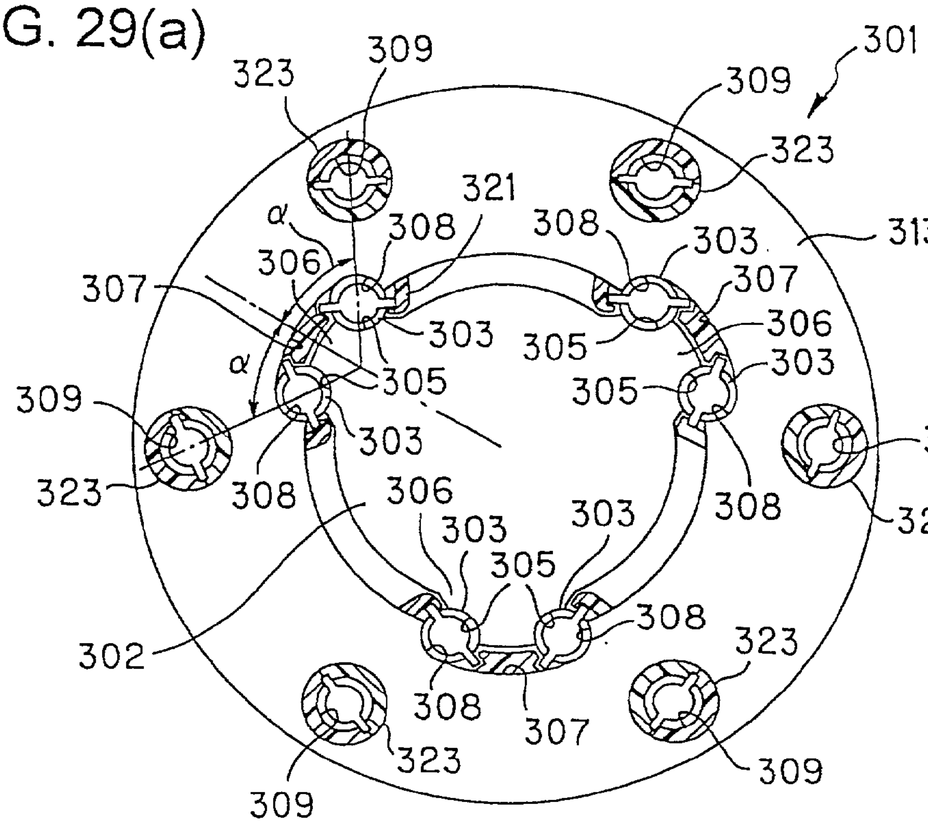


FIG. 29(b)

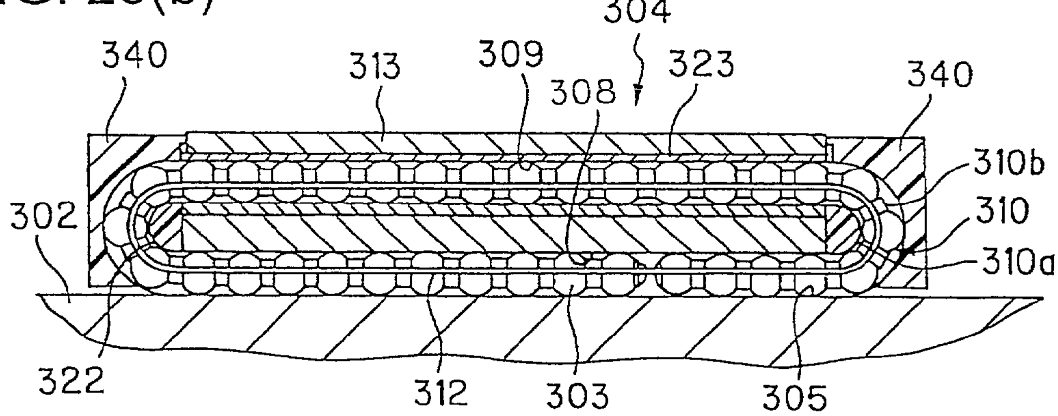
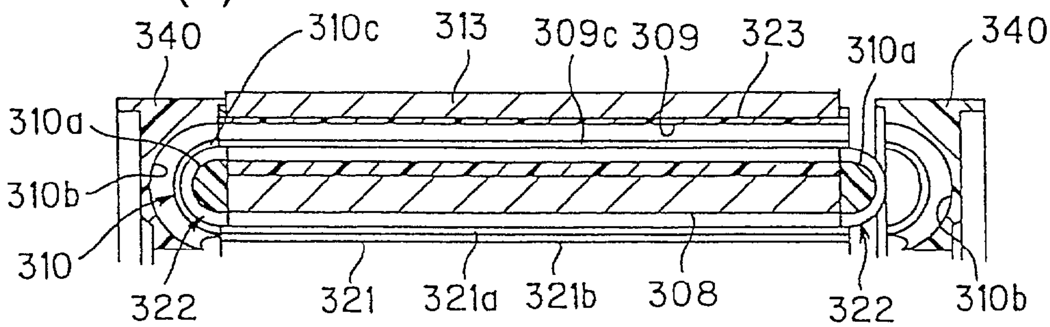


FIG. 29(c)



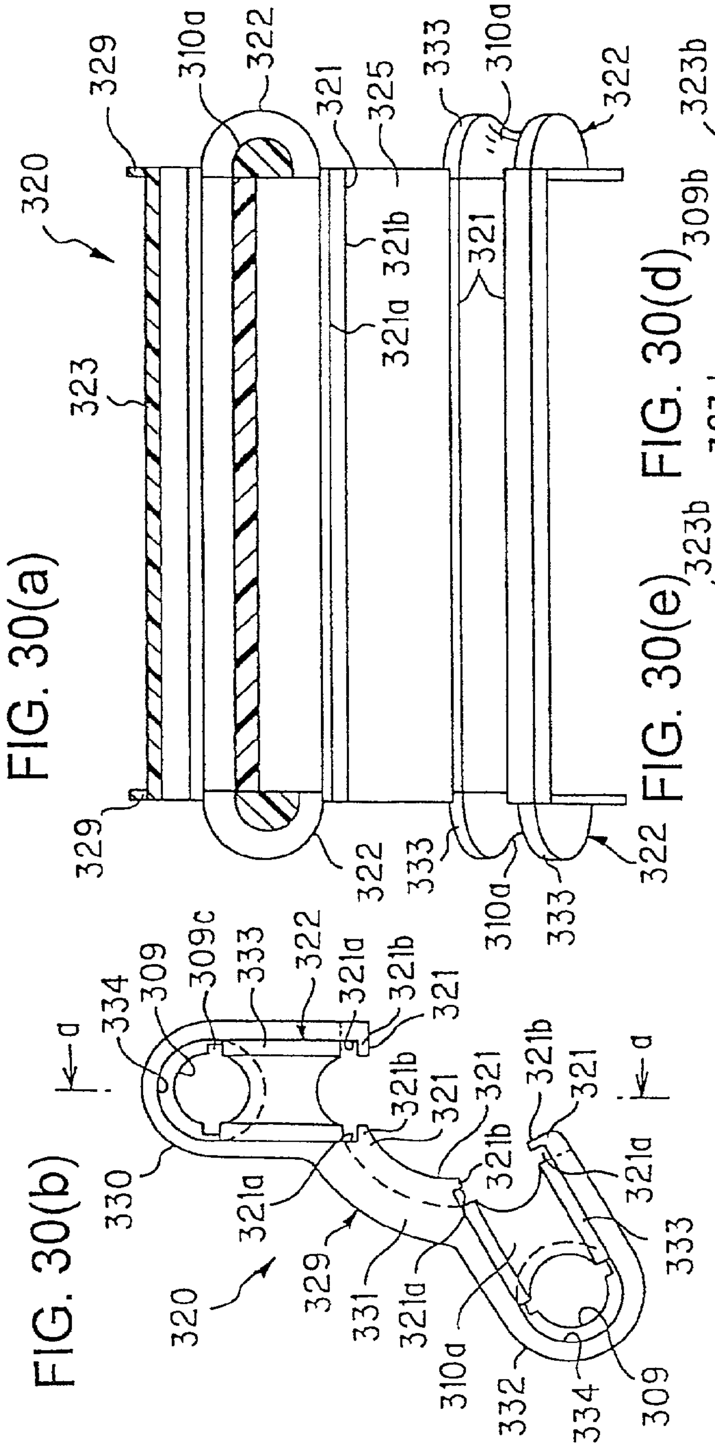


FIG. 30(a)

FIG. 30(b)

FIG. 30(c)

FIG. 30(d)

FIG. 30(e)

FIG. 30(f)

FIG. 30(g)

FIG. 31

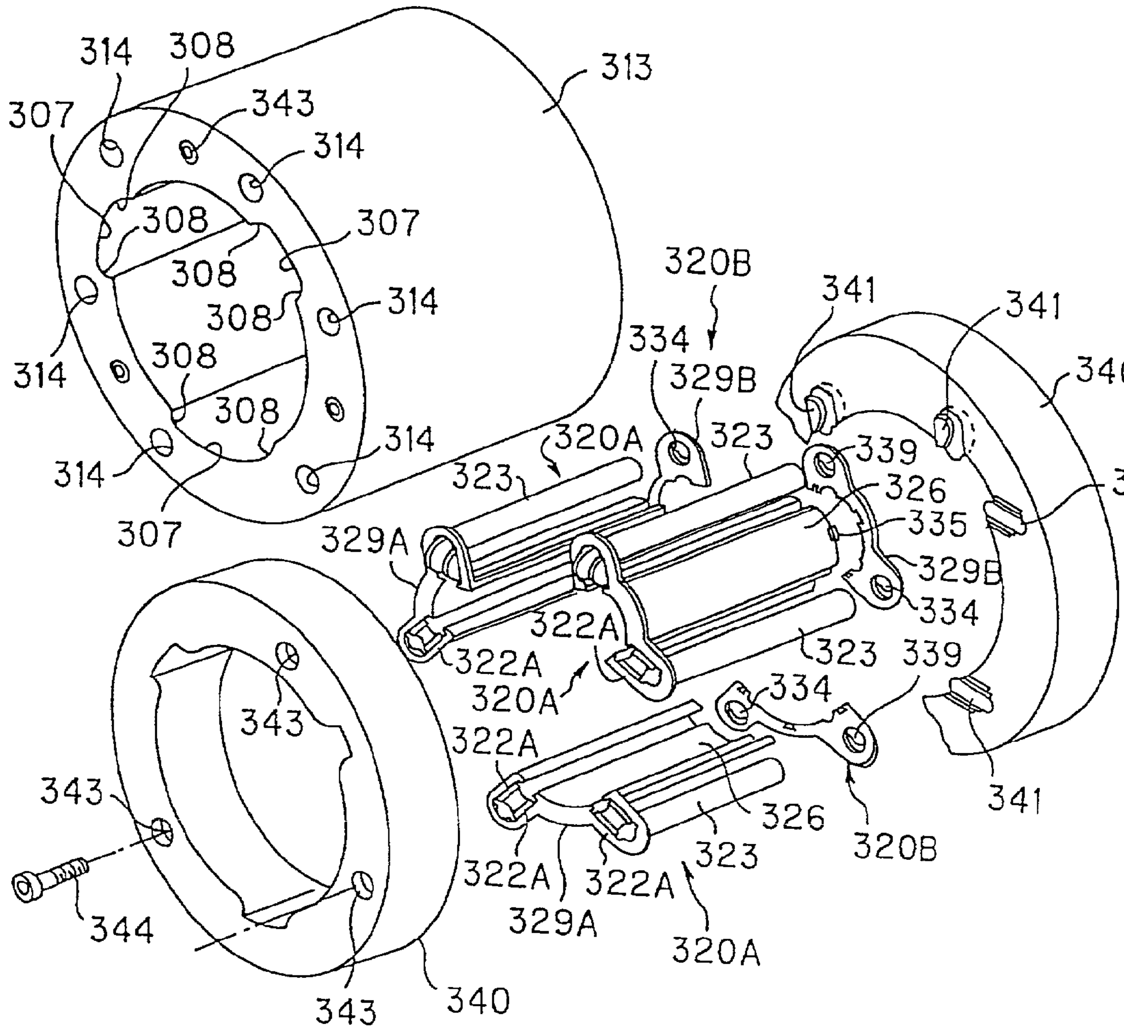

314
308
313
307
343
314
308
307
308
308
314
314
308
308
314
307
314
320B
341
341
334
329B
340
320A
323
323
339
326
335
341
329A
329B
334
322A
323
339
322A
334
320A
343
322A
343
326
320B
341
323
322A
322A
344
329A
320A
343
340

FIG. 32(a)

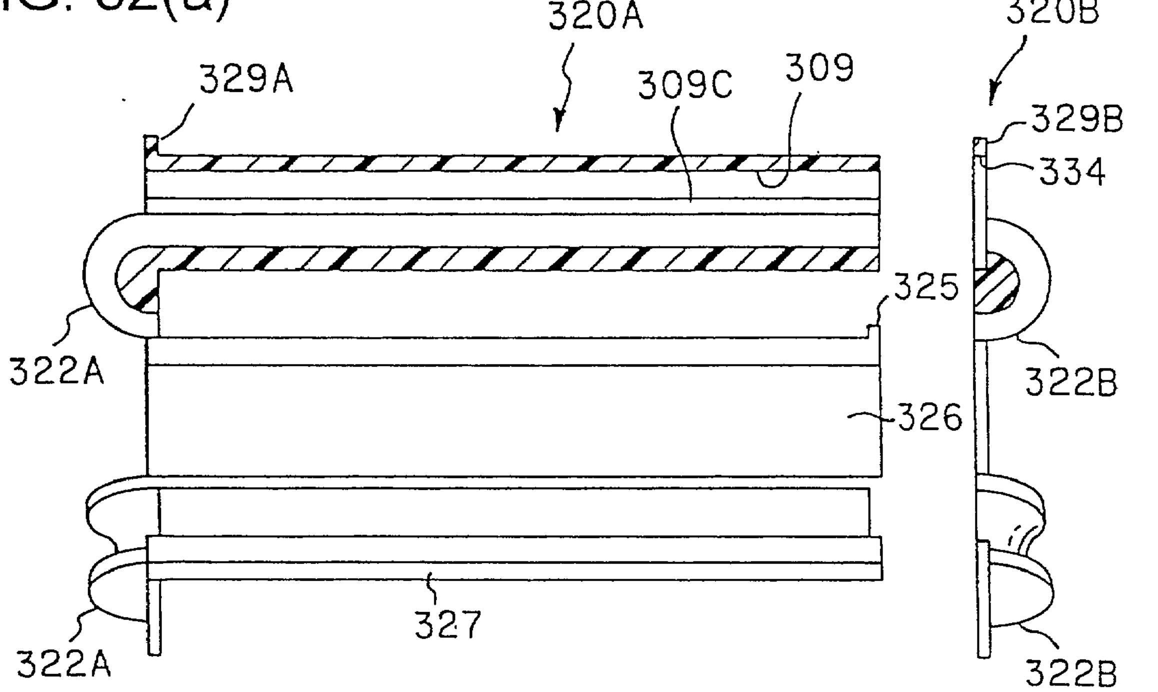


FIG. 32(b)

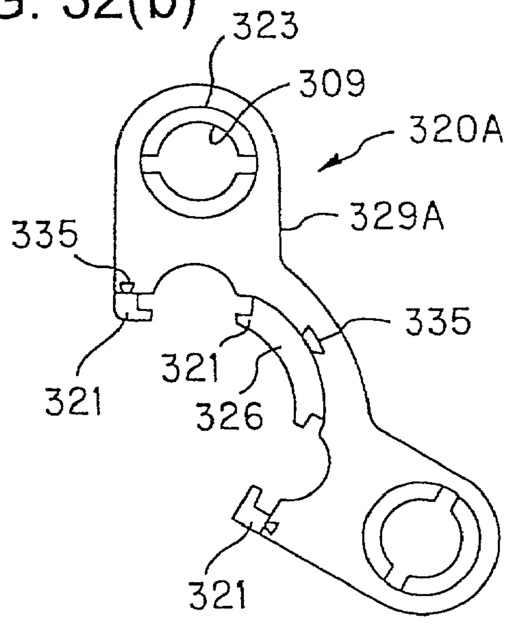


FIG. 32(c)

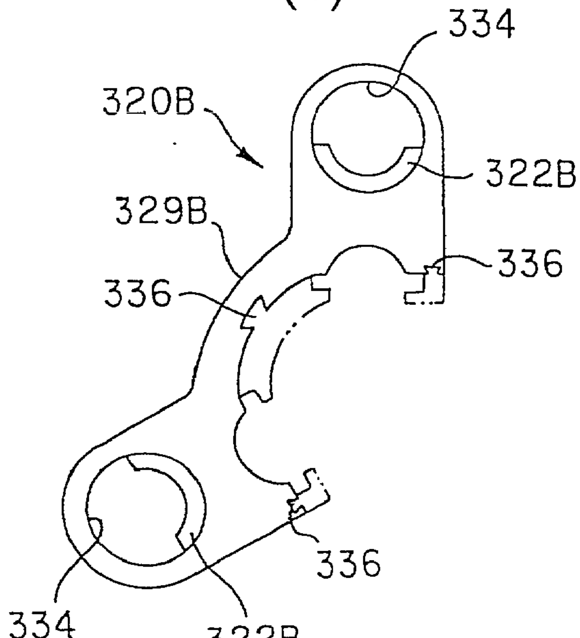
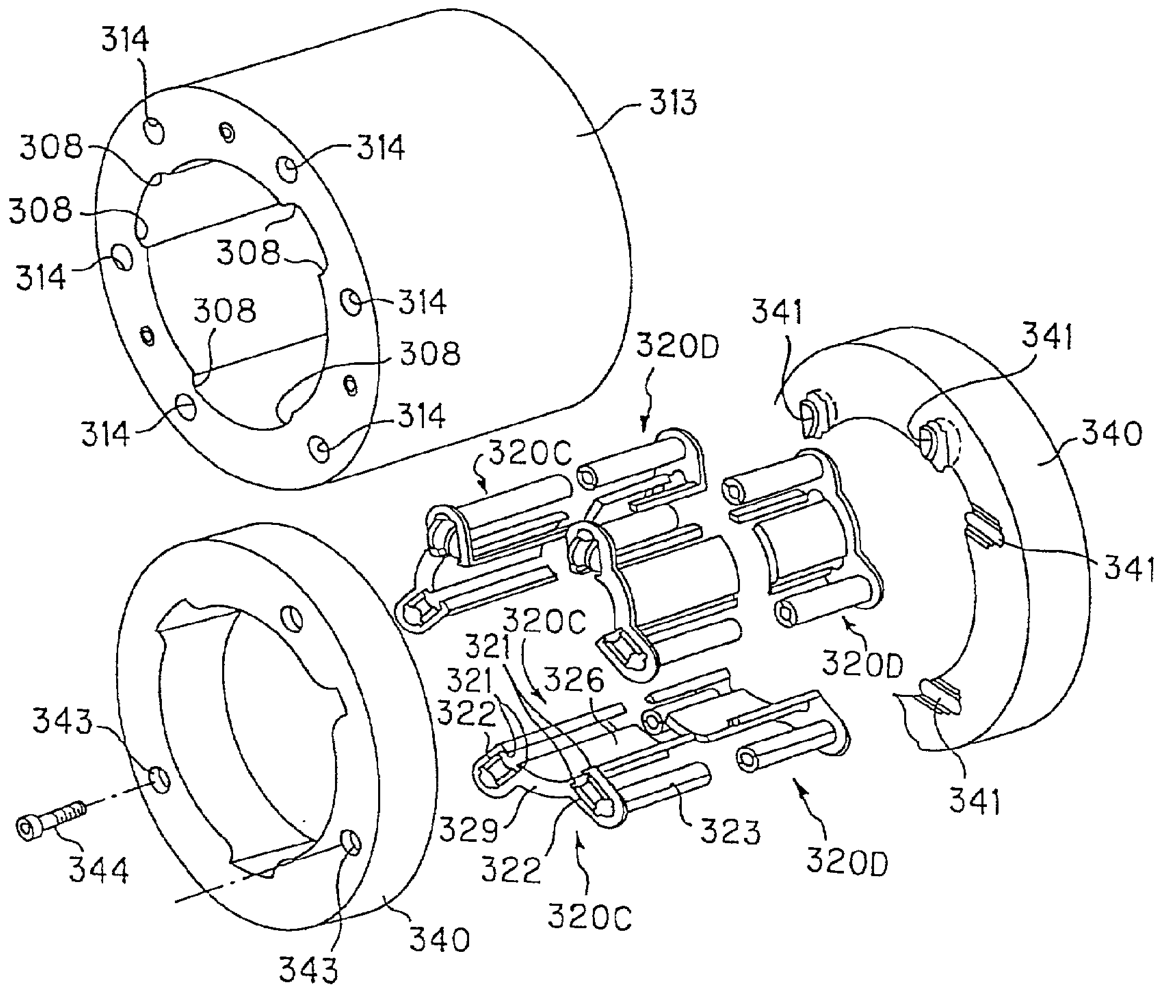


FIG. 33



314
308
313
314
308
308
314
314
308
308
341
320D
341
314
314
340
320C
341
320C
320D
321
321
326
322
343
341
329
323
320D
344
322
320C
340
343

FIG. 34(a)

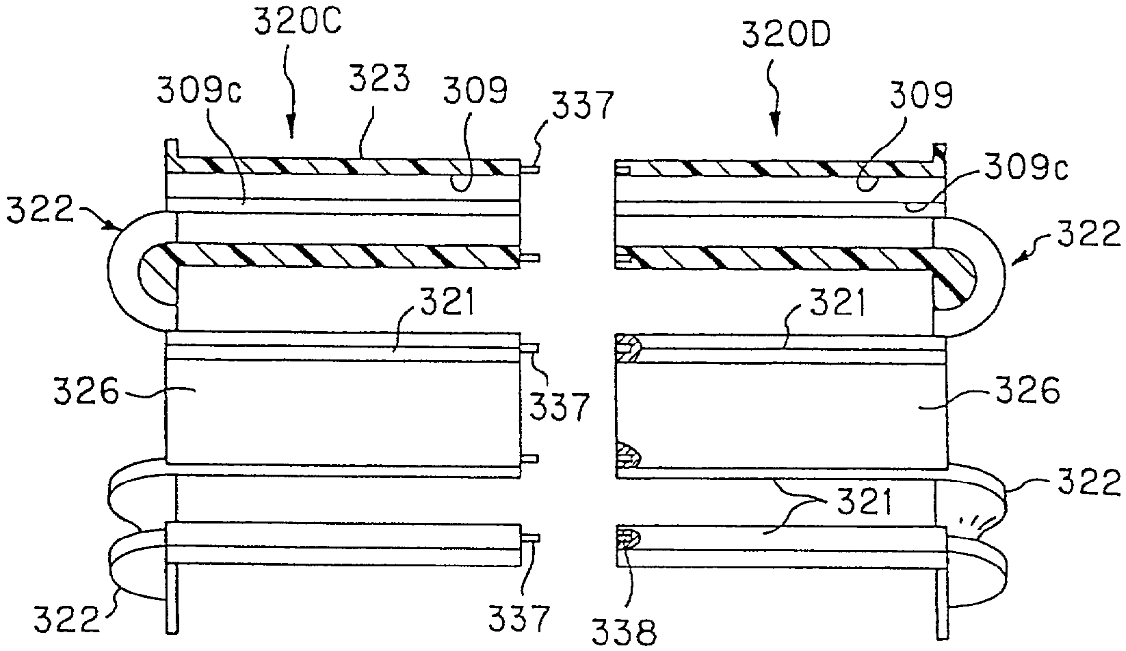


FIG. 34(b)

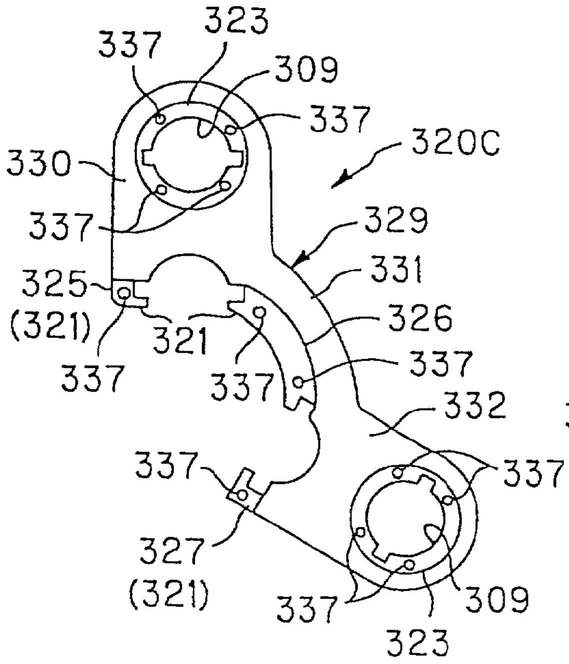


FIG. 34(c)

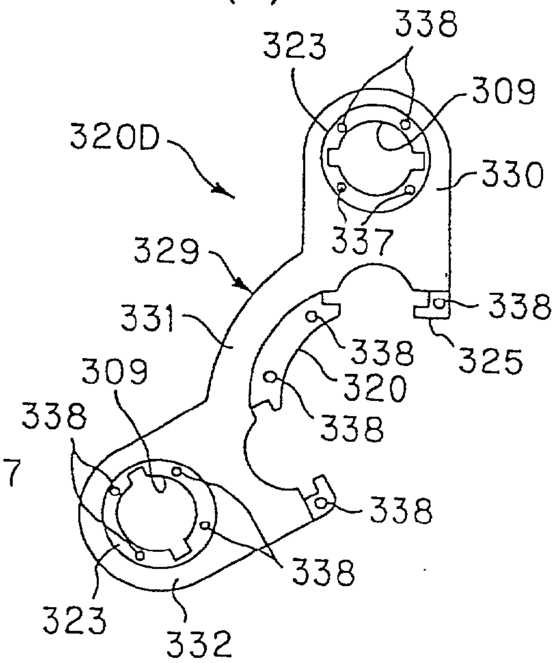


FIG. 35

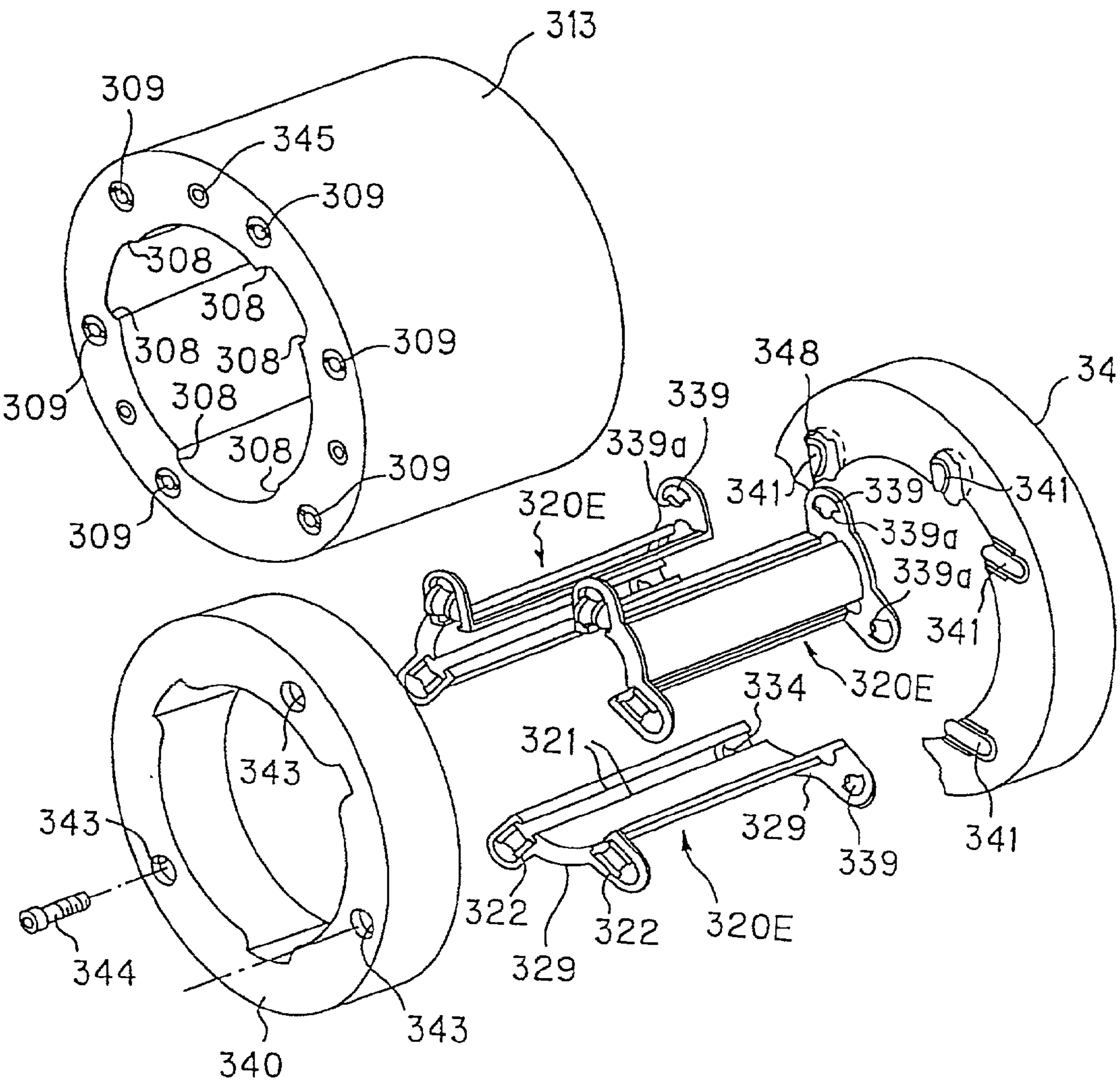

313
309
345
309
308
308
308
308
309
309
308
308
309
309
348
340
339
339a
320E
341
339
341
339a
339a
341
320E
334
321
343
343
329
339
341
343
322
322
320E
329
344
343
340

FIG. 36

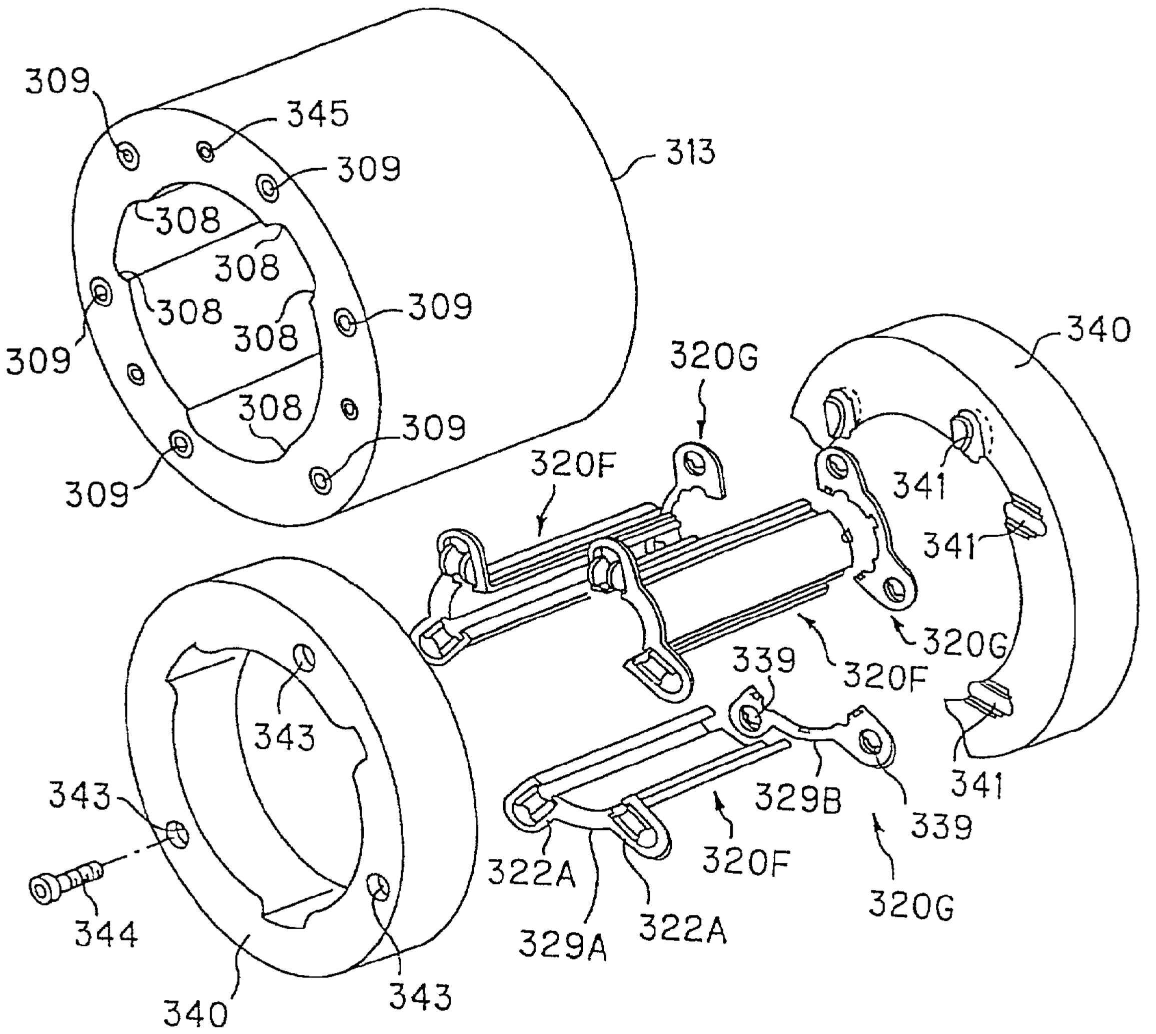

309
345
309
313
308
308
308
308
309
309
308
309
309
340
320G
320F
341
341
320G
339
320F
343
343
329B
339
341
343
322A
320F
320G
322A
329A
344
340
343

FIG. 37

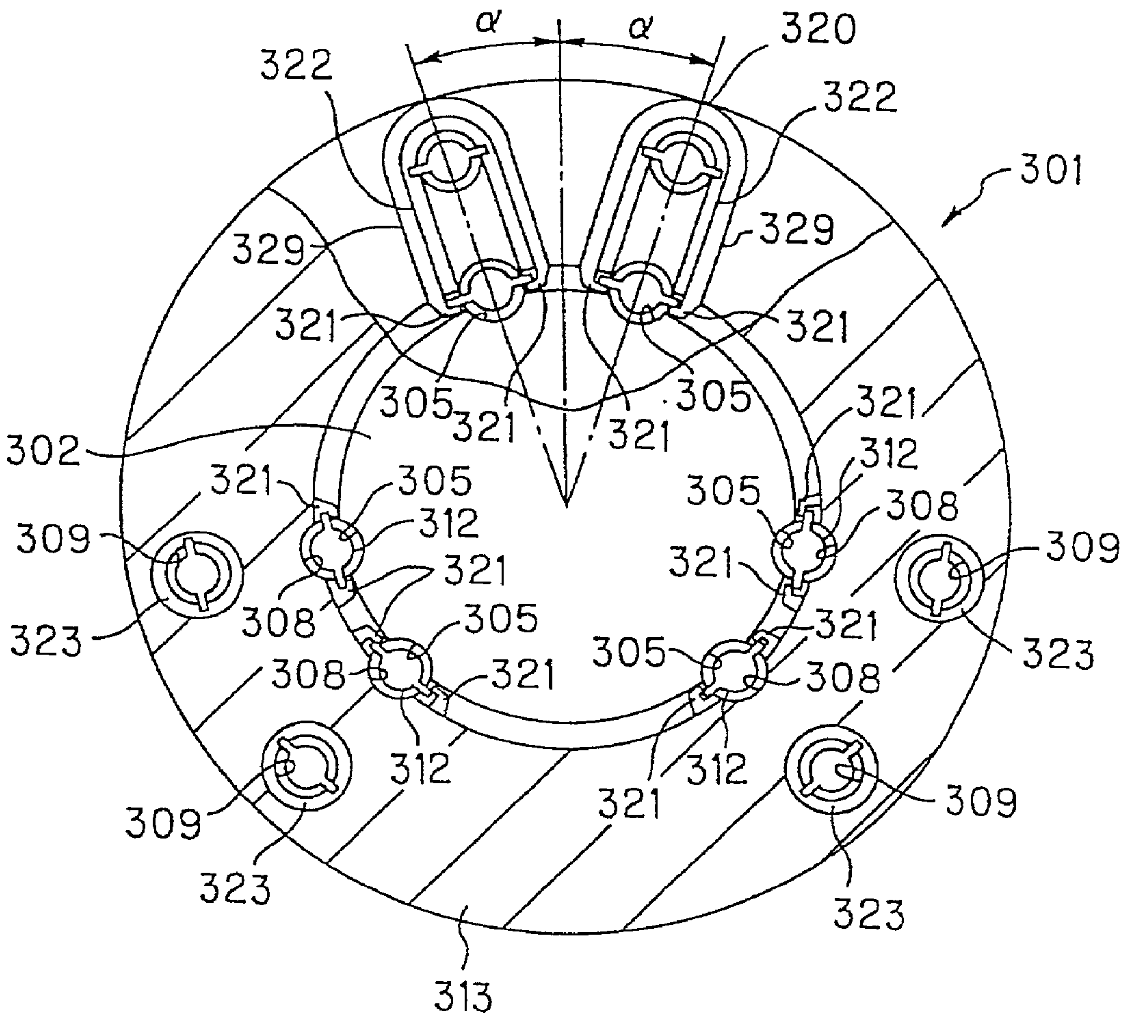

α
α
320
322
322
301
329
329
321
321
305
305
305
321
321
321
302
312
321
305
305
308
309
312
309
321
321
308
308
321
305
305
321
323
323
308
321
308
312
312
309
321
309
323
323
313

FIG. 38(a)

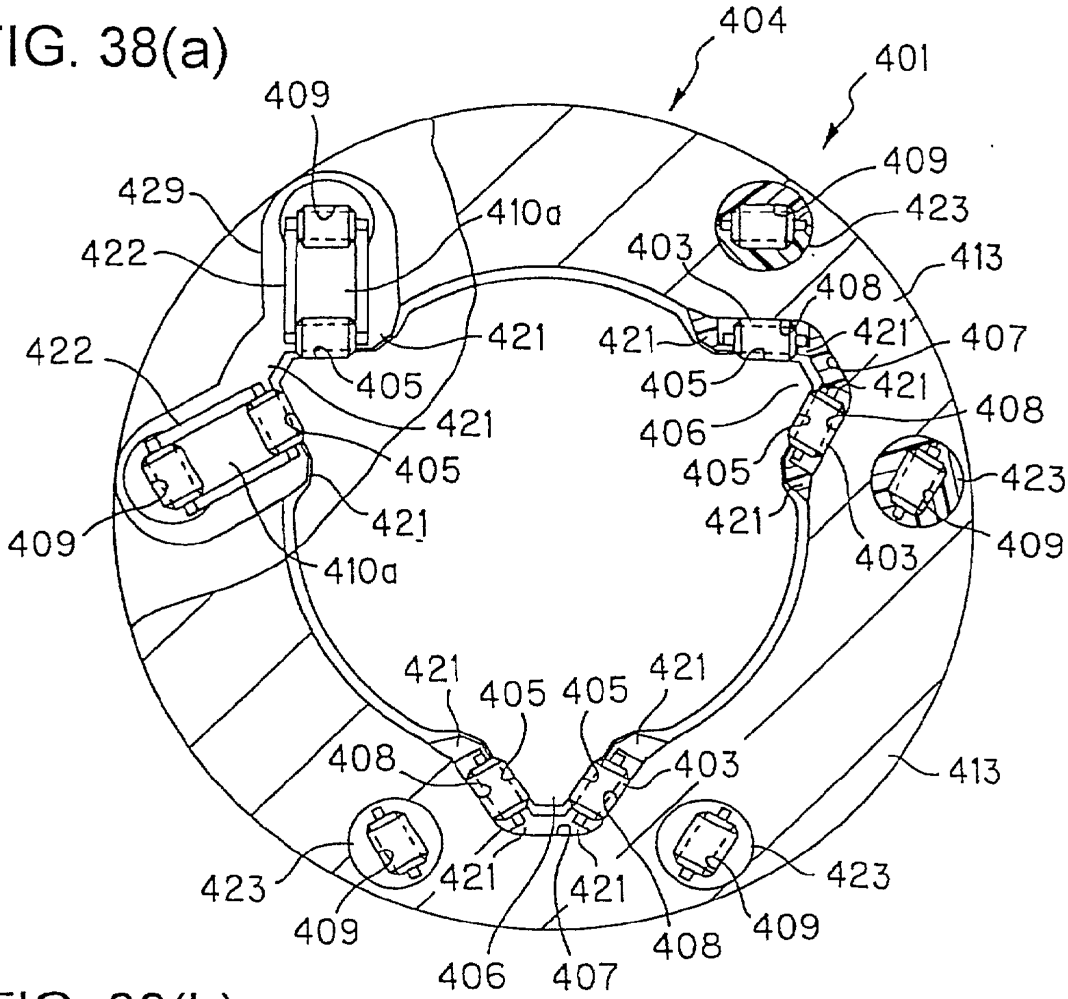


FIG. 38(b)

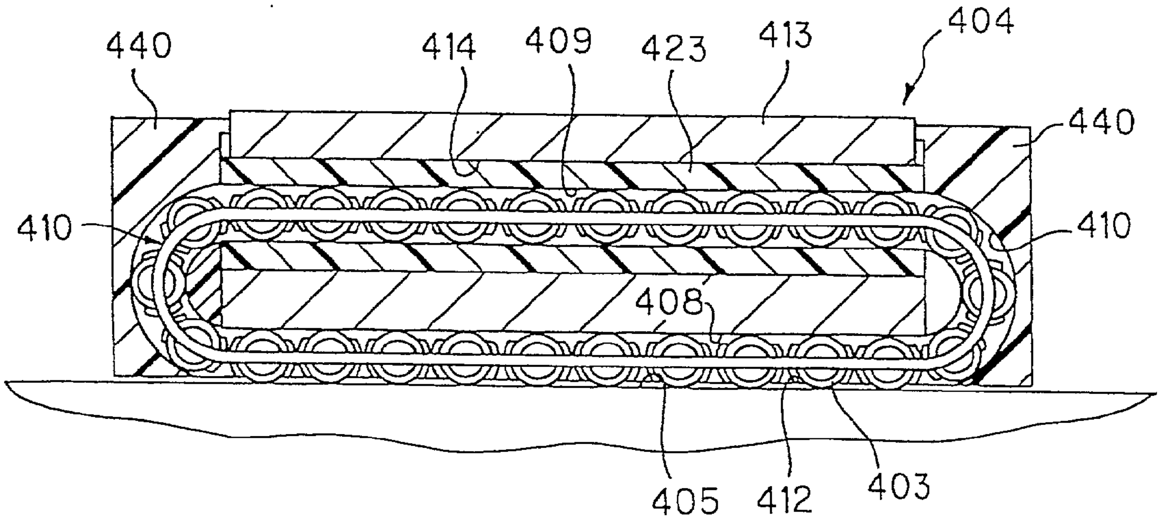


FIG. 39(a)

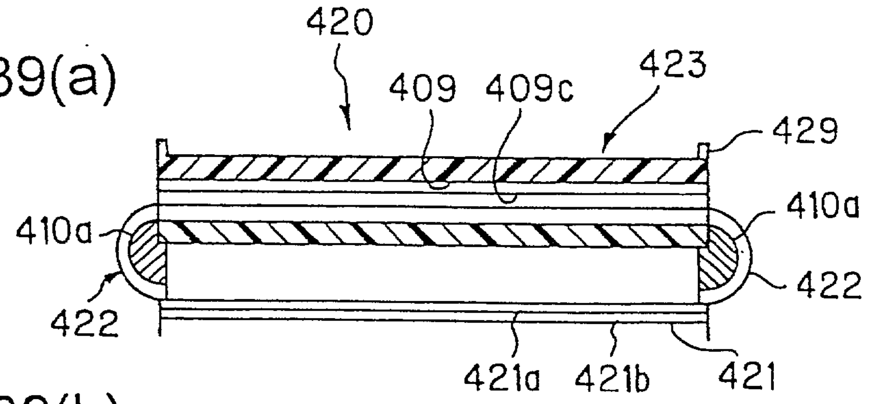


FIG. 39(b)

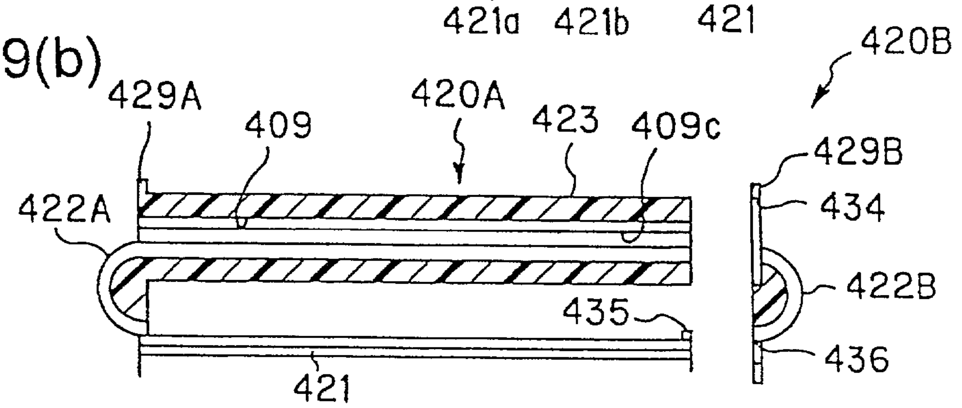


FIG. 39(c)

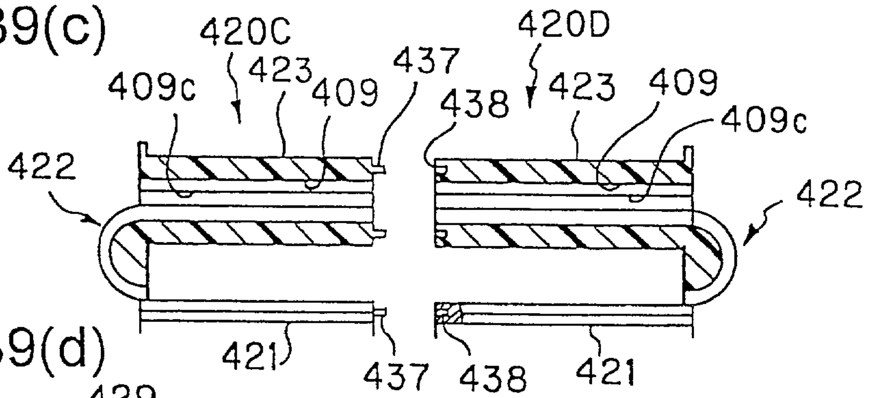


FIG. 39(d)

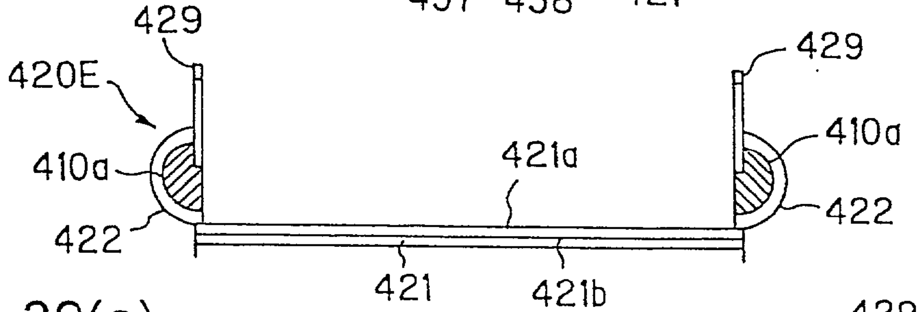


FIG. 39(e)

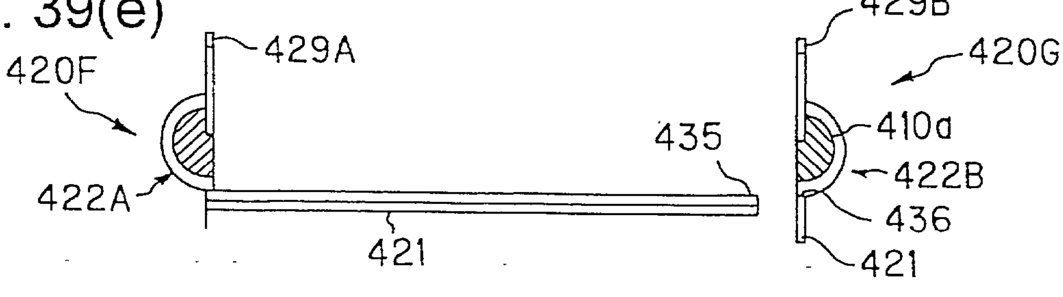


FIG.40(a)

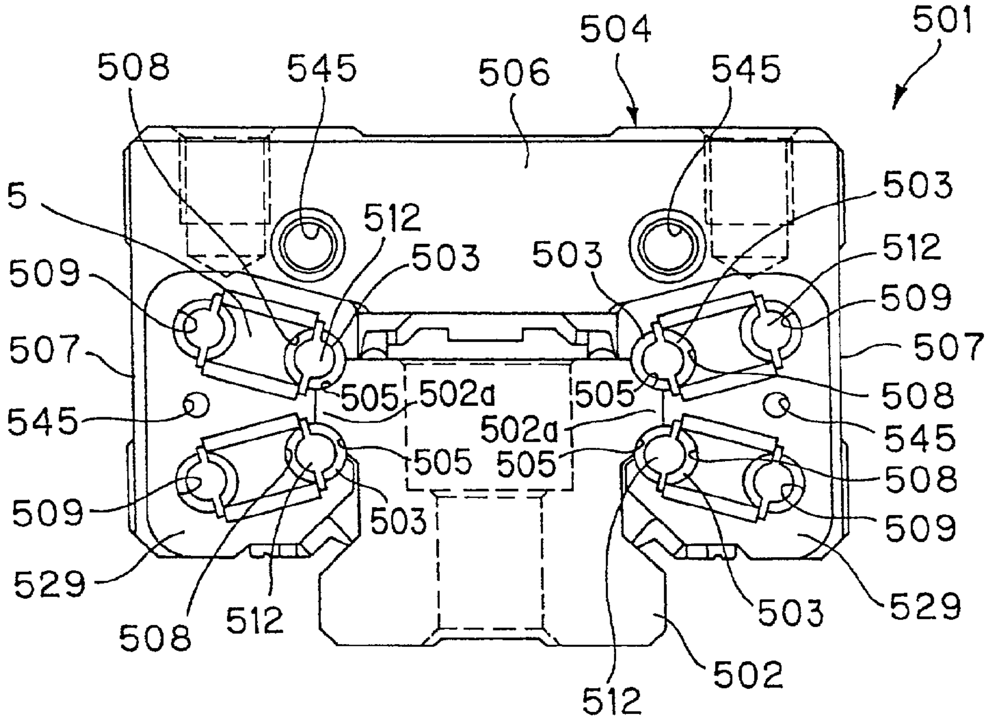


FIG.40(b)

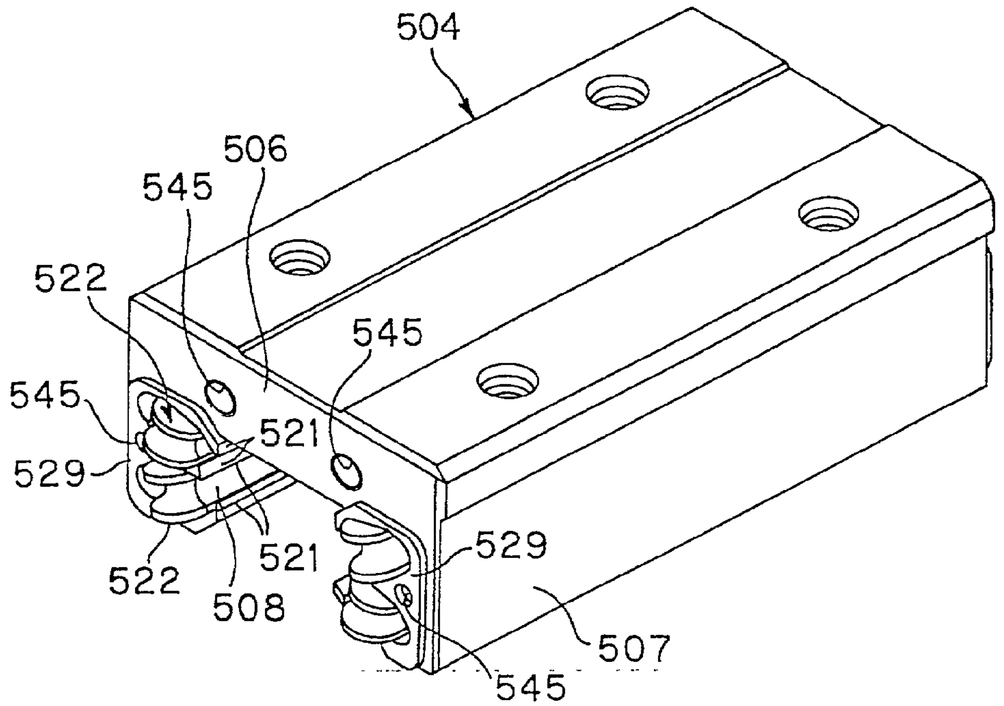


FIG.41

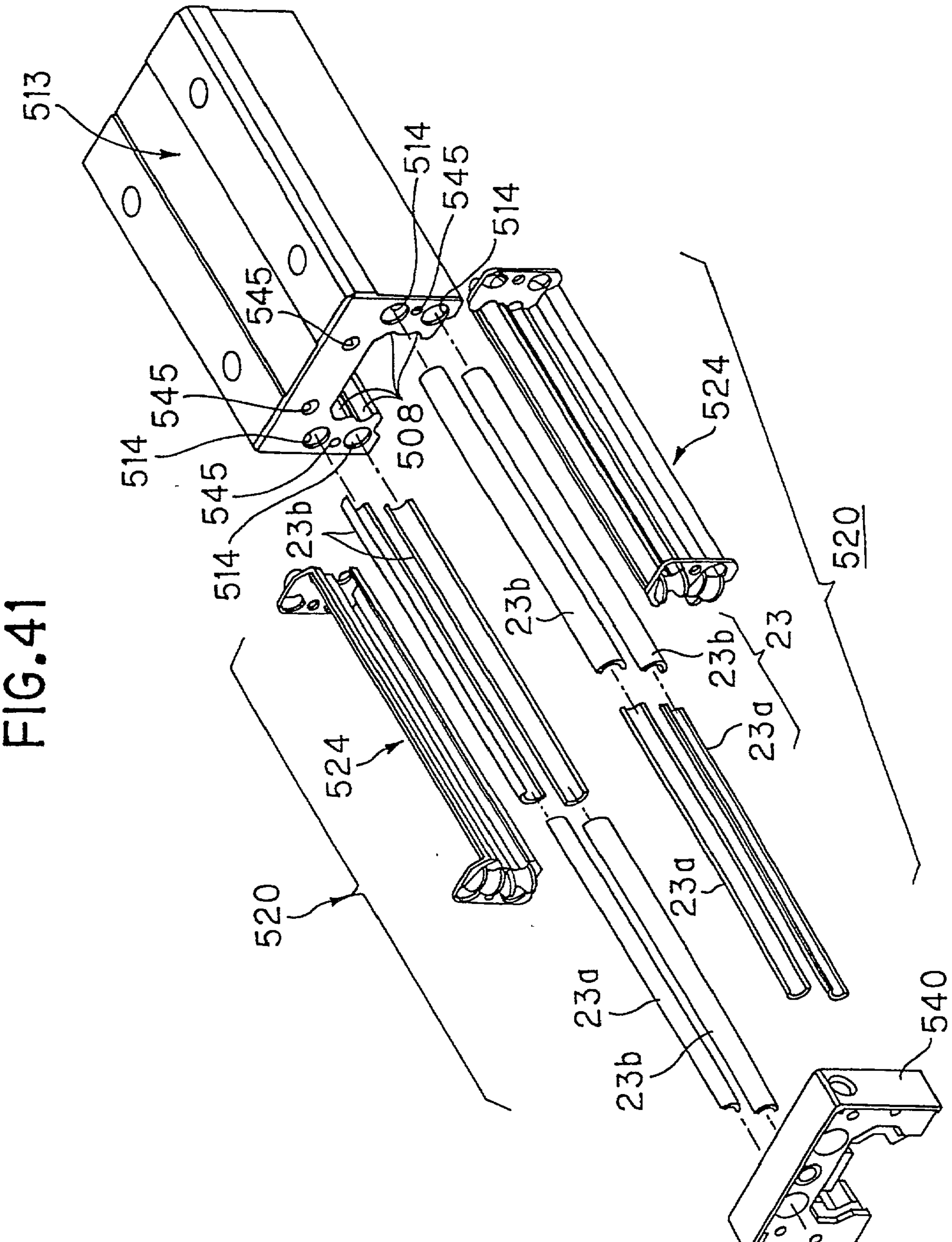

513
514
545
514
545
545
545
514
508
545
514
23b
524
520
23b
23b
23
23a
524
520
23a
23a
23b
540

FIG.42(a)

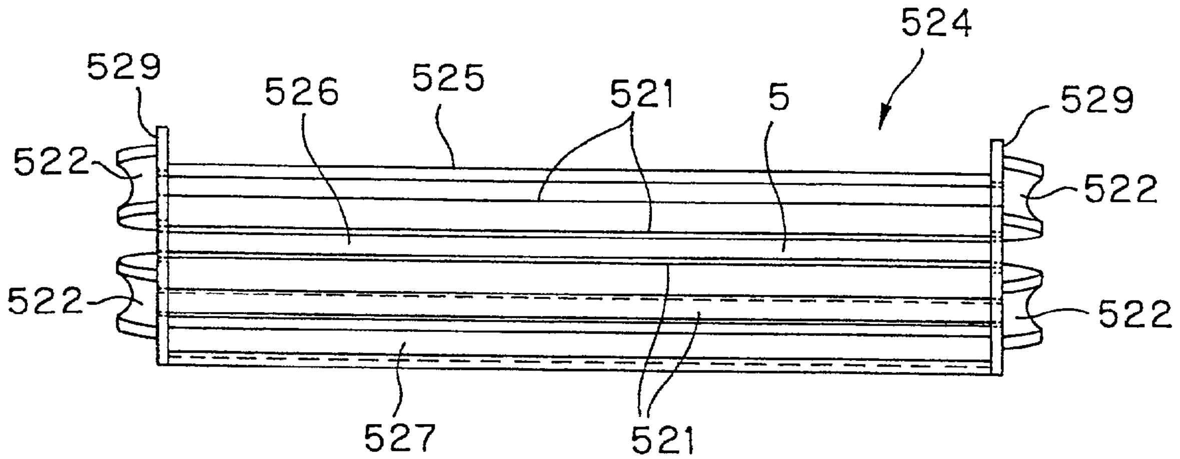


FIG.42(b)

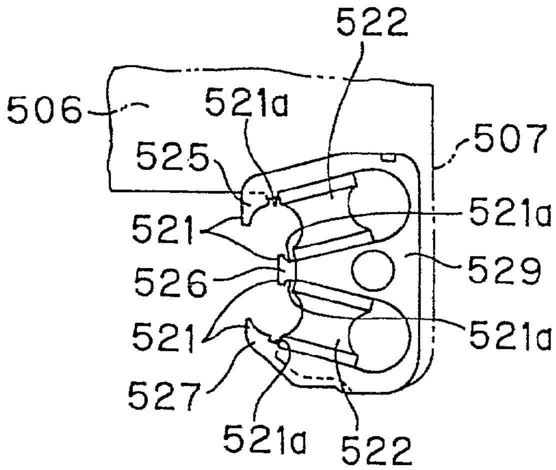


FIG.42(c)

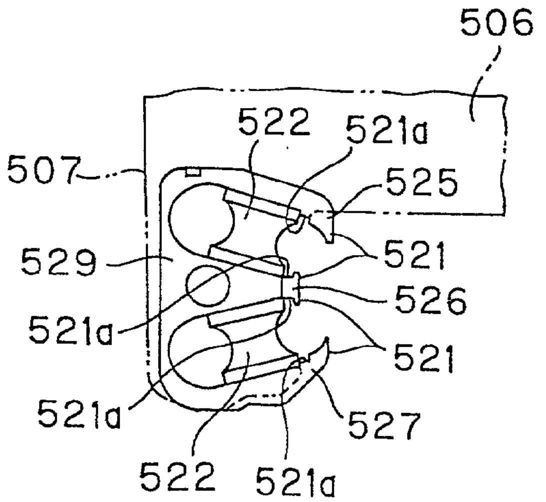


FIG.43(a)

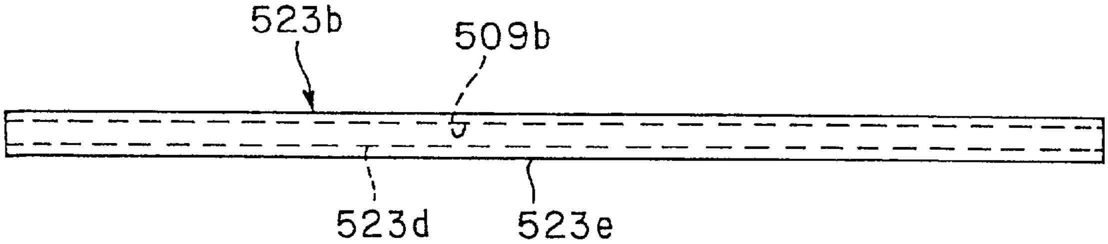


FIG.43(b)

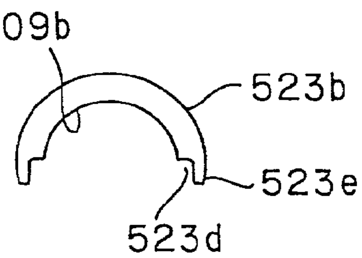


FIG.43(c)

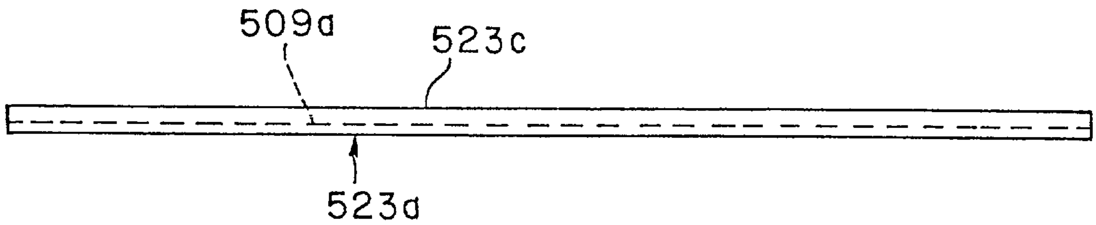


FIG.43(d)

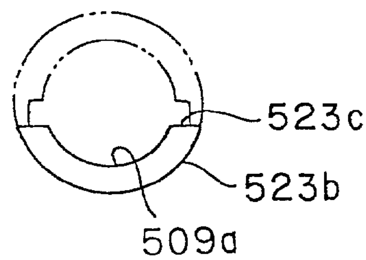


FIG.44(a)

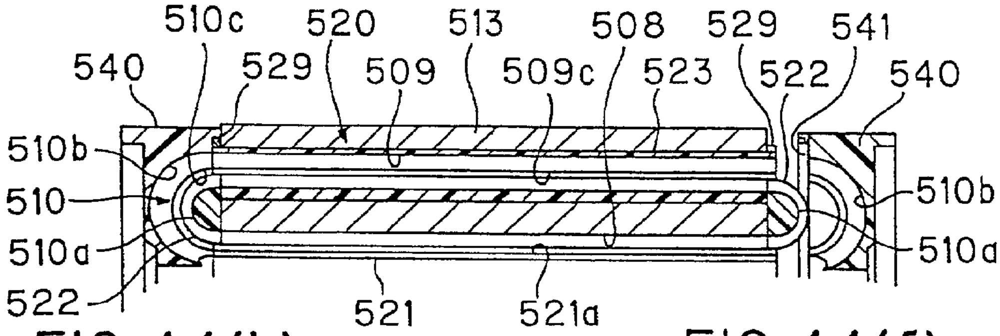


FIG.44(b)

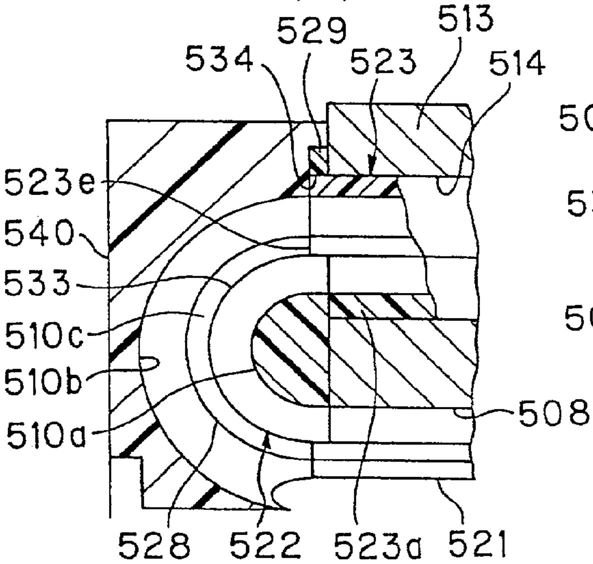


FIG.44(f)

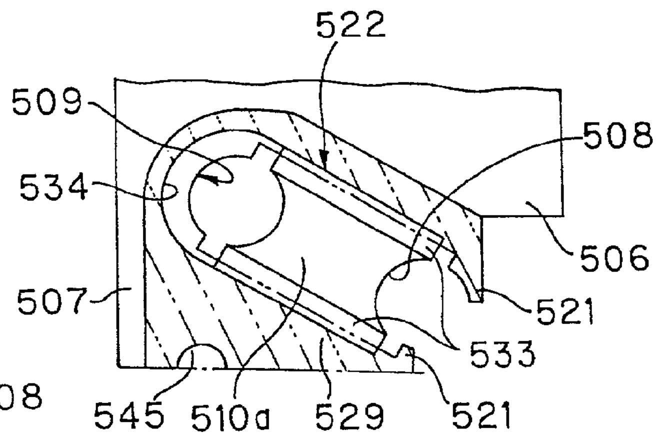


FIG.44(g)

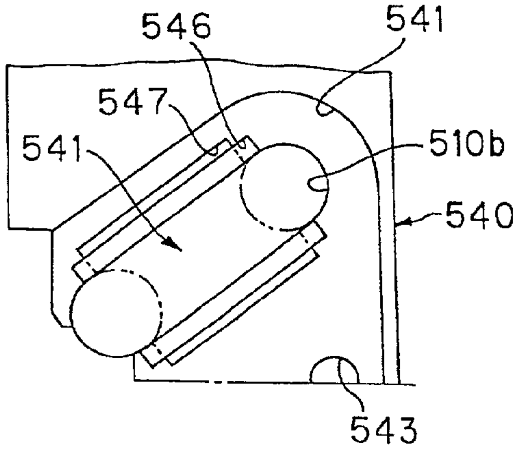


FIG.44(c)

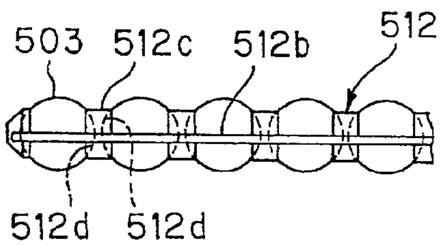


FIG.44(d)

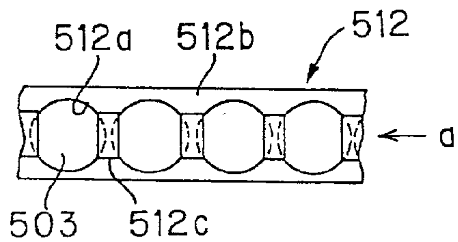
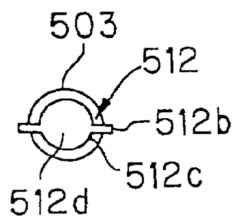


FIG.44(e)



LINEAR MOTION GUIDING APPARATUS

BACKGROUND OF THE INVENTION

[0001] 1. Field Of The Invention

[0002] The present invention relates to a linear motion guiding apparatus in which a passage forming member formed of resin is built into a body of movable member.

[0003] 2. Description Of The Related Art

[0004] The applicant has already proposed a technical idea that, in a movable block of a linear motion guiding apparatus, a pair of ball passage forming portions extending along the opposite longitudinal sides of a loaded-ball running groove, a ball returning passage forming portion and a pair of direction changing passage-inner guide forming portions were integrally formed of resin with a body of the movable block (refer to Japanese Patent Provisional Publication No. H7-317,762).

[0005] More specifically, when a resin forming is carried out, the body of the movable block is inserted in a die, and the ball passage forming portions, the direction changing passage-inner guide forming portions or the ball returning passage forming portion is integrally formed with the block body.

[0006] In the conventional movable block obtained by the integral forming, the block body is inserted in the die, as mentioned above. When the block body has a large size, a large-scaled die is required to be used. It is not easy to prepare such a large-scaled die, and there is actual restriction in size. The ball passage forming portions located at the opposite longitudinal sides of the ball running groove extending along the longitudinal direction of the block body are thin and long, with the result that molten resin may not reach every part of the space for forming the ball passage forming portions during the resin forming treatment.

[0007] Increase in number of gates formed on the die may solve the above-mentioned problem of misrun of the molten resin. However, when the block body is inserted in the die, the block body may deteriorate the run of the molten resin.

[0008] When the movable block has a pair of wing portions, which face right and left-hand side portions of the guide rail so that the guide rail is held between the wing portions, and there are four trains of balls between the right and left-hand side portions of the guide rail and the right and left-hand wing portions of the moving block, and more specifically, the upper and lower trains of balls are arranged at each of a gap between the right-hand side portion of the guide rail and the corresponding right-hand wing portion of the moving block and another gap between the left-hand side portion of the guide rail and the corresponding left-hand wing portion of the moving block, the block body inserted in the die may deteriorate the run of the molten resin in the width direction of the moving block.

SUMMARY OF THE INVENTION

[0009] An object of the present invention is therefore to provide a linear motion guiding apparatus in which a resin-formed body for forming a rolling member circulation passage is formed separately from a body of a movable member so as to permit easy formation of the resin-formed body, and such a resin-formed body is able to be built in the body of the movable member, ensuring integral formability of the maximum number of unit parts for defining the rolling member circulation passage.

[0010] In order to attain the aforementioned object, a linear motion guiding apparatus comprises:

[0011] a guide member provided with a rolling member running track, and

[0012] a movable member arranged so as to be movable along the guide member through a large number of rolling members, said movable member being provided with (i) a rolling member running counter-track corresponding to the rolling member running track of said guide member, (ii) a rolling member returning passage arranged away from said rolling member running counter-track by a prescribed distance and in parallel therewith and (iii) a pair of direction changing passages for connecting the rolling member running counter-track and the rolling member returning passage to permit circulation of the rolling members,

[0013] characterized in that:

[0014] a resin-formed body for forming a rolling member circulation passage comprises a pair of rolling member passage forming portions extending along both longitudinal sides of said rolling member running counter-track, a returning passage forming portion for forming the rolling member returning passage and a pair of direction changing passage-inner guide forming portions for forming inner peripheral guide portions of **129** said direction changing passages, said resin-formed body being separately formed from a body of said movable member; and

[0015] at least two portions of (a) said pair of rolling member passage forming portions, (b) said returning passage forming portion, (c) one of said pair of direction changing passage-inner guide forming portions and (d) another of said pair of direction changing passage-inner guide forming portions are connected with each other through integral forming so that said resin-formed body can be built in the body of said movable member.

[0016] Embodiments of the combination of these portions (a) to (d) for the resin-formed body for forming the rolling member circulation passage may include the following three examples:

[0017] the first example in which the resin-formed body comprises (i) an integral body of the pair of rolling member passage forming portions and the pair of direction changing passage-inner guide forming portions, and (ii) the returning passage forming portion separately formed from the integral body the second example in which the resin-formed body comprises (i) an integral body of the pair of rolling member passage forming portions, the returning passage forming portion and one of the pair of direction changing passage-inner guide forming portions, and (ii) another of the pair of direction changing passage-inner guide forming portions separately formed from the integral body; and

[0018] the third example in which the resin-formed body is manufactured by preparing an integral body of the pair of rolling member passage forming portions, the returning passage forming portion and the pair of direction changing passage-inner guide forming portions, and then dividing the pair of rolling member passage forming portions and the returning passage forming portion in longitudinal intermediate portions thereof into respective two parts.

[0019] According to the present invention, the resin-formed body for forming the rolling member circulation passage is separately formed from the body of the movable member. Even if the movable member has a large size, the flow of molten resin is not therefore restricted by the body of the movable member unlike the conventional prior art in which the body of the movable member and the resin-formed body are integrally formed with each other, and it is possible to ensure proper run of molten resin through increase in a number of gates in the die, thus leading to an excellent formability. In general, it is hard to achieve proper run of molten resin especially at the rolling member passage forming portions extending along the longitudinal sides of the rolling member running counter-track, and it is therefore effective to separately form the resin-formed body from the body of the movable member in the same manner as the present invention.

[0020] The rolling member circulation passage is formed by the resin-formed body. Therefore, the direct positioning can be achieved in the relative positional relationship between the direction changing passage-inner guide forming portions and the rolling member passage forming portion, as well as the relative positional relationship between the direction changing passageinner guide forming portions and the returning passage forming portion, and the continuity of the rolling member circulation passage is properly ensured, thus leading to smooth run of the rolling members.

[0021] Since the rolling member passage forming portions are located along the both longitudinal sides of the rolling member running counter-track, the direction changing passage-inner guide forming portions having a proper relative positional relationship with the rolling member passage forming portions are accurately set on the both ends of the rolling member running counter-track.

[0022] Maintenance of a proper relative positional relationship of the direction changing passage-inner guide forming portions with the rolling member returning passage causes the direction changing passage-inner guide forming portions to be accurately connected to the inner surface of the rolling member returning passage.

[0023] Especially, change in a running direction of the rolling members takes place in the connection area of the rolling member passage forming portions with the direction changing passage-inner guide forming portions as well as in the connection area of the direction changing passage-inner guide forming portions with returning passage forming portion. When two portions in such a connection area are connected with each other by integral forming, a step for assembling these two portions is not required, thus making it possible to ensure a smooth continuity of these two portions without being affected by accuracy of assembly.

[0024] The rolling member returning passage may be a through-hole formed in the body of the movable member, the resin formed-body may comprise the pair of direction changing passage-inner guide forming portions and the rolling member passage forming portions extending along the both longitudinal sides of the rolling member running counter-track, and the rolling member passage forming portions and at least one of the pair of direction changing passage-inner guide forming portions may be connected with each other through integral forming.

[0025] When the rolling member passage forming portions and the direction changing passage-inner guide forming portions are integrally formed with each other so as to provide the smooth connection area in this manner, it is possible to achieve the smooth run of the rolling members in the connection area of these portions, thus improving circulation property of the rolling member without providing any returning passage forming portion made of resin. Such a construction causes easy manufacture of the apparatus due to no existence of the returning passage forming portion.

[0026] The present invention may have additional features that a rolling member retainer is provided, the rolling member retainer being able to retain the rolling members in a train with a prescribed distance kept between adjacent two of the rolling members, and the rolling member retainer having side edge portions projecting from both sides of each of the rolling members; and guide grooves for guiding the side edge portions of the rolling member retainer are formed on an entire periphery of the rolling member circulation passage.

[0027] The present invention may have additional features that a retaining portion is provided on the rolling member passage forming portion, for preventing the rolling member retainer being out of place, when the movable member is removed from the guide member, and a guide portion is continuously formed on the entire periphery of the rolling member circulation passage, for guiding the side edge portions of the rolling member retainer.

[0028] Such provision of the rolling member retainer permits the smooth run of the rolling members by means of the rolling member retainer, due to proper maintenance of continuity of the guide portion for the rolling member retainer.

[0029] Since the guide portion for the rolling member retainer having a small thickness is not formed by inserting the body of the movable member in a die and then injecting molten resin into the die, but is separately formed from the body of the movable member, position of gates can freely be determined without being restricted by the body of the movable member, with the result that molten resin can reach, during formation of the guide portion, the entire space therefor, which is formed in the die.

[0030] The present invention may have additional features that each of the direction changing passage-inner guide forming portions has a thin sheet portion, which is to be brought into contact with the end face of the body of the movable member, and each of the direction changing passage-inner guide forming portions is connected to the rolling member passage forming portions or the returning passage forming portion by means of the thin sheet portion.

[0031] When each of the direction changing passage-inner guide forming portions is connected to the rolling member passage forming portions by means of the thin sheet portion, deformation of the thin sheet portion can absorb distortion, which occurs between the direction changing passage-inner guide forming portion and the rolling member passage forming portion, or between the direction changing passage-inner guide forming portion and the returning passage forming portion. Accordingly, it is possible to maintain an accurate positional relationship between the end of the direction changing passage-inner guide forming portion and the rolling member passage forming portion or between the direction changing passage-inner guide forming portion and the returning passage forming portion.

[0032] The thin sheet portion is urged against the flat end face of the body of the movable member by a clamping force, which is applied to the side cover plate. The position of the direction changing passage-inner guide forming portion can therefore be corrected through deformation of the thin sheet portion, even when the direction changing passage-inner guide forming portion is not correctly positioned relative to the end face of the body of the movable member. In addition, the thin sheet portion can firmly be secured between the side cover plate and the body of the movable member by the clamping force, which is applied to the side cover plate, thus preventing the direction changing passage-inner guide forming portion from being incorrectly placed.

[0033] The apparatus of the present invention may have the construction that the guide member comprises a guide rail; the movable member comprises a movable block, which is provided with a horizontal portion, which faces an upper surface of the guide rail and a pair of wing portions, between which the guide rail is held at right and left-hand side surfaces thereof; two trains of the rolling members are arranged in a gap between the upper surface of the guide rail and a lower surface of the movable block, and a single train of the rolling members is arranged in each of gaps between the right and left-hand side surfaces of the guide rail and both of the wing portions, so as to provide a total number of trains of four.

[0034] The apparatus of the present invention may have the construction that the guide member comprises a guide rail; the movable member comprises a movable block, which is provided with a pair of wing portions, between which the guide rail is held at right and left-hand side surfaces thereof; and two trains of the rolling members are arranged in each of gaps between the right and left-hand side surfaces of the guide rail and both of the wing portions, so as to provide a total number of trains of four.

[0035] In these cases, the respective four direction changing passage-inner guide forming portions may be formed into an integral body, or the respective two direction changing passage-inner guide forming portions at each of the right and left-hand sides of the movable block may be formed into an integral body.

[0036] The apparatus of the present invention may have the construction that the guide member comprises a guide rail; the movable member is provided with a horizontal portion, which faces an upper surface of the guide rail and a single wing portion, which faces one side surface of the guide rail; a single train of the rolling members is arranged in a gap between the one side surface of the guide rail and the single wing portion, and another single train of the rolling members is arranged in a gap between the upper surface of the guide rail and a lower surface of the horizontal portion in a vicinity of a corner of the guide rail.

[0037] The apparatus of the present invention may have the construction that the guide member comprises a guide rail; the movable member comprises a movable block, which is provided with a pair of wing portions, between which the guide rail is held at right and left-hand side surfaces thereof; and a single train of the rolling members is arranged in each of gaps between the right and left-hand side surfaces of the guide rail and both of the wing portions, so as to provide a total number of trains of two.

[0038] The apparatus of the present invention may have the construction that the guide member comprises a guide rail; the movable member comprises a movable block arranged along one side surface of the guide rail; and two trains of the rolling members are arranged in a gap between the one side surface of the guide rail and the movable block.

[0039] The apparatus of the present invention may have the construction that the guide member comprises a spline shaft; and the movable member comprises an outer tube, which is movably supported on the spline shaft through a plurality of trains of the rolling members.

[0040] In addition, according to the present invention, there is also provided a linear motion guiding apparatus comprising:

[0041] a guide rail provided with two rolling member running tracks on each of right and left-hand side surfaces of the guide rail, so as to provide a total number of the rolling member running tracks of four; and

[0042] a movable block provided with a pair of wing portions, between which the guide rail is held at the right and left-hand side surfaces thereof, each of said wing portions having on an inner surface thereof two rolling member running counter-tracks corresponding to said two rolling member running tracks of the guide rail, so as to provide a total number of the rolling member running counter-tracks of four, said movable block having four endless circulation passages, which are formed by four rolling member returning passages arranged in parallel with said four rolling member running countertracks, respectively, and rolling member returning passages for connecting both ends of each of said four rolling member running counter-tracks with both ends of each of said four rolling member returning passages, respectively

[0043] characterized in that:

[0044] a resin-formed body comprises, for each of said endless circulation passages, a pair of rolling member passage forming portions extending along both longitudinal sides of said rolling member running counter-track, a returning passage forming portion for forming the rolling member returning passage and a pair of direction changing passage-inner guide forming portions for forming inner peripheral guide portions of said direction changing passages, said resin-formed body being separately formed from a body of said movable block;

[0045] said resin-formed body is divided into two body-parts, which are arranged on the wing portions of the movable block, respectively, so as to form the two endless circulation passages at an inner side of each of the wing portions; and

[0046] in each of the two body-parts, the rolling member running counter-track and the pair of direction changing passage-inner guide forming portions are formed into an integral body, and the returning passage forming portion is separately formed from said integral body.

[0047] According to the present invention, the resin-formed body for forming the rolling member circulation passage is separately formed from the body of the movable block. Even if the movable block has a large size, the flow of molten resin is not therefore restricted by the body of the movable block unlike the conventional prior art in which the body of the movable block and the resin-formed body are integrally formed with each other, and it is possible to ensure proper run of molten resin through increase in a number of gates in the die, thus leading to an excellent formability. In general, it is hard to achieve proper run of molten resin especially at the rolling member passage forming portions extending along the longitudinal sides of the rolling member running counter-track, and it is therefore effective to separately form the resin-formed body from the body of the movable block in the same manner as the present invention.

[0048] Especially, since the resin-formed body is divided into the two body-parts, each of which forms two endless circulation passages, a proper run of molten resin can be ensured, even when the block of the movable block has a larger width.

[0049] The rolling member circulation passage is formed by the resin-formed body. Therefore, the direct positioning can be achieved in the relative positional relationship between the direction changing passage-inner guide forming portions and the rolling member passage forming portion, as well as the relative positional relationship between the direction changing passage-inner guide forming portions and the returning passage forming portion, and the continuity of the rolling member circulation passage is properly ensured, thus leading to smooth run of the rolling members.

[0050] Since the rolling member passage forming portions are located along the both longitudinal sides of the rolling member running counter-track, the direction changing passage-inner guide forming portions having a proper relative positional relationship with the rolling member passage forming portions are accurately set on the both ends of the rolling member running counter-track.

[0051] Maintenance of a proper relative positional relationship of the direction changing passage-inner guide forming portions with the rolling member returning passage causes the direction changing passage-inner guide forming portions to be accurately connected to the inner surface of the rolling member returning passage.

[0052] Especially, change in a running direction of the rolling members takes place in the connection area of the rolling member passage forming portions with the direction changing passage-inner guide forming portions. When these two portions in such a connection area are connected with each other by integral forming, a step for assembling these two portions is not required, thus making it possible to ensure a smooth continuity of these two portions without being affected by accuracy of assembly.

[0053] The present invention may have additional features that a rolling member retainer is provided, the rolling member retainer being able to retain the rolling members in a train with a prescribed distance kept between adjacent two of the rolling members, and the rolling member retainer having side edge portions projecting from both sides of each of the rolling members; and guide grooves for guiding the side edge portions of the rolling member retainer are formed on an entire periphery of the rolling member circulation passage.

[0054] Such provision of the rolling member retainer permits the smooth run of the rolling members by means of the rolling member retainer, due to proper maintenance of continuity of the guide portion for the rolling member retainer.

[0055] Since the guide portion for the rolling member retainer having a small thickness is not formed by inserting the body of the movable block in a die and then injecting molten resin into the die, but is separately formed from the body of the movable block, position of gates can freely be determined without being restricted by the body of the movable block, with the result that molten resin can reach, during formation of the guide portion, the entire space therefor, which is formed in the die.

[0056] The present invention may have additional features that each of the direction changing passage-inner guide forming portions has a thin sheet portion, which is to be brought into contact with the end face of the body of the movable block, and each of the direction changing passage-inner guide forming portions is connected to the rolling member passage forming portions or the returning passage forming portion by means of the thin sheet portion.

[0057] When each of the direction changing passage-inner guide forming portions is connected to the rolling member passage forming portions by means of the thin sheet portion, deformation of the thin sheet portion can absorb distortion, which occurs between the direction changing passage-inner guide forming portion and the rolling member passage forming portion, or between the direction changing passage-inner guide forming portion and the returning passage forming portion. Accordingly, it is possible to maintain an accurate positional relationship between the end of the direction changing passage-inner guide forming portion and the rolling member passage forming portion or between the direction changing passage-inner guide forming portion and the returning passage forming portion.

[0058] The thin sheet portion is urged against the flat end face of the body of the movable member by a clamping force, which is applied to the side cover plate. The position of the direction changing passage-inner guide forming portion can therefore be corrected through deformation of the thin sheet portion, even when the direction changing passage-inner guide forming portion is not correctly positioned relative to the end face of the body of the movable block. In addition, the thin sheet portion can firmly be secured between the side cover plate and the body of the movable block by the clamping force, which is applied to the side cover plate, thus preventing the direction changing passage-inner guide forming portion from being incorrectly placed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0059] **FIG. 1** is a schematic disassembling perspective view illustrating a movable block of a linear motion guiding apparatus of the first embodiment of the present invention;

[0060] **FIG. 2** shows a resin frame member as shown in **FIG. 1**, as one of resin-formed bodies for forming a ball circulation passage, and more specifically, **FIG. 2**(*a*) is a front view of the resin frame member, **FIG. 2**(*b*) is a side view thereof, **FIG. 2**(*c*) is a cross-sectional view cut along the line C-C as indicated in **FIG. 2**(*a*), **FIG. 2**(*d*) is a cross-sectional view cut along the line D-D as indicated in **FIG. 2**(*b*), **FIG. 2**(*e*) is an enlarged cross-sectional view cut along the line E-E as indicated in **FIG. 2**(*a*) and **FIG. 2**(*f*) is an enlarged cross-sectional view cut along the line F-F as indicated in **FIG. 2**(*a*);

[0061] **FIG. 3**(*a*) is a front view having a cross-section, illustrating the linear motion guiding apparatus of the first embodiment of the present invention as shown in **FIG. 1**, **FIG. 3**(*b*) is a front view of the apparatus as shown in **FIG. 3**(*a*), in which a half portion of a side cover plate is omitted, and FIGS. **3**(*c*) to (*f*) are partially cross-sectional views illustrating embodiments of the structure of a ball passage forming portion and the vicinity thereof, as shown in **FIG. 3**(*a*);

[0062] **FIG. 4**(*a*) is a side view having a partial cross section, of the linear motion guiding apparatus of the first embodiment of the present invention, **FIG. 4**(*b*) is a cross-sectional view of a ball circulation passage of the movable block as shown in **FIG. 4**(A), from which a ball retainer is removed, **FIG. 4**(*c*) is a partial side view of the ball retainer, **FIG. 4**(*d*) is a plan view of the ball retainer as shown in **FIG. 4**(*c*) and **FIG. 4**(*e*) is a view of the ball retainer, with sight being placed in a direction of an arrow of "a" as indicated in **FIG. 4**(*d*);

[0063] **FIG. 5** shows a side cover plate of the movable block, and more specifically, **FIG. 5**(*a*) is a front view of the side cover plate, **FIG. 5**(*b*) is a back view thereof and **FIG. 5**(*c*) is a transverse sectional view thereof at its central portion;

[0064] FIGS. **6**(*a*) to **6**(*i*) are descriptive views illustrating steps for assembling the movable block as shown in **FIG. 1**;

[0065] **FIG. 7**(*a*) is an enlarged partial view of the direction changing passage as shown in **FIG. 4**(*b*), **FIG. 7**(*b*) is a partial side view of the direction changing passage as shown in **FIG.4***b*(*b*), in which the side cover plate is removed, **FIG. 7**(*c*) is a partial side view illustrating a recess portion, which forms the direction changing passage in the side cover plate as shown in **FIG. 7**(*a*), **FIG. 7**(*d*) is a partial cross-sectional view of an outer peripheral side-half pipe member for forming a part of a resin pipe as shown in **FIG. 7**(*a*), **FIG. 7**(*e*) is a side view of the outer peripheral side-half pipe member as shown in **FIG. 7**(*d*), **FIG. 7**(*f*) is a partial cross-sectional view of an inner peripheral side-half pipe member for forming another part of the resin pipe as shown in **FIG. 7**(*a*), **FIG. 7**(*g*) is a side view of the inner peripheral side-half pipe member as shown in **FIG. 7**(*f*);

[0066] **FIG. 8** is a schematic disassembling perspective view illustrating the first modification of the resin-formed body for forming the ball circulation passage in the first embodiment of the present invention;

[0067] **FIG. 9**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in **FIG. 8**, **FIG. 9**(*b*) is a view illustrating the first resin frame of the resin-formed body, **FIG. 9**(*c*) is a view illustrating the second resin frame thereof, **FIG. 9**(*d*) is a back view of the first resin frame and **FIG. 9**(*e*) is a back view of the second resin frame;

[0068] **FIG. 10** is a schematic disassembling perspective view illustrating the second modification of the resin-formed body for forming the ball circulation passage in the first embodiment of the present invention;

[0069] **FIG. 11**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in **FIG. 10**, **FIG. 11**(*b*) is a side view illustrating the connecting end of one of divided resin frames, as shown in **FIG. 11**(*a*) and **FIG. 11**(*c*) is an enlarged cross-sectional view illustrating the connecting portion of the resin frames;

[0070] **FIG. 12** is a schematic disassembling perspective view illustrating the third modification of the resin-formed body for forming the ball circulation passage in the first embodiment of the present invention;

[0071] **FIG. 13**(*a*) is a side view having a partial cross section, illustrating the linear motion guiding apparatus, in which the movable block as shown in **FIG. 12** is used, and **FIG. 13**(*b*) is a cross-sectional view of the resin-formed body for forming the ball circulation passage as shown in **FIG. 13**(*a*);

[0072] **FIG. 14**(*a*) is an enlarged partial cross-sectional view of the direction changing passage as shown in **FIG. 13**(*b*), which is formed in the side cover plate removed from the ball passage forming portion, **FIG. 14**(*b*) is a partial cross-sectional view illustrating the side cover as shown in **FIG. 14**(*a*), which is secured to the ball passage forming portion, **FIG. 14**(*c*) is a partial side view illustrating the ball passage forming portion, in which the side cover plate as shown in **FIG. 14**(*a*) is removed, and **FIG. 14**(*d*) is a partial side view illustrating a recess portion, which forms the direction changing passage in the side cover plate as shown in **FIG. 14**(*a*);

[0073] **FIG. 15** is a schematic disassembling perspective view illustrating the fourth modification of the resin-formed body for forming the ball circulation passage in the first embodiment of the present invention;

[0074] FIGS. **16**(*a*) to **16**(*h*) are descriptive views illustrating the other embodiments of arrangement of the trains of balls in the linear motion guiding apparatus of the first embodiment of the present invention;

[0075] **FIG. 17** is a perspective view illustrating the constructional elements other than the resin-formed body for forming the ball circulation passage of the linear motion guiding apparatus as shown in **FIG. 16**(*a*), which is provided with two trains of balls at each of the both sides;

[0076] **FIG. 18** is a schematic disassembling perspective view illustrating a movable block of a linear motion guiding apparatus of the second embodiment of the present invention;

[0077] **FIG. 19**(*a*) is a front view illustrating the linear motion guiding apparatus of the second embodiment of the present invention as shown in **FIG. 18**, **FIG. 19**(*b*) is a partial cross-sectional view illustrating one ball circulation passage of the apparatus as shown in **FIG. 19**(*a*), **FIG. 19**(*c*) is a partial plan view of a roller retainer as shown in **FIG. 19**(*b*) and **FIG. 19**(*d*) is a view of the roller retainer, with sight being placed in a direction of an arrow of "d" as indicated in **FIG. 19**(*c*);

[0078] **FIG. 20** shows the resin-formed body for forming the ball circulation passage as shown in **FIG. 18**, and more specifically, **FIG. 20**(*a*) is a cross-sectional view cut along the line a-a as indicated in **FIG. 20**(*b*), **FIG. 20**(*b*) is a front view of the resin-formed body for forming the ball circulation passage as shown in **FIG. 20**(*a*), **FIG. 20**(*c*) is a partial side view of the resin-formed body for forming the ball circulation passage, in which the resin pipe as shown in **FIG. 20**(*a*) is removed, **FIG. 20**(*d*) is a cross-sectional view of an outer peripheral side-half pipe member for forming a part of a resin pipe as shown in **FIG. 20**(*a*), **FIG. 20**(*e*) is a side view of the outer peripheral side-half pipe member as shown in **FIG. 20**(*d*), **FIG. 20**(*f*) is a cross-sectional view of an inner peripheral side-half pipe member for forming another part of the resin pipe as shown in **FIG. 20**(*a*), **FIG. 20**(*g*) is a side view of the inner peripheral side-half pipe member as shown in **FIG. 20**(*f*) and **FIG. 20**(*h*) is a partial cross-sectional view illustrating the constructional example of the roller passage forming portion, in which the roller retainer is not used;

[0079] **FIG. 21** is a schematic disassembling perspective view illustrating the first modification of the resin-formed body for forming the ball circulation passage in the second embodiment of the present invention;

[0080] **FIG. 22**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in **FIG. 21**, **FIG. 22**(*b*) is a view illustrating the first resin frame as shown in **FIG. 22**(*a*), with sight being placed on the divided end side thereof and **FIG. 22**(*c*) is a view illustrating the second resin frame as shown in **FIG. 22**(*a*), with sight being placed on the divided end side thereof;

[0081] **FIG. 23** is a schematic disassembling perspective view illustrating the second modification of the resin-formed body for forming the ball circulation passage in the second embodiment of the present invention;

[0082] **FIG. 24**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in **FIG. 23**, **FIG. 24**(*b*) is a view illustrating one resin frame as shown in **FIG. 24**(*a*), with sight being placed on the divided end side thereof and **FIG. 24**(*c*) is a view illustrating the other resin frame as shown in **FIG. 24**(*a*), with sight being placed on the divided end side thereof;

[0083] **FIG. 25** is a schematic disassembling perspective view illustrating the third modification of the resin-formed body for forming the ball circulation passage in the second embodiment of the present invention;

[0084] **FIG. 26** is a schematic disassembling perspective view illustrating the fourth modification of the resin-formed body for forming the ball circulation passage in the second embodiment of the present invention;

[0085] **FIG. 27** is a front view having a cross-sectional half portion, illustrating the other embodiment of arrangement of the trains of balls in the linear motion guiding apparatus of the second embodiment of the present invention;

[0086] **FIG. 28** is a schematic disassembling perspective view of an outer tube of a ball-spline as a linear motion guiding apparatus of the third embodiment of the present invention;

[0087] **FIG. 29**(*a*) is a front view having a cross-section, illustrating the ball spline of the third embodiment of the present invention, in which the outer tube as shown in **FIG. 28** is used, **FIG. 29**(*b*) is a partial cross-sectional view illustrating one ball circulation passage of the apparatus as shown in **FIG. 29**(*a*) and **FIG. 29**(*c*) is a disassembling cross-sectional view illustrating the construction of the ball circulation passage, in which the roller retainer as shown in **FIG. 29**(*b*) is removed;

[0088] **FIG. 30** shows the resin-formed body for forming the ball circulation passage as shown in **FIG. 29**, and more specifically, **FIG. 30**(*a*) is a cross-sectional view cut along the line a-a as indicated in **FIG. 30**(*b*), **FIG. 30**(*b*) is a front view of the resin-formed body for forming the ball circulation passage as shown in **FIG. 30**(*a*), **FIG. 30**(*c*) is a partial side view of the resin-formed body for forming the ball circulation passage, in which the resin pipe as shown in **FIG. 30**(*a*) is removed, **FIG. 30**(*d*) is a cross-sectional view of an outer peripheral side-half pipe member for forming a part of a resin pipe as shown in **FIG. 30**(*a*), **FIG. 30**(*e*) is a side view of the outer peripheral side-half pipe member as shown in **FIG. 30**(*d*), **FIG. 30**(*f*) is a cross-sectional view of an inner peripheral side-half pipe member for forming another part of the resin pipe as shown in **FIG. 30**(*a*) and **FIG. 30**(*g*) is a side view of the inner peripheral side-half pipe member as shown in **FIG. 30**(*f*)

[0089] **FIG. 31** is a schematic disassembling perspective view illustrating the first modification of the resin-formed body for forming the ball circulation passage in the third embodiment of the present invention;

[0090] **FIG. 32**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in **FIG. 31**, **FIG. 32**(*b*) is a view illustrating the first resin frame as shown in **FIG. 32**(*a*), with sight being placed on the divided end side thereof and **FIG. 32**(*c*) is a view illustrating the second resin frame as shown in **FIG. 32**(*a*), with sight being placed on the divided end side thereof;

[0091] **FIG. 33** is a schematic disassembling perspective view illustrating the second modification of the resin-formed body for forming the ball circulation passage in the third embodiment of the present invention;

[0092] **FIG. 34**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in **FIG. 33**, **FIG. 34**(*b*) is a view illustrating one resin frame as shown in **FIG. 34**(*a*), with sight being placed on the divided end side thereof and **FIG. 34**(*c*) is a view illustrating the other resin frame as shown in **FIG. 34**(*a*), with sight being placed on the divided end side thereof;

[0093] **FIG. 35** is a schematic disassembling perspective view illustrating the third modification of the resin-formed body for forming the ball circulation passage in the third embodiment of the present invention;

[0094] **FIG. 36** is a schematic disassembling perspective view illustrating the fourth modification of the resin-formed body for forming the ball circulation passage in the third embodiment of the present invention;

[0095] **FIG. 37** is a front view having a partial cross-section, illustrating the another embodiment of arrangement of the trains of balls in the ball spline as the linear motion guiding apparatus of the third embodiment of the present invention;

[0096] **FIG. 38**(*a*) is a front view having a partial cross-section, illustrating a roller-spline as the linear motion guiding apparatus of the fourth embodiment of the present invention, in which a side cover plate is removed, and **FIG. 38**(*b*) is a longitudinal partial cross-sectional view of one roller circulation passage as shown in **FIG. 38**(*b*);

[0097] **FIG. 39**(*a*) is a partial cross-sectional view illustrating the constructional example of the resin-formed body for forming the roller circulation passage of the roller spline as shown in **FIG. 38**, and FIGS. **39**(*b*) to **39**(*e*) are views illustrating the first to fourth modifications of the resin-formed body for forming the roller circulation passage;

[0098] **FIG. 40**(*a*) is a front view of the movable block of the linear motion guiding apparatus of the fourth embodiment of the present invention, in which the side cover plate is removed, and **FIG. 40**(*b*) is a perspective view of the movable block as shown in **FIG. 40**(*a*);

[0099] **FIG. 41** is a schematic disassembling perspective view of the resin-formed bodies for forming the ball circulation passage as shown in **FIG. 40**;

[0100] **FIG. 42** is a front view of the resin frame composing the resin-formed body for forming the ball circulation passage, as shown in **FIG. 41**, **FIG. 42**(*b*) is a left-hand side view of the resin-formed body as shown in **FIG. 42**(*a*) and **FIG. 42**(*c*) is a right-hand side view of the resin-formed body as shown in **FIG. 42**(*a*);

[0101] **FIG. 43** shows a resin pipe for forming a part of the resin-formed body for forming the ball circulation passage, as shown in **FIG. 41**, and more specifically, **FIG. 43**(*a*) is a front view of an outer peripheral side-half pipe member, **FIG. 43**(*b*) is a side view of the outer peripheral side-half pipe member as shown in **FIG. 43**(*a*), **FIG. 43**(*c*) is a front view of an inner peripheral side-half pipe member, **FIG. 43**(*d*) is a side view of the inner peripheral side-half pipe member as shown in **FIG. 43**(*c*); and

[0102] **FIG. 44**(*a*) is a cross-sectional view of one ball circulation passage, in which the ball retainer is removed from the movable block as shown in **FIG. 40**(*a*), **FIG. 44**(*b*) is an enlarged partial view of the direction changing passage as shown in **FIG. 44**(*a*), **FIG. 44**(*c*) is a partial side view of the ball retainer, **FIG. 44**(*d*) is a plan view of the ball retainer as shown in **FIG. 44**(*c*), **FIG. 44**(*e*) is a view of the ball retainer, with sight being placed in a direction of an arrow of "a" as indicated in **FIG. 44**(*d*), **FIG. 44**(*f*) is a partial side view of the direction changing passage as shown in **FIG. 44**(*b*), in which the side cover plate is removed, and **FIG. 44**(*g*) is a partial side view illustrating a recess portion, which forms the direction changing passage in the side cover plate as shown in **FIG. 44**(*b*).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0103] Now, embodiments of a linear motion guiding apparatus the present invention will be described in detail below with reference to the accompanying drawings.

[0104] First Embodiment

[0105] FIGS. **1** to **7** show a linear motion guiding apparatus of the first embodiment of the present invention.

[0106] The linear motion guiding apparatus **1** is provided with a guide rail **2** as a guide member, which extends linearly, and a movable block **4** as a movable member, which is arranged so as to be movable along the guide rail **2** through a large number of balls **3** as rolling members.

[0107] The guide rail **2** is formed into a long bar shape having a rectangular cross-section. Two ball running grooves **5**, **5** as a rolling member running track are formed on the horizontal upper surface of the guide rail **2**, and a single ball running groove **5** as the rolling member running track is formed on each of the right and left-hand vertical surfaces of the guide rail **2**, so as to provide a total number of grooves **5** of four.

[0108] The movable block **4** is formed as a block body having an inverse U-shaped cross-section, with its opening end being directed downwardly. The block body is provided with a horizontal portion **6**, which faces the upper surface of the guide rail **2** and with a pair of wing portions **7**, **7**, which extend downwardly from the right and left ends of the horizontal portion **6** and face the right and left-hand side surfaces of the guide rail **2**, respectively. The horizontal portion **6** has on its lower surface two ball running counter-grooves **8**, **8** as a rolling member running counter-track, which correspond to the ball running grooves **5**, **5** formed on the upper surface of the guide rail **2**. Each of the wing portions **7**, **7** has on its inner surface a single ball running counter-groove **8** as the rolling member running counter-track, which corresponds to the respective ball running grooves **5**, **5** formed on the right and left-hand side surfaces of the guide rail **2**.

[0109] In addition, in the movable block **4**, there are formed four ball returning passages **9**, **9**, **9**, **9** as a rolling member returning passage, which are provided in parallel with the four ball running counter-grooves **8**, **8**, **8**, **8**, respectively, as well as four pairs of direction changing passages **10**, **10**, **10**, **10** each having a U-shape, for connecting the respective both ends of the ball running counter-grooves **8**, **8**, **8**, **8** with the respective both ends of the ball returning passages **9**, **9**, **9**, **9**, so as to form four endless circulation passages. The ball returning passages **9**, **9** respectively corresponding to the ball running grooves **5**, **5** formed on the upper side of the guide rail **2** are formed in the horizontal portion **6**. The other ball returning passages **9**, **9** respectively corresponding to the ball running grooves **5**, **5** formed on the right and left hand vertical surfaces of the guide rail **2** are formed in the wing portions **7**, **7** of the movable block **4**, respectively.

[0110] In each of the four endless circulation passages in this embodiment, the balls **3** are retained in the form of train by means a ball retainer **12** as a rolling member retainer, as shown in **FIG. 4** so that the balls **3** can be circulated while being guided by the ball retainer **12**.

[0111] The ball retainer **12** comprises a flexible belt portion **12***b*, which is provided with ball holes **12***a* for respectively receiving the balls **3**, and spacing portions **12***c* provided between the adjacent two balls **3**, **3**. The belt portion **12***b* has a width longer than the diameter of the ball **3** so that the both side edges of the belt portion **12***b* extend outwardly from the ball **3**.

[0112] The spacing portion **12***c* is provided with a ball supporting spherical recess **12***d* corresponding to the spherical surface of the ball **3**. The ball **3** is supported on its both sides by a pair of supporting spherical recesses **12***d* so as to prevent the ball **3** from coming off the belt portion **12***b*. In this embodiment, the one end of the belt portion **12***b* is not connected to the other end thereof, thus forming a strip-shaped belt having the both ends. The one end of the belt portion **12***b* may be connected to the other end thereof so as to form an endless belt.

[0113] The movable block **4** is composed of a block body **13** having ball running counter-grooves **8**, **8**, **8**, **8**, a resin-formed body **20** for forming ball circulation passages, which is inserted in the block body **13**, and a pair of side cover plates **40**, **40** secured to the both end surfaces of the block body **13**, in which the resin-formed body **20** is inserted.

[0114] Each of the ball circulation passages of the resin-formed body **20** comprises a pair of ball passage forming portions **21**, **21** extending along both longitudinal sides of the ball running counter-groove **8**, a pair of direction changing passage-inner guide forming portions **22**, **22** provided on the both side faces of the block body **13**, and a resin pipe **23** as a returning passage forming portion, which is inserted into a through-hole formed in the block body **13**. In this embodiment, the ball passage forming portions **21**, **21** and the pair of direction changing passage-inner guide forming portions **22**, **22** are integrally formed with each other into an integral body, and the resin pipe **23** is separately formed from the above-mentioned integral body. More specifically, there is used a construction that the ball passage forming portions **21**, **21** and the pair of direction changing passage-inner guide forming portions **22**, **22** are integrally connected with each other through integral forming to form an integral resin frame **24**, and the four resin pipes **23** can respectively be inserted into the block body **13**.

[0115] The ball passage forming portions **21**, **21** are provided with guide grooves for guiding the both side edges of the belt portion **12***b* of the ball retainer **12** in a loaded area. The guide grooves can prevent the ball retainer **12** not only from being swung during run of the ball, but also from being sagged by engaging the side edges of the belt portion **12***b* with the guide groove **21***a,* when the movable block **4** is removed from the guide rail **2**. The balls **3** are supported by the ball retainer **12**. More specifically, the ball retainer **12** is supported by a jaw portion of the guide groove **21***a,* with the result that the balls **3** are kept in its proper position so as not to come off the movable block **4**.

[0116] In this embodiment, a distance between the pair of ball passage forming portions **21**, **21** arranged in parallel with each other on the both longitudinal sides of the ball running counter-groove **8** is slightly larger than the diameter of the ball **3**. The balls **3** come off the ball running counter-groove **8**, if the ball retainer **12** is not used. When an amount of projection of the jaw portion **21***b* is predetermined so that a distance between the pair of ball passage forming portions **21**, **21** is slightly smaller than the diameter of the ball **3** as shown in FIG: **3**(*d*), it is however possible to prevent the balls **3** from coming off the ball running counter-groove **8** even without the ball retainer **12**. Such a construction can apply not only to the case where the balls **3** are inserted into the ball circulation passage with the use of the ball retainer **12**, but also to the case where the balls are inserted therein without the ball retainer **12**. The distance between the pair of ball passage forming portions **21**, **21** may be slightly smaller than the diameter of the ball **3** so that the ball passage forming portions **21**, **21** directly hold the ball **3** without the use of the ball retainer **12** as shown in **FIG. 3**(*e*).

[0117] Guide grooves **9***c,* **10***c* are also formed in the ball returning passage **9** and the direction changing passage **10** as non-loaded areas, in order to guide the side edges of the belt portion **12***b*. The guide grooves **9***c,* **10***c* are connected to the above-mentioned guide groove **21***a* in the loaded area so as to form an endless groove on the entire periphery.

[0118] When the ball retainer **12** is not used as shown in **FIG. 3**(*f*), the distance between the pair of ball passage forming portions **21**, **21** arranged on the both longitudinal sides of the ball running counter-groove **8**, which portions do not have any jaw portions **21**, may be slightly smaller than the diameter of the ball **3**, thus preventing the balls **3** from coming off the ball running counter-groove **8**.

[0119] The four sets of ball passage forming portions **21**, **21** are composed of the first thin connecting plate portion **25** extending longitudinally along the under surface of the horizontal portion **6** of the block body **13**, a pair of second connecting plate portions **26**, **26**, which have an L-shaped cross section and extend in the longitudinal direction of the block body **13** along the corner portions between the horizontal portion **6** and the wing portions **7**, **7** of the block body **13**, and a pair of third connecting plate portions **27**, **27**, which extend in the longitudinal direction of the block body **13** along the lower surfaces of the wing portions **7**, **7** of the block body **13**.

[0120] More specifically, the right and left-hand side edges of the first connecting plate portion **25** and the upper edges of the pair of right and left-hand second connecting plate portions **26**, **26** are located at the both sides of the respective ball running counter-grooves **8**, **8** provided on the under surface of the horizontal portion **6**, so as to form the ball passage forming portions **21**, **21**; **21**, **21**. The lower edges of the second connecting plate portions **26**, **26** and the inner edges of the third connecting plate portions **27**, **27** are located at the both sides of the respective ball running counter-grooves **8**, **8** provided on the respective inner surface of the wing portions **7**, **7**, so as to form the other ball passage forming portions **21**, **21**; **21**, **21**.

[0121] The direction changing passage-inner guide forming portion **22** has a thin sheet portion **29**, which is to be connected to the end surface of the block body **13**. The ball passage forming portions **21**, **21** and the resin pipe **23** are connected through the above-mentioned thin sheet portion **29**. In this embodiment, the direction changing passage-inner guide forming portions **22**, **22** and the ball passage forming portions **21**, **21** are connected by means of the thin sheet portion **29** through integral forming. The resin pipe **23** is inserted in a hole **34** formed on the thin sheet portion **29** so as to make a faucet joint, and fixed to the thin sheet portion **29**.

[0122] The thin sheet portion **29** has the first end plate portion **30** corresponding to the end surface of the horizontal portion **6** of the block body **13**, a pair of third end plate portions **32**, **32** corresponding to the end surfaces of the wing portions **7**, **7** and the second end plate portions **31**, **31** for connecting the first end plate portion **30** and the respective third end plate portions **32**, **32**. The first end plate portion **30** has the direction changing passage-inner guide forming portions **22**, **22**, which are formed so as to project corresponding to the two trains of balls **3**, **3** on the upper surface side of the guide rail **2**. Each of the third end plate portions **32**, **32** has the direction changing passage-inner guide forming portion **22**, which is formed so as to project corresponding to the single train of balls **3** on the side surface of the guide rail **2**

[0123] The first end plate portions **30**, **30**, which are to be placed respectively on the both ends of the block body **13** are connected at its lower portion with the both ends of the first connecting plate portion **25** extending longitudinally between the first end plate portions **30**, **30**. The second end plate portions **31**, **31**, which are to be placed respectively on the both ends of the block body **13** are connected at its inner edge portion with the both ends of the second connecting plate portion **26** extending longitudinally between the second end plate portions **31**, **31**. The other second end plate portions **31**, **31** have the same connecting structure. The third end plate portions **32**, **32**, which are to be placed respectively on the both ends of the block body **13** are connected at its inner edge portion with the both ends of the third connecting plate portion **27** extending longitudinally between the third end plate portions **32**, **32**. The other third end plate portions **32**, **32** have the same connecting structure. A single resin frame **24** is formed in this way.

[0124] Each of the direction changing passage-inner guide forming portions **22** has a semi-cylindrical shape. On the outer periphery of the direction changing passage-inner guide forming portion **22**, there is formed an inner guide groove **10***a* having a semicircular cross section so as to form the inner guide portion for the direction changing passage **10**. The one end of the inner guide groove **10***a* is connected to the end of the ball running counter-groove **8**. Accordingly, the one end of the inner guide groove **10***a* has the same crosssectional shape as the ball running counter-groove **8** so as to make an alignment of the one end of the inner guide groove **10***a* with the end of the ball running counter-groove **8**. The other end of the inner guide groove **10***a* of the direction changing passage **10** is connected to the end of the ball returning passage **9**. Accordingly, the other end of the inner guide groove **10***a* has the same cross-sectional shape as the ball returning passage **9** so as to make an alignment of the other end of the inner guide groove **10***a* with the end of the ball returning passage **9**.

[0125] Cylindrical flange portions **33**, **33** are formed on the both ends of the inner guide groove **10***a*. The distance between the respective outer surfaces of the cylindrical flange portions **33**, **33** is larger than the width of the belt portion **12***b*. The cylindrical flange portions **33**, **33** form a retainer-guide groove **10***c* for the ball retainer **12** in cooperation with a semi-circular recess portion having cutouts, which is formed on the inner periphery of the recess of the side cover plate **40** described later.

[0126] The both ends of the inner guide groove **10***a* for the direction changing passage **10** extend to the contacting surface of the first and third end plate portions **30**, **32** with the end surface of the block body **13** so as to be connected to the respective ends of the ball running counter-groove **8** and the ball returning passage **9**. Pipe inserting holes **34**, **34**, **34**, **34** having a semicircular shape, in which the ends of the resin pipes **23** are to be inserted are formed on the first and third end plate portions **30**, **32**. As shown in **FIG. 7**, the resin pipe **23** is composed of an inner peripheral side-half pipe member **23***a* located in the inner peripheral side of the ball circulation passage, which is continuously connected to the inner guide groove **10***a* for the direction changing passage, and an outer peripheral side-half pipe member **23***b* located in the outer peripheral side of the ball circulation passage, which is continuously connected to an outer guide groove **10***b* for the direction changing passage **10**, which is formed on the side cover plate **40**. The inner peripheral side-half pipe member **23***a* has a groove portion **9***a* having a semi-circular cross section, and side edge portions **23***c* extending longitudinally along the groove portion **9***a*.

[0127] The outer peripheral side-half pipe member **23***b* is formed into a linear member having the same circular cross section as the outer guide groove **10***b* for the direction changing passage, which is formed on the side cover plate **40**. The outer peripheral side-half pipe member **23***b* has a groove portion **9***b*, which is continuously connected to the outer guide groove **10***b*, and side edge portions **23***d* extending longitudinally along the groove portion **9***b* . The side edge portions **23***d* is provided on its outer edges with projections **23***e*, which are to be brought into contact with the outer edges of the side edge portions **23***c* of the inner peripheral side-half pipe member **23***a* to form the retainer-guide groove **9***c* for the ball retainer **12**.

[0128] The inner peripheral side-half pipe member **23***a* of the resin pipe **23** has the same length of the block body **13**. The inner peripheral side-half pipe member **23***a* is positioned so as to be brought into contact with the back surface of the direction changing passage-inner guide forming portion **22**.

[0129] The outer peripheral side-half pipe member **23***b* of the resin pipe **23** has on the other hand a longer length than the block body **13** by a length corresponding to the thickness of the thin sheet portion **29**. The outer peripheral side-half pipe members **23***b* are inserted in the inserting holes **34** of the first and third end plate portions **30**, **32**. Longitudinal positional determination of the outer peripheral side-half pipe member **23***b* is made by bringing the both ends of the outer peripheral side-half pipe member **23***b* inserted in the inserting holes **34** into contact with the peripheral edge of the end portion of the outer guide grooves **10***b* for the direction changing passage, which are formed on the side cover plate **40**. The projections **23***e* formed on the both side edges of the outer peripheral side-half pipe member **23***b* come into contact with the outer edges of the cylindrical flange portions **33** formed on the direction changing passage-inner guide forming portion **22** to form a part of the guide groove **10***c*, and the outer peripheral side-half pipe member **23***b* and the inner peripheral side-half pipe member **23***a* are restricted to be turned in the inserting hole **14**.

[0130] The resin pipes **23** and the direction changing passage-inner guide forming portions **22** are accurately positioned through the inserting holes **34** formed on the first and third end plate portions **30**, **32** of the thin sheet portion **29** and a proper assembling is carried out in this manner.

[0131] As shown in **FIG. 5**, the side cover plate **40** is provided with an inserting recess portion **40***a*, in which the thin sheet portion **29** is inserted, four recess portions **41** having the outer guide grooves **10***b* for the direction changing passage, into which portions the direction changing passage-inner guide forming portions **22** are fitted, and screw-fixing portions for securing the side cover plate **40** to the block body **13**. In the screw-fixing portions, the side cover plate **40** is fixed to the block body **13** by inserting bolts **44** into holes **43** formed on the side cover plate **40** and engaging the bolts with screwed holes **45** formed on the end surface of the block body **13**. The holes **43** are located between the first and third end plate portions **30**, **32** of the thin sheet portion

[0132] As shown in **FIG. 7**, the outer guide groove **10***b* for the direction changing passage in the recess portion **41** has on its side edges larger-diameter arcuate recesses **46**, which form the retainer-guide groove **10***c* in cooperation with the cylindrical flange portions **33** of the direction changing passage-inner guide forming portions **22**, and a smaller-diameter arcuate recesses **47**, in which the cylindrical flange portions **33** are inserted. The direction changing passage-inner guide forming portion **22** provided with the inner guide groove **10***a* for the direction changing passage is fitted into the recess portion **41** of the side cover plate **40**, and the thin sheet portion **29** is received in the inserting recess portion **40***a* of the side cover plate **40**. The thin sheet portion **29** is held between the side cover plate **40** and the end surface of the block body **13** through a clamping force so as to be firmly fixed therebetween.

[0133] The direction changing passage-inner guide forming portions **22** and the ball passage forming portion **21** are connected through the thin sheet portion **29**, thus making it possible to maintain an accurate positional relationship of the end of the inner guide groove **10***a* for the direction changing passage formed in the direction changing passage-inner guide forming portion **22** relative to the ball passage forming portions **21**, **21**, as well as an accurate positional relationship of the inner guide groove **10***a* for the direction changing passage relative to the ball returning passage **9**.

[0134] The thin sheet portion **29** located in the vicinity of the direction changing passage-inner guide forming portion **22** is uniformly urged against the flat end surface of the block body **13** through a clamping force applied to the side cover plate **40** (see **FIG. 7**). Even when the direction changing passage-inner guide forming portion **22** is not located in a correct position, the thin sheet portion **29** changes its shape on the end surface of the block body **13**, thus permitting the correct positioning of the direction changing passage-inner guide forming portion **22**. The thin sheet portion **29** is firmly clamped and fixed through a clamping force, which is applied to the side cover plate **40**, and frictional force caused by such a clamping step may prevent an unfavorable movement of the inner guide groove **10***a* for the direction changing passage.

[0135] The side cover plate **40** is secured to the block body **13** so that the direction changing passage-inner guide forming portion **22** assembled to the block body **13** is fitted into the recess portion **41** of the side cover plate **40**. Such a fitting step permits to make an accurate positioning of the side cover plate **40** relative to the block body **13**.

[0136] **FIG. 6** shows assembling steps for the above-described resin-formed body for forming the ball circulation passage.

[0137] First, the inner peripheral side-half pipe member **23***a* of the resin pipe **23** is inserted in the through-hole **14** of the block body **13** (see FIGS. **6**(*a*) and **6**(*b*)).

[0138] Then, the resin frame **24** obtained by integral forming is inserted in the recess of the block body **13**, while causing the thin sheet portions **29** at the both ends of the resin frame **24** to slide on the respective end surfaces of the block body **13** (see FIGS. **6**(*c*) and **6**(*d*)). The first connecting plate portion **25** of the resin frame **24** comes into contact with the under surface of the horizontal portion **6**, thus making positional determination in the vertical direction of the resin frame **24**. The second connecting plate portion **26** and the third connecting plate portion **27** of the resin frame **24** come into contact with the respective inner surfaces of the wing portions **7**, **7** of the block body **13**, thus making positional determination of the ball passage forming portions **21**, **21** and the direction changing passage-inner guide forming portion **22** (see FIGS. **6**(*e*) and **6**(*f*)). At this time, the inserting hole **34** of the thin sheet portion **29** is aligned with the through-hole **14** of the block body **13**.

[0139] Then, the outer peripheral side-half pipe member **23***b* is inserted in the through-hole **14** from the inserting hole **34**, thus completing the assembling step of the resin-formed body **20** for forming the ball circulation passage (see FIGS. **6**(*g*) and **6**(*h*)).

[0140] Then, the one side cover plate **40** is secured to the one end surface of the block body **13** by a clamping step, the ball retainer **12** holding the balls is inserted, and the other side cover plate **40** is secured to the other end surface of the block body **13** by the same clamping step, thus completing the assembling step of the movable block **4**.

[0141] According to the present invention, the resin-formed body **20** for forming the ball circulation passage is separately formed from the block body **13**. Even when the movable block **4** has a larger size, there is no restriction of flow of molten resin by the block body **13**, unlike the case where the block body **13** is integrally formed with the resin-formed body **20**. Increase in number of gates formed on a die may ensure proper run of the molten resin, thus improving the formability. Especially, the ball passage forming portions **21**, **21** located at the opposite longitudinal sides of the ball running groove **8** are thin, with the result that molten resin may not reach every part of the space for forming the ball passage forming portions **21**, **21**. It is therefore effective to form the resin-formed body **20** separately from the block body **13** in accordance with the embodiment of the present invention.

[0142] The continuous circulation passage is formed by the resin-formed body **20**, and it is therefore possible to make positional determination of the inner guide groove **10***a* for the direction changing passage relative to the ball passage forming portions **21**, **21**, as well as positional determination of the inner guide groove **10***a* for the direction changing passage relative to the ball returning passage **9**, thus ensuring continuity of the circulation passage so as to make smooth circulation of the balls **3**.

[0143] When the proper positional relationship of the inner guide groove **10***a* for the direction changing passage relative to the ball passage forming portions **21**, **21**, is maintained, the ball passage forming portions **21**, **21** are located at the longitudinal both sides of the ball running groove **8** so as to be aligned with the ends of the inner guide groove **10***a* for the direction changing passage.

[0144] When the proper positional relationship of the inner guide groove **10***a* for the direction changing passage relative to the ball returning passage **9** is maintained, the inner guide groove **10***a* for the direction changing passage can be aligned with the inner groove **23***a* of the ball returning passage **9**.

[0145] The connecting portion of the ball passage forming portions **21**, **21** and the direction changing passage-inner guide forming portion **22** is obtained by integral forming, thus permitting omission of an assembling step of the connecting portion. Although the running direction of the balls **3** is changed in such a connecting portion, the above-mentioned integral structure may ensure continuity of the circulation passage, without being affected by assembling accuracy. It is therefore possible to make smooth run of the balls **3** from the ball running passage between the ball running groove **5** and the ball running counter-groove **8** to the direction changing passage **10**, as well as from the direction changing passage **10** to the ball returning passage **9**.

[0146] Description will be given of modifications of the resin-formed body **20** for forming the ball circulation passage, which is divided into parts In the description of the modifications, modified features will only be explained in comparison with the first embodiment of the present invention. The same reference numerals will be given to the same components as those in the first embodiment of the present invention, and description thereof will be omitted.

[0147] First Modification

[0148] **FIGS. 8 and 9** show the first modification of the resin-formed body **20** for forming the ball circulation passage, which is described in the first embodiment.

[0149] In the first modification, the resin-formed body **20** for forming the ball circulation passage is composed of the first resin-formed frame **20**A, which is obtained by integrally connecting both of the ball passage forming portions **21**, **21** and the resin pipes **23** at their ends with the direction changing passage-inner guide forming portions **22**A for one side, and the second resin-formed frame **20**B, which is provided with the direction changing passage-inner guide forming portions **22**B for the other side and separately formed from the first resin-formed frame **20**A.

[0150] In this case, the ball passage forming portions **21**, **21** are integrally connected with the direction changing passage-inner guide forming portions **22**A through the thin sheet portion **29**A as in the first embodiment.

[0151] The direction changing passage-inner guide forming portions **22**A are also integrally connected with the resin pipes **23** through the thin sheet portion **29**A. In this case, the resin pipe **23** is formed into a tubular integral body, although the half pipe members are used in the first embodiment. Accordingly, there exists no inserting hole **34** in the thin sheet portion **29**A, and the ball returning passage **9** is exposed on the thin sheet portion **29**A.

[0152] The first resin-formed frame **20**A and the second resin-formed frame **20**B are connected, as shown in **FIG. 9**, by means of a joint method using the combination of a recess and a projection to be inserted therein, such as a faucet joint method. In the illustrated example, a recess portion **36** of a dove-tail groove is formed in the second resin-formed frame **20**B, and an engaging projection **35** to be engaged with the recess portion **36** is formed, on the other hand, in the ball passage forming portions **21**, **21**.

[0153] In this case, the resin pipe **23** of the first resin-formed frame **20**A is inserted in the through-hole **14** of the block body **13**, and the first, second and third connecting plate portions **25**, **26**, **27** are inserted along the under surface of the horizontal portion **6** of the block body **13** and the inner surfaces of the wing portions **7**,.**7**.

[0154] Then, the engaging projections **35** formed at the respective free end portions of the first, second and third connecting plate portions **25**, **26**, **27** are engaged with the recess portions **36** formed on the thin sheet portion **29**B of the second resin-formed frame **24**B, which is arranged on the other end surface of the block body **13**.

[0155] The recess portions **36** may be formed on the first resin-formed frame **20**A and the engaging projections **35** may be formed on the second resin-formed frame **20**B. The connecting method is not limited to the method described above, and there may be used any conventional connecting method, in which the ends of the divided parts can be maintained in a proper connecting position and connected.

[0156] Second Modification

[0157] **FIGS. 10 and 11** show the second modification of the resin-formed body **20** for forming the ball circulation passage, which is described in the first embodiment.

[0158] In the second modification, the resin-formed body **20** for forming the ball circulation passage, which has been obtained by integrally forming both of the ball passage forming portions **21**, **21** and the resin pipes **23** as a returning passage forming portion with a pair of direction changing passageinner guide forming portions **22**, **22**, is divided at the middle portion of each of the ball passage forming portions **21**, **21** and the resin pipes **23** into two parts. More specifically, the ball passage forming portions **21**, **21** and the resin pipes **23** are divided at their middle portion into the respective two half parts, and each of the thus divided two half parts is integrally formed with the direction changing passage-inner guide forming portions **22**, **22**, thus forming two resin-formed frames **20**C, **20**D having substantially the same shape.

[0159] Four sets of the ball passage forming portions **21**, **21** are formed on the first, second and third connecting plate portions **25**, **26**, **27**. Recess portions **38** and engaging projections **37** to be inserted therein are formed on the divided ends of the first, second and third connecting plate portions **25**, **26**, **27** and the divided ends of the resin pipes **23**.

[0160] Third Modification

[0161] FIGS. **12** to **14** show the third modification of the resin-formed body **20** for forming the ball circulation passage, which is described in the first embodiment.

[0162] In the third modification, there is not used the resin pipe **23** as a returning passage forming portion described in the first embodiment, and a resin-formed frame **20**E is obtained by integrally forming the first, second and third connecting plate portions **25**, **26**, **27** having the ball passage forming portions **21**, **21** with the thin sheet portions **29**, **29** each having the pair of direction changing passage-inner guide forming portions **22**, **22**. The ball returning passage **9** is composed as a through-hole formed in the block body **13**.

[0163] In this case, an engaging projection **39***a*, which is engageable with a tapered portion **15** formed in the opening end of the ball returning passage **9** may be formed in the opening end of the ball hole **39** of the thin sheet portion **29**. Such a construction permits to make a proper connection of the end of the ball returning passage **9** and the direction changing passage-inner guide forming portion **22**.

[0164] In the illustrated example, an arcuate engaging projection **48** is additionally formed on the connection portion of the outer guide groove **10***b* for the direction changing passage with the ball returning passage **9**. The engaging projection **48** can be fitted into the ball hole **39** of the thin sheet portion **29** and engaged with the tapered portion **15** of the opening end of the ball returning passage **9**.

[0165] Fourth Modification

[0166] **FIG. 15** shows the fourth modification of the resin-formed body **20** for forming the ball circulation passage, which is described in the first embodiment.

[0167] In the fourth modification, there is not used the resin pipe **23** described in the third modification, a resin-formed frame **24**B is obtained by integrally forming the ball passage forming portions **21** with the direction changing passage-inner guide forming portions **22** for the one side, the other resin-formed frame **24**C provided with the direction changing passage-inner guide forming portions **22** for the other side is separately formed from the above-mentioned resin-formed frame **24**B, and the resin-formed frames **24**B, **24**C are connected with each other by engagement of the engaging projection **35** with the recess **36**. The structure other than the above-mentioned construction is the same as that of the third modification.

[0168] Modifications of the ball train

[0169] In the first embodiment and the first to fourth modifications, there is described that two trains of the balls are provided on the upper surface of the guide rail **2** and the single train of the balls is provided on each of the side surfaces of the guide rail **2**, so as to provide the total number of trains of four. In the present invention, the other type of ball trains can however be applied as shown in **FIG. 16**. With respect to the division of the resin-formed body **20** for forming the ball circulation passage, all the modifications as shown in **FIG. 16** are based on the divisional pattern of the first embodiment. All the divisional patterns of the first to fourth modifications may however be applied to the modifications of the ball train as shown in **FIG. 16**.

[0170] In the example as shown in FIGS. **16**(*a*) and **16**(*b*), two lower and upper trains of the balls as rolling members are provided on each of the gaps between the right and left-hand side surfaces of the guide rail **2** and the inner surfaces of the right and left-hand wing portions **7**, **7** of the movable block **13**, so as to provide the total number of trains of four.

[0171] **FIG. 16**(*b*) shows the resin-formed body **20** in which all the ball passage forming portions for the four trains of the balls are integrally formed with each other. The resin-formed body **20** may however be divided into two resin-formed bodies **20**, **20**, which correspond to two trains of the balls for each of the right and left-hand sides of the guide rail **2**, as shown in **FIG. 18**.

[0172] In the example as shown in FIGS. **16**(*c*) and **16**(*d*), the movable block **4** is provided with the horizontal portion **6** facing the upper surface of the guide rail **2** and a single wing portion **7** facing the one side surface of the guide rail **2**. The single train of the balls **3** as rolling members is provided between the one side surface of the guide rail **2** and the single wing portion **7** of the movable block **4**, and the other single train of the balls **3** is provided between the upper surface of the guide rail **2** and the lower surface of the horizontal portion in the vicinity of the corner of the guide rail **2**, so as to provide the total number of trains of two.

[0173] In the example as shown in FIGS. **16**(*e*) and **16**(*f*), the movable block **4** is provided with a pair of wing portions **7**, **7** between which the guide rail **2** is held at its right and left-hand surfaces. The single train of the balls **3** is provided in each of the gaps between the right and left-hand surfaces of the guide rail **2** and the inner surfaces of the right and left-hand wing portions **7**, **7** of the movable block **4**, so as to provide the total number of trains of two.

[0174] In the example as shown in FIGS. **16**(*g*) and **16**(*h*), the movable block **4** is arranged along the one side surface of the guide rail **2**. Two upper and lower trains of the balls **3** are provided between the one side surface of the guide rail **2** and the movable block **4**.

[0175] Second Embodiment

[0176] FIGS. **18** to **20** show a linear motion guiding apparatus of the second embodiment of the present invention.

[0177] In the second embodiment, rollers are used as rolling members. More specifically, the linear motion guiding apparatus comprises a guide rail **202** as a guide member, extending linearly, and a movable block **204** arranged so as to be movable along the guide rail **202** through a large number of rollers **203** as rolling members.

[0178] The guide rail **202** is formed into a long bar shape having a rectangular cross-section. Two roller running surfaces **205**, **205** as a rolling member running track are formed on the horizontal upper surface of the guide rail **2**, and a single roller running surface **205** as the rolling member running track is formed on each of the right and left-hand vertical surfaces of the guide rail **2**, so as to provide a total number of surfaces **5** of four.

[0179] The movable block **204** is formed as a block body having an inverse U-shaped cross-section, with its opening end being directed downwardly. The block body is provided with a horizontal portion **206**, which faces the upper surface of the guide rail **202** and with a pair of wing portions **207**, **207**, which extend downwardly from the right and left ends of the horizontal portion **206** and face the right and left-hand side surfaces of the guide rail **202**, respectively. The horizontal portion **206** has on its lower surface two roller running counter-surfaces **208**, **208** as a rolling member running counter-track, which correspond to the roller running surfaces **205, 205** formed on the upper surface of the guide rail **202**. Each of the wing portions **207, 207** has on its inner surface a single roller running counter-surface **208** as the rolling member running counter-track, which corresponds to the respective roller running surfaces **205, 205** formed on the right and left-hand side surfaces of the guide rail **202**.

[0180] In addition, in the movable block **204**, there are formed four roller returning passages **209, 209, 209, 209** as a rolling member returning passage, which are provided in parallel with the four roller running counter-surfaces **208, 208, 208, 208**, respectively, as well as four pairs of direction changing passages **210, 210, 210, 210** each having a U-shape, for connecting the respective both ends of the roller running counter-surfaces **208, 208, 208, 208** with the respective both ends of the roller returning passages **209, 209, 209, 209**, so as to form four endless circulation passages.

[0181] The roller returning passages **209, 209** respectively corresponding to the roller running surfaces **205, 205** formed on the upper side of the guide rail **202** are formed in the horizontal portion **206**. The other roller returning passages **209, 209** respectively corresponding to the roller running surfaces **205, 205** formed on the right and left-hand vertical surfaces of the guide rail **202** are formed in the wing portions **207, 207** of the movable block **204**, respectively.

[0182] In each of the endless circulation passages in this embodiment, the rollers **3** are retained in the form of train by means a roller retainer **212** as a rolling member retainer so that the rollers **203** can be circulated while being guided by the roller retainer **212**.

[0183] As shown in FIGS. **19**(*b*) to **19**(*d*), the roller retainer **212** comprises a flexible belt portion **212***b*, which is provided with roller holes **212***a* for respectively receiving the rollers **203**, and spacing portions **212***c* provided between the adjacent two rollers **203, 203**. The belt portion **212***b* has a width longer than the diameter of the roller **203** so that the both side edges of the belt portion **212***b* extend outwardly from the roller **203**.

[0184] The spacing portion **212***c* is provided with a roller supporting recess **212***d* corresponding to the cylindrical surface of the roller **203**. The roller **203** is supported on its both sides by a pair of supporting recesses **212***d* so as to prevent the roller **203** from coming off the belt portion **212***b*. In this embodiment, the one end of the belt portion **212***b* is not connected to the other end thereof, thus forming a strip-shaped belt having the both ends. The one end of the belt portion **212***b* may be connected to the other end thereof so as to form an endless belt.

[0185] As shown in **FIGS. 18 and 20**, the movable block **204** is composed of a metallic block body **213** having roller running counter-surfaces **208, 208, 208, 208**, a resin-formed body **220** for forming roller circulation passages, which is inserted in the block body **213**, and a pair of side cover plates **214, 214** secured to the both end surfaces of the block body **213**, in which the resin-formed body **220** is inserted.

[0186] In the second embodiment, four circulation passages are formed by two resin-formed bodies **220, 220** for forming the roller circulation passage, which are arranged at the right and left-hand sides.

[0187] Each of the roller circulation passages of the resin-formed bodies **220** comprises a pair of roller passage forming portions **221, 221** extending along both longitudinal sides of the roller running counter-surface **208**, a pair of direction changing passage-inner guide forming portions **222, 222** provided on the both side surfaces of the block body **213**, and a resin pipe **223** as a returning passage forming portion, which is inserted into a through-hole formed in the block body **213**.

[0188] The roller passage forming portions **221, 221** are provided with guide surfaces for guiding the both side edges of the belt portion **212***b* of the roller retainer **212** in a loaded area as illustrated in detain in **FIG. 20**. The guide grooves can prevent the roller retainer **212** not only from being swung during run of the roller, but also from being sagged by engaging the side edges of the belt portion **212***b* with the guide groove **221***a*. The rollers **203** are supported by the roller retainer **212**. More specifically, the roller retainer **212** is supported by a jaw portion of the guide groove **221***a*, with the result that the rollers **203** are kept-in its proper position so as not to come off the movable block **204**.

[0189] In this embodiment, the one end of the belt portion **212***b* is not connected to the other end thereof, thus forming a strip-shaped belt having the both ends. The one end of the belt portion **212***b* may be connected to the other end thereof so as to form an endless belt.

[0190] Guide grooves **209***c*, **210***c* are also formed in the roller returning passage **209** and the direction changing passage **210** as non-loaded areas, in order to guide the side edges of the belt portion **212***b*. The guide grooves **209***c*, **210***c* are connected to the above-mentioned guide groove **221***a* in the loaded area so as to form an endless groove on the entire periphery.

[0191] In each of the resin-formed bodies **220, 220** for forming the roller circulation passage, the roller passage forming portions **221, 221** and the pair of the direction changing passage-inner guide forming portions **222, 222** are integrally formed with each other. The resin pipe **223** for forming the roller returning passage **209** is separately formed from the resin-formed bodies **220, 220**. More specifically, the one ends of the two pairs of the roller passage forming portions **221, 221** are integrally connected with the ends of the pair of direction changing passage-inner guide forming portions **222, 222** to form a single resin frame **220A** so that the thus formed resin frame **220A** can be inserted into the block body **213**. The other resin frame **220A** has the same construction.

[0192] The roller passage forming portions **221, 221** to be arranged on the upper surface of the guide rail **202** are integrally connected with the other roller passage forming portions **221, 221** to be arranged on the side surface of the guide rail **202** by means of a thin connecting plate portion **226**.

[0193] The direction changing passage-inner guide forming portion **222** is integrally formed with a thin sheet portion **229**, which is to be brought into contact with the end surface of the block body **213**.

[0194] The thin sheet portion **229** has the first end plate portion **230**, which is to be brought into contact with the end surface of the horizontal portion **206** of the block body **213**, the third end plate portion **232**, which is to be brought into contact with the end surface of the wing portion **207**, and the second end plate portion **231**, which is arranged at the corner between the horizontal portion **206** and the wing portion **207** on the end surface of the block body **213**, and connects the first end plate portion **230** with the third end plate portion **232**.

[0195] The pair of roller passage forming portions **221**, **221**, which are arranged on the both longitudinal sides of the roller running surface **208** are integrally formed on the inside edge of the first end plate portion **230** and the inside edge of the third end plate portion **232**, respectively. The both ends of the connecting plate portion **226** are integrally connected with the inside edges of the second plate portions **231**, **231**.

[0196] Each of the direction changing passage-inner guide forming portions **222** has a semi-cylindrical shape. On the outer periphery of the direction changing passage-inner guide forming portion **222**, there is formed an inner guide groove **210***a* having a rectangular cross section so as to form the inner guide portion for the direction changing passage **210**. The one end of the bottom of the inner guide groove **210***a* is connected to the end of the roller running counter-surface **208**. Accordingly, the one end of the inner guide groove **210***a* has the same cross-sectional shape as the roller running counter-surface **208** so as to make an alignment of the one end of the inner guide groove **210***a* with the end of the roller running counter-surface **208**. The other end of the inner guide groove **210***a* of the direction changing passage **210** is connected to the end of the roller returning passage **229**. Accordingly, the other end of the inner guide groove **210***a* has the same cross-sectional shape as the roller returning passage **209** so as to make an alignment of the other end of the inner guide groove **210***a* with the end of the roller returning passage **209**.

[0197] Cylindrical flange portions **233**, **233** are formed on the both ends of the inner guide groove **210***a*. The distance between the respective outer surfaces of the cylindrical flange portions **233**, **233** is larger than the width of the belt portion **212***b*. The cylindrical flange portions **233**, **233** form a guide groove **210***c* for the roller retainer **212** in cooperation with the side cover plate **240** described later.

[0198] The one end of the inner guide groove **210***a* for the direction changing passage **210** extends to the contacting surface of the first and third end plate portions **230**, **232** with the end surface of the block body **213** so as to be connected to the end of the roller running counter-surface **208**. The other end of the inner guide groove **210***a* for the direction changing passage **210** extends to the end surface of the thin sheet portion **229**, which the block body **213**. A step portion **222***a* having a depth identical to the thickness of the thin sheet portion **229** is formed at the other end of the inner guide groove **210***a*. The inner peripheral side-half pipe member for the resin pipe **223** projects from the end surface of the block body **13** by a length identical to the thickness of the thin sheet portion **229**. The projected end of the half pipe member **223***a* is fitted into the step portion **222***a* of the thin sheet portion **229**.

[0199] Pipe inserting holes **234**, **234** having a semi-circular shape, in which the ends of for the outer peripheral side-half pipe member **223***a*for the resin pipes **223** for forming the roller returning passage **209** are to be inserted are formed on the first and third end plate portions **230**, **232** of the thin sheet portion **229**. The resin pipe **223** is inserted into the circular through-hole **214** formed in the block body **213** so that the inner peripheral surface of the resin pipe **223** form the roller returning passage **209**.

[0200] As shown in **FIG. 20**, the resin pipe **223** is composed of the inner peripheral side-half pipe member **223***a*, which is continuously connected to the inner guide groove **210***a* for the direction changing passage, and the outer peripheral side-half pipe member **223***b*, which is continuously connected to the outer guide groove **210***b* for the direction changing passage **210**, which is formed on the side cover plate **240**. The inner peripheral side-half pipe member **223***a* has an inner groove portion **209***a* having a rectangular cross section, and side edge portions **223***b* extending longitudinally along the inner groove portion **209***a*. The longitudinal edge portions **223***c* of the inner peripheral side-half pipe member **223***a* has the same width as the flange portion **233** of the portion **228**.

[0201] The outer peripheral side-half pipe member **223***b* is formed into a linear member having the same rectangular cross section as the outer guide groove **210***b* for the direction changing passage, which is formed on the side cover plate **240**. The outer peripheral side-half pipe member **223***b* has a outer groove portion **209***b*, which is continuously connected to the outer guide groove **210***b*, and side edge portions **223***d* extending longitudinally along the outer groove portion **209***b*. The side edge portions **223***d* is provided on its outer edges with projections **223***e*, which are to be brought into contact with the side edge portions **223***c* of the inner peripheral side-half pipe member **223***a* to form the guide groove for the belt portion **212** of the roller retainer **212**.

[0202] The inner peripheral side-half pipe member **223***a* of the resin pipe **223** has the same length of the block body **213**. The inner peripheral side half pipe member **223***a* is positioned so as to be brought into contact with the end surface of the direction changing passage-inner guide forming portion **222**, which is arranged on the side of the block body **213**.

[0203] The outer peripheral side-half pipe member **223***b* of the resin pipe **223** has on the other hand a longer length than the block body **213** by a length corresponding to the thickness of the first and third end plate portions of the thin sheet portion **229**, which are arranged on the both ends of the block body **213**. The outer peripheral side-half pipe members **223***b* are inserted in the inserting holes **234** of the first and third end plate portions **230**, **232**. Longitudinal positional determination of the outer peripheral side-half pipe member **223***b* is made by bringing the both ends of the outer peripheral side-half pipe member **223***b* inserted in the inserting holes **234** into contact with the peripheral edge of the end portion of the outer guide grooves **210***b* for the direction changing passage, which are formed on the side cover plate **240** The projections **223***e* formed on the both longitudinal side edges **223** of the outer peripheral side-half pipe member **223***b* come into contact with the cylindrical flange portions **233** at the side edges of the inner guide groove **210***a* of the direction changing passage-inner guide forming portion **222**, and the outer peripheral side-half pipe member **223***b* and the inner peripheral side-half pipe member **223***a* are restricted to be turned in the inserting hole **214**.

[0204] The resin pipes **223** and the direction changing passage-inner guide forming portions **222** are accurately positioned through the inserting holes **234** formed on the first and third end plate portions **230**, **232** of the thin sheet portion **229** and a proper assembling is carried out in this manner.

[0205] The side cover plate **240** is provided with four recess portions **241** having the outer guide grooves **210***b* for the direction changing passage, into which the portions **228** of the direction changing passage-inner guide forming portions **222** are fitted, and screw-fixing portions for securing the side cover plate **240** to the block body **213**. In the screw-fixing portions, the side cover plate **240** is fixed to the block body **213** by inserting bolts **244** into holes **243** formed on the side cover plate **240** and engaging the bolts **244** with screwed holes **245** formed on the end surface of the block body **213**. The holes **243** are located between the first and third end plate portions **230**, **232** of the thin sheet portion **229**.

[0206] The direction changing passage-inner guide forming portion **222** provided with the inner guide groove **210***a* for the direction changing passage is fitted into the recess portion **241** of the side cover plate **240**. The thin sheet portion **229** is held between the side cover plate **240** and the end surface of the block body **213** through a clamping force so as to be firmly fixed therebetween.

[0207] The direction changing passage-inner guide forming portions **222** and the roller passage forming portion **221** are connected through the thin sheet portion **229**, thus making it possible to maintain an accurate positional relationship of the end of the inner guide groove **210***a* for the direction changing passage relative to the roller passage forming portions **221**, as well as an accurate positional relationship of the inner guide groove **210***a* for the direction changing passage relative to the roller returning passage **209**.

[0208] The thin sheet portion **229** is uniformly urged against the flat end surface of the block body **213** through a clamping force applied to the side cover plate **240**. Even when the direction changing passage-inner guide forming portion **222** is not located in a correct position, the thin sheet portion **229** changes its shape, thus permitting the correct positioning of the direction changing passage-inner guide forming portion **222**. The thin sheet portion **229** is firmly clamped and fixed through a clamping force, which is applied to the side cover plate **240**, and frictional force caused by such a clamping step may prevent an unfavorable movement of the inner guide groove **210***a* for the direction changing passage.

[0209] Description will be given of modifications of the resin-formed body **220** for forming the roller circulation passage, which is divided into parts In the description of the modifications, modified features will only be explained in comparison with the second embodiment of the present invention. The same reference numerals will be given to the same components as those in the second embodiment of the present invention, and description thereof will be omitted.

[0210] First Modification

[0211] **FIGS. 21 and 22** show the first modification of the resin-formed body **20** for forming the ball circulation passage, which is described in the second embodiment.

[0212] In the first modification, the resin-formed body **220** for forming the ball circulation passage is composed of the first resin-formed frame **220**A, which is obtained by integrally connecting both of the roller passage forming portions **221**, **221** and the resin pipes **223** at their ends with the direction changing passage-inner guide forming portions **222**A for one side, and the second resin-formed frame **220**B, which is provided with the direction changing passage-inner guide forming portions **222**B for the other side and separately formed from the first resin-formed frame **220**A.

[0213] In this case, the roller passage forming portions **221**, **221** are integrally connected with the direction changing passage-inner guide forming portions **222**A through the thin sheet portion **229**A as in the second embodiment.

[0214] The direction changing passage-inner guide forming portions **222** are also integrally connected with the resin pipes **223** through the thin sheet portion **229**A. In this case, the resin pipe **223** is formed into a tubular integral body, although the half pipe members are used in the second embodiment. Accordingly, there exists no inserting hole **234** in the thin sheet portion **229**A, and the roller returning passage **209** is exposed on the thin sheet portion **229**A.

[0215] The first resin-formed frame **220**A and the second resin-formed frame **220**B are connected, as shown in **FIG. 22**, by means of a joint method using the combination of a recess and a projection to be inserted therein, such as a faucet joint method. In the illustrated example, a recess portion **236** of a dove-tail groove is formed in the second resin-formed frame **220**B, and an engaging projection **235** to be engaged with the recess portion **236** is formed, on the other hand, in the roller passage forming portions **221**, **221**.

[0216] In this case, the resin pipe **223** of the first resin-formed frame **220**A is inserted in the through-hole **214** of the block body **213**, and the roller passage forming portions **221**, **221** and the connecting plate portion **226** are inserted along the under surface of the horizontal portion **206** of the block body **213** and the inner surfaces of the wing portions **207**,.**207**.

[0217] Then, the engaging projections **235** formed at the roller passage forming portions **221**, **221** and the connecting plate portion **226** are engaged with the recess portions **236** formed on the thin sheet portion **229**B of the second resin-formed frame **224**B, which is arranged on the other end surface of the block body **213**.

[0218] The recess portions **236** may be formed on the first resin-formed frame **220**A and the engaging projections **235** may be formed on the second resin-formed frame **220**B. The connecting method is not limited to the method described above, and there may be used any conventional connecting method in which the ends of the divided parts can be maintained in a proper connecting position and connected.

[0219] Second Modification

[0220] **FIGS. 23 and 24** show the second modification of the resin-formed body **220** for forming the ball circulation passage, which is described in the second embodiment.

[0221] In the second modification, the resin-formed body **220** for forming the roller circulation passage, which has been obtained by integrally forming both of the roller passage forming portions **221**, **221** and the resin pipes **223** as a returning passage forming portion with a pair of direction changing passage-inner guide forming portions **222**, **222**, is divided at the middle portion of each of the roller passage forming portions **221**, **221** and the resin pipes **223** into two parts. More specifically, the roller passage forming portions **221**, **221** and the resin pipes **223** are divided at their middle portion into the respective two half parts, and each of the thus divided two half parts is integrally formed with the direction changing passage-inner guide forming portions **222**, **222**, thus forming two resin-formed frames **220**C, **220**D having substantially the same shape.

[**0222**] Recess portions **238** and engaging projections **237** to be inserted therein are formed on the divided ends of the roller passage forming portions **221**, **221** and the divided ends of the connecting plate portion **226** and the divided ends of the resin pipes **223**.

[**0223**] Third Modification

[**0224**] FIGS. **25** to **26** show the third modification of the resin-formed body **220** for forming the roller circulation passage, which is described in the second embodiment.

[**0225**] In the third modification, there is not used the resin pipe **223** as a returning passage forming portion described in the second embodiment, and a resin-formed frame **220**E is obtained by integrally forming the both of the roller passage forming portions and the connecting plate portion **226** with the thin sheet portions **229**, **229** each having the pair of direction changing passage-inner guide forming portions **222**, **222**. The roller returning passage **209** is composed as a through-hole formed in the block body **213**.

[**0226**] In this case, an engaging projection **239***a*, which is engageable with a tapered portion **215** formed in the opening end of the roller returning passage **209** may be formed in the opening end of the roller hole **239** of the thin sheet portion **229**. Such a construction permits to make a proper connection of the end of the roller returning passage **209** and the direction changing passage-inner guide forming portion **222**.

[**0227**] In the illustrated example, an arcuate engaging projection **248** is additionally formed on the connection portion of the outer guide groove **210***b* for the direction changing passage with the roller returning passage **209**. The engaging projection **248** can be fitted into the roller hole **239** of the thin sheet portion **229** and engaged with the tapered portion **215** of the opening end of the roller returning passage **209**.

[**0228**] Fourth Modification

[**0229**] **FIG. 26** shows the fourth modification of the resin-formed body **220** for forming the roller circulation passage, which is described in the second embodiment.

[**0230**] In the fourth modification, there is not used the resin pipe **223** described in the third modification, a resin-formed frame **220**F is obtained by integrally forming the roller passage forming portions **221** with the direction changing passage-inner guide forming portions **222** for the one side, the other resin-formed frame **220**F provided with the direction changing passage-inner guide forming portions **222** for the other side is separately formed from the above-mentioned resin-formed frame **220**F, and the resin-formed frames **220**F, **220**F are connected with each other by engagement of the engaging projection **235** with the recess **236**. The structure other than the above-mentioned construction is the same as that of the third modification.

[**0231**] Modifications Of The Roller Train

[**0232**] In the second embodiment and the first to fourth modifications, there is described that two trains of the rollers are provided on the upper surface of the guide rail **2** and the single train of the rollers is provided on each of the side surfaces of the guide rail **2**, so as to provide the total number of trains of four. In the present invention, the other type of roller trains can however be applied as shown in the figures. With respect to the division of the resin-formed body **220** for forming the roller circulation passage, all the modifications are based on the divisional pattern of the first embodiment. All the divisional patterns of the first to fourth modifications may however be applied to the modifications of the roller train.

[**0233**] In the example as shown in **FIG. 27**, two lower and upper trains of the rollers as rolling members are provided on each of the gaps between the right and left-hand side surfaces of the guide rail **202** and the inner surfaces of the right and left-hand wing portions **207**, **207** of the movable block **204**, so as to provide the total number of trains of four.

[**0234**] In this case, four inner guide portions **210***a* corresponding to the four trains of the rollers **203** are integrally formed with each other in the direction changing passage-inner guide forming portions **222**.

[**0235**] In the above description, the present invention is applied to the linear motion guiding apparatus, in which the movable block is arranged on the guide rail as a track shaft through the rolling members. The present invention may however be applied to a so-called ball-spline, in which an outer tube as a movable member is fitted on a spline shaft as a track shaft, as described below.

[**0236**] Third Embodiment

[**0237**] A ball spline **301** as shown in FIGS. **28** to **30** is of a so-called "angular contact" ball spline, and has a spline shaft **302** as a guide member extending linearly and an outer tube **304** arranged so as to be movable along the spline shaft **302** through balls **303** as a large number of rolling members.

[**0238**] The spline shaft **304** is formed into a long bar shape having a circular cross-section. The spline shaft **304** has on its outer periphery three projections **306**. Two ball running grooves **305**, **305** are formed on the both sides of each of the projections **306**, so as to provide the total number of groove of six.

[**0239**] The outer tube **304** has on its inner periphery three recesses **307** corresponding to the projections **306** of the spline shaft **302**, respectively. Ball running counter-grooves **308**, **308** are formed at the both corners of each of the recesses **307**, so as to correspond to the above-mentioned ball running In addition, the outer tube **304** has six ball returning passage **309**, **309**; **309**, **309**; **309**, **309**, which are in parallel with the six ball running counter-grooves **308**, **308**; **308**, **308**; **308**, **308**, and six direction changing passages **310**, **310**; **310**, **310**; **310**, **310** formed into a U-shaped tube, which connect the ends of the above-mentioned ball running counter-grooves **308**, **308**; **308**, **308**; **308**, **308** with the ends of the above-mentioned ball returning passage **309**, **309**; **309**, **309**; **309**, **309**. The outer tube **304** has six circulation passages in this manner.

[**0240**] The ball arranged at each of the both side surfaces of the projection **306** of the spline shaft **302** comes in contact, at its opposite points, with the ball running groove

305 and the ball running counter-groove **308**, respectively. A line connecting the above-mentioned contact points is referred to as the "contact angle line". A contact angle α, i.e., an angle between the contact angle line and the radius line, which connects the center of the spline shaft **302** and the central portion of the projection **306** is relatively large. The ball returning passage **309** is located on the contact angle line.

[0241] In this third embodiment, the balls **303** inserted in each of the circulation passages are connected with each other by means of a ball retainer **312** so as to form the train of the balls **303**. The balls **303** are guided by means of the ball retainer **312** and circulated in each of the circulation passages. The ball retainer **312** has the same structure as shown in **FIG. 14** and the description thereof is therefore omitted.

[0242] The outer tube **304** is composed of a tubular main body **313** having the ball running counter-grooves **308, 308**; **308, 308**; **308, 308**, three resin-formed bodies **320, 320, 320** for forming the ball circulation passage, which are to be inserted in the main body **313**, and a pair of side cover plates **314, 314** secured on the both ends of the main body **313** after the insertion of the resin-formed bodies **320, 320, 320** in the main body **313**.

[0243] In the third embodiment, the six circulation passages are formed by the three resin-formed bodies **320, 320, 320**.

[0244] Each of the circulation passages **311** of the resin-formed bodies **320** for forming the ball circulation passage has a pair of the ball passage forming portions **321, 321** extending along the longitudinal side edges of the ball running counter-groove **308**, a pair of direction changing passage-inner guide forming portions **322, 322** provided on the both ends of the main body **313**, and resin pipes **323** as a returning passage forming portion, which are inserted in through-holes formed in the main body **313**.

[0245] The ball passage forming portions **321, 321** are provided with guide grooves for guiding the both side edges of the belt portion **312***b* of the ball retainer **312** in a loaded area. The guide grooves can prevent the ball retainer **312** not only from being swung during run of the ball, but also from being sagged by engaging the side edges of the belt portion **312***b* with the guide groove **321***a*, when the outer tube **304** is removed from the spline shaft **302**. The balls **303** are supported by the ball retainer **312**. More specifically, the ball retainer **312** is supported by a jaw portion of the guide groove **321***a*, with the result that the balls **303** are kept in its proper position so as not to come off the outer tube **304**.

[0246] Guide grooves **309***c*, **310***c* are also formed in the ball returning passage **309** and the direction changing passage **310** as non-loaded areas, in order to guide the side edges of the belt portion **312***b*. The guide grooves **309***c*, **310***c* are connected to the above-mentioned guide groove **321***a* in the loaded area so as to form an endless groove on the entire periphery.

[0247] In each of the resin-formed bodies **320** for forming the ball circulation passage, the ball passage forming portions **321, 321** and the pair of the direction changing passage-inner guide forming portions **322, 322** are integrally connected with each other. The resin-formed body **320** is divided at the other portions into separate parts so as to be able to be inserted in the main body **313**. In the third embodiment, a single resin frame **324** is obtained by integrally connecting the ends of the four sets of ball passage forming portions **321, 321** with the end of the pair of direction changing passage-inner guide forming portions **322, 322**, and the thus obtained resin frame **324** is divided at the connecting portion of the returning passage forming portion **323** with the direction changing passage-inner guide forming portions **322, 322** into the separate parts so as to be able to be inserted in the main body **313**.

[0248] The adjacent two of the roller passage forming portions **321, 321, 321, 321** are integrally connected with each other by means of a thin connecting sheet portion **326**. The direction changing passage-inner guide forming portion **322** is integrally formed with the thin sheet portion **329**, which is to be brought into contact with the end surface of the main body **313**.

[0249] The thin sheet portion **329** is provided with the first end plate portions **330, 330** and the second end plate portion **231** for connecting the first end plate portions **330, 330** with each other. Each of the pair of ball passage forming portions **321, 321** is integrally connected with the inner edge of the first end plate portion **230**. The both ends of the connecting plate portion **326** are integrally connected with the inner edge of the second end plate portion **331**.

[0250] Each of the direction changing passage-inner guide forming portions **322** has a semi-cylindrical shape. On the outer periphery of the direction changing passage-inner guide forming portion **322**, there is formed an inner guide groove **310***a* having a semi-circular cross section so as to form the inner guide portion for the direction changing passage **310**. The one end of the inner guide groove **310***a* is connected to the end of the ball running counter-groove **308**. Accordingly, the one end of the inner guide groove **310***a* has the same cross-sectional shape as the ball running counter-groove **308** so as to make an alignment of the one end of the inner guide groove **310***a* with the end of the ball running counter-groove **308**. The other end of the inner guide groove **310***a* of the direction changing passage **310** is connected to the end of the ball returning passage **309**. Accordingly, the other end of the inner guide groove **310***a* has the same cross-sectional shape as the ball returning passage **309** so as to make an alignment of the other end of the inner guide groove **310***a* with the end of the ball returning passage **309**.

[0251] Cylindrical flange portions **333, 333** are formed on the both ends of the inner guide groove **310***a*. The distance between the respective outer surfaces of the cylindrical flange portions **333, 333** is larger than the width of the belt portion **312***b*. The cylindrical flange portions **333, 333** form a retainer-guide groove **310***c* for the ball retainer **312** in cooperation with the side cover plate **340** described later.

[0252] The both ends of the inner guide groove **310***a* for the direction changing passage **310** extend to the contacting surface of the first end plate portion **330** with the end surface of the main body **313** so as to be connected to the respective ends of the ball running counter-groove **308** and the ball returning passage **309**.

[0253] Pipe inserting holes **334, 334** having a semi-circular shape, in which the ends of for the outer peripheral side-half pipe member **323***a* for the resin pipes **323** for forming the roller returning passage **309** are to be inserted are formed on the first and third end plate portions **330, 332** of the thin sheet portion **329**. The resin pipe **323** is inserted into the circular through-hole **314** formed in the main body **313** so that the inner peripheral surface of the resin pipe **323** form the ball returning passage **309**.

[**0254**] The resin pipe **323** is composed of the inner peripheral side-half pipe member **323***a*, which is continuously connected to the inner guide groove **310***a* for the direction changing passage, and the outer peripheral side-half pipe member **323***b*, which is continuously connected to the outer guide groove **310***b* for the direction changing passage **310**, which is formed on the side cover plate **340**. The inner peripheral side-half pipe member **323***a* has an inner groove portion **309***a* having a rectangular cross section, and side edge portions **323***b* extending longitudinally along the inner groove portion **309***a*. The longitudinal edge portions **323***c* of the inner peripheral side-half pipe member **323***a* has the same width as the flange portion **333** of the direction changing passage-inner guide forming portion **322**.

[**0255**] The outer peripheral side-half pipe member **323***b* is formed into a linear member having the same rectangular cross section as the outer guide groove **310***b* for the direction changing passage, which is formed on the side cover plate **340**. The outer peripheral side-half pipe member **323***b* has a outer groove portion **309***b*, which is continuously connected to the outer guide groove **310***b*, and side edge portions **323***d* extending longitudinally along the outer groove portion **309***b*. The side edge portions **323***d* is provided on its outer edges with projections **323***e*, which are to be brought into contact with the side edge portions **323***c* of the inner peripheral side-half pipe member **323***a* to form the guide groove for the belt portion **312** of the ball retainer **312**.

[**0256**] The inner peripheral side-half pipe member **323***a* of the resin pipe **323** has the same length of the main body **313**. The inner peripheral side-half pipe member **323***a* is positioned so as to be brought into contact with the end surface of the direction changing passage-inner guide forming portion **322**, which is arranged on the side of the main body **313**.

[**0257**] The outer peripheral side-half pipe member **323***b* of the resin pipe **323** has on the other hand a longer length than the main body **313** by a length corresponding to the thickness of the first end plate portions **330, 330** of the thin sheet portion **329**, which are arranged on the both ends of the main body **313**. The outer peripheral side-half pipe members **323***b* are inserted in the inserting holes **334** of the first end plate portions **330, 332**. Longitudinal positional determination of the outer peripheral side-half pipe member **323***b* is made by bringing the both ends of the outer peripheral side-half pipe member **323***b* inserted in the inserting holes **334** into contact with the peripheral edge of the end portion of the outer guide grooves **310***b* for the direction changing passage, which are formed on the side cover plate **340**. The projections **323***e* formed on the both longitudinal side edges **323** of the outer peripheral side-half pipe member **323***b* come into contact with the outer edges of the cylindrical flange portions of the direction changing passage-inner guide forming portion **322** to form a guide groove, and the outer peripheral side-half pipe member **323***b* and the inner peripheral side-half pipe member **323***a* are restricted to be turned in the inserting hole **314**.

[**0258**] The resin pipes **323** and the direction changing passage-inner guide forming portions **322** as the ball returning passage forming portions are accurately positioned through the inserting holes **334** formed on the first end plate portion **330, 330** of the thin sheet portion **329** and a proper assembling is carried out in this manner.

[**0259**] The side cover plate **340** is provided with four recess portions **341** having the outer guide grooves **310***b* for the direction changing passage, into which the direction changing passage-inner guide forming portions **322** are fitted, and screw-fixing portions for securing the side cover plate **340** to the main body **313**. In the screw-fixing portions, the side cover plate **340** is fixed to the main body **313** by inserting bolts **344** into holes **343** formed on the side cover plate **340** and engaging the bolts **344** with screwed holes **345** formed on the end surface of the main body **313**. The holes **343** are located between the first end plate portions **330, 330** of the thin sheet portion **329**.

[**0260**] The direction changing passage-inner guide forming portion **322** is fitted, into the recess portion **341** of the side cover plate **340**. The thin sheet portion **329** is held between the side cover plate **340** and the end surface of the main body **313** through a clamping force so as to be firmly fixed therebetween.

[**0261**] The direction changing passage-inner guide forming portions **322** and the ball passage forming portion **321** are connected through the thin sheet portion **329**, thus making it possible to maintain an accurate positional relationship of the end of the inner guide groove **310***a* for the direction changing passage relative to the ball passage forming portions **321**, as well as an accurate positional relationship of the inner guide groove **310***a* for the direction changing passage relative to the ball returning passage **309**.

[**0262**] The thin sheet portion **329** is uniformly urged against the flat end surface of the main body **313** through a clamping force applied to the side cover plate **340**. Even when the direction changing passage-inner guide forming portion **322** is not located in a correct position, the thin sheet portion **329** changes its shape, thus permitting the correct positioning of the direction changing passage-inner guide forming portion **322**. The thin sheet portion **329** is firmly clamped and fixed through a clamping force, which is applied to the side cover plate **340**, and frictional force caused by such a clamping step may prevent an unfavorable movement of the inner guide groove **310***a* for the direction changing passage.

[**0263**] According to the present invention, only the ball running counter-groove **308** for the circulation passage **311** is formed of the main body **313** having high rigidity, and the other portions are formed of the resin-formed bodies **320** for forming the ball circulation passage. Precision working of the ball running counter-groove **308** of the main body **313** suffices, thus permitting reduction in steps for working and decrease in the production cost.

[**0264**] The resin-formed body **320** for forming the ball circulation passage is separately formed from the main body **313**. Even when the outer tube **304** has a larger size, there is no restriction of flow of molten resin by the main body **313**, unlike the case where the main body **313** is integrally formed with the resin-formed body **320**. Increase in number of gates formed on a die may ensure proper run of the molten resin, thus improving the formability. Especially, the ball passage forming portions **321, 321** located at the opposite longitudinal sides of the ball running groove **308** are thin, with the result that molten resin may not reach every part of the space for forming the ball passage forming portions **321**, **321**. It is therefore effective to form the resin-formed body **320** separately from the main body **313** in accordance with the embodiment of the present invention.

[**0265**] The ball passage forming portions **321**, **321** are continuously and integrally connected with the direction changing passage-inner guide forming portions **322**, and the divided parts are jointed so as to make alignment of them to make a faucet Joint. It is therefore possible to ensure a proper continuity of the connecting portion of the circulation passage and to make a smooth run of the balls **303** from the ball running passage between the ball running groove **305** and the ball running counter-groove **308** to the direction changing passage **310**, as well as from the direction changing passage **310** to the ball returning passage **309**.

[**0266**] Description will be given of modifications of the resin-formed body **320** for forming the ball circulation passage, which is divided into parts In the description of the modifications, modified features will only be explained in comparison with the third embodiment of the present invention. The same reference numerals will be given to the same components as those in the third embodiment of the present invention, and description thereof will be omitted.

[**0267**] First Modification

[**0268**] **FIGS. 31 and 32** show the first modification of the resin-formed body **320** for forming the ball circulation passage, which is described in the third embodiment.

[**0269**] In the first modification, the resin-formed body **320** for forming the ball circulation passage is composed of the first resin-formed frame **320**A, which is obtained by integrally connecting both of the ball passage forming portions **321**, **321** and the resin pipes **323** at their ends with the direction changing passage-inner guide forming portions **322**A for one side, and the second resin-formed frame **320**B, which is provided with the direction changing passage-inner guide forming portions **322**B for the other side and separately formed from the first resin-formed frame **320**A.

[**0270**] In this case, the ball passage forming portions **321**, **321** are integrally connected with the direction changing passage-inner guide forming portions **322**A through the thin sheet portion **329**A as in the first embodiment.

[**0271**] The direction changing passage-inner guide forming portions **322**A are also integrally connected with the resin pipes **323** through the thin sheet portion **329**A. In this case, the resin pipe **323** is formed into a tubular integral body, although the half pipe members are used in the third embodiment. Accordingly, there exists no inserting hole s**34** in the thin sheet portion **329**A, and the ball returning passage **309** is exposed on the thin sheet portion **329**A.

[**0272**] The first resin-formed frame **320**A and the second resin-formed frame **320**B are connected, as shown in **FIG. 32**, by means of a joint method using the combination of a recess and a projection to be inserted therein, such as a faucet joint method. In the illustrated example, a recess portion **336** of a dove-tail groove is formed in the second resin-formed frame **320**B, and an engaging projection **335** to be engaged with the recess portion **336** is formed, on the other hand, in the ball passage forming portions **321**, **321**.

[**0273**] In this case, the resin pipe **323** of the first resin-formed frame **320**A is inserted in the through-hole **314** of the main body **313**, and the ball passage forming portions **321**, **321** and the connecting plate portion **236** are inserted along the inner surface of the recess **307** of the main body **313**.

[**0274**] Then, the engaging projetions **335** formed at the respective free end portions of the ball passage forming portions **321**, **321** and the connecting plate portion **326** are engaged with the recess portions **336** formed on the thin sheet portion **329**B of the second resin-formed frame **324**B, which is arranged on the other end surface of the main body **313**.

[**0275**] The recess portions **336** may be formed on the first resin-formed frame **320**A and the engaging projections **335** may be formed on the second resin-formed frame **320**B. The connecting method is not limited to the method described above, and there may be used any conventional connecting method, in which the ends of the divided parts can be maintained in a proper connecting position and connected.

[**0276**] Second Modification

[**0277**] **FIGS. 33 and 34** show the second modification of the resin-formed body **320** for forming the ball circulation passage, which is described in the third embodiment.

[**0278**] In the second modification, the resin-formed body **320** for forming the ball circulation passage, which has been obtained by integrally forming both of the ball passage forming portions **321**, **321** and the resin pipes **323** as a returning passage forming portion with a pair of direction changing passage-inner guide forming portions **322**, **322**, is divided at the middle portion of each of the ball passage forming portions **321**, **321** and the ball returning passage forming portions **323** into two parts. More specifically, the ball passage forming portions **321**, **321** and the ball returning passage forming portions **323** are divided at their middle portion into the respective two half parts, and each of the thus divided two half parts is integrally formed with the direction changing passage-inner guide forming portions **322**, **322** thus forming two resin-formed frames **320**C, **320**D having substantially the same shape.

[**0279**] Recess portions **338** and engaging projections **337** to be inserted therein are formed on the divided ends of the ball passage forming portions **321**, **321**, the divided ends of the central connecting plate portion **326** and the divided ends of the resin pipes **323**.

[**0280**] Third Modification

[**0281**] **FIG. 35** shows the third modification of the resin-formed body **320** for forming the ball circulation passage, which is described in the third embodiment.

[**0282**] In the third modification, there is not used the resin pipe **323** as a returning passage forming portion described in the first embodiment, and a resin-formed frame **320**E is obtained by integrally forming the ball passage forming portions, the connecting plate portions **326** with the thin sheet portions **329**, **329** each having the pair of direction changing passage-inner guide forming portions **322**, **322**. The ball returning passage **309** is composed as a through-hole formed in the main body **313**.

[**0283**] In this case, an engaging projection **339***a*, which is engageable with a tapered portion **315** formed in the opening end of the ball returning passage **309** may be formed in the opening end of the ball hole **339** of the thin sheet portion **329**. Such a construction permits to make a proper connection of the end of the ball returning passage **309** and the direction changing passage inner guide forming portion **322**. In the illustrated example, an arcuate engaging projection **348** is additionally formed on the connection portion of the outer guide groove **310***b* formed on the side cover plate **340** with the ball returning passage **309**. The engaging projection **48** can be engaged with the thin sheet portion **329**.

[0284] Fourth Modification

[0285] **FIG. 36** shows the fourth modification of the resin-formed body **320** for forming the ball circulation passage, which is described in the third embodiment.

[0286] In the fourth modification, there is not used the resin pipe **323** described in the third modification, a resin-formed frame **320**F is obtained by integrally forming the ball passage forming portions **321** with the direction changing passage-inner guide forming portions **322** for the one side, the other resin-formed frame **320**G provided with the direction changing passage-inner guide forming portions **322** for the other side is separately formed from the above-mentioned resin-formed frame **320**F, and the resin-formed frames **320**F, **320**G are connected with each other by engagement of the engaging projection **335** with the recess **336**. The structure other than the above-mentioned construction is the same as that of the third modification.

[0287] In the third embodiment described above, there are used three sets of resin-formed bodies for forming the ball circulation passage, each of which is divided into two parts. Six sets of resin-formed bodies may however be used for the respective circulation passages. The single set of resin-formed body may also be used. In this case, the divisional method of the resin-formed body should be based on the first, second and fourth modifications described above, taking into consideration the difficulty of insertion of the resin-formed body into the main body of the outer tube.

[0288] Modifications Of The Ball Train

[0289] In the third embodiment and the first to fourth modifications thereof, the ball spline has the angular contact type ball train. The present invention may also be applied to the ball spline having the radial contact type ball train as shown in **FIG. 37**. In such a radial contact type ball train, the spline shaft has no projections on the outer periphery so as to reveal the circular crosssection, and the outer tube has no recesses on the inner periphery so as to reveal the hollow cylindrical shape. The radial contact type ball train has the smaller contact angle a than that of the angular contact type ball train. With respect to the divisional method of the resin-formed body **320** for forming the ball circulation passage, all the patterns described in the third embodiment and the first to fourth modifications thereof may be used.

[0290] In the example illustrated in **FIG. 37**, six resin-formed bodies **320** for forming the ball circulation passage are separately provided from each other for the respective six ball trains. The two sets of resin-formed bodies **320** mentioned above may be integrally formed with each other so as to prepare three sets of resin-formed bodies **320** having the six ball circulation passages. The single resin-formed body having the six ball circulation passages may also be used.

[0291] Fourth Embodiment

[0292] **FIGS. 38 and 39** illustrate the forth embodiment of the present invention. In the fourth embodiment, the present invention is applied to a roller spline, in which rollers are used as the rolling members.

[0293] The roller spline **401** as shown in **FIG. 38** is composed of a spline shaft **402** as a guide member extending linearly, and an outer tube **404** arranged so as to be movable along the spline shaft **402** through the rollers **403** as the rolling members.

[0294] The spline shaft **402** is formed into a long bar shape having a modified cross-section. The spline shaft **402** has on its outer periphery three projections **406**. Two roller running surfaces **405, 405** are formed on the both sides of each of the projections **406**, so as to provide the total number of running surfaces of six.

[0295] The outer tube **404** has on its inner periphery three recesses **407** corresponding to the projections **406** of the spline shaft **402**, respectively. Roller running counter-surfaces **408, 408** are formed at the both corners of each Of the recesses **407**, so as to correspond to the above-mentioned roller running surfaces **405, 405**.

[0296] In addition, the outer tube **404** has six roller returning passage **409, 409; 409, 409; 409, 409**, which are in parallel with the six roller running counter-surfaces **408, 408; 408, 408; 408, 408**, and six direction changing passages **410, 410; 410, 410; 410, 410** formed into a U-shaped tube, which connect the ends of the above-mentioned roller running counter-surfaces **408, 408; 408, 408; 408, 408** with the ends of the above-mentioned roller returning passage **409, 409; 409, 409; 409, 409**. The outer tube **404** has six circulation passages in this manner.

[0297] The rollers **403** inserted in each of the circulation passages are connected with each other by means of the same roller retainer **412** as the roller retainer **212** shown in **FIG. 19**, so as to form the train of the rollers **403**. The rollers **403** are guided by means of the roller retainer **412** and circulated in each of the circulation passages.

[0298] The outer tube **404** is composed of a tubular main body **413** having the roller running counter-grooves **408, 408; 408, 408; 408, 408**, three resin-formed bodies **420, 420, 420** for forming the ball circulation passage, which are to be inserted in the main body **413**, and a pair of side cover plates **440, 440** secured on the both ends of the main body **413** after the insertion of the resin-formed bodies **420, 420, 420** in the main body **413**.

[0299] In the fourth embodiment, the six circulation passages are formed by the three resin-formed bodies **420, 420, 420** as in the third embodiment.

[0300] Each of the resin-formed bodies **420** for forming the ball circulation passage has a pair of the roller passage forming portions **421, 421** extending along the longitudinal side edges of the roller running counter-groove **408**, a pair of direction changing passage-inner guide forming portions **422, 422** provided on the both ends of the main body **413**, and resin pipes **423** as a returning passage forming portion, which are inserted in through-holes formed in the main body **413**.

[0301] The roller passage forming portions **421, 421** are provided with guide grooves for guiding the both side edges of the belt portion **412***b* of the roller retainer **412** in a loaded area. The guide grooves can prevent the roller retainer **412** not only from being swung during run of the roller, but also from being sagged by engaging the side edges of the belt portion **412***b* with the guide groove **421***a*, when the outer tube **404** is removed from the spline shaft **402**. The rollers **403** are supported by the roller retainer **412**. More specifically, the roller retainer **412** is supported by a jaw portion of the guide groove **421***a*, with the result that the rollers **403** are kept in its proper position so as not to come off the outer tube **404**.

[**0302**] Guide grooves **409***c*, **410***c* are also formed in the roller returning passage **409** and the direction changing passage **410** as non-loaded areas, in order to guide the side edges of the belt portion **412***b*. The guide grooves **409***c*, **410***c* are connected to the above-mentioned guide groove **421***a* in the loaded area so as to form an endless groove on the entire periphery.

[**0303**] When the roller retainer **412** is not used, the guide grooves **421***a*, **410***a* , **409***a* are not needed, and the jaw portions as shown in **FIG. 20**(*h*) for supporting the ends of the roller are formed on the roller passage forming portions **421**.

[**0304**] In each of the resin-formed bodies **420** for forming the roller circulation passage, at least one of four connecting portions of the roller passage forming portions **421, 421** with the pair of the direction changing passage-inner guide forming portions **422, 422** are integrally connected with each other. The resin-formed body **420** is divided at the other portions into separate parts so as to be able to be inserted in the main body **413**.

[**0305**] The fundamental embodiment of the resin-formed body for forming the roller circulation passage, which is to be used for the spline unit is described in detail in the third embodiment. The structure of the resin-formed body for forming the roller circulation passage is described in detail in the second embodiment. Here, only the fundamental divisional pattern of the resin-formed body **420** for forming the roller circulation passage will be briefly described below with reference to **FIG. 39**.

[**0306**] In **FIG. 39**(*a*), the both ends of the four sets of roller passage forming portions **421, 421** are integrally connected with the respective one end of the pair of direction changing passage-inner guide forming portions **422, 422** to form a single resin frame **424**, and the both ends of each of the returning passage forming portions **423** are not connected with the other end of the direction changing passage-inner guide forming portion **422** so that these parts can be assembled into the main body **413**.

[**0307**] In **FIG. 39**(*b*), the resin-formed body **420** for forming the roller circulation passage is composed of the first resin-formed frame **420**A, which is obtained by integrally connecting both of the roller passage forming portions **421, 421** and the resin pipes **423** as a returning passage forming portion at their ends with the direction changing passage-inner guide forming portions **422**A for one side, and the second resin-formed frame **420**B, which is provided with the direction changing passage-inner guide forming portions **422**B for the other side and separately formed from the first resin-formed frame **420**A.

[**0308**] In **FIG. 39**(*c*), the resin-formed body **420** for forming the roller circulation passage, which has been obtained by integrally forming both of the roller passage forming portions **421, 421** and the resin pipes **423** as a returning passage forming portion with a pair of direction changing passage-inner guide forming portions **422, 422**, is divided at the middle portion of each of the roller passage forming portions **421, 421** and the returning passage forming portions **423** into two parts. More specifically, the roller passage forming portions **421, 421** and the resin pipes **423** are divided at their middle portion into the respective two half parts, and each of the thus divided two half parts is integrally formed with the direction changing passage-inner guide forming portions **422, 422**, thus forming two resin-formed frames **420**C, **420**D having substantially the same shape.

[**0309**] In **FIG. 39**(*d*), there is not used the resin pipe **423** as shown in **FIG. 39**(*a*), and a resin-formed frame **420**E is obtained by integrally forming both of the roller passage forming portions and the connecting plate portion **326** with the thin sheet portions **429, 429** each having the pair of direction changing passage-inner guide forming portions **422, 422**. The roller returning passage **409** is composed as a through-hole formed in the main body **413**.

[**0310**] In **FIG. 39**(*e*), there is not used the resin pipe **423** as shown in **FIG. 39**(*b*), and a resin-formed frame **420**F is obtained by integrally forming the roller passage forming portions **421** with the direction changing passage-inner guide forming portions **422** for the one side, the other resin-formed frame **420**G provided with the direction changing passage-inner guide forming portions **422** for the other side is separately formed from the above-mentioned resin-formed frame **420**F.

[**0311**] In FIGS. **39**(*a*) to **29**(*e*), the resin-formed frames are connected with each other by means of the conventional joint method such as a faucet joint, which uses engagement of the engaging projection with the recess.

[**0312**] Fifth Embodiment

[**0313**] FIGS. **40** to **44** show a linear motion guiding apparatus of the fifth embodiment of the present invention.

[**0314**] The linear motion guiding apparatus **501** is provided with a guide rail **502** as a guide member, which extends linearly, and a movable block **504** as a movable member, which is arranged so as to be movable along the guide rail **502** through a large number of balls **503** as rolling members.

[**0315**] The guide rail **502** is formed into a long bar shape having a rectangular cross-section. Two ball running grooves **505, 505** as a rolling member running track are formed on each of the right and left-hand side surfaces of the guide rail **502**, so as to provide a total number of grooves **505** of four. The guide rail **502** has on each of its side surfaces a projection **502***a*, on the upper and lower positions of which the ball running grooves **505, 505** are arranged.

[**0316**] The movable block **504** is formed as a block body having an inverse U-shaped cross-section, with its opening end being directed downwardly. The block body is provided with a horizontal portion **506**, which faces the upper surface of the guide rail **502** and with a pair of wing portions **507, 507**, which extend downwardly from the right and left ends of the horizontal portion **506** and face the right and left-hand side surfaces of the guide rail **502**, respectively. Each of the wing portions **507**, **507** has on its inner surface two ball running counter-grooves **508**, **508** as a rolling member running counter track, which correspond to the ball running grooves **505**, **505** formed on the right and left-hand side surfaces of the guide rail **502**.

[0317] Each of the right and left-hand wing portions **507**, **507** of the movable block **504** has two ball returning passage forming portions **509**, **509** formed therein, which extend in parallel with the ball running counter-grooves **508**, **508**. At both the longitudinal ends of each of the wing portions **507**, **507**, there are arranged direction changing passages **510**, **510**; **510**, **510** for connecting the ends of the ball running counter-grooves **508**, **508**; **508**, **508** with the ends of the ball returning passage **509**, **509**; **509**, **509**. In summary, each of the wing portions **507**, **507** of the movable block **504** has two endless circulation passages, in which the balls **503** are circulated, so as to provide the total number of passage of four.

[0318] In each of the four endless circulation passages in this embodiment, the balls **503** are retained in the form of train by means a ball retainer **512** as a rolling member retainer so that the balls **503** can be circulated while being guided by the ball retainer **512**.

[0319] As shown in FIGS. **44**(*c*) to **44**(*e*), the ball retainer **512** comprises a flexible belt portion **512***b*, which is provided with ball holes **512***a*for respectively receiving the balls **503**, and spacing portions **512***c*provided between the adjacent two balls **503**, **503**. The belt portion **512***b*has a width longer than the diameter of the ball **503** so that the both side edges of the belt portion **512***b* extend outwardly from the ball **503**.

[0320] The spacing portion **512***c* is provided with a ball supporting spherical recess **512***d* corresponding to the spherical surface of the ball **503**. The ball **503** is supported on its both sides by a pair of supporting spherical recesses **512***d* so as to prevent the ball **503** from coming off the belt portion **512***b*. In this embodiment, the one end of the belt portion **512***b* is not connected to the other end thereof, thus forming a strip-shaped belt having the both ends. The one end of the belt portion **512***b* may be connected to the other end thereof so as to form an endless belt.

[0321] As shown in **FIG. 41**, the movable block **504** is composed of a block body **513** having ball running counter-grooves **508**, **508**, **508**, **508**, a pair of right and left-hand resin-formed bodies **520**, **520** for forming ball circulation passages, which is inserted in the block body **513**, and a pair of side cover plates **540** (only one cover plate **540** is illustrated) secured to the both end surfaces of the block body **13**, in which the resin-formed bodied **520**, **520** are inserted.

[0322] Each of the right and left-hand resin-formed bodies **520**, **520** for forming the ball circulation passage forms two endless circulation passages. The right and left-hand resin-formed bodies **520**, **520** have the symmetrical shape. One of them will be described below and the description of other thereof will be omitted.

[0323] More specifically, the resin-formed body **520** for forming the ball circulation passage is composed of a resin frame **524** obtained by integrally forming the ball passage forming portions **521**, **521** extending along both longitudinal sides of the ball running counter-groove **508** with the pair of direction changing passage-inner guide forming portions **522**, **522** (see **FIG. 42**); and a pair of resin pipes **523**, **523** as a returning passage forming portion, which are to be inserted in through-holes **514**, **514** formed in the block body **513** (see **FIG. 43**). The ball passage forming portions **521**, **521** are integrally formed with the pair of direction changing passage-inner guide forming portions **522**, **522** to form the resin frame **524** as an integral body, and the pair of resin pipes **523**, **523** are separately formed from such an integral body, so that these parts can be assembled into the block body **513**.

[0324] As shown in **FIG. 42**, the ball passage forming portions **521**, **521** are provided with guide grooves for guiding the both side edges of the belt portion **512***b* of the ball retainer **512** in a loaded area. The guide grooves can prevent the ball retainer **512** not only from being swung during run of the ball, but also from being sagged by engaging the side edges of the belt portion **512***b* with the guide groove **521***a*, when the movable block **504** is removed from the guide rail **502**. The balls **503** are supported by the ball retainer **512**. More specifically, the ball retainer **512** is supported by a jaw portion of the guide groove **521***a*, with the result that the balls **503** are kept in its proper position so as not to come off the movable block **504**.

[0325] The distance between the pair of ball passage forming portions **521**, **521** arranged in parallel with each other on the both longitudinal sides of the ball running counter-groove **508** is slightly smaller than the diameter of the ball **503**. In such a construction, it is possible to prevent the balls **503** from coming off the ball passage forming portions **521**, **521** even when the ball retainer **512** is not used.

[0326] Guide grooves **509***c*, **510***c* are also formed, as shown in FIGS. **44**(*a*) and **44**(*b*), in the ball returning passage **509**, **509** and the direction changing passage **510**, **510** as non-loaded areas, in order to guide the side edges of the belt portion **512***b*. The guide grooves **509***c*, **510***c* are connected to the above-mentioned guide groove **521***a* in the loaded area so as to form an endless groove on the entire periphery.

[0327] The ball passage forming portions **521**, **521**; **521**, **521** are composed, as shown in **FIG. 42**(*a*), of the first connecting plate portion **525** extending longitudinally along the corner between the horizontal portion **506** and the wing portion **507** of the block body **513** in the longitudinal direction of the block body **513**; the second connecting plate portion **526** extending longitudinally between the ball running counter-grooves **508**, **508** on the inner surface of each of the wing portions **507** of the block body **513**; and a pair of third connecting plate portions **527** extending along the under surface of the wing portion **507** of the block body **513** in the longitudinal direction thereof.

[0328] The upper edge of the first connecting plate portion **525** and the lower edge of the second connecting plate portion **526**, which face to each other, are placed on the opposite longitudinal sides of the upper ball running counter-groove **508** provided in the wing portion **507**, so as to form the ball passage forming portions **521**, **521**. The lower edge of the second connecting plate portion **526** and the upper edge of the third connecting plate portion **527**, which face to each other, are placed on the opposite longitudinal sides of the lower ball running counter-groove **508** provided in the wing portion **507**, so as to form the ball passage forming portions **521, 521**.

[**0329**] As shown in FIGS. **44**(*a*), **44**(*b*) and **44**(*c*), the direction changing passage-inner guide forming portions **522** and the ball passage forming portions **521, 521** are connected by means of the thin sheet portion **529** through integral forming. The resin pipe **523** is inserted in a hole **534** formed on the thin sheet portion **529** so as to make a faucet joint, and fixed to the thin sheet portion **529**.

[**0330**] The thin sheet portion **529** has the direction changing passage-inner guide forming portions **522, 522**, which are formed so as to project corresponding to the two trains of balls **503, 503** on the side surface of the guide rail **502**. The both ends of the first, second and third connecting plate portions **525-527** are connected to the thin sheet portion **529** to be arranged on the end of the block body **513** so as to form the single resin frame **524**.

[**0331**] Each of the direction changing passage-inner guide forming portions **522** has a semi-cylindrical shape. On the outer periphery of the direction changing passage-inner guide forming portion **522**, there is formed an inner guide groove **510***a* having a semi-circular cross section so as to form the inner guide portion for the direction changing passage **510**. The one end of the inner guide groove **510***a* is connected to the end of the ball running counter-groove **508**. Accordingly, the one end of the inner guide groove **510***a* has the same cross-sectional shape as the ball running counter-groove **508** so as to make an alignment of the one end of the inner guide groove **510***a* with the end of the ball running counter-groove **508**. The other end of the inner guide groove **510***a* of the direction changing passage **510** is connected to the end of the ball returning passage **509**. Accordingly, the other end of the inner guide groove **510***a* has the same cross-sectional shape as the ball returning passage **509** so as to make an alignment of the other end of the inner guide groove **510***a* with the end of the ball returning passage **509**.

[**0332**] Cylindrical flange portions **533, 533** are formed on the both ends of the inner guide groove **510***a* . The distance between the respective outer surfaces of the cylindrical flange portions **533, 533** is larger than the width of the belt portion **512***b*. The cylindrical flange portions **533, 533** form a retainer-guide groove **510***c* for the ball retainer **512** in cooperation with a semi-circular recess portion having cutouts, which is formed on the inner periphery of the recess of the side cover plate **5040** described later.

[**0333**] The both ends of the inner guide groove **510***a* for the direction changing passage **510** extend to the contacting surface of the thin sheet portion **529** with the end surface of the block body **513** so as to be connected to the respective ends of the ball running counter-groove **508** and the ball returning passage **509**. Pipe inserting holes **534, 534** having a semi-circular shape, in which the ends of the resin pipes **523** are to be inserted are formed on the thin sheet portion **529**.

[**0334**] As shown in **FIG. 43**, the resin pipe **523** is composed of an outer peripheral side-half pipe member **523***b* located in the outer peripheral side of the ball circulation passage, which is continuously connected to the outer guide groove **510***b* for the direction changing passage **510** of the side cover plate **540**, and an inner peripheral side-half pipe member **523***a* located in the inner peripheral side of the ball circulation passage, which is continuously connected to an inner guide groove **510***a* for the direction changing passage **510** of the side cover plate **540**.

[**0335**] The inner peripheral side-half pipe member **523***a* has a groove portion **509***a* having a semi-circular cross section, and side edge portions **523***c* extending longitudinally along the groove portion **509***a* , as shown in FIGS. **43**(*c*) and **43**(*d*). The outer peripheral side-half pipe member **523***b* is formed into a linear member having the same circular cross section as the outer guide groove **510***b* for the direction changing passage, which is formed on the side cover plate **540**. The outer peripheral side-half pipe. member **523***b* has a groove portion **509***b*, which is continuously connected to the outer guide groove **510***b*, and side edge portions **523***d* extending longitudinally along the groove portion **509***b*. The side edge portions **523***d* is provided on its outer edges with projections **523***e*, which are to be brought into contact with the outer edges of the side edge portions **523***c* of the inner peripheral side-half pipe member **523***a* to form the retainer-guide groove **509***c* for the ball retainer **512**.

[**0336**] The inner peripheral side-half pipe member **523***a* of the resin pipe **523** has the same length of the block body **513**. The inner peripheral side-half pipe member **523***a* is positioned so as to be brought into contact with the back surface of the direction changing passage-inner guide forming portion **522**.

[**0337**] The outer peripheral side-half pipe member **523***b* of the resin pipe **523** has on the other hand a longer length than the block body **513** by a length corresponding to the thickness of the thin sheet portion **529**. The outer peripheral side-half pipe members **523***b* are inserted in the inserting holes **534**. Longitudinal positional determination of the outer peripheral side-half pipe member **523***b* is made by bringing the both ends of the outer peripheral side-half pipe member **523***b* inserted in the inserting holes **534** into contact with the peripheral edge of the end portion of the outer guide grooves **510***b* for the direction changing passage, which are formed on the side cover plate **540**. The projections **523***e* formed on the both side edges of the outer peripheral side-half pipe member **523***b* come into contact with the outer edges of the cylindrical flange portions **533** formed on the direction changing passage-inner guide forming portion **522** to form a part of the guide groove **510***c*, and the outer peripheral side-half pipe member **523***b* and the inner peripheral side-half pipe member **523***a* are restricted to be turned in the inserting hole **514**.

[**0338**] The resin pipes **523** and the direction changing passage-inner guide forming portions **522** are accurately positioned through the inserting holes **534** formed on the thin sheet portion **529** and a proper assembling is carried out in this manner.

[**0339**] As shown in FIGS. **44**(*f*) and **44**(*g*), the side cover plate **540** is provided with an inserting recess portion **540***a*, in which the thin sheet portion **529** is inserted, recess portions **541** having the outer guide grooves **510***b* for the direction changing passage, into which portions the direction changing passage-inner guide forming portions **522** are fitted, and screw fixing portions for securing the side cover plate **540** to the block body **513**. In the screw-fixing portions, the side cover plate **540** is fixed to the block body **513** by inserting bolts (not shown) into holes **543** formed on the side cover plate **540** and engaging the bolts with screwed holes

545 formed on the end surface of the block body **513**. The holes **543** are located at four positions, i.e., the position corresponding to the thin sheet portion **529** between the direction changing passage-inner guide forming portions **522**, **522** of each of the resin-formed bodies **520**, **520**, and the positions in the vicinity of the thin sheet portions **529**, **529** on the horizontal portion **506**.

[0340] As shown in **FIG. 44**(*g*), the outer guide groove **510***b* for the direction changing passage in the recess portion **541** has on its side edges larger diameter arcuate recesses **546**, which form the retainer-guide groove **510***c* in cooperation with the cylindrical flange portions **533** of the direction changing passage-inner guide forming portions **522** as shown in **FIG. 44**(*t*), and a smaller-diameter arcuate recesses **547**, in which the cylindrical flange portions **533** are inserted. The direction changing passage-inner guide forming portion **522** provided with the inner guide groove **510***a* for the direction changing passage is fitted into the recess portion **541** of the side cover plate **540**, and the thin sheet portion **529** is received in the inserting recess portion **540***a* of the side cover plate **540**. The thin sheet portion **529** is held between the side cover plate **540** and the end surface of the block body **513** through a clamping force so as to be firmly fixed therebetween. The direction changing passage-inner guide forming portions **522** and the ball passage forming portion **521** are connected through the thin sheet portion **529**, thus making it possible to maintain an accurate positional relationship of the end of the inner guide groove **510***a* for the direction changing passage formed in the direction changing passage-inner guide forming portion **522** relative to the ball passage forming portions **521**, **521**, as well as an accurate positional relationship of the inner guide groove **510***a* for the direction changing passage relative to the ball returning passage **509**.

[0341] The thin sheet portion **529** located in the vicinity of the direction changing passage-inner guide forming portion **522** is uniformly urged against the flat end surface of the block body **513** through a clamping force applied to the side cover plate **540** (see **FIG. 44**). Even when the direction changing passage-inner guide forming portion **522** is not located in a correct position, the thin sheet portion **529** changes its shape on the end surface of the block body **513**, thus permitting the correct positioning of the direction changing passage-inner guide forming portion **522**. The thin sheet portion **529** is firmly clamped and fixed through a clamping force, which is applied to the side cover plate **540**, and frictional force caused by such a clamping step may prevent an unfavorable movement of the inner guide groove **510***a* for the direction changing passage.

[0342] The side cover plate **540** is secured to the block body **513** so that the direction changing passage-inner guide forming portion **522** assembled to the block body **513** is fitted into the recess portion **541** of the side cover plate **40**. Such a fitting step permits to make an accurate positioning of the side cover plate **540** relative to the block body **513**.

[0343] Now, description will be given of assembling steps for the above-mentioned resin-formed bodies **520** for forming the ball circulation passage.

[0344] First, the inner peripheral side-half pipe member **523***a* of the resin pipe **523** is inserted in the through-hole **514** of the wing portion **507** of the block body **513**.

[0345] Then, the resin frame **524** obtained by integral forming is inserted in the recess of the block body **513**, while causing the thin sheet portions **529** at the both ends of the resin frame **524** to slide on the respective end surfaces of the wing portion **507** of the block body **513**. The first connecting plate portion **525** of the resin frame **524** comes into contact with the corner portion between the horizontal portion **506** and the wing portion **507**, thus making positional determination in the vertical direction of the resin frame **524**. The second connecting plate portion **526** and the third connecting plate portion **527** of the resin frame **524** come into contact with the respective inner surfaces of the wing portions **507** of the block body **513**, thus making positional determination of the ball passage forming portions **521**, **521** and the direction changing passage-inner guide forming portions **522**, **522**. At this time, the inserting holes **534**, **534** of the thin sheet portion **529** are aligned with the through-holes **514**, **514** of the block body **513**.

[0346] Then, the outer peripheral side-half pipe members **523***b*, **523***b* are inserted in the through-holes **514**, **514** from the inserting holes **534**, **534**, thus completing the assembling step of one of the resin-formed bodies **520**, **520** for forming the ball circulation passage.

[0347] The assembling step of the other of the resin-formed bodies **520**, **520** is carried out in the same manner.

[0348] Then, the one side cover plate **540** is secured to the one end surface of the block body **513** by a clamping step, the ball retainer **512** holding the balls is inserted, and the other side cover plate **540** is secured to the other end surface of the block body **513** by the same clamping step, thus completing the assembling step of the movable block **504**.

[0349] According to the present invention, the resin-formed bodies **520**, **520** for forming the ball circulation passage are separately formed from the block body **513**. Even when the movable block **504** has a larger size, there is no restriction of flow of molten resin by the block body **513**, unlike the case where the block body **513** is integrally formed with the resin-formed bodies **520**, **520**. Increase in number of gates formed on a die may ensure proper run of the molten resin, thus improving the formability. Especially, the ball passage forming portions **521**, **521** located at the opposite longitudinal sides of the ball running groove **508** are thin, with the result that molten resin may not reach every part of the space for forming the ball passage forming portions **521**, **521**. It is therefore effective to form the resin-formed bodies **520**, **520** separately from the block body **513** in accordance with the embodiment of the present invention.

[0350] In addition, since there are formed the right and left-hand resin-formed bodies **520**, **520** for forming the ball circulation passage, each of which has two endless circulation passages, a proper run of molten resin is ensured even when the movable block **513** has a larger width.

[0351] The continuous circulation passage is formed by the resin-formed body **520**, and it is therefore possible to make positional determination of the inner guide groove **510***a* for the direction changing passage relative to the ball passage forming portions **521**, **521**, as well as positional determination of the inner guide groove **510***a* for the direction changing passage relative to the ball returning passage **509**, thus ensuring continuity of the circulation passage so as to make smooth circulation of the balls **503**.

[0352] When the proper positional relationship of the inner guide groove **510***a* for the direction changing passage relative to the ball passage forming portions **521**, **521**, is maintained, the ball passage forming portions **521**, **521** are located at the longitudinal both sides of the ball running groove **508** so as to be aligned with the ends of the inner guide groove **510***a* for the direction changing passage.

[**0353**] When the proper positional relationship of the inner guide groove **510***a* for the direction changing passage relative to the ball returning passage **509** is maintained, the inner guide groove **510***a* for the direction changing passage can be aligned with the inner groove **523***a* of the ball returning passage **509**.

[**0354**] The connecting portion of the ball passage forming portions **521**, **521** and the direction changing passage-inner guide forming portion **522** is obtained by integral forming, thus permitting omission of an assembling step of the connecting portion. Although the running direction of the balls **503** is changed in such a connecting portion, the above-mentioned integral structure may ensure continuity of the circulation passage, without being affected by assembling accuracy. It is therefore possible to make smooth run of the balls **503** from the ball running passage between the ball running groove **505** and the ball running counter-groove **508** to the direction changing passage **510**, as well as from the direction changing passage **510** to the ball returning passage **509**.

[**0355**] According to the present invention as described in detail, since the resin-formed body for forming the rolling member circulation passage is separately formed from the block body, even when the movable block has a larger size, increase in number of gates formed on a die may ensure proper run of the molten resin, thus improving the formability. It is therefore effective to form the resin-formed body separately from the block body in accordance with the present invention, taking into consideration the fact that the rolling member passage forming portions located at the opposite longitudinal sides of the rolling member running track are thin, with the result that molten resin may not reach every part of the space for forming the rolling member passage forming portions.

[**0356**] The continuous circulation passage is formed by the resin-formed body, and it is therefore possible to make positional determination of the inner guide groove for the direction changing passage relative to the rolling member passage forming portions, as well as positional determination of the inner guide groove for the direction changing passage relative to the rolling member returning passage, thus ensuring continuity of the circulation passage so as to make smooth circulation of the rolling members.

[**0357**] When the connecting portion of the rolling member passage forming portions and the direction changing passage-inner guide forming portion or the connecting portion of the direction changing passage-inner guide forming portion and the returning passage forming portion, in which portion the running direction of the rolling members is changed is obtained by integral forming, it is possible to omit an assembling step of the connecting portion and to ensure continuity of the circulation passage, without being affected by assembling accuracy.

[**0358**] The integral formation of the connecting portion of the rolling member passage forming portion with the direction changing passage-inner guide forming portion may cause the smooth running of the rolling members between the rolling member running track in the loaded area and the direction changing passage-inner guide forming portion, even when the returning passage forming portion formed of resin is not used.

[**0359**] When the rolling member retainer is used, it is possible to maintain a proper continuity on the entire periphery of the circulation passage in the retainer guide portion for guiding the rolling member retainer.

[**0360**] The thin retainer guide portion is formed without insertion of the body of the movable member in a die, and position of gates in the die can freely be determined without being restricted by the body of the movable member, with the result that molten resin can reach, during formation of the guide portion, the entire space therefor, which is formed in the die.

[**0361**] In addition, the formation of the right and left-hand resin-formed bodies for forming the rolling member circulation passage, each of which has two endless circulation passages may ensure a proper run of molten resin even when the body of the movable member has a larger width.

[**0362**] The connection of the direction changing passage-inner guide forming portion with the rolling member passage forming portion through the thin sheet portion makes it possible to maintain, through deformation of the thin sheet portion, a proper positional relationship between the direction changing passage-inner guide forming portion and the rolling member passage forming portion or a proper positional relationship between the direction changing passage-inner guide forming portion and the rolling member returning passage forming portion, thus making an accurate positional determination of the end of the direction changing passage-inner guide forming portion relative to the rolling member returning passage forming portion as well as an accurate positional determination of the direction changing passage-inner guide forming portion relative to the rolling member returning passage forming portion.

[**0363**] The thin sheet portion is urged against the flat end face of the body of the movable member by a clamping force, which is applied to the side cover plate. It is therefore possible to correct the position of the direction changing passage-inner guide forming portion through deformation of the thin sheet portion, even when the direction changing passage-inner guide forming portion is not correctly positioned relative to the end face of body of the movable member.

[**0364**] In addition, the thin sheet portion can firmly be secured between the side cover plate and the body of the movable member by the clamping force, which is applied to the side cover plate, and it is therefore possible to prevent the direction changing passage-inner guide forming portion from being incorrectly placed.

What is claimed is:

1. A linear motion guiding apparatus comprising:

a guide member provided with a rolling member running track, and

a movable member arranged so as to be movable along the guide member through a large number of rolling members, said movable member being provided with (i) a rolling member running counter-track corresponding to the rolling member running track of said guide member, (ii) a rolling member returning passage arranged away from said rolling member running counter-track by a prescribed distance and in parallel therewith and (iii) a pair of direction changing passages for connecting the rolling member running counter-track and the rolling member returning passage to permit circulation of the rolling members,

characterized in that:

a resin-formed body for forming a rolling member circulation passage comprises a pair of rolling member passage forming portions extending along both longitudinal sides of said rolling member running counter-track, a returning passage forming portion for forming the rolling member returning passage and a pair of direction changing passage-inner guide forming portions for forming inner peripheral guide portions of said direction changing passages, said resin-formed body being separately formed from a body of said movable member; and

at least two portions of (a) said pair of rolling member passage forming portions, (b) said returning passage forming portion, (c) one of said pair of direction changing passage-inner guide forming portions and (d) another of said pair of direction changing passage-inner guide forming portions are connected with each other through integral forming so that said resin-formed body can be built in the body of said movable member.

2. An apparatus as claimed in claim 1, wherein:

said resin-formed body comprises (i) an integral body of said pair of rolling member passage forming portions and said pair of direction changing passage-inner guide forming portions, and (ii) said returning passage forming portion separately formed from said integral body.

3. An apparatus as claimed in claim 1, wherein:

said resin-formed body comprises (i) an integral body of said pair of rolling member passage forming portions, said returning passage forming portion and one of said pair of direction changing passage-inner guide forming portions, and (ii) another of said pair of direction changing passage-inner guide forming portions separately formed from said integral body.

4. An apparatus as claimed in claim 1, wherein:

said resin-formed body is manufactured by preparing an integral body of said pair of rolling member passage forming portions, said returning passage forming portion and said pair of direction changing passage-inner guide forming portions, and then dividing said pair of rolling member passage forming portions and said returning passage forming portion in longitudinal intermediate portions thereof into respective two parts.

5. An apparatus as claimed in claim 1, wherein

a rolling member retainer is provided, said rolling member retainer being able to retain the rolling members in a train with a prescribed distance kept between adjacent two of the rolling members, and said rolling member retainer having side edge portions projecting from both sides of each of the rolling members; and

guide grooves for guiding the side edge portions of the rolling member retainer are formed on an entire periphery of the rolling member circulation passage.

6. An apparatus as claimed in claim 1, wherein:

each of said direction changing passage-inner guide forming portions has a thin sheet portion, which is to be brought into contact with an end face of the body of said movable member, and said each of said direction changing passage-inner guide forming portions is connected to the rolling member passage forming portions or the returning passage forming portion by means of said thin sheet portion.

7. An apparatus as claimed in claim 1, wherein:

said guide member comprises a guide rail;

said movable member comprises a movable block, which is provided with a horizontal portion, which faces an upper surface of said guide rail and a pair of wing portions, between which the guide rail is held at right and left-hand side surfaces thereof; and

two trains of the rolling members are arranged in a gap between the upper surface of the guide rail and a lower surface of the movable block, and a single train of the rolling members is arranged in each of gaps between the right and left-hand side surfaces of the guide rail and both of the wing portions, so as to provide a total number of trains of four.

8. An apparatus as claimed in claim 1, wherein:

said guide member comprises a guide rail;

said movable member comprises a movable block, which is provided with a pair of wing portions, between which the guide rail is held at right and left-hand side surfaces thereof; and

two trains of the rolling members are arranged in each of gaps between the right and left-hand side surfaces of the guide rail and both of the wing portions, so as to provide a total number of trains of four.

9. An apparatus as claimed in claim 8, wherein:

four direction changing passage-inner guide forming portions are formed corresponding to the four trains of the rolling members, respectively, and said four direction changing passage-inner guide forming portions are integrally connected with each other.

10. An apparatus as claimed in claim 8 wherein:

two direction changing passage-inner guide forming portions located at a side of the right-hand side surface of the guide rail are integrally connected with each other, and other two direction changing passage-inner guide forming portions located at a side of the left-hand side surface of the guide rail are integrally connected with each other.

11. An apparatus as claimed in claim 1, wherein:

said guide member comprises a guide rail;

said movable member is provided with a horizontal portion, which faces an upper surface of said guide rail and a single wing portion, which faces one side surface of the guide rail; and

a single train of the rolling members is arranged in a gap between said one side surface of the guide rail and said single wing portion, and another single train of the rolling members is arranged in a gap between the upper surface of the guide rail and a lower surface of said horizontal portion in a vicinity of a corner of the guide rail.

12. An apparatus as claimed in claim 1, wherein:

said guide member comprises a guide rail;

said movable member comprises a movable block, which is provided with a pair of wing portions, between which the guide rail is held at right and left-hand side surfaces thereof; and

a single train of the rolling members is arranged in each of gaps between the right and left-hand side surfaces of the guide rail and both of the wing portions, so as to provide a total number of trains of two.

13. An apparatus as claimed in claim 1, wherein:

said guide member comprises a guide rail;

said movable member comprises a movable block arranged along one side surface of the guide rail; and

two trains of the rolling members are arranged in a gap between said one side surface of the guide rail and the movable block.

14. An apparatus as claimed in claim 1, wherein:

said guide member comprises a spline shaft; and

said movable member comprises an outer tube, said outer tube is movably supported on said spline shaft through a plurality of trains of the rolling members.

* * * * *

US 20010026651A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2001/0026651 A1**

Michioka et al. (43) **Pub. Date: Oct. 4, 2001**

(54) **ROLLING ELEMENT SPACER IN ROLLING GUIDE DEVICE**

(75) Inventors: **Hidekazu Michioka**, Tokyo (JP); **Kentarou Nishimura**, Tokyo (JP); **Yasuyuki Abe**, Tokyo (JP); **Kiyomi Tamura**, Tokyo (JP); **Hiroshi Niwa**, Tokyo (JP)

Correspondence Address:
ARENT FOX KINTNER PLOTKIN & KAHN, PLLC
Suite 600
1050 Connecticut Avenue, N.W.
Washington, DC 20036-5339 (US)

(73) Assignee: **THK CO., LTD**

(21) Appl. No.: **09/803,145**

(22) Filed: **Mar. 12, 2001**

(30) **Foreign Application Priority Data**

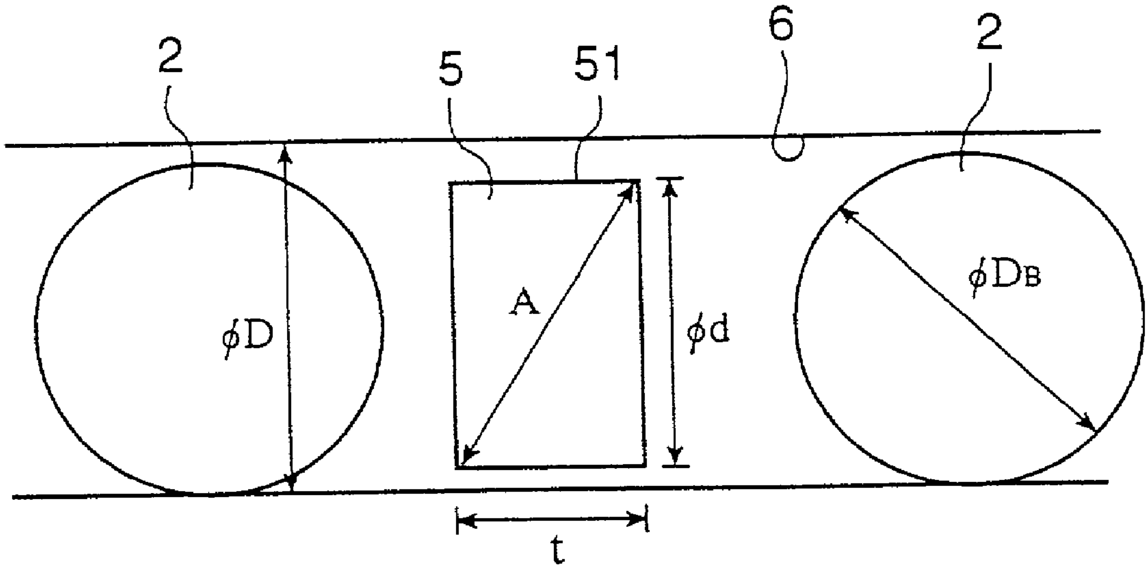
Mar. 31, 2000 (JP) 97027/2000

Publication Classification

(51) **Int. Cl.**[7] **F16C 19/00**
(52) **U.S. Cl.** **384/51**

(57) **ABSTRACT**

There is provided a rolling element spacer used in a rolling guide device having an endless circulation passage for balls, arranged alternately with many balls in the endless circulation passage, and circulating together with the balls in the endless circulation passage. In order to prevent the rolling element spacer from falling sideways and avoid a trouble such as malfunction of the rolling guide device, the rolling element spacer is formed such that its diagonal dimension in a thickness direction becomes larger than an inner diameter of the endless circulation passage.



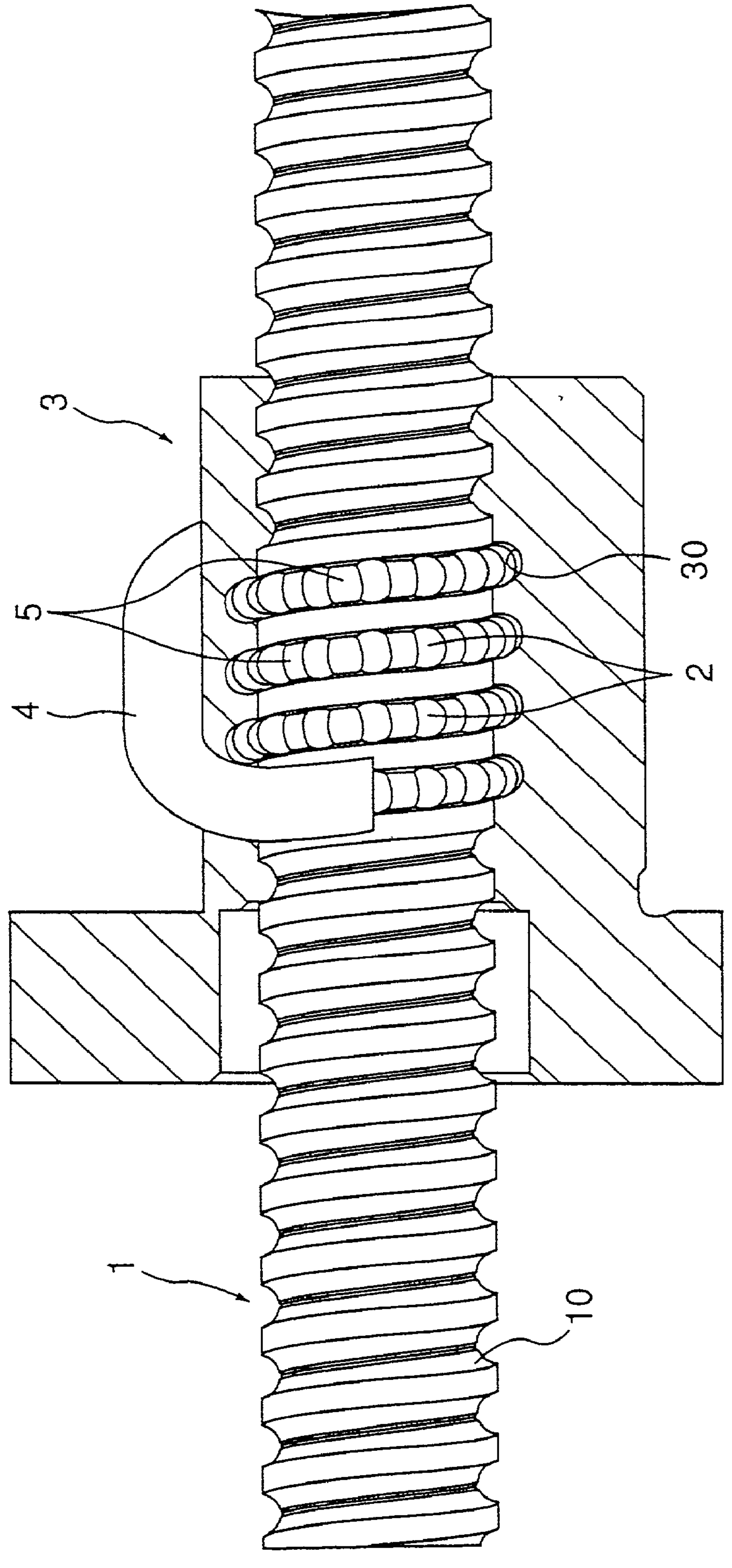


Fig. 1

Fig.2

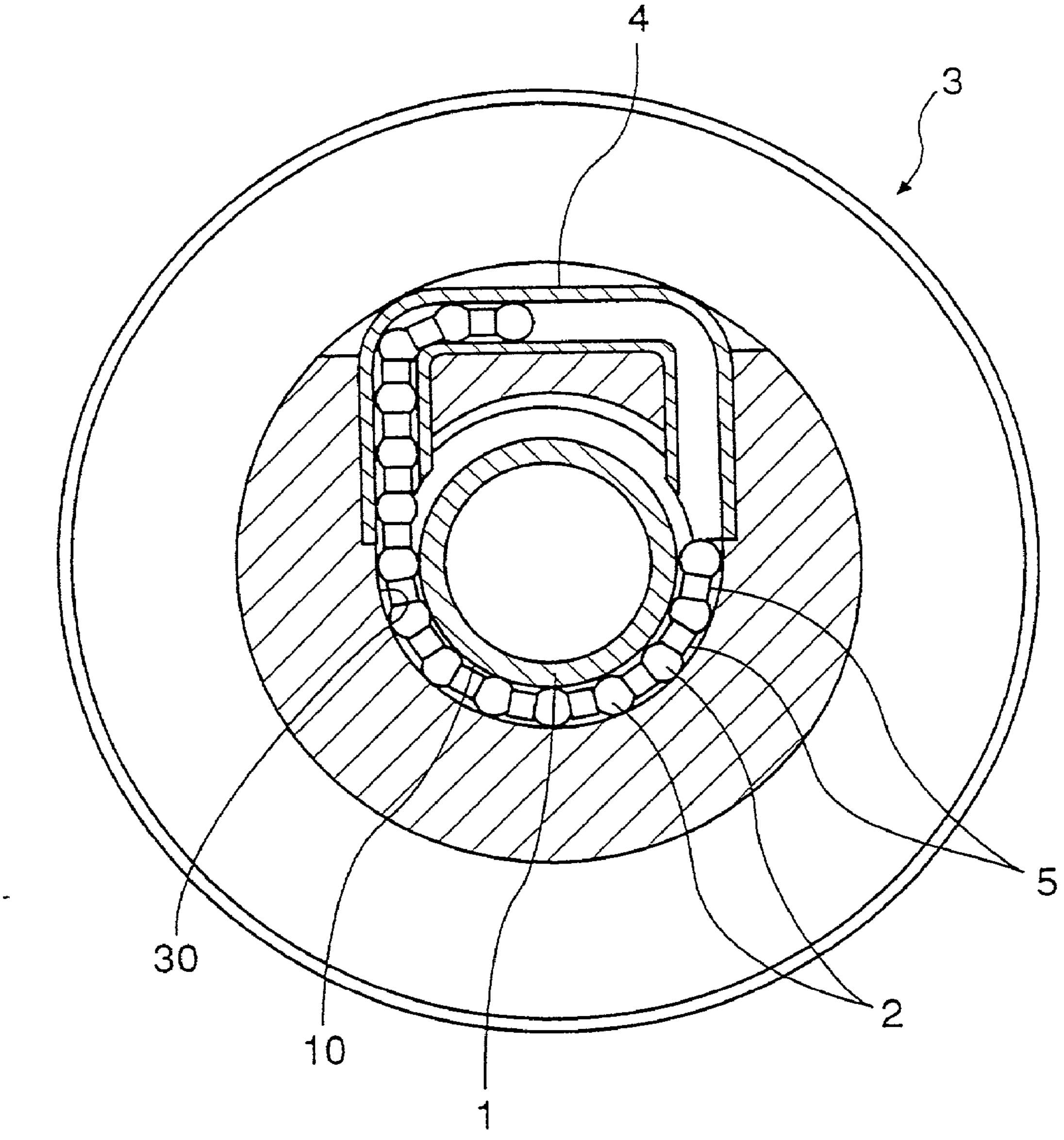


Fig.3

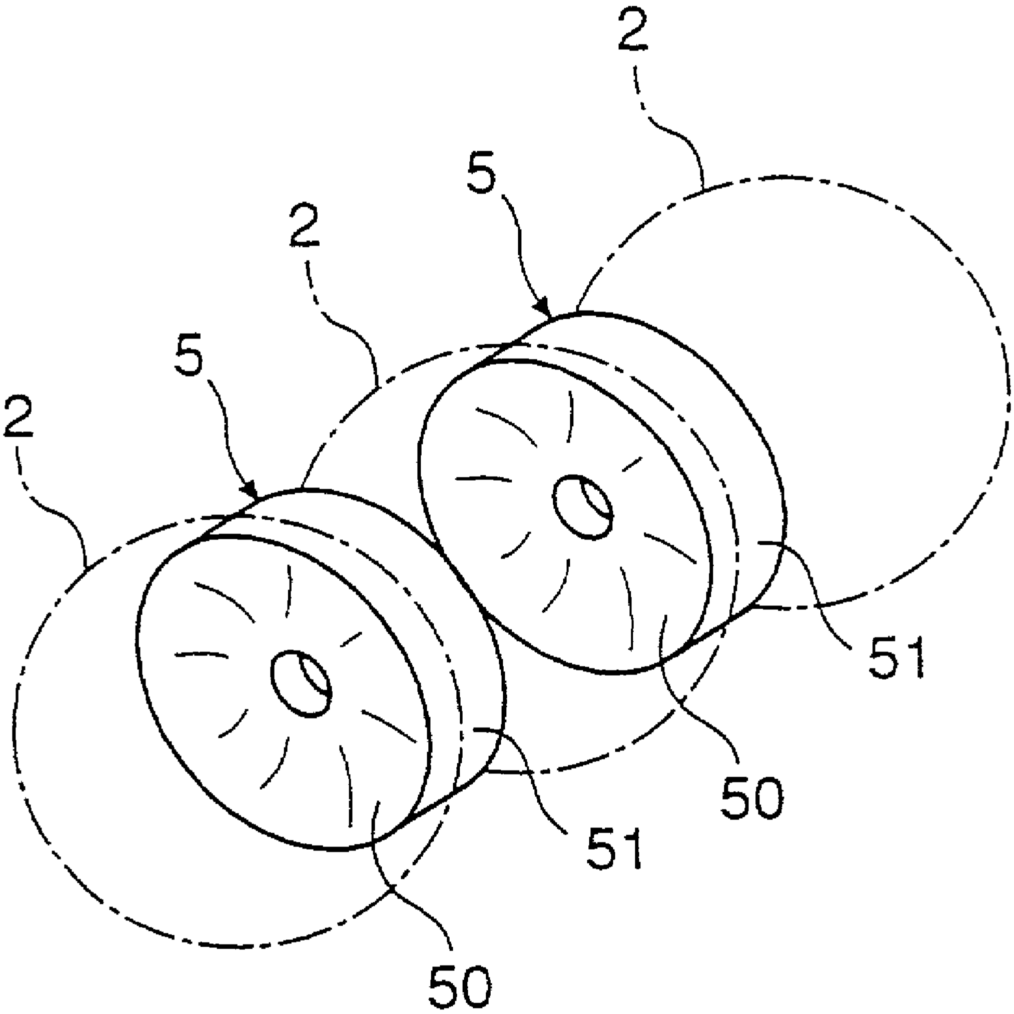


Fig.4

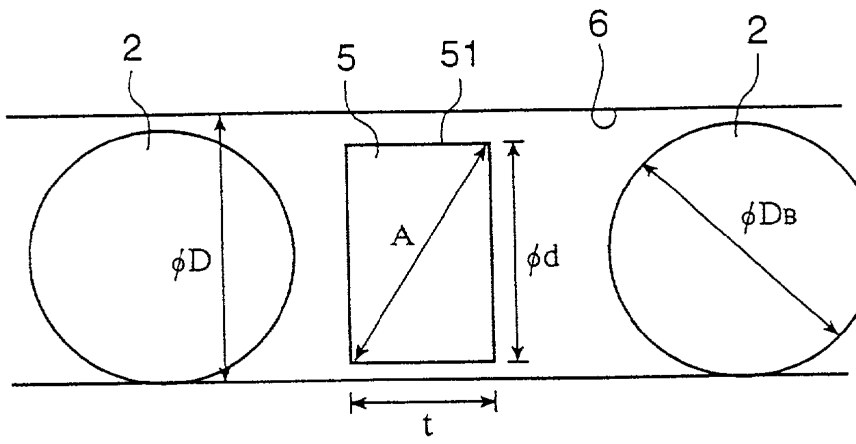


Fig.5

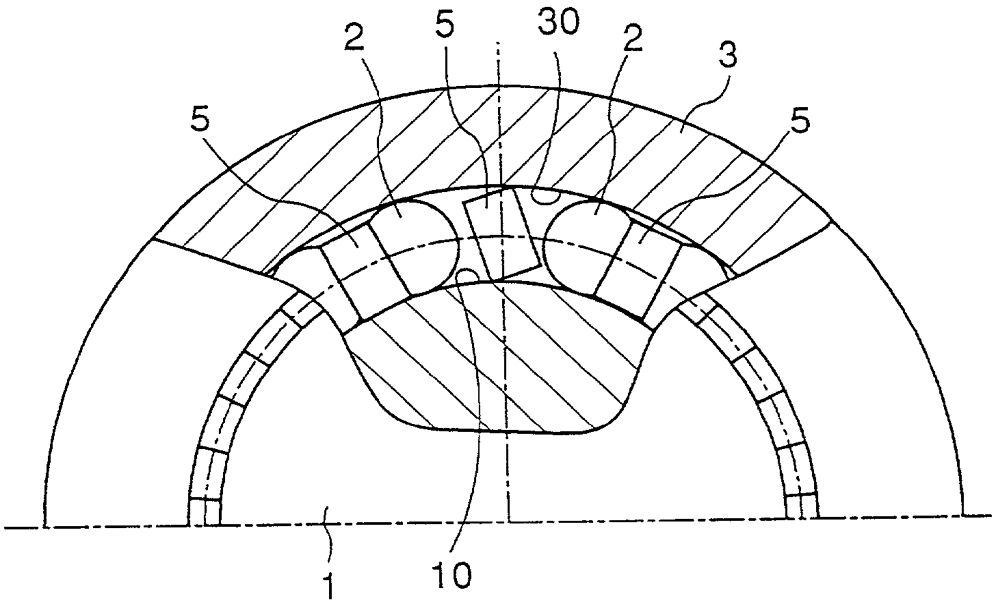


Fig.6

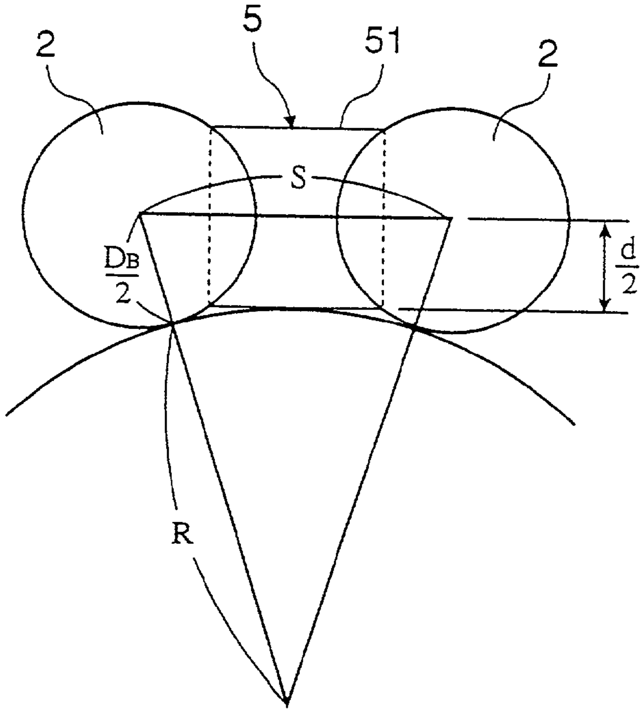


Fig.7

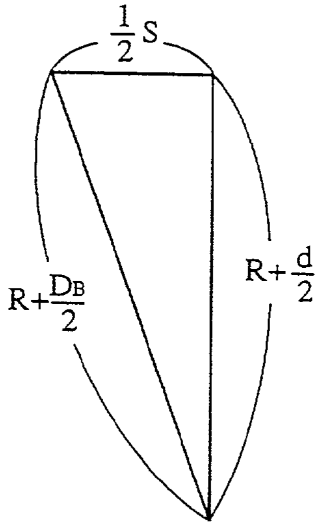


Fig.8

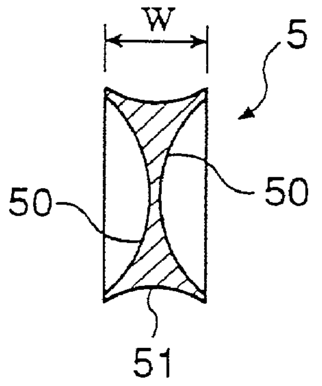


Fig.9

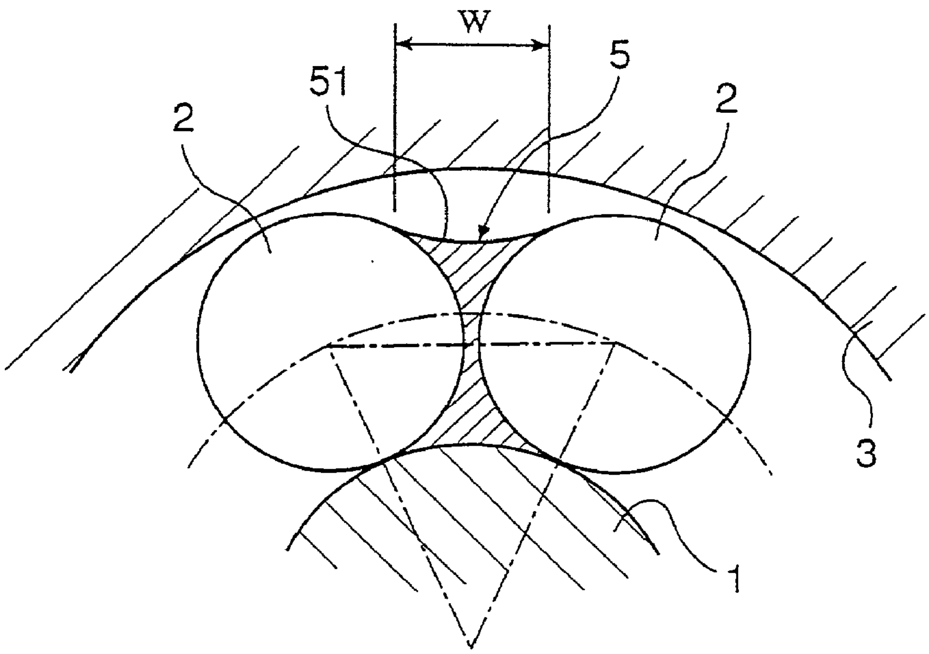


Fig.10

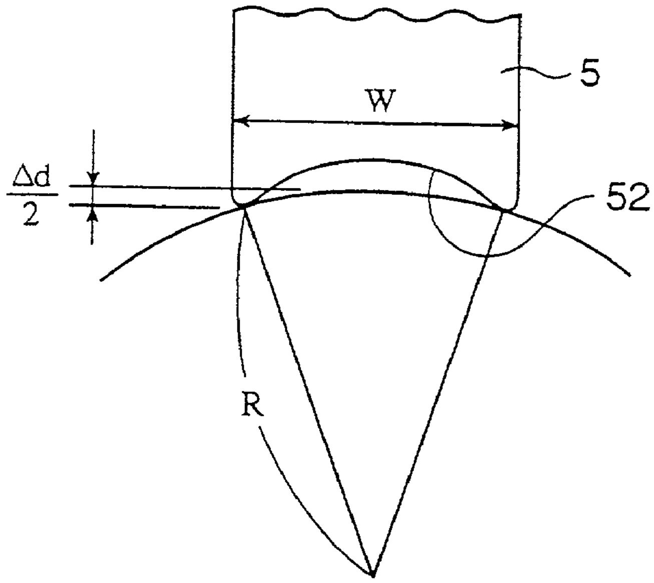


Fig.11

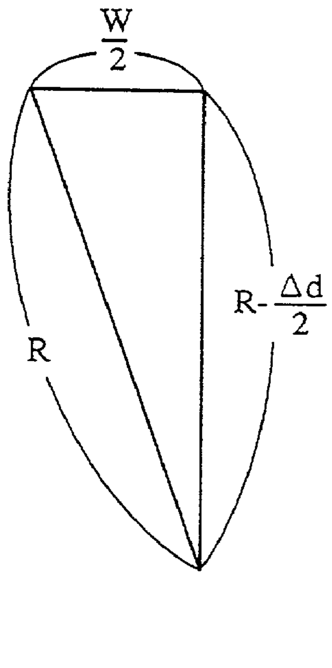


Fig.12

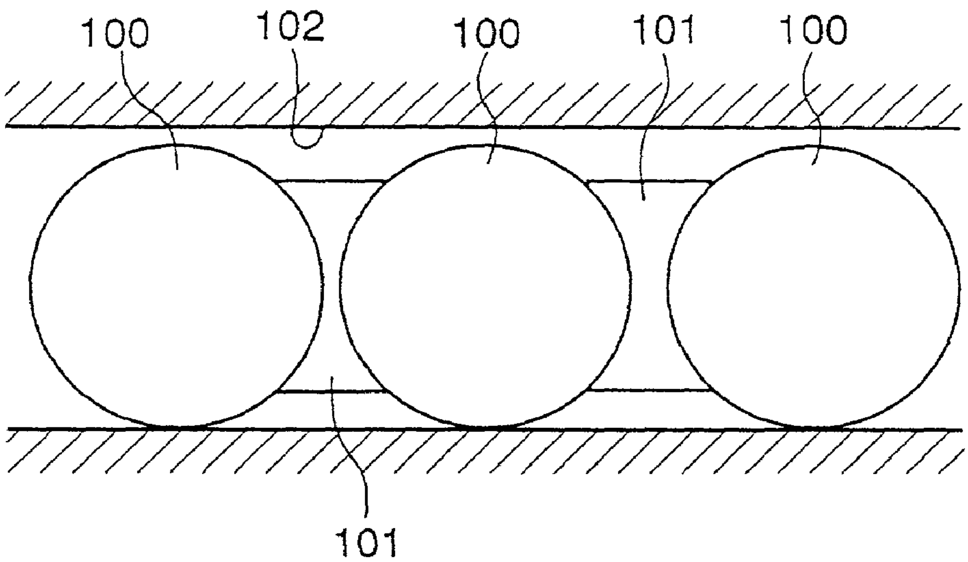
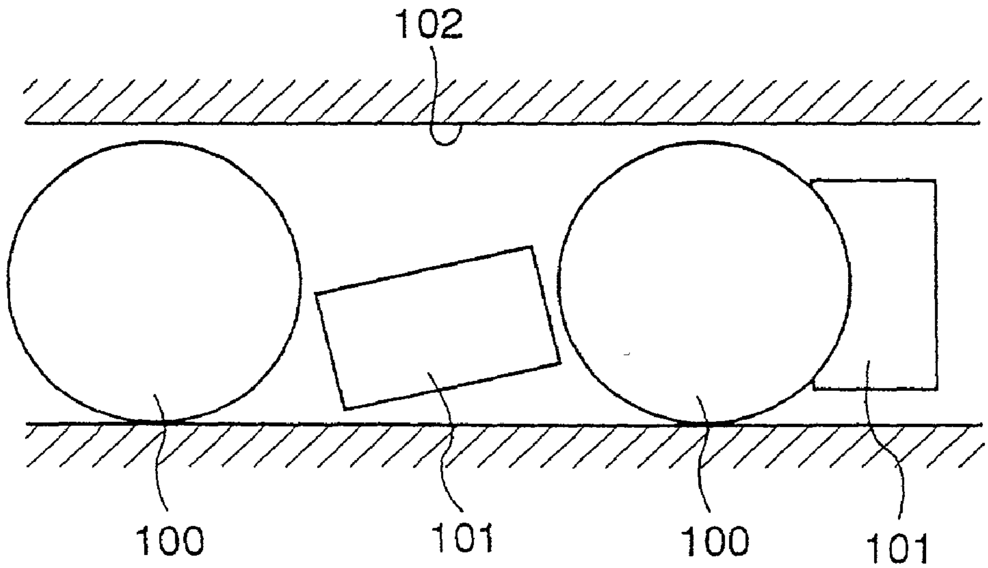


Fig. 13



ROLLING ELEMENT SPACER IN ROLLING GUIDE DEVICE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a rolling element spacer which, in various rolling guide devices each having an endless circulation passage for balls such as a linear guide device and a ball screw device, is interposed between the mutually adjoining balls in the endless circulation passage and reduces frictions between the balls and a heat generation to thereby smoothen the rolling thereof.

[0003] 2. Description of the Related Art

[0004] Hitherto, as a rolling guide device in which a pair of members continuously performing a relative motion through an endlessly circulating ball row, there have been known devices such as a linear guide device which is used in a linear guide portion in a machine tool, a carrying device and the like and which guides a movable body such as a table on a stationary portion such as a bed or a saddle, and a ball screw which is used together with this linear guide device and which gives a stroke of a linear motion corresponding to a rotation amount of a motor to the movable body.

[0005] The former linear guide device comprises a bearing rail which is disposed on the stationary portion and in which a rolling groove for the balls is formed along a longitudinal direction, and a sliding base which has a load rolling groove facing the rolling groove of the bearing rail through many balls and in which there is formed an endless circulation groove for the balls rolling on the load rolling groove, and it is constituted such that, in accompaniment with the endless circulation of the balls, the sliding base supporting the movable body continuously performs the linear motion along the bearing rail. Further, reversely to this, there is a case where it is constituted such that the bearing rail is moved relative to the fixed sliding base.

[0006] On the other hand, the latter ball screw comprises a screw shaft in which there is formed a spiral ball rolling groove with a predetermined lead, and a nut member which has a load rolling groove facing the ball rolling groove through many balls and in which there is formed an endless circulation passage for the balls rolling on the load rolling groove, and it is constituted such that, in accompaniment with a relative rotation motion between the screw shaft and the nut member, the balls circulate in the endless circulation passage, and the nut member and the screw shaft relatively move in an axial direction.

[0007] On the other hand, in such a rolling guide device, since the individual ball circulating in the endless circulation passage mutually contacts with the balls positioned before and after it, in case that it is used at a high speed, there have been such fears that, besides the fact that the balls are worn in relatively short time by a friction between the balls for instance, there arises a disadvantage such as the fact that the ball or the load rolling groove generates a seizure owing to a friction heat. Therefore, as one for solving such a drawback, in Japanese Patent Laid-Open No. 315835/1999 Gazette, there is disclosed a rolling guide device in which a rolling element spacer is interposed between the balls mutually adjoining in the endless circulation passage.

[0008] In the rolling guide device disclosed in the above Gazette, it is adapted such that a synthetic resin made rolling element spacer referred to as separator is arranged alternately with the ball in the endless circulation passage, thereby preventing the balls from mutually contacting. Such a separator is formed in a disk-like form whose outer diameter is smaller than a diameter of the ball and, in its both front/rear faces contacting with the balls, there are formed spherical face seats whose curvatures are larger than a curvature of a spherical face of the ball. By this, as shown in **FIG. 12**, if the ball **100** and the separator **101** are alternately arranged without a gap in the endless circulation passage **102**, each separator **101** becomes a state of being sandwiched between a pair of balls **100**, **100** adjoining its both front/rear faces, so that it circulates in the endless circulation passage **102** together with the ball **100** while being held in its predetermined attitude.

[0009] However, it is difficult to arrange the balls **100** and the spacers **101** without a gap in the endless circulation passage **102** provided in the rolling guide device. Further, if an accumulated use time of such a rolling guide device is increased, a gap is generated between the ball **100** and the rolling element spacer **101** by a wear. In case that the gap between the rolling element spacer **101** and the ball **100** cannot be removed in this manner and the gap is generated resultantly, the attitude of the rolling element spacer **101** becomes unstable as shown in **FIG. 13**, so that there is a fear that it falls sideways between the balls **100** in the endless circulation passage **102**.

[0010] And, in case that the rolling element spacer has fallen sideways in this manner, since a movement of the rolling element spacer is not restrained by the adjacent balls, the rolling element spacer is separated from the balls to spring out of the endless circulation passage and, in case of the ball screw device for instance, it is discharged outside from between a screw shaft and a nut member. Further, if one of the rolling element spacers drops out in this manner, the gap between the ball and the remaining rolling element spacer in the endless circulation passage widens increasingly, so that the rolling element spacer drops out one after another from the endless circulation passage.

[0011] On the other hand, if the rolling element spacer falls sideways in the endless circulation passage, since the ball attempts to run on this rolling element spacer, the balls are clogged without circulating in the endless circulation passage and, in the ball screw device for instance, there is a fear that the nut member is locked to the screw shaft, so that an operation becomes impossible.

SUMMART OF THE INVENTION

[0012] The invention has been made in view of such a problem, and its object is to prevent the rolling element spacers arranged together with the balls in the endless circulation passage from falling sideways in the endless circulation passage, thereby providing a rolling element spacer capable of avoiding such a trouble that the rolling element spacer drops out of the endless circulation passage and the rolling guide device becomes impossible to operate.

[0013] In order to achieve the above object, the invention provides a rolling element spacer used in a rolling guide device in which a pair of members perform a relative continuous motion through an endlessly circulating ball row, interposed between balls mutually adjoining in its endless circulation passage, and circulating together with the balls, characterized in that a diagonal dimension in a thickness direction is larger than an inner diameter of the endless circulation passage.

[0014] According to such a technical means, since the rolling element spacer arranged in the endless circulation passage is formed such that the diagonal dimension in the thickness direction, i.e., a diagonal dimension between both front/rear faces contacting with a pair of balls, is larger than an inner diameter of the endless circulation passage provided in the rolling guide device, even if a gap is generated between the ball and the rolling element spacer and thus the rolling element spacer slants in the endless circulation passage, the rolling element spacer does not fall sideways completely because its corner portions engage with an inner wall of the endless circulation passage, so that it is restored to an original attitude, i.e., a stable state in which it is sandwiched by the balls from both sides while it circulates together with the balls. By this, it is possible to avoid such troubles that the rolling element spacer drops out of the endless circulation passage and that the balls are clogged in the endless circulation passage.

[0015] According to the rolling element spacer of the invention, by setting the diagonal dimension in the thickness direction of the rolling element spacer larger than the inner diameter of the endless circulation passage provided in the rolling guide device, even if the rolling element spacer slants in the endless circulation passage, such a drawback that this rolling element spacer falls sideways between the balls can be prevented, so that it becomes possible to avoid such a trouble that the rolling guide device itself becomes impossible to operate owing to the fact that the rolling element spacer, which has fallen sideways and thus is not held in a predetermined attitude by the balls, drops out of the endless circulation passage and thus the balls are clogged in the endless circulation passage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] **FIG. 1** is a side sectional view showing one embodiment of a ball screw device in which rolling element spacers of the invention are arranged together with balls in an endless circulation passage;

[0017] **FIG. 2** is a front sectional view of the ball screw device shown in **FIG. 1**;

[0018] **FIG. 3** is a perspective view showing an arrangement state between the ball and the rolling element spacer in the endless circulation passage;

[0019] **FIG. 4** is a view clearly showing various dimensions defined in the invention;

[0020] **FIG. 5** is a sectional view showing a state that the rolling element spacer of the invention is slanted in the endless circulation passage;

[0021] **FIG. 6** is an explanatory view showing a dimensional relation for, in case that an outer periphery face of the rolling element spacer of the invention is formed in a cylindrical form, computing its maximum outer diameter ϕd;

[0022] **FIG. 7** is a view showing a right-angled triangle derived from the dimensional relation of **FIG. 6**;

[0023] **FIG. 8** is a sectional view showing an example in which the outer periphery face of the rolling element spacer of the invention is formed in a concave face form;

[0024] **FIG. 9** is a sectional view showing a contact state between the rolling element spacer whose outer periphery face is formed in the concave face form and an inner wall of the endless circulation passage;

[0025] **FIG. 10** is an explanatory view showing a dimensional relation for, in case that the outer periphery face of the rolling element spacer of the invention is formed in the cylindrical form, computing a correction value Δd of its maximum outer diameter ϕd;

[0026] **FIG. 11** is a view showing a right-angled triangle derived from the dimensional relation of **FIG. 10**;

[0027] **FIG. 12** is a sectional view showing a state that conventional rolling element spacers and balls are arranged without gaps in the endless circulation passage; and

[0028] **FIG. 13** is a view showing a problem in case that the gap is generated between the rolling element spacer and the ball, which are arranged in the endless circulation passage.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0029] Hereunder, a rolling element spacer of the invention is detailedly explained on the basis of the attached drawings.

[0030] **FIG. 1** and **FIG. 2** show one embodiment of a ball screw device in which the rolling element spacers of the invention are arranged together with balls in an endless circulation passage. In these drawings, the reference numeral **1** denotes a screw shaft, the reference numeral **2** a ball and the reference numeral **3** a nut member, and the nut member **3** meshes with the screw shaft **1** through many balls **2**.

[0031] A spiral ball rolling groove **10** is formed in an outer periphery face of the screw shaft **1**, while a spiral load rolling groove **30** facing the ball rolling groove **10** of the screw shaft **1** is formed in an inner periphery face of the nut member **3**, and the ball rolling groove **10** and the load rolling groove **30** form a spiral load ball passage between the screw shaft **1** and the nut member **3**. That is, if a relative rotary motion occurs between the screw shaft **1** and the nut member **3**, the ball **2** spirally rolls in the load ball passage while bearing a load. Further, a return pipe **4** mutually communicating both ends of the load ball passage to thereby constitute the endless circulation passage for the balls **2** is attached to the nut member **3**, so that the ball **2** having finished to roll in the load ball passage and having been released from the load becomes a no-load state and rolls in the return pipe **4**, and is returned to an inlet of the load ball passage while jumping the ball rolling groove **10** by several turns. Accordingly, if the screw shaft **1** and the nut member **3** are relatively rotated, it follows that the ball **2** rolls from the load ball passage to the return pipe **4** and from the return pipe **4** to the load ball passage, and is circulated inside the endless circulation passage constituted by the load ball passage and the return pipe **4**.

[0032] In this ball screw device, in order to prevent the balls **2** incorporated in the endless circulation passage from mutually contacting, a rolling element spacer **5** is interposed between the mutually adjoining balls **2**, **2**. As shown in **FIG. 3**, the rolling element spacer **5** is formed by deforming a synthetic resin into an approximately disk form and, in its both front/rear faces, there are respectively formed spherical faces **50** on which the balls **2** slide. The ball **2** and the rolling element spacer **5** are alternately arranged in the endless circulation passage. By this, it is adapted such that the balls **2** rolling in the endless circulation passage are prevented from mutually contacting, a smooth circulation of the ball **2** and, in turn, smoothening of the rotary motion of the nut member **3** relative to the screw shaft **1** are intended, and additionally a generation of noise owing to a collision between the balls during an operation of the ball screw device is reduced.

[0033] As shown in **FIG. 4**, such a rolling element spacer **5** is formed such that—when it is suppose that t is a thickness between both front/rear faces in which the spherical face seats **50** are formed and ϕd an outer diameter—a diagonal dimension A, in a thickness direction, expressed by $\sqrt{(d^2+t^2)}$ becomes larger than an inner diameter ϕD of the endless circulation passage **6** for the ball **2**. That is, the thickness t and the outer diameter ϕd of the rolling element spacer are set such that $\phi D<A=\sqrt{(d^2+t^2)}$ is met. Therefore, it is adapted such that even in case that the gap is generated between the ball **2** and the rolling element spacer **5** in the endless circulation passage **6** and thus the rolling element spacer **5** slants without being supported in a predetermined attitude by the balls **2**, since periphery edges of the rolling element spacer **5** formed in the disk-like form are locked by inner walls of the endless circulation passage as shown in **FIG. 5**, such a trouble is prevented that the rolling element spacer **5** falls sideways in the endless circulation passage **6**.

[0034] Here, since the diagonal dimension A of the rolling element spacer **5** is determined by the thickness t and the outer diameter ϕd of the rolling element spacer **5**, it follows that, in order to make the diagonal dimension A larger than the outer diameter ϕD, the thickness t or the outer diameter ϕd may be set large. However, in case that the thickness of the rolling element spacer **5** is set large, it follows that the number of the balls **2** in the endless circulation passage **6** is reduced correspondingly. Accordingly, in order to avoid a reduction in rated load of the ball screw device and avoid the device concerned from becoming large, it is preferable to set the thickness t small within such a range that the mutually adjoining balls **2** do not contact.

[0035] On the other hand, it is necessary that the outer diameter ϕd of the rolling element spacer **5** is smaller than a ball diameter ϕD_B and, even if the outer diameter ϕd is how large in this range, basically there is no problem. However, as shown in **FIG. 2**, in the ball screw, since the ball **2** and the rolling element spacer **5** spirally circulate around the screw shaft **1**, in case that the outer diameter ϕd of the rolling element spacer **5** is too large, there is a drawback that the outer periphery face **51** of such rolling element spacer **5** interferes with the ball rolling groove **10** of the screw shaft **1**. Further, also in another rolling guide device other than the ball screw, a linear guide device for instance, since a curved portion necessarily exists in the endless circulation passage, in case that the outer diameter ϕd of the rolling element spacer **5** is too large, there is also a drawback that the outer periphery face **51** of such rolling element spacer **5** interferes with an inner diameter side's wall of the endless circulation passage. Accordingly, in order to avoid such an interference between the rolling element spacer **5** and the inner wall of the endless circulation passage to thereby achieve a smooth ball circulation, it is necessary to limit a maximum value of the outer diameter ϕd of the rolling element spacer **5** from a relation with a radius of curvature of the curved portion in the endless circulation passage.

[0036] Here, as shown in **FIG. 6**, if it is supposed that D_B is an outer diameter of the ball **2**, S an inter-center distance between the mutually adjoining balls **2**, **2**, R a radius of curvature in an inner diameter side of the endless circulation passage through which the ball **2** circulates and d an outer diameter of the rolling element spacer **5**, and if it is imagined that an outer periphery face of the rolling element spacer **5** contacts with an inner wall of the endless circulation passage, it is possible to derive a right-angled triangle having such a dimensional relation as shown in **FIG. 7**. Accordingly, from the dimensional relation of this triangle, the following equation is established.

$$(R+D_B/2)^2=(S/2)^2+(R+d/2)^2$$

[0037] And, if d is derived from this equation, it becomes as follows.

$$d\ (d_{max})=\sqrt{\{(2R+D_B)^2-S^2\}}-2R \quad \text{(Equation 1)}$$

[0038] Incidentally, since the outer periphery face **51** of the rolling element spacer **5** is liable to interfere with the inner wall of the endless circulation passage as the radius of curvature in the curved portion of the endless circulation passage becomes small, R used in the Equation 1 is a minimum radius of curvature in the endless circulation passage.

[0039] Since this Equation represents a state that the outer periphery face **51** of the rolling element spacer **5** contacts with the inner wall of the endless circulation passage, i.e., a maximum value d_{max} of the outer diameter of the rolling element spacer **5**, in order to prevent the rolling element spacer **5** from interfering with the endless circulation passage, the outer diameter d of the rolling element spacer **5** must be smaller than this d_{max}. That is, if

$$d<d_{max}=\sqrt{\{(2R+D_B)^2-S^2\}}-2R \quad \text{(Equation 2)}$$

[0040] is met, the rolling element spacer **5** can smoothly circulate in the endless circulation passage with the balls **2** without interfering with the inner wall of the endless circulation passage.

[0041] Accordingly, on setting the diagonal dimension A of the rolling element spacer **5** larger than the inner diameter ϕD of the endless circulation passage, it is preferable to set the outer diameter ϕd of the rolling element spacer **5** as large as possible within a range determined by the Equation 2, and to set the thickness t small. By this, it is possible for the endless circulation passage to arrange the balls **2** in the maximum number while preventing the rolling element spacer **5** from interfering with the endless circulation passage.

[0042] Further, as to the Equation 2, there is imagined a case that the outer periphery face **51** of the rolling element spacer **5** is formed in a cylindrical form. However, as shown in **FIG. 8** and **FIG. 9**, in case that the outer periphery face **51** of the rolling element spacer **5** is formed in a concave face form, since the outer periphery face **51** of the rolling element spacer **5** becomes correspondingly difficult to interfere with the inner wall of the endless circulation passage, it becomes possible to set the outer diameter of the rolling element spacer **5** slightly larger than the aforesaid d_{max}. Accordingly, in this case, it is necessary to add a correction value Δd to the aforesaid d_{max}.

[**0043**] Here, as shown in **FIG. 10**, if it is supposed that W is a width of a recessed portion **52** formed in the outer periphery face **51** of the rolling element/spacer **5**, Δd/2 a height of an inner wall of the endless circulation passage, protruding into the recessed portion **52** and, similarly to the previous time, R the radius of curvature in the inner diameter side of the endless circulation passage, it is possible to derive a right-angled triangle of such a dimensional relation as shown in **FIG. 11**. Accordingly, from the dimensional relation of this triangle, the following equation is established.

$$R^2(W/2)-\surd(4R^2-W^2) \qquad \text{(Equation 3)}$$

[**0044**] And, if Δd is derived from this equation, it becomes as follows.

$$\Delta d=2R-\surd(4R^2W^2) \qquad \text{(Equation 4)}$$

[**0045**] And, in case that the recessed portion **52** exists in the outer periphery face **51** of the rolling element spacer **51** in this manner, if the maximum outer diameter ϕd of the rolling element spacer **5** is smaller than a value obtained by adding the correction value Δd to d_{max} prescribed by the aforesaid Equation 2, i.e., if

$$\phi d<d_{max}+2R-\surd(4R^2-W^2) \qquad \text{(Equation 5)}$$

[**0046**] is met, the outer periphery face **51** of the rolling element spacer **5** is prevented from interfering with the inner wall of the endless circulation passage.

[**0047**] Accordingly, in case that the recessed portion **52** is formed in the outer periphery face **51** of the rolling element spacer **5**, it is possible to set the outer diameter of the rolling element spacer **5** larger by the aforesaid Δd than the case where the outer periphery face **51** is formed merely in the cylindrical form. Therefore, on determining the diagonal dimension A, by correspondingly reducing the thickness t of the rolling element spacer **5**, the number of the balls **2** in the endless circulation passage can be increased, so that it is possible to increase a rated load of the ball screw device by a more compact constitution and prevent the rolling element spacer **5** from falling sideways in the endless circulation passage.

What is claimed is:

1. A rolling element spacer used in a rolling guide device in which a pair of members perform a relative continuous motion through an endlessly circulating ball row, interposed between balls mutually adjoining in its endless circulation passage, and circulating together with the balls,

characterized in that a diagonal dimension in a thickness direction is larger than an inner diameter of the endless circulation passage.

2. A rolling element spacer set forth in claim 1, characterized in that when it is supposed that DB is a ball diameter, S an inter-center distance of the mutually adjoining balls and R a minimum radius of curvature of the endless circulation passage through which the balls circulate, an outer diameter d meets the following equation

$$d<\surd\{(2R+D_B)^2-S^2\}-2R=d_{max}.$$

3. A rolling element spacer set forth in claim 2, characterized in that an outer periphery face is formed in a concave face form, and when it is supposed that W is a width of its concave face portion, the outer diameter meets the following equation

$$d<d_{max}+2R\surd(4R^2-W^2).$$

* * * * *

US 20010022868A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2001/0022868 A1**
Teramach et al. (43) **Pub. Date: Sep. 20, 2001**

(54) **ROLLING GUIDE DEVICE AND DRIVE SYSTEM USING ROLLING GUIDE DEVICE**

(75) Inventors: **Akihiro Teramach**, Tokyo-to (JP); **Takeki Shirai**, Tokyo-to (JP); **Kaoru Hoshide**, Tokyo-to (JP)

Correspondence Address:
ARMSTRONG,WESTERMAN, HATTORI, MCLELAND & NAUGHTON, LLP
1725 K STREET, NW, SUITE 1000
WASHINGTON, DC 20006 (US)

(73) Assignee: **THK Co., Ltd.**, Tokyo (JP)

(21) Appl. No.: **09/804,222**

(22) Filed: **Mar. 13, 2001**

(30) **Foreign Application Priority Data**

Mar. 13, 2000	(JP)	P2000-073932
Dec. 1, 2000	(JP)	P2000-367605
Feb. 14, 2001	(JP)	P2001-037486

Publication Classification

(51) **Int. Cl.**[7] **F16C 29/06**
(52) **U.S. Cl.** **384/45**

(57) **ABSTRACT**

A rolling guide device comprises: a track rail formed with a rolling member rolling surface extending along a longitudinal direction thereof; a movable rail formed with a loaded rolling member rolling surface extending along a longitudinal direction thereof so as to oppose to the rolling member rolling surface of the track rail; a track rail side rolling member circulation passage formed to the track rail so as to circulate the rolling members rolling between the track rail and the movable rail; a movable rail side rolling member circulation passage formed to the movable rail so as to circulate the rolling members rolling between the track rail and the movable rail; and a number of rolling members disposed and arranged in the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage. A drive system comprises such rolling guide device and linear motors having a primary side mounted to either one of the track rail and the movable rail and a secondary side mounted to another one of the track rail and the movable rail.

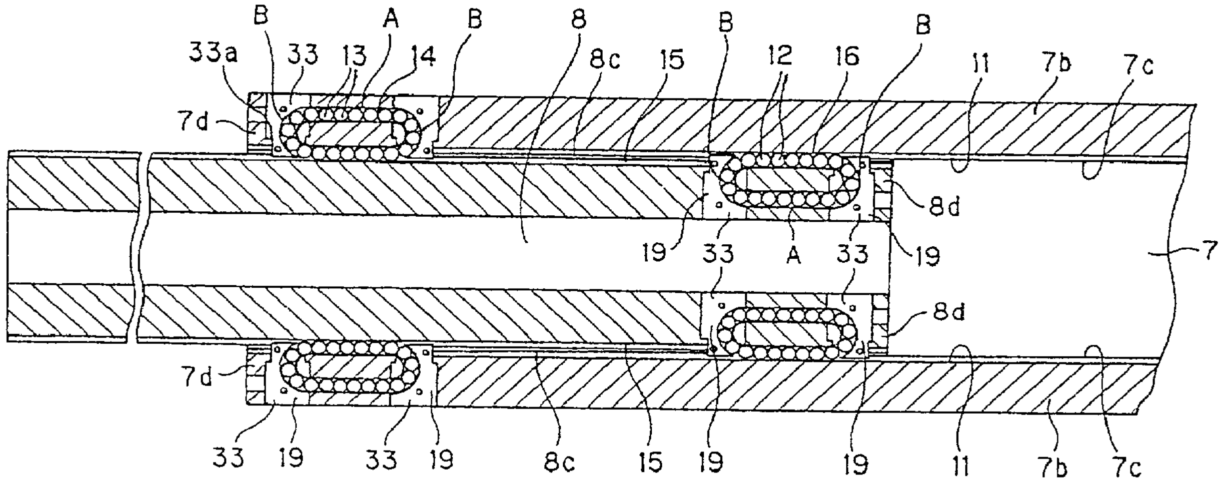


FIG. 1

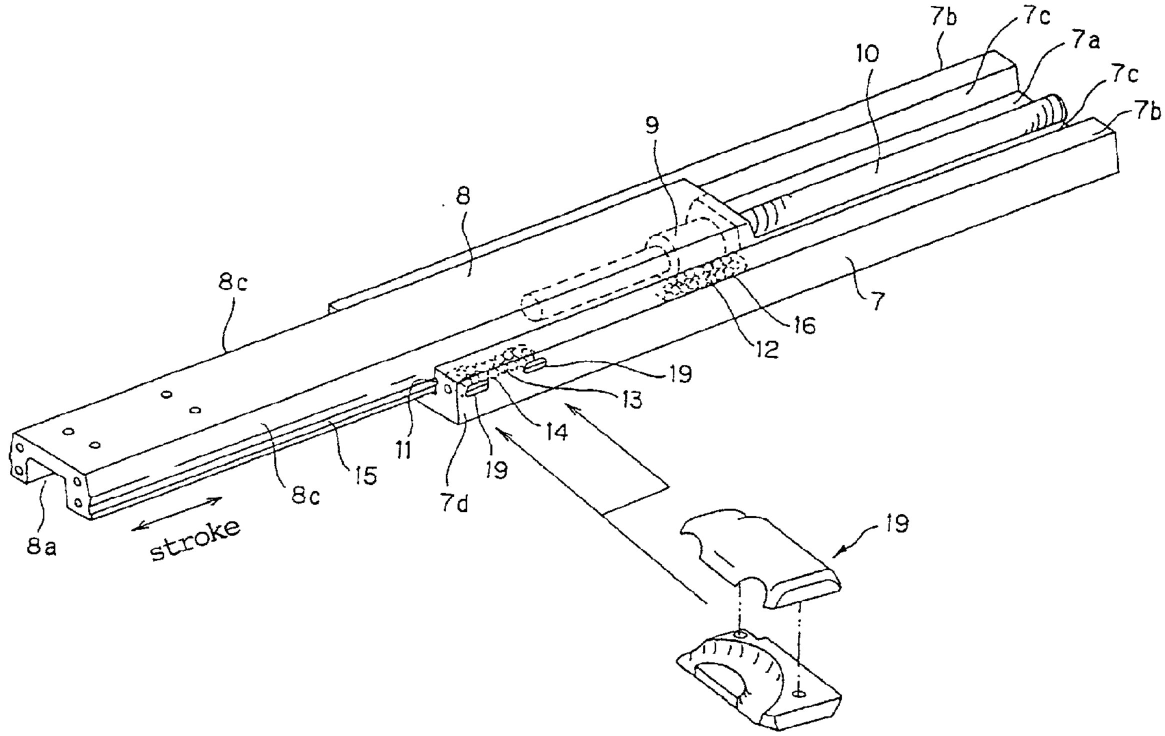


FIG. 2

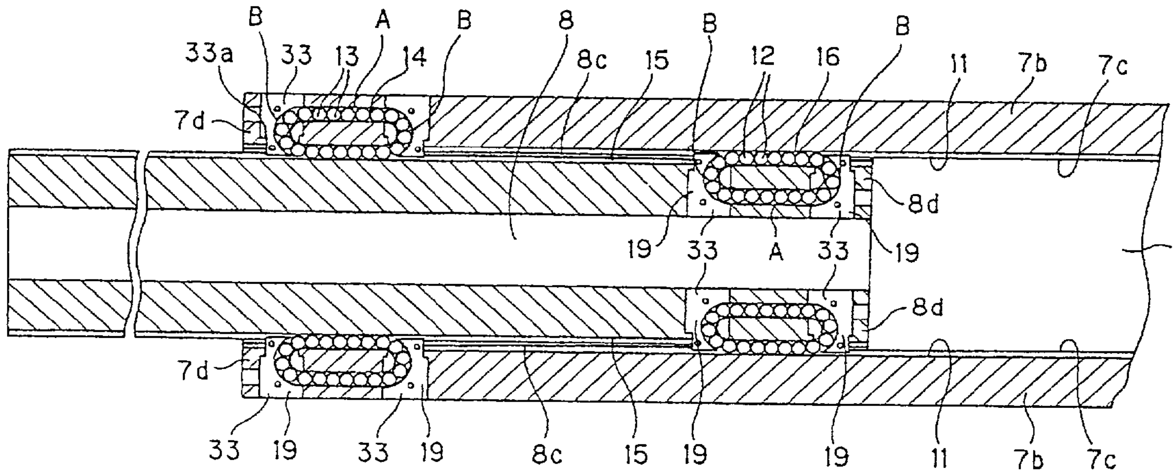

B
A
B
8
B
B
33a
33
13
14
8c
15
12
16
11
7b
7c
7d
8d
19
33
A
33
19
7
8d
7d
33
19
33
19
8c
15
19
19
11
7b
7c

FIG. 3

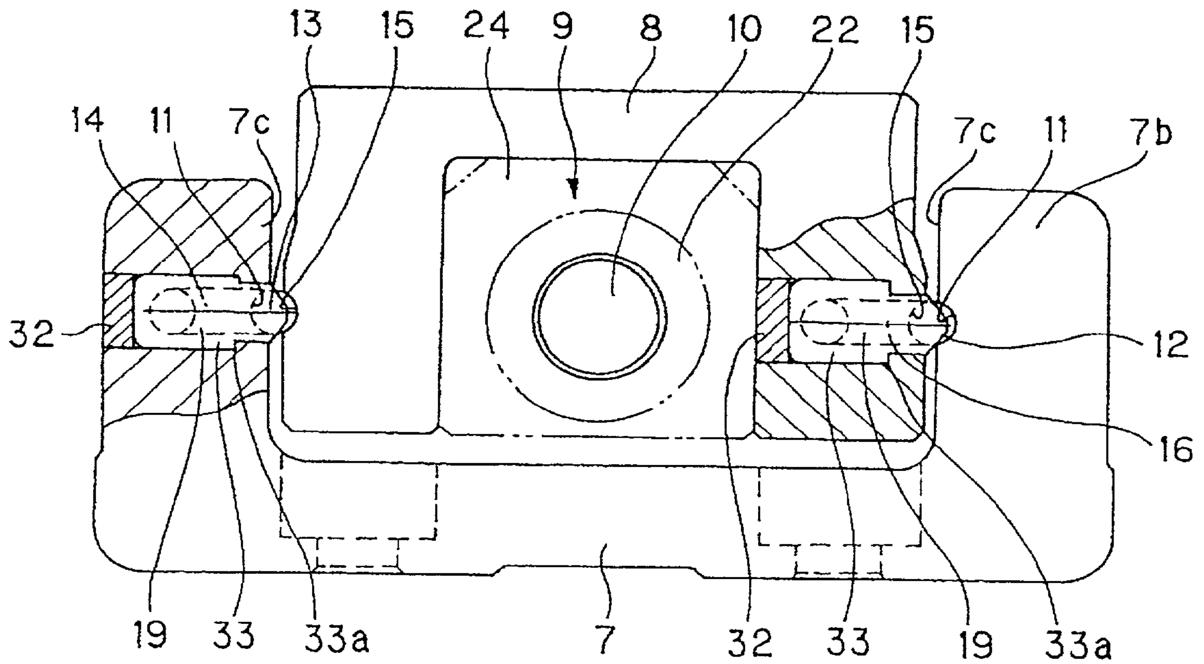

13
15
24
9
8
10
22
15
14
11
7c
7c
11
7b
32
12
32
16
19
33
33a
7
32
33
19
33a

FIG. 4

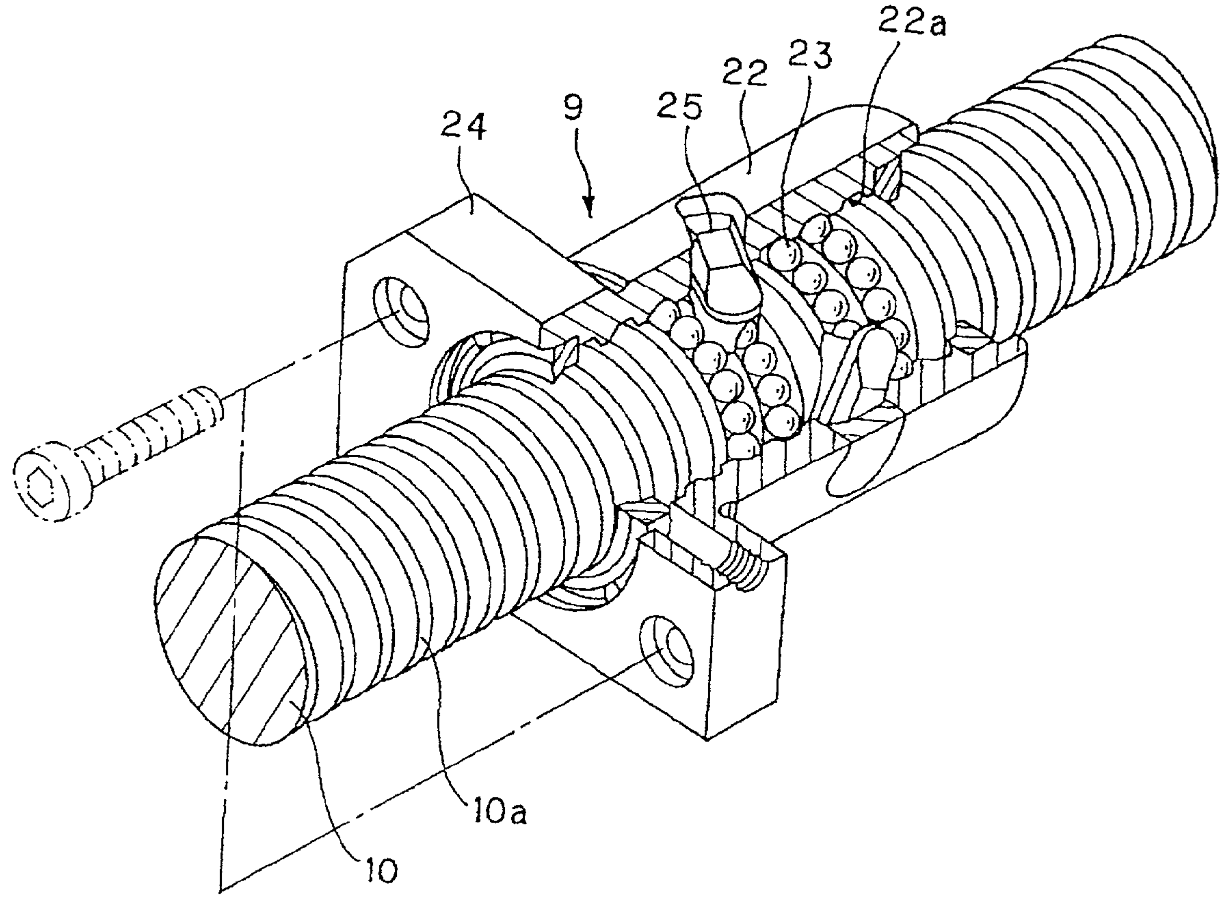


FIG. 5

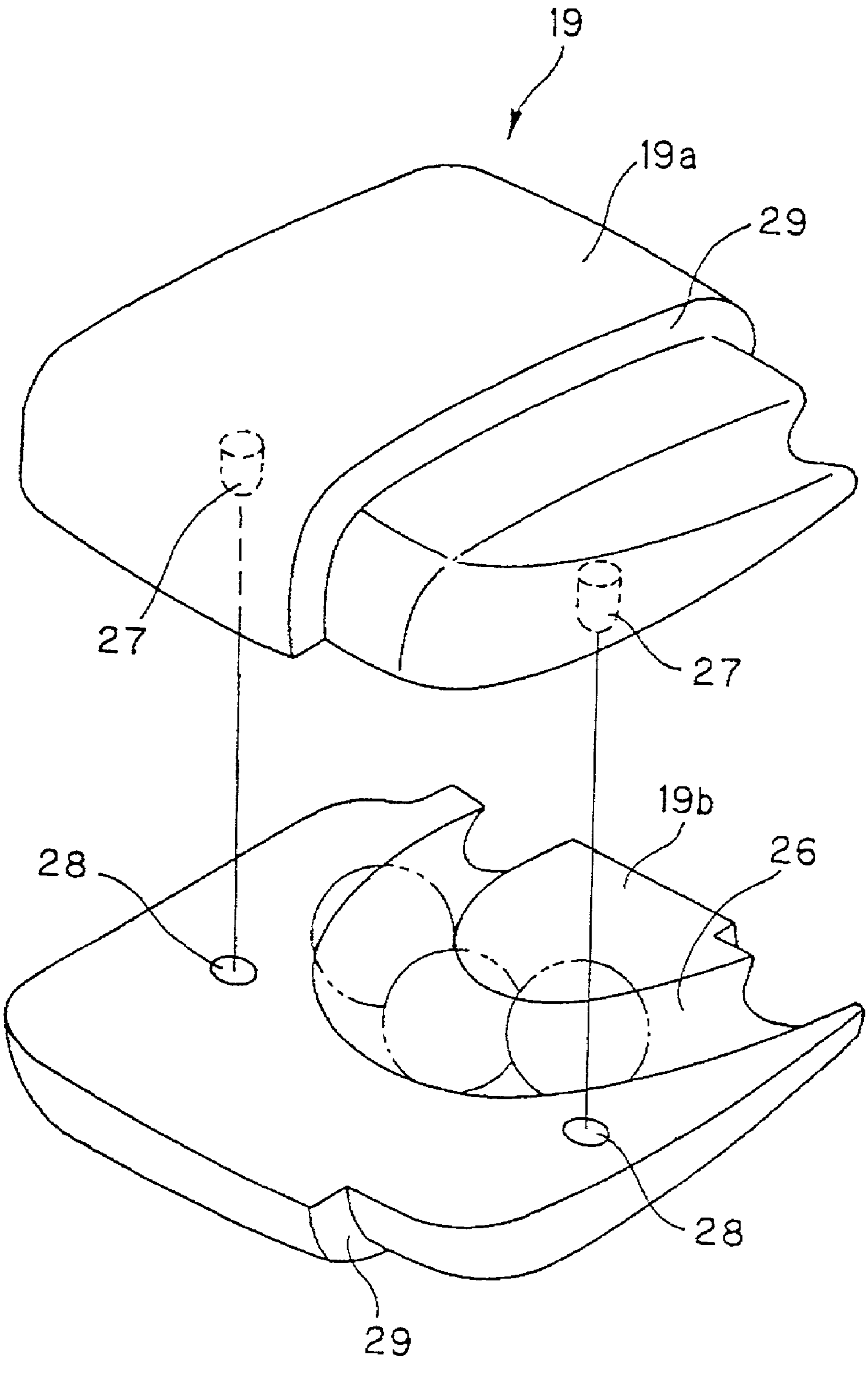


FIG. 6

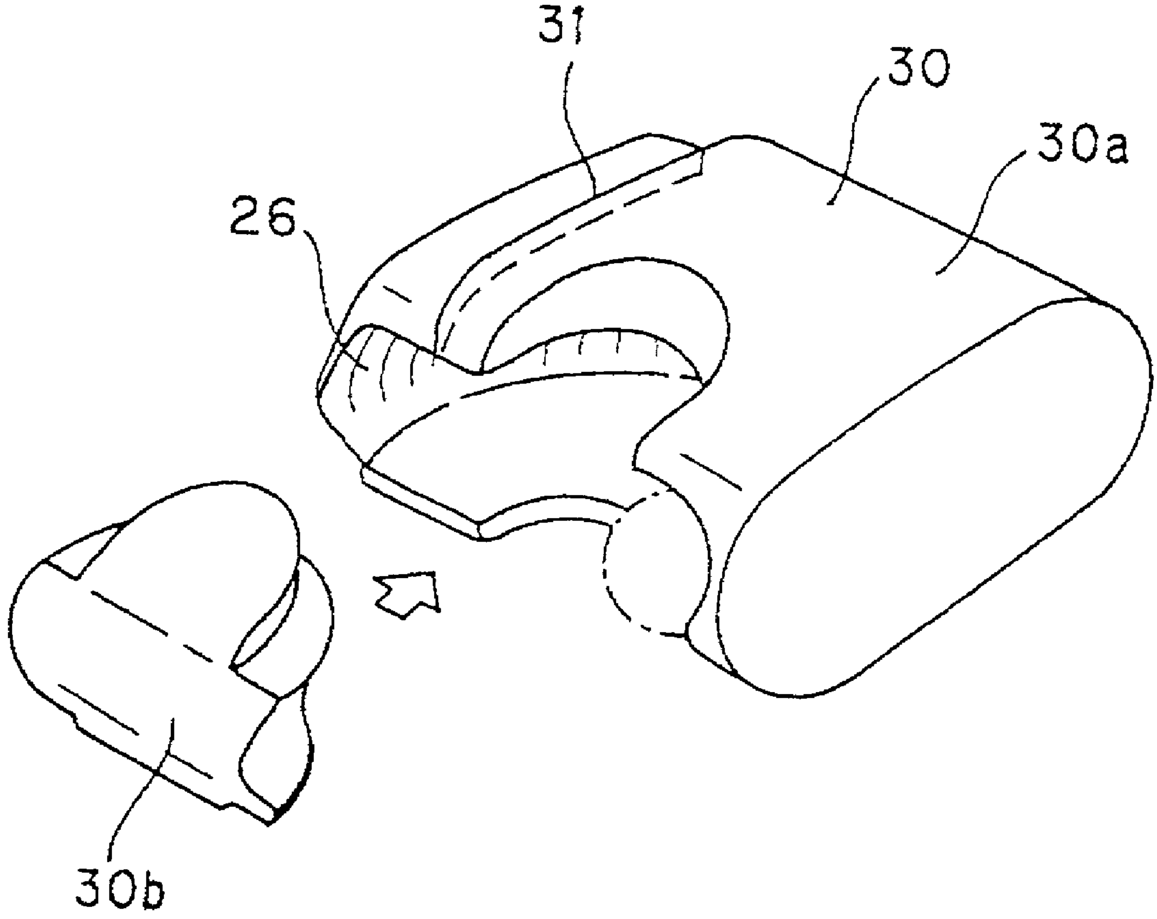


FIG. 7

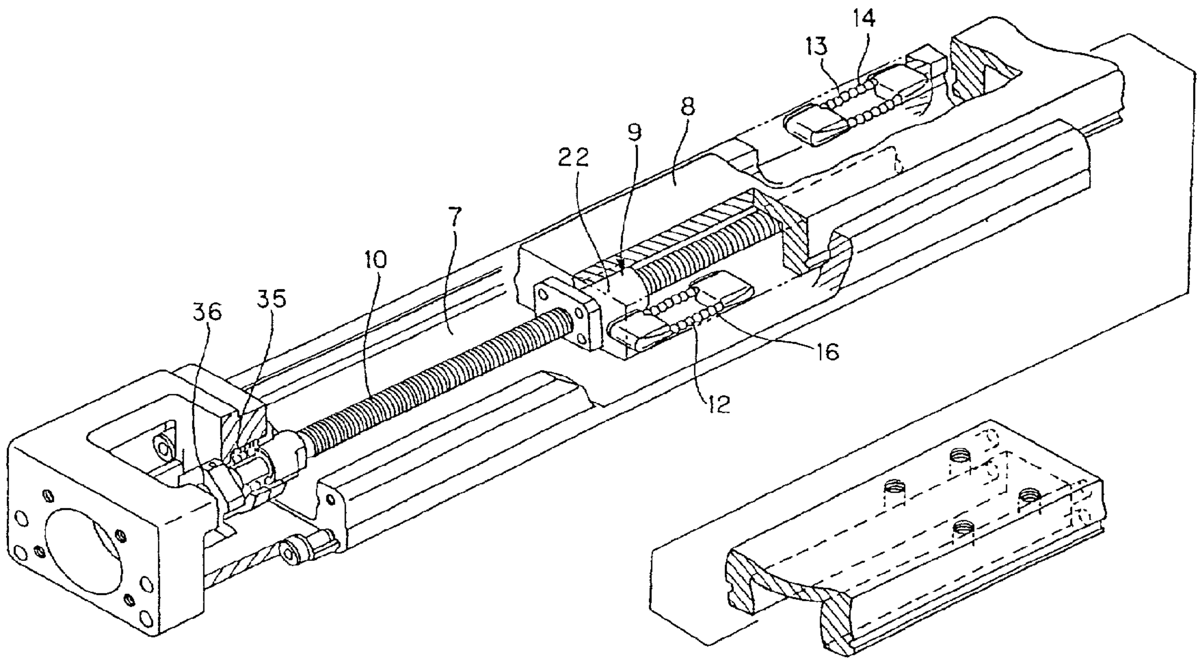


FIG. 8

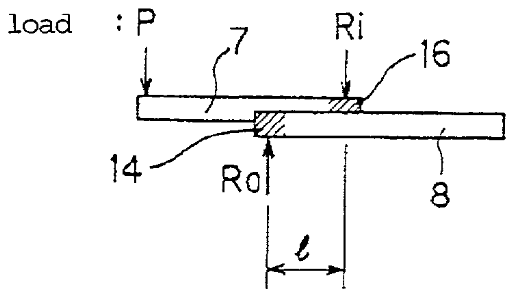


FIG. 9A

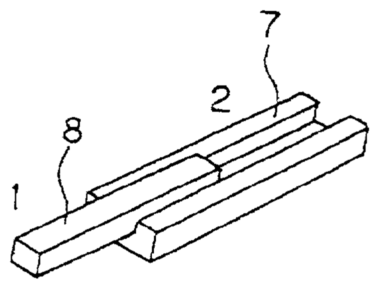


FIG. 9B

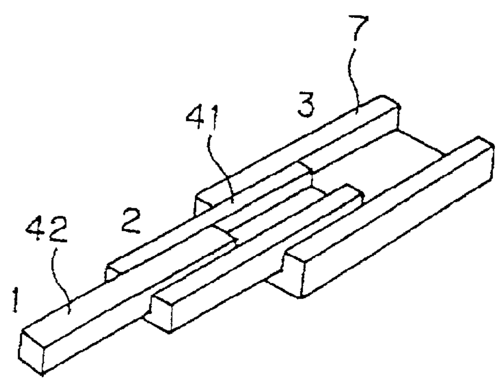


FIG. 10

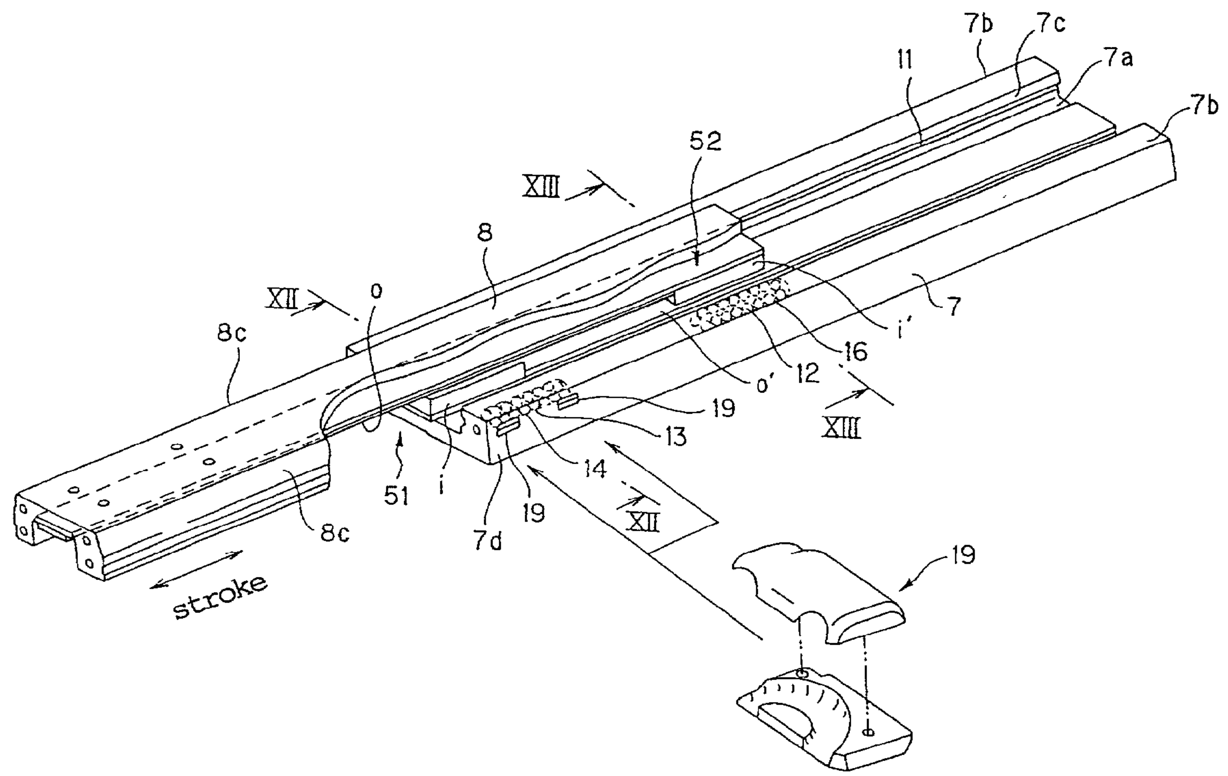

7b
7c
7a
7b
11
52
XIII
8
XII
o
8c
i'
7
16
12
o'
19
13
XIII
14
51
i
7d
19
XII
8c
19
stroke

FIG.11

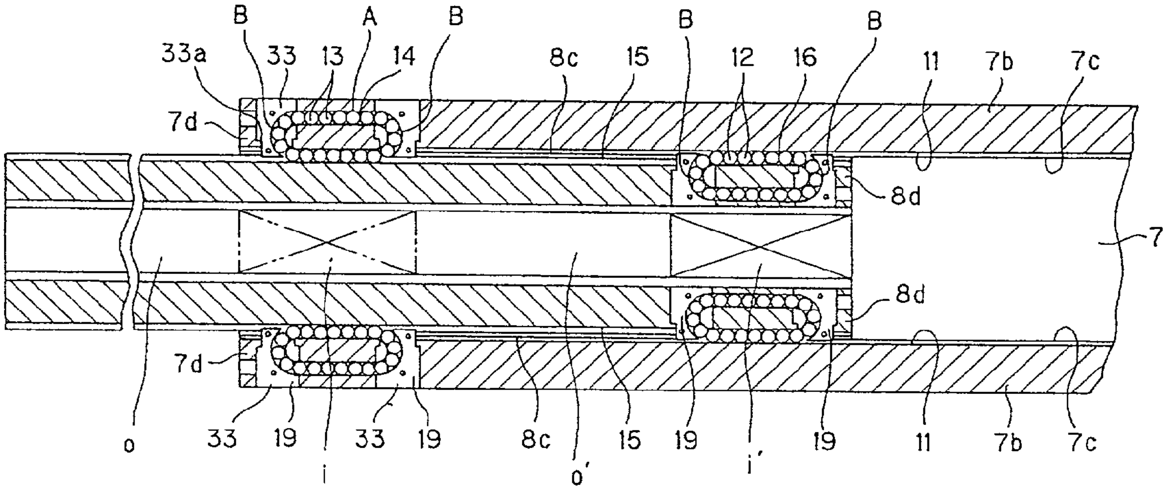

B
A
B
B
B
33a
33
13
14
8c
15
12
16
11
7b
7c
7d
8d
7
8d
7d
o
33
19
33
19
8c
15
19
19
11
7b
7c
i
o'
i'

FIG. 12

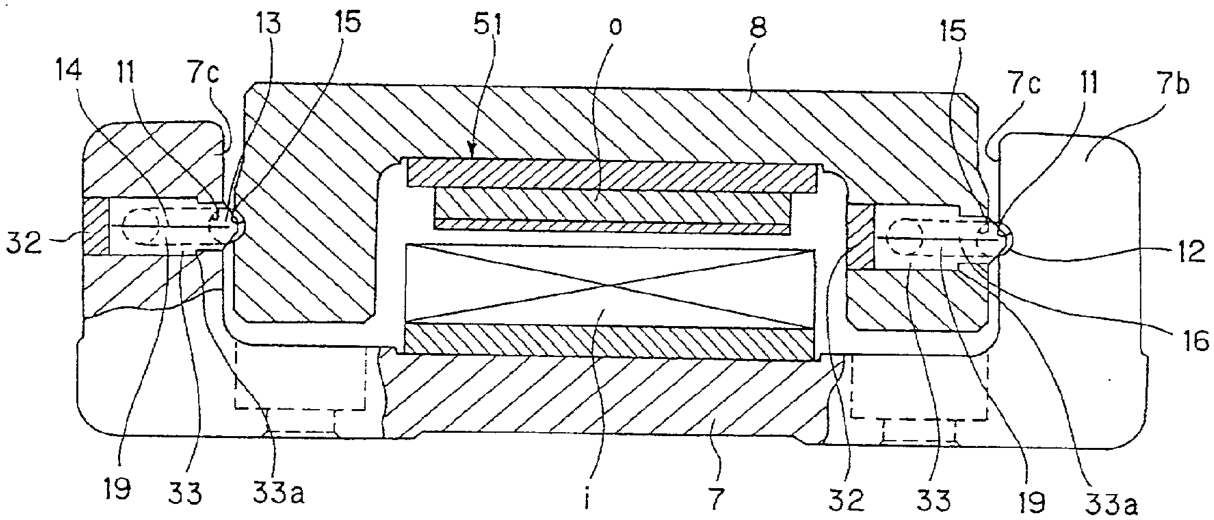


FIG. 13

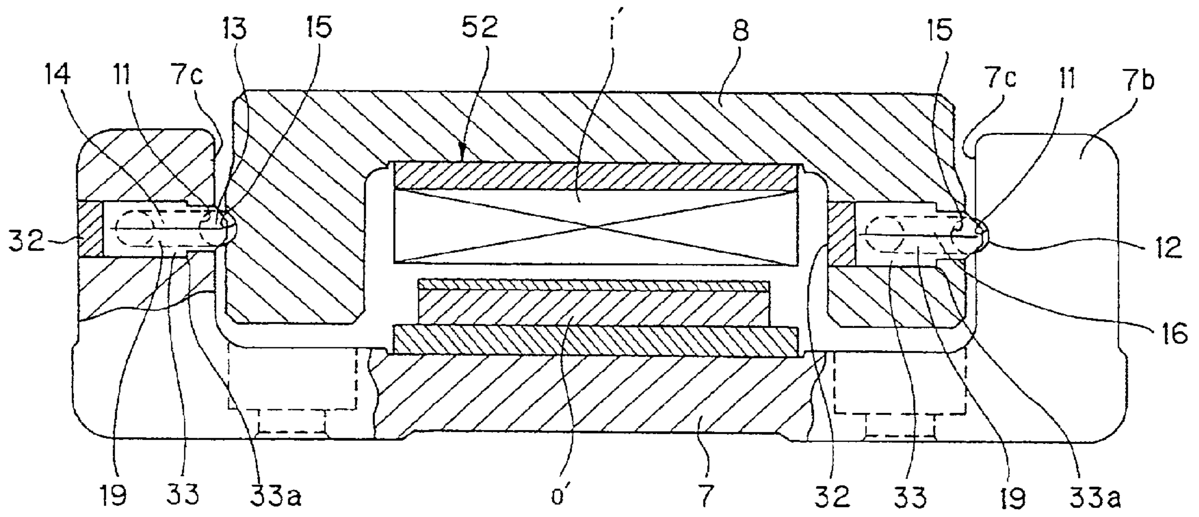


FIG. 14

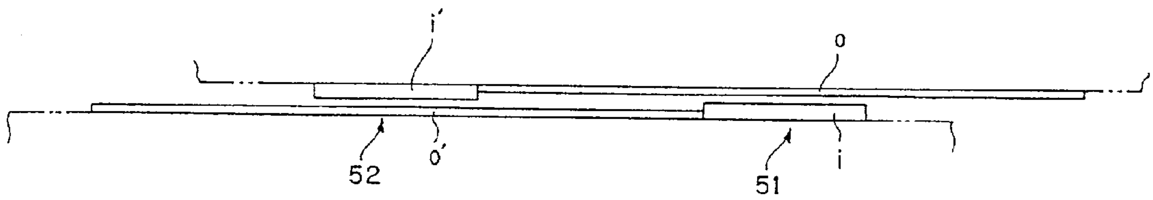


FIG. 15

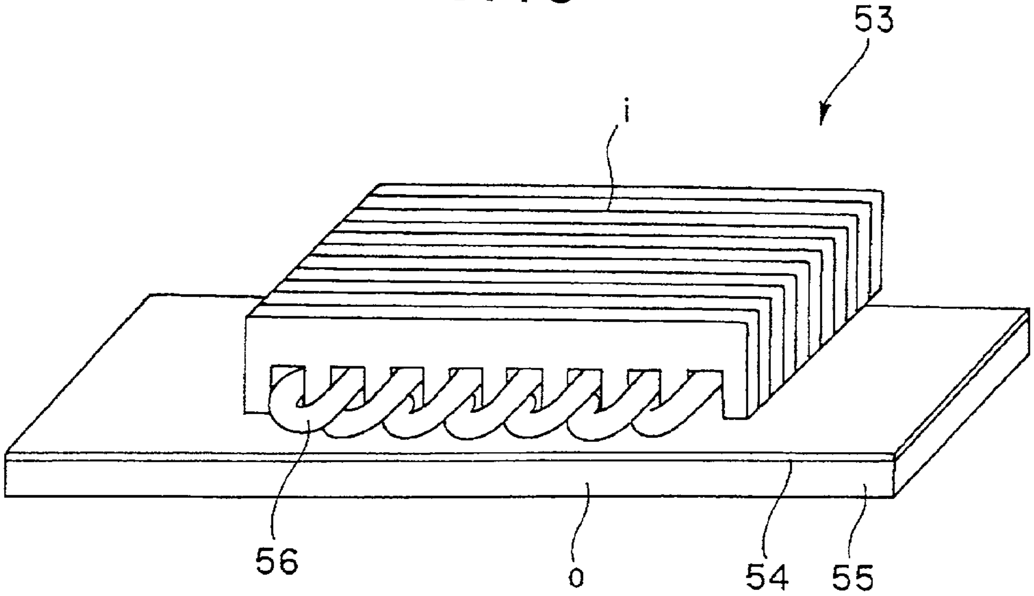

53
i
56
o
54
55

FIG. 16

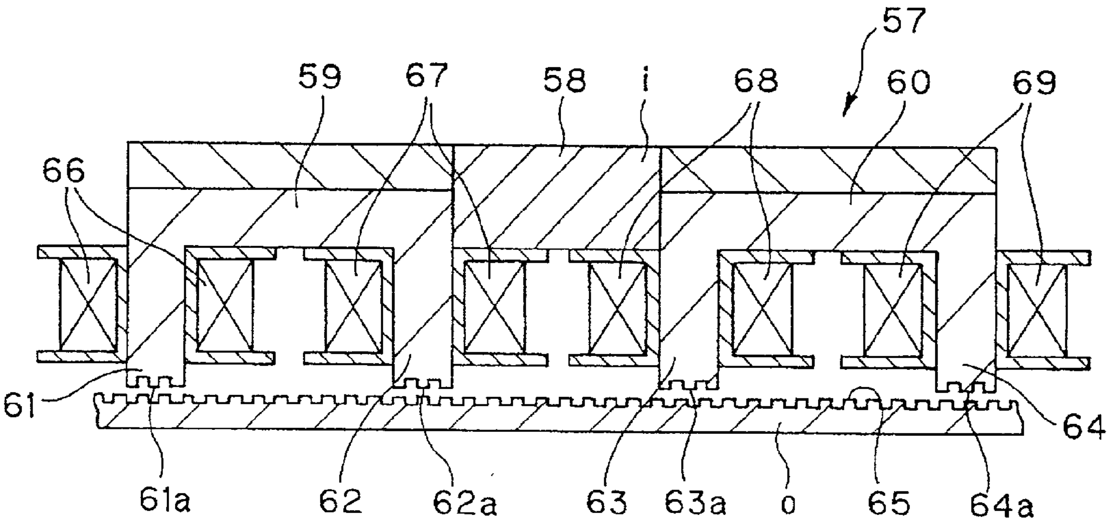

57
59
67
58
i
68
60
69
66
61
64
61a
62
62a
63
63a
o
65
64a

FIG.17A

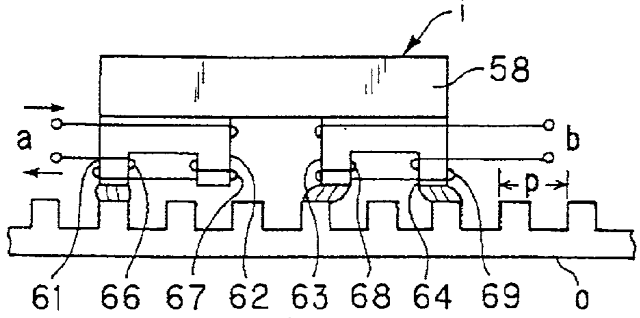


FIG.17B

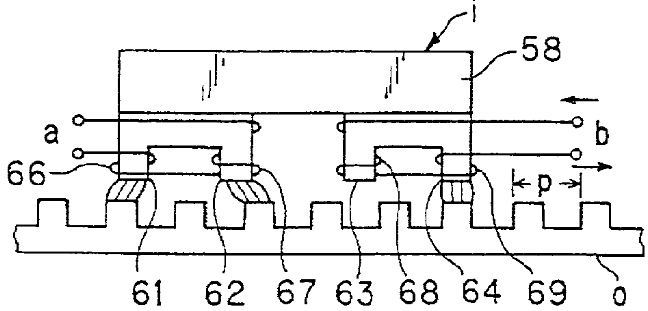


FIG.17C

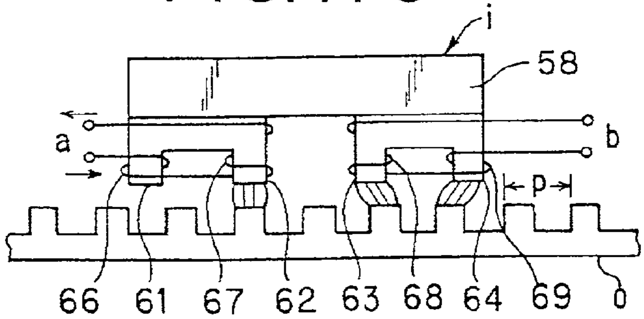


FIG.17D

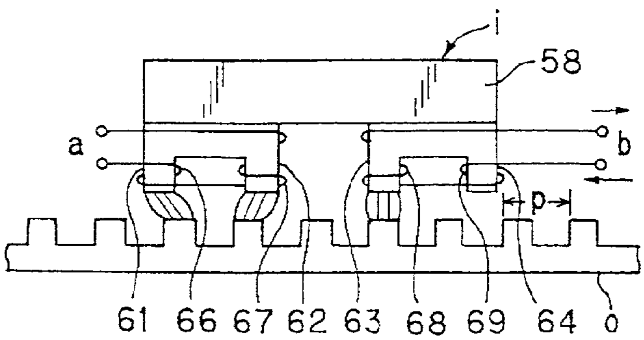


FIG. 18

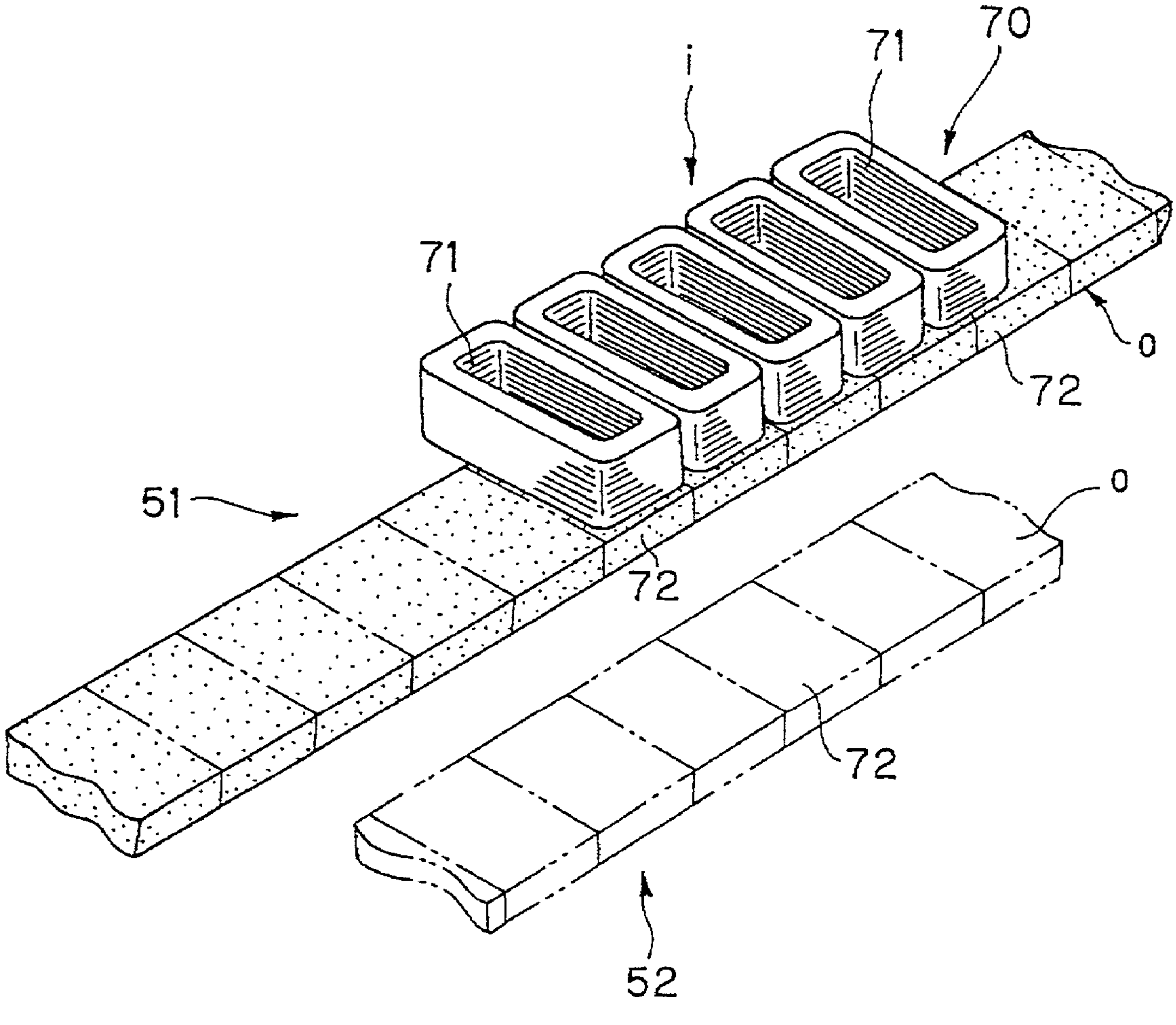


FIG. 19

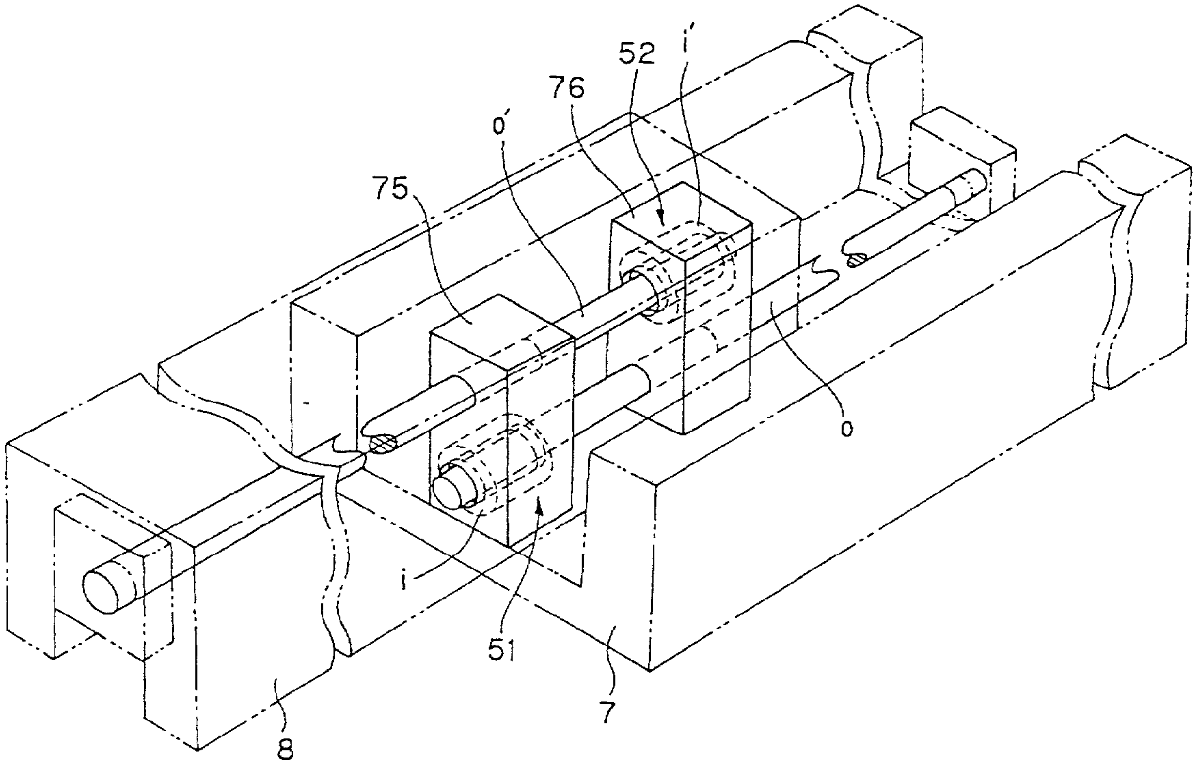
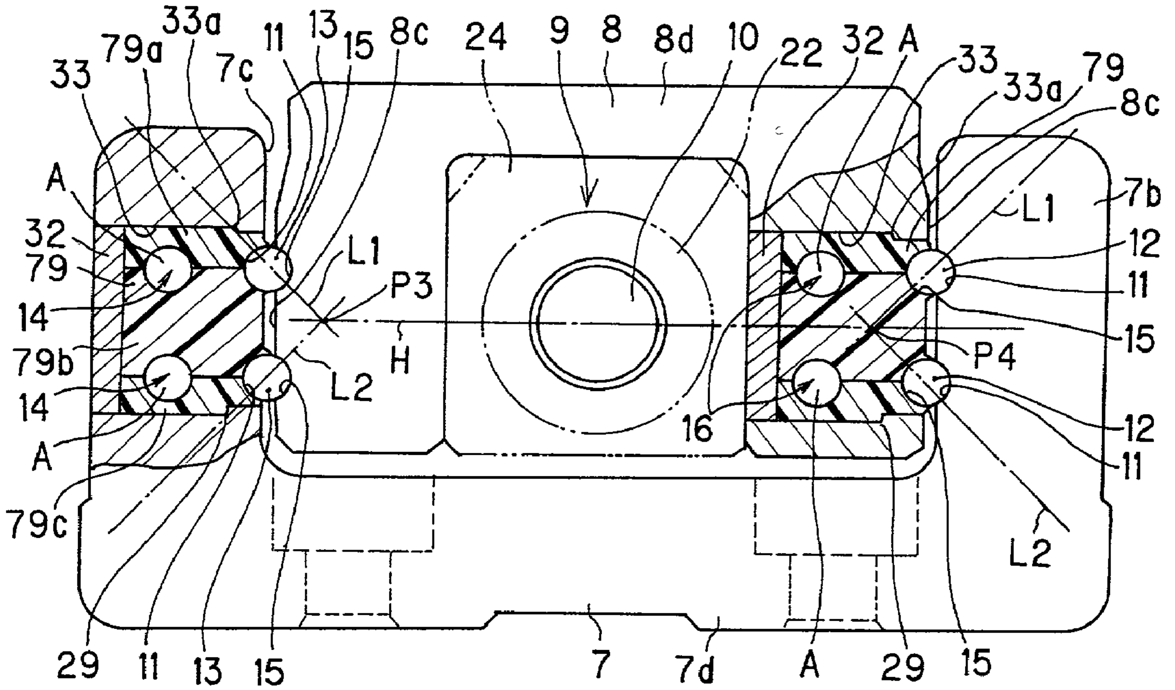


FIG. 20



33
79a
33a
7c
11
13
15
8c
24
9
8
8d
10
22
32
A
33
33a
79
8c
7b
L1
12
11
15
P4
12
11
L2
A
32
79
14
79b
14
A
79c
L1
P3
H
L2
16
29
11
13
15
7
7d
A
29
15

FIG. 21

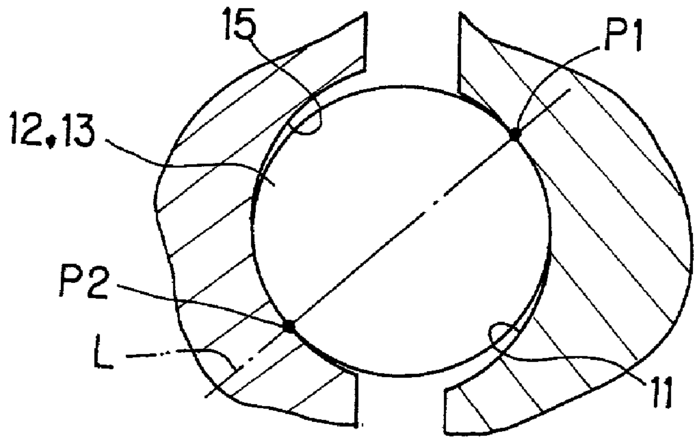


FIG. 22

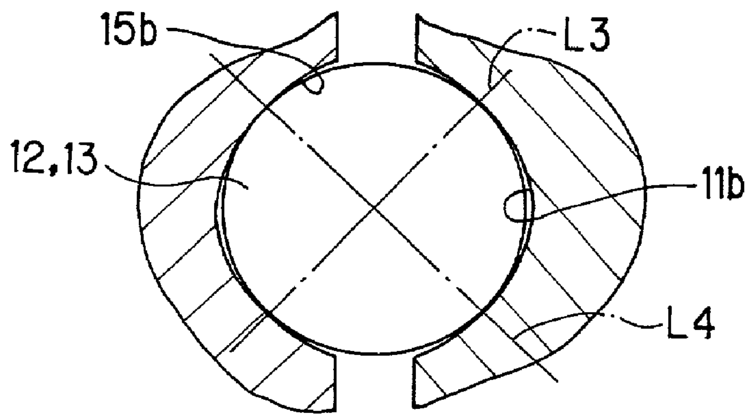


FIG. 23

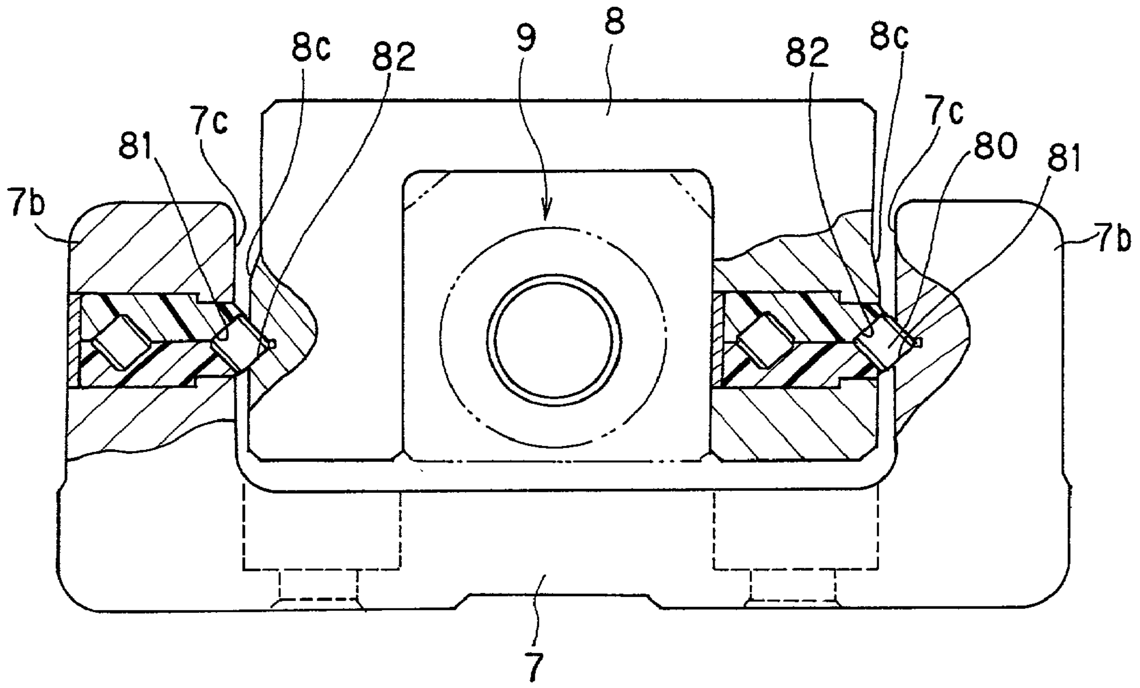


FIG. 24

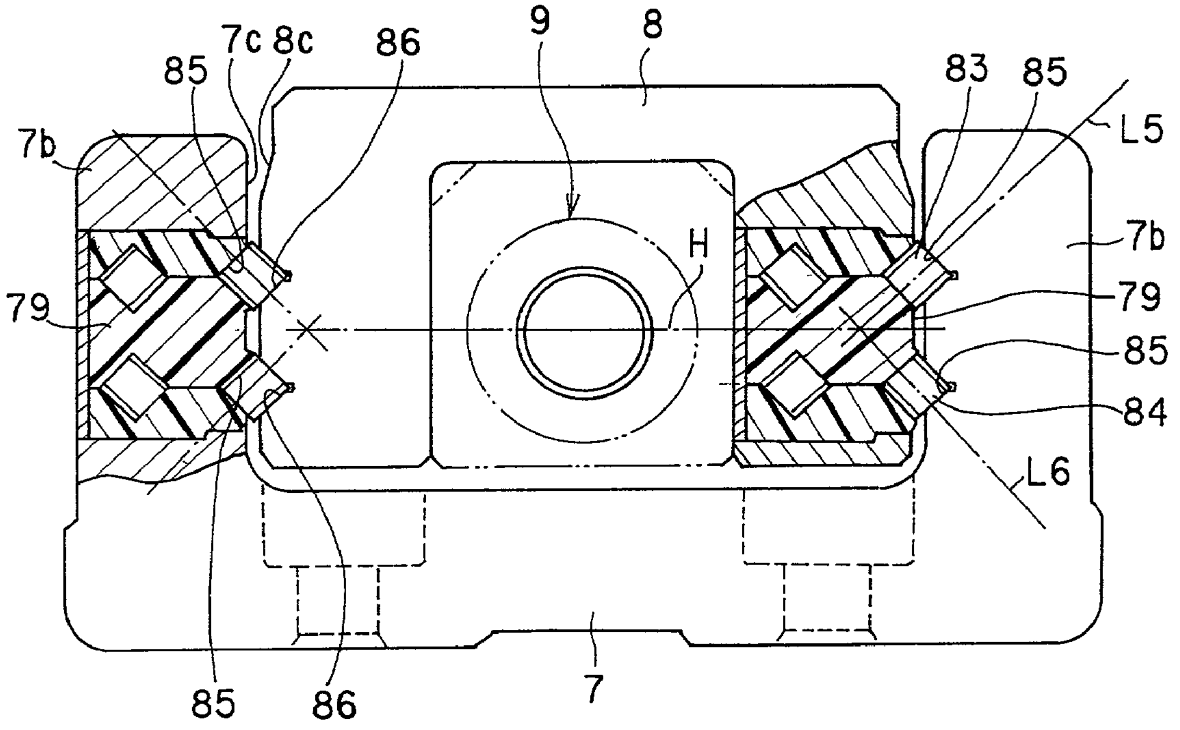
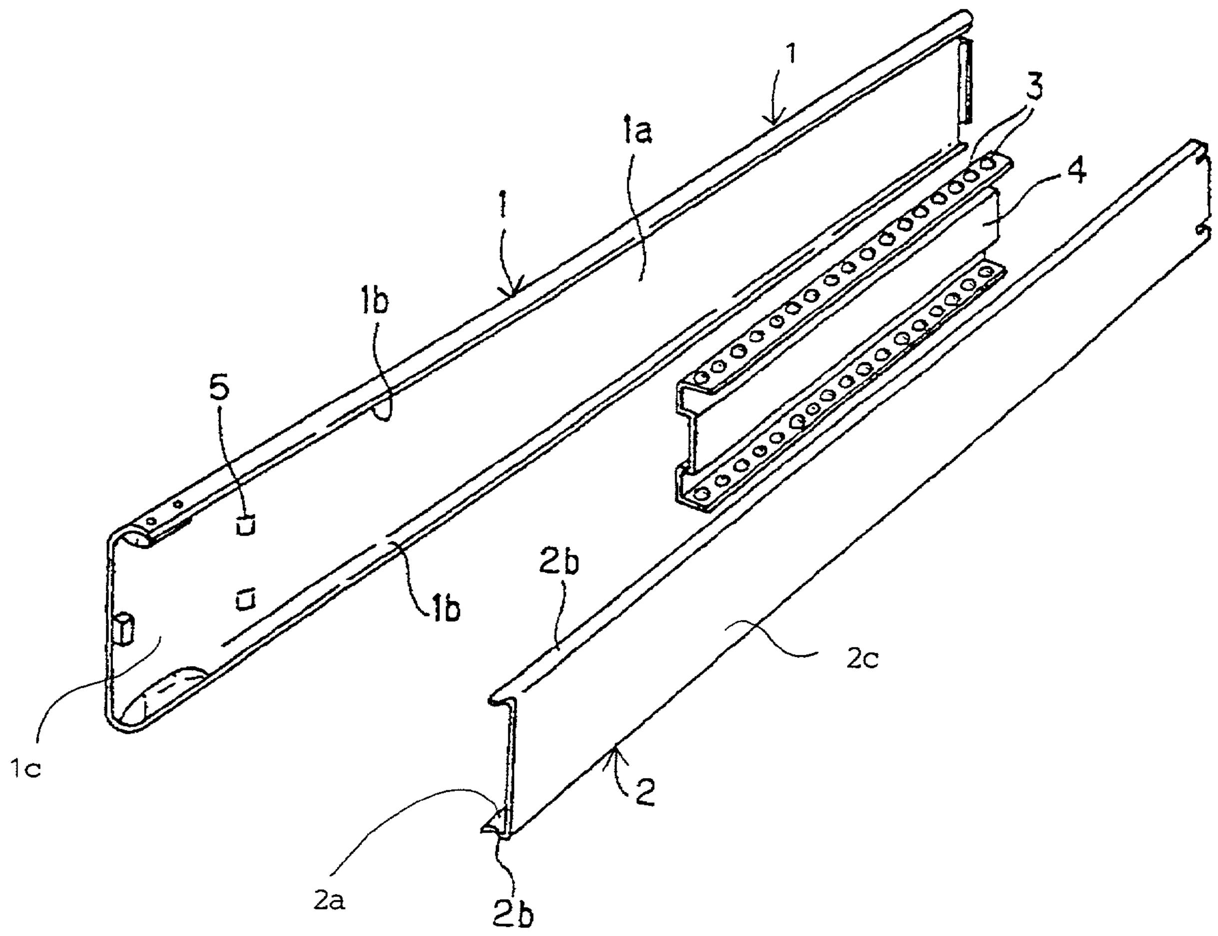


FIG. 25

PRIOR ART



ROLLING GUIDE DEVICE AND DRIVE SYSTEM USING ROLLING GUIDE DEVICE

[0001] The present application claims priority under 35 U.S.C §119 to Japanese Patent Application No. 2000-073932 filed Mar. 13, 2000 entitled "ROLLING GUIDE DEVICE", No. 2000-367605 filed Dec. 1, 2000 entitled "ROLLING GUIDE DEVICE AND DRIVE SYSTEM USING ROLLING GUIDE DEVICE", and No. 2001-037486 filed Feb. 14, 2001 entitled "ROLLING GUIDE DEVICE AND DRIVE SYSTEM USING ROLLING GUIDE DEVICE". The contents of that application are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to a rolling guide device in which a movable rail is made slidable with respect to a track rail and also relates to a drive system using such rolling guide device.

[0003] As a rolling guide device in which a movable rail is made slidable with respect to a track rail, there has been known a slide rail such as shown in **FIG. 25** (see Japanese Utility Model Publication No. SHO 62-8765). Such slide rail comprises a track rail member **1** having an opened recess **1***a* (i.e. having substantially ⊐-shaped (box-shaped) cross section) formed by both inner side surfaces **1***b*, **1***b* and a bottom surface **1***c* and a movable rail member **2** which is supported between both the inner side surfaces **1***b*, **1***b* of the track rail member **1** to be movable in the longitudinal direction thereof. The movable rail member **2** also has an opened recess **2***a* (i.e. having substantially ⊐-shaped (box-shaped) cross section).

[0004] The track rail member **1** and the movable rail member **2** have substantially the same longitudinal length. The inner side surfaces **1***b* of the track rail member **1** are formed with ball rolling grooves, respectively, along which balls roll in the longitudinal direction thereof, and outer side surfaces **2***b* of the movable rail member **2** are also formed with loaded ball rolling grooves, respectively, so as to extend in the longitudinal direction thereof and oppose to the ball rolling grooves formed to the track rail member **1**.

[0005] A number of balls **3** are arranged and housed between these ball rolling grooves and loaded ball rolling grooves, and these balls **3** are held by a cage **4** to be rotatable and slidable. When the movable rail member **2** is slid with respect to the track rail member **1** in the longitudinal direction thereof, these balls **3** roll and, hence, the slide rail becomes smoothly expandable or contractive.

[0006] Further, though not shown, there is also known a cam-follower type drawer device of a structure that movable and track rails are both provided with wheels so that the movable rail is drawn with respect to the track rail, as a rolling guide device in which a movable rail is slidable with respect to a track rail.

[0007] However, in the conventional slide rail such as mentioned above, a number of balls **3** disposed and arranged between the track rail member **1** and the movable rail member **2** do not completely perform the rolling motion and will roll with a slight sliding motion. In the conventional slide rail, since the balls **3** do not circulate and only reciprocally move along the loaded rolling passage between the ball rolling grooves and the loaded ball rolling grooves, if the balls **3** are slid, the cage **4** supporting (bearing) the balls **3** would be displaced from the initial position. As a result, in spite of the fact that an effective stroke of the movable rail member **2** is not achieved, the cage **4** collides with a stopper **5** of the track rail member **1** and, hence, such effective stroke could not be obtained. In this case, when it is required to slide the movable rail member **2** with the cage **4** colliding with the stopper **5**, the movable rail member **2** will be slid with the balls **3** being slipped, and accordingly, a large force is required to move the movable rail member **2**.

[0008] Furthermore, in the conventional structure of the slide rail, in order to obtain a large stroke of the movable rail member **2**, it is necessary for the movable rail member **2** to be once come off from a portion at which the balls **3** exist and then to be engaged with that portion at which the balls **3** exist. That is, in the case where the movable rail member **2** is come off from the portion at which the balls **3** exist, for example, the movable rail member **2** which has been loaded with ten (10) balls **3** is loaded with, for example, six (6) balls **3**, and hence, ability for bearing moment load, radial load and thrust load is deteriorated, thus being inconvenient.

[0009] Moreover, with the cam-follower type drawer device, since the wheels generally have backlash or looseness, the movable rail member **2** is not smoothly slid, and furthermore, since the wheel has a cylindrical structure, a direction along which a load is received is determined, and hence, the thrust load cannot be received.

SUMMARY OF THE INVENTION

[0010] An object of the present invention is to substantially eliminate defects or drawbacks encountered in the prior art mentioned above and to provide a rolling guide device capable of taking a large expansion/contraction stroke and sufficiently bearing moment load, radial load and thrust load at any expanded (contracted) attitude and also provide a drive system incorporated with such rolling guide device.

[0011] This and other objects can be achieved according to the present invention by providing, in one aspect, a rolling guide device comprising:

[0012] a track rail formed with a rolling member rolling surface extending along a longitudinal direction thereof;

[0013] a movable rail formed with a loaded rolling member rolling surface extending along a longitudinal direction thereof so as to oppose to the rolling member rolling surface of the track rail;

[0014] a track rail side rolling member circulation passage formed to the track rail so as to circulate the rolling members rolling between the track rail and the movable rail;

[0015] a movable rail side rolling member circulation passage formed to the movable rail so as to circulate the rolling members rolling between the track rail and the movable rail; and

[0016] a number of rolling members disposed and arranged in the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage.

[0017] According to the invention of this aspect, when the movable rail is slid with respect to the track rail, the rolling members arranged between the track rail and the movable rail endlessly circulate in the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage while rolling therealong. As mentioned, since the rolling members circulate in the endless manner, even if the rolling member slides during the rolling motion, there is no causing of a case that a cage is shifted from the initial position as in the conventional structure, and hence, a large expansion (contraction) stroke is obtainable. Furthermore, in an optional expanded (contracted) attitude, there remains a considerable distance between the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage, so that a rolling guide device, which can bear even the moment load, can be realized.

[0018] Further, when the movable rail is slid and its stroke is made large, the considerable distance corresponding to this stroke is made short and capability of bearing the moment load is reduced. However, according to the present invention, the movable rail is not come off from the balls, so that the capability of bearing the moment load is not extremely reduced. Moreover, since the movable rail is not come off from the balls and the number of the rolling members supported at an optional expansion (contraction) attitude is not changed, different from the conventional slide rail, there can be provided a rolling guide device bearing the constant radial load and thrust load.

[0019] In the above aspect, the following preferred embodiments or examples may be provided with advantageous functions and effects thereof.

[0020] The track rail side rolling member circulation passage is formed to one longitudinal end side of the track rail and the movable rail side rolling member circulation passage is formed to one longitudinal end side, opposing to that one end side of the track rail, of the movable rail.

[0021] Accordingly, the distance between the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage can be made large, so that a rolling guide device bearing the large moment load can be provided.

[0022] Furthermore, the track rail has an opened recess having ⊐-shaped section and has inside surfaces to which the rolling member rolling surfaces are formed, the movable rail is fitted into the recess of the track rail, and the movable rail has outside surfaces to which the loaded rolling member rolling surfaces are formed so as to oppose to the rolling member rolling surfaces formed to the track rail inside surfaces.

[0023] Thus, various kinds of loads including radial load, thrust load and moment load can be supported in a balanced condition.

[0024] The track rail side rolling member circulation passage is provided with a rolling member return passage substantially parallel to the rolling member rolling surface and a rolling direction changing passage communicating the rolling member rolling surface and the rolling member return passage, the movable rail side rolling member circulation passage is provided with a rolling member return passage substantially parallel to the loaded rolling member rolling surface and a rolling direction changing passage communicating the rolling member rolling surface and the rolling member return passage, the rolling direction changing passages of the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage are formed to a deflector which is formed independently from a track rail body and a movable rail body, and the deflector is fitted to holes formed to the track rail body and movable rail body from the side portions thereof.

[0025] According to this embodiment, the rolling direction changing passages can be easily formed to fine long track rail and movable rail.

[0026] The return passages are drilled to the track rail body and the movable rail body from the longitudinal end portions thereof.

[0027] According to this embodiment, the return passages can be easily formed to fine long track rail and movable rail.

[0028] The deflector is composed of a plurality of sections splittable along the rolling direction changing passages.

[0029] Accordingly, the rolling direction changing passages having complicated structure may be easily formed to the deflector.

[0030] The deflector is made of a synthetic resin.

[0031] Accordingly, the rolling direction changing passages having complicated structure may be easily formed to the deflector, and moreover, noise which may be generated when the rolling members roll in the rolling direction changing passages will be suppressed.

[0032] The above mentioned object of the present invention can be also achieved by providing, in another aspect, a drive system comprising:

[0033] a track rail formed with a rolling member rolling surface extending along a longitudinal direction thereof;

[0034] a movable rail formed with a loaded rolling member rolling surface extending along a longitudinal direction thereof so as to oppose to the rolling member rolling surface of the track rail;

[0035] a track rail side rolling member circulation passage formed to the track rail so as to circulate the rolling members rolling between the track rail and the movable rail;

[0036] a movable rail side rolling member circulation passage formed to the movable rail so as to circulate the rolling members rolling between the track rail and the movable rail;

[0037] a number of rolling members disposed and arranged in the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage; and

[0038] a linear motor means having a primary side mounted to either one of the track rail and the movable rail and a secondary side mounted to another one of the track rail and the movable rail.

[0039] According to the present invention of this aspect, the expansion (contraction) stroke can be made large and the moment load, the radial load and the thrust load can be sufficiently supported at an optional attitude of the system. Furthermore, since the linear motors are incorporated between the track rail and the movable rail, the use of the ball screw or like can be eliminated, thus moving the movable rail at high speed with less noise. Moreover, since it is not necessary to provide a space for a rotary motor, the drive system can be made thin and compact.

[0040] According to preferred embodiments or examples of this aspect, the following advantageous functions and effects may be attained.

[0041] The track rail side rolling member circulation passage is formed to one longitudinal end side of the track rail and the movable rail side rolling member circulation passage is formed to one longitudinal end side, opposing to that one end side of the track rail, of the movable rail, and the linear motor means comprises first and second linear motors, the first linear motor having a primary side mounted to a portion near the track rail side rolling member circulation passage of the track rail, the second linear motor having a secondary side mounted to the track rail along the longitudinal direction thereof so as to be continuous to the primary side of the first linear motor, and the second linear motor having a primary side mounted to a portion near the movable rail side rolling member circulation passage of the movable rail, the first linear motor having a secondary side mounted to the movable rail along the longitudinal direction thereof so as to be continuous to the primary side of the second linear motor.

[0042] According to this embodiment, since two sets of linear motors are incorporated in the drive system, the thrust force can be made two times (twice), and the excitation is averaged to thereby make smooth the movement of the movable rail. Furthermore, the first linear motor has a primary side mounted to a portion near the track rail side rolling member circulation passage of the track rail and the second linear motor has a primary side mounted to a portion near the movable rail side rolling member circulation passage of the movable rail, so that the thrust force can be generated at substantially the same positions of the movable side rolling member circulation passage and the track rail side rolling member circulation passage, regardless of the stroke of the movable rail. Therefore, even if pitching or yawing moment is applied to the movable rail, the thrust force can be stably applied to the movable rail.

[0043] The first and second linear motors may be composed of linear induction motors or linear pulse motors such that the secondary sides thereof are opposed to each other.

[0044] For example, in a case where linear D.C. motors are used, two sets of linear motors are disposed in back-to-back arrangement and a distance between the secondary side magnets is short, an alternating magnetic field may be generated between the magnets. However, according to this embodiment of the present invention, since the linear induction motors or linear pulse motors are used without using the magnets, there is no fear of causing any alternating magnetic filed. However, a linear D.C. motor may be utilized as far as a relatively large distance between the secondary sides of the linear D.C. motors can be taken so as not to influence from each other.

[0045] The nature and further characteristic features of the present invention may be made clear from the following descriptions made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0046] In the accompanying drawings:

[0047] **FIG. 1** is a perspective view of a rolling guide device according to one embodiment of the present invention;

[0048] **FIG. 2** is a transverse sectional view of the rolling guide device of **FIG. 1**, partially cut away, in the longitudinal direction thereof;

[0049] **FIG. 3** is a sectional view in a direction normal to the axis of the rolling guide device;

[0050] **FIG. 4** is a perspective view showing a ball screw to be incorporated in the rolling guide device of **FIG. 1**;

[0051] **FIG. 5** is a perspective view showing one example of a deflector to be assembled with the rolling guide device;

[0052] **FIG. 6** is a perspective view showing another example of the deflector;

[0053] **FIG. 7** is a perspective view of a drive system using the rolling guide device of **FIG. 1**;

[0054] **FIG. 8** is an illustration showing a state that a load is **1**. applied to a front end portion of the rolling guide device of FIG.

[0055] **FIG. 9** is an illustration of a further embodiment of the rolling guide device and includes **FIG. 9A** showing a two-stage type rolling guide device and **FIG. 9B** showing a three-stage type rolling guide device;

[0056] **FIG. 10** is a perspective view of a drive system, according to another embodiment of the present invention, incorporated with a liner motor;

[0057] **FIG. 11** is a transverse sectional view of the drive system of **FIG. 10**, partially cut away, in the longitudinal direction thereof;

[0058] **FIG. 12** is a sectional view taken along the line XII-XII in **FIG. 10**;

[0059] **FIG. 13** is a sectional view taken along the line XIII-XIII in **FIG. 10**;

[0060] **FIG. 14** is an illustration showing an example in which two set of linear motors are disposed in back-to-back arrangement;

[0061] **FIG. 15** is a perspective view showing a linear induction motor;

[0062] **FIG. 16** is a vertical sectional view of a liner pulse motor in a longitudinal direction thereof;

[0063] **FIGS. 17A** to **17D** show operation principle of the liner pulse motor;

[0064] **FIG. 18** is a perspective view of a linear D.C. motor;

[0065] **FIG. 19** is a perspective view showing a drive system according to a further embodiment of the present invention;

[0066] **FIG. 20** is a sectional view of a rolling guide device formed with lateral two rows of rolling member (ball) rolling grooves;

[0067] **FIG. 21** is a view showing a contacting state of a ball to a ball rolling groove and a loaded ball rolling groove (circular-arc groove);

[0068] **FIG. 22** is a view showing a contacting state of a ball to a ball rolling groove and a loaded ball rolling groove (Gothic-arch groove);

[0069] **FIG. 23** is a sectional view of one example of a rolling guide device using rollers as rolling members;

[0070] **FIG. 24** is a sectional view of another example of a rolling guide device using rollers as rolling members; and

[0071] **FIG. 25** is a perspective view showing a slide rail having a conventional structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0072] FIGS. **1** to **3** represent a first embodiment of a rolling guide device according to the present invention.

[0073] With reference to FIGS. **1** to **3**, a rolling guide device comprises an outer rail **7** as a track rail, an inner rail **8**, as a movable rail, supported by the outer rail **7** to be slidable in the longitudinal direction thereof and a ball screw **9** driving the inner rail **8**. When a screw shaft **10** of the ball screw **9** is rotated, the inner rail **8** is slid with respect to the outer rail **7**. Such rolling guide device will be utilized for a welding servo-gan, fork-lift or like usable in a stockroom, for example. In a case where the rolling guide device is utilized for the welding servo-gan, a welding rod is attached to the inner rail **8** and, then, the inner rail **8** is slid so as to press the welding rod against an object to be welded. On the other hand, in a case where the rolling guide device is utilized for the fork-lift, an inner rail **8** having a front fork member is slid and the fork-lift is then moved while supporting a cargo by the projected fork member. It is of course to be noted that the illustrated rolling guide device is not limited in its use to the welding servo-gan and the fork-lift and can be applied for various usages as far as expansion/contraction stroke is required and a load is supported.

[0074] The outer rail **7** has a recess **7***a* having an upper opening, in an illustrated state, so as to provide substantially a ⊐-shaped (box-shaped) section having an upper opening. That is, the recess **7***a* is defined by a bottom portion and a lateral pair of ridges **7***b*, **7***b* extending in parallel to each other at both longitudinal side portions of the bottom portion. Each of the ridges **7***b* has an inside surface **7***c* to which one row of ball rolling groove **11** is formed as a rolling member rolling surface extending in the longitudinal direction thereof. An outer rail side ball circulation passage **14** for circulating balls **13**, as rolling members, rolling between the inner rail **8** and the outer rail **7** is formed to one longitudinal side end portion of the outer rail **7**.

[0075] The inner rail **8** is fitted to the recess **7***a* of the outer rail **7** and supported thereby through balls **12, 13** so as to be clamped between the ridges **7***b*, **7***b* of the outer rail **7**. The inner rail **8** has a recess **8***a* having a lower opening, in an installed state, so as to provide substantially a ⊐-shape section having a lower opening, thus easily forming a space into which the screw shaft **10** is moved.

[0076] In the fitted state of the inner and outer rails **8** and **7**, the inside surfaces **7***c*, **7***c* of the outer rail **7** face the outside surfaces **8***c*, **8***c* of the inner rail **8**, respectively, so that the ball rolling grooves **11** formed to the inside surfaces **7***c*, **7***c* of the outer rail **7** oppose to the loaded ball rolling grooves **15** formed to the outside surfaces **8***c*, **8***c* of the inner rail **8**. Inner rail side ball circulation passages **16** are formed to one longitudinal end side of the inner rail **8** opposing to the outer rail side ball circulation passages **14** so as to circulate the balls **12** rolling between the outer and inner rails **7** and **8**. That is, in the structure in which the inner rail **8** projects from (extends over) the outer rail **7**, the outer rail side ball circulation passages **14** on the exit side end of the outer rail **7** and the inner rail side ball circulation passages **16** are formed to the rear side end of the inner rail **8**. This will be explained through a manufacturing processes. The outer rail side ball circulation passages **14** are formed to one end side of the outer rail **7** and the inner rail side ball circulation passages **16** are formed to one end side of the inner rail **8**, and thereafter, the inner and outer rails **8** and **7** are assembled (fitted) from the direction in which both the circulation passages **14** and **16** do not interfere.

[0077] As shown in **FIG. 2**, each of the outer rail side ball circulation passages **14** is composed of a portion of the ball rolling groove **11**, a ball return passage A as a rolling member return passage substantially parallel to the ball rolling groove **11** and a pair of rolling member rolling direction changing passages B communicating with the ball rolling groove **11** and the ball return passage A. On the other hand, each of the inner rail side ball circulation passage **16** is also composed of a portion of the loaded ball rolling groove **15**, a ball return passage A as a rolling member return passage substantially parallel to the ball rolling groove **15** and a pair of rolling member rolling direction changing passages B communicating with the loaded ball rolling groove **15** and the ball return passage A. The ball return passage A is formed through a drilling working effected along the longitudinal direction from the end portions of an outer rail body **7***d* and an inner rail body **8***d*. The rolling direction changing passages B formed to the outer and inner ball circulation passages **14** and **16** are formed to deflectors **19** formed independently from the inner and outer rail bodies **8***d* and **7***d*. The details of such deflector **19** will be described hereinlater.

[0078] The ball screw **9** is engaged with the inner rail **8** so that the ball screw **9** is arranged in the recess **8***a* of the inner rail **8**.

[0079] With reference to **FIG. 4** showing the ball screw **9**, the ball screw **9** comprises the screw shaft **10**, a nut member **22** assembled to the screw shaft **10** to be relatively movable and a number of balls **23** disposed in the ball circulation passage. The screw shaft **10** has an outer peripheral surface on which a spiral rolling member rolling groove **10***a* is formed, the nut member **22** has an inner peripheral surface to which is formed a ball circulation passage including a spiral loaded rolling member rolling groove **22***a* opposing to the ball rolling groove, and the number of balls **23** are arranged in the ball circulation passage so as to circulate therein in association with the relative movement of the nut member **22** with respect to the screw shaft **10**. The nut member **22** has a flanged portion **24** formed at its one end side and is secured to the inner rail **8** by means of screws or like. The nut member **22** is also provided with a deflector **25** (direction changing passage forming member) for taking out the ball **23** rolling along the ball rolling groove **10***a* formed to the screw shaft **10** at one portion thereof and returning the ball **23** to the other portion (one-lead on this side from the ball taken out portion) of the ball rolling groove **10***a* over an outer large diameter portion of the screw shaft **10**. The screw shaft **10** is operatively coupled with an output (drive) shaft of a motor, mentioned hereinlater.

[0080] When the screw shaft **10** is rotated, the ball **23** rolling in the circumferential direction of the screw shaft under load is scooped up by the deflector **25** and the scooped ball **23** is then returned to the position, one-lead on this side of the ball rolling groove **10***a*. When the screw shaft **10** is rotated in the reverse direction, the balls **23** are circulated along the route reverse to that mentioned above. Further, in the described embodiment, although the balls **23** are scooped up by using the direction changing passage forming member (deflector) **25** and returned to the position, one-lead on this side of the ball rolling groove **10***a*, a return pipe may be substituted for such deflector **25**. That is, according to the structure using the return pipe, the ball **23** rolling along the ball rolling groove **10***a* of the screw shaft **10** is scooped up by one end of the return pipe and is then returned through the other one end thereof. Furthermore, so-called a side-cover (lid) type ball screw may be adapted, in which the nut member **22** is composed of a nut body formed with a loaded rolling groove and side lids applied to both ends of this nut body, a ball return passage is formed to the nut body, and both the side lids are formed with communication passages communicated with the loaded rolling groove and the return passage, respectively. An arrangement utilizing rollers in place of balls may be also applicable to the present invention.

[0081] **FIG. 5** shows the details of the deflector **19**, which is utilized commonly for the inner rail side ball circulation passage **16** and the outer rail side ball circulation passage **14**. With reference to the deflector **19** of **FIG. 5**, the deflector **19** is formed with rolling direction changing passage **26** in a semi-circular shape, and the deflector is composed of two bodies **19***a* and **19***b* divided along the rolling direction changing passage **26** for the sake of easy formation of this passage **26**. That is, these two body sections **19***a* and **19***b* are divided vertically, as viewed, through a plane including a central line of the rolling direction changing passage **26**. Both the body sections **19***a* and **19***b* are positioned through the engagement of dowels **27** and holes **28** formed to the body sections **19***a* and **19***b*. The deflector **19** is further formed with a stepped abutment portion **29** for the purpose of positioning it to the inner rail side ball circulation passage **16** and the outer rail side ball circulation passage **14**. The deflector **19** of the structure mentioned above will be formed from synthetic resin, for example, through an injection formation process.

[0082] **FIG. 6** shows another example of the deflector **30**. This deflector **30** is also composed of two divided body sections **30***a* and **30***b* separated along the rolling direction changing passage **26** for the easy formation thereof as mentioned before. In this example, however, the rolling direction changing passage **26** is divided into two sections as inner peripheral side section and outer peripheral side section. This deflector **30** is also formed with a stepped abutment portion **31**.

[0083] With reference to **FIGS. 2 and 3**, the outer rail body **7***d* is drilled from the side thereof to form holes **33** by means of end mill, for example, and the deflectors **19** are fitted to these holes **33**. The fitted deflectors **19** is secured to the outer rail body **7***d* by fastening means **32** such as binder members. The holes **33** are formed so as to penetrate the ball return passages A and extend ball rolling grooves **11** or ball rolling grooves **15** and formed inside with stepped portions **33***a* abutting against the abutment portions **29** of the deflectors **19**. When fitting the deflector **19**, the outer periphery of the deflector **19** is fitted to the hole **33** and the abutment portion **29** of the deflector **19** abuts against the stepped portion **33***a* of the hole **33**, thus positioning the deflector **19** with respect to the outer rail body **7***d* or inner rail body **8***d*.

[0084] Through such positioning of the deflector **19**, the balls **12** and **13** can be surely scooped from the ball rolling groove **11** or loaded ball rolling groove **15** and then returned to the ball return passage A.

[0085] On the other hand, other holes **33** are formed to the inner rail body **8***d* from the side thereof by means of end mill, for example, and the deflectors **19** are fitted to these holes **33**. Furthermore, in the described embodiment, although the holes **33** are formed to the outer rail body **7***d* from the outside thereof and formed to the inner rail body **8***d* from the inside thereof, the holes **33** may be formed to the outer rail body **7***d* from the inside thereof and formed to the inner rail body **8***d* from the outside thereof.

[0086] **FIG. 7** shows one preferred example of a drive system according to the present invention, which uses the rolling guide device mentioned above and is assembled with a rotation motor.

[0087] The screw shaft **10** is screwed with the nut member **22** and has one end rotatably supported by a bearing **35** disposed at one end portion of the outer rail **7** and coupled to a motor, not shown, through a joint member **36**. According to this structure, when the motor is driven, the screw shaft **10** is rotated and the rotational motion thereof is transferred to the inner rail **8** through the ball screw to thereby linearly move the inner rail **8** along the outer rail **7**. According to this linear motion of the inner rail **8** along the outer rail **7**, the rolling guide device is expanded or contracted, and the balls **12** and **13** circulate in an endless manner in the inner rail side ball circulation passage **16** and the outer rail side ball circulation passage **14** while rolling therealong. Since the balls **12** and **13** endlessly circulate, even if the balls **12** and **13** be slid during the rolling motion, there is no fear of being shifted from the original position as in a conventional slide rail, and a rolling guide device having a large expansion stroke can be realized, in which the inner rail **8** can be smoothly moved.

[0088] **FIG. 8** is an illustration showing a state that a load P is applied to the front end of the inner rail **8** of the rolling guide device. In an optional expanded or contracted state, since a considerable distance **1** exists between the outer rail side ball circulation passage **14** and the inner rail side ball circulation passage **16**, there can be provided a rolling guide device bearing the moment load. For example, when the load P is applied to the front end portion of the inner rail **8**, a reaction force Ro acts on the outer rail side ball circulation passage **14** and a reaction force Ri acts on the inner rail side ball circulation passage **16**, thus bearing the moment load of (Ri×1). When the inner rail **8** slides and the stroke of the rolling guide device is made large, the above-mentioned distance **1** is gradually reduced and an ability for loading this moment load is also reduced. However, even if the inner rail

8 is slid, the inner rail 8 never come off as in the conventional slide rail from the balls, so that the moment load bearing ability cannot be largely reduced. Furthermore, the movable rail is not come off from the ball as in the conventional slide rail and the number of balls born in the optional expanded or contracted attitude does not change, so that a rolling guide device capable of bearing constant radial load and thrust load can be realized.

[0089] Furthermore, as mentioned above, the outer rail **7** has a recess **7***a* having an upper opened portion has a box-shaped section and the ball rolling grooves **11** are formed to the inside surfaces **7***c*, respectively. The inner rail **8** is fitted into the recess **7***a* of the outer rail **7** and the loaded ball rolling grooves **15** are formed to the outside surfaces **8***c* of the inner rail **8** so as to oppose to the inside surfaces **7***c* of the outer rail **7**. Accordingly, there is provided the rolling guide device capable of bearing the radial load, the thrust load and the moment load in a balanced condition.

[0090] **FIG. 9** includes perspective views of the rolling guide device according to another embodiment of the present invention. Referring to **FIG. 9**A, the device is provided with inner and outer rails **8** and **7**, constituting a single-stroke structure in which only the inner rail **8** is slid. Further, as shown in **FIG. 9**B, the rolling guide device may be composed of three rail sections comprising the outer rail **7**, a first inner rail **41** fitted to the outer rail **7** and a second inner rail **42** fitted to the first inner rail **41**. In this structure, the first inner rail **41** is slid with respect to the outer rail **8** and the second inner rail **42** is slid with respect to the first inner rail **41**. That is, the first inner rail **41** acts like the inner rail **8** of the aforementioned embodiment with respect to the outer rail **7** and also acts like the outer rail **7** of the aforementioned embodiment with respect to the second inner rail **42**. The second inner rail **42** has a structure identical to that of the inner rail **8**. According to this rolling guide device of the embodiment of **FIG. 9**B, since the first inner rail **41** is slid with double strokes, the expansion stroke can be made further long. As mentioned above, when the rolling guide device is composed of a plurality of members (rail members), the expansion stroke composed of a plurality of expansion stages can be realized, thus providing a rolling guide device having a large stroke.

[0091] In the embodiment described above, although the inner rail side ball circulation passage **16** and the outer rail side ball circulation passage **14** are formed to the inner rail **8** and the outer rail **7**, respectively, these passages may be formed as block members independently from the inner and outer rails **8** and **7**. Furthermore, although the inner rail **8** and the outer rail **7** are formed as linear (straight) rail members, a curved rail member may be utilized therefor. The balls may be also substituted with other rolling members such as rollers. Retainers each having a belt shape having flexibility may be arranged for supporting the balls **12** and **13** to be rotatable, and spacers may be also arranged between the balls **12** and **13** for supporting them to be rotatable and slidable.

[0092] **FIGS. 10 and 11** represent a drive system, using a linear motor as drive source, according to one embodiment of the present invention.

[0093] This drive system comprises an outer rail **7** as a track rail, an inner rail **8** as a movable rail supported by the outer rail **8** to be linearly slidable along the longitudinal direction thereof and first and second linear motors **51** and **52** disposed between the inner and outer rails **8** and **7** to be back-to-back arrangement. The outer rail **7** is provided with a primary side movable piece (called merely movable piece i hereinlater) of the first linear motor **51** and a secondary side stationary piece (called merely stationary piece O**40** hereinlater) of the second linear motor **52**. On the other hand, the inner rail **8** is provided with a secondary side movable piece (called merely movable piece i' hereinlater) of the second linear motor **52** and a primary side stationary piece (called merely stationary piece O hereinlater) of the first linear motor **51**. According to this structure, when energized, suction (attracting) forces are induced between the movable piece i and the stationary piece O and between the movable piece i' and the stationary piece O'.

[0094] As like as the rolling guide device mentioned above, the outer rail **7** is formed with a recess **7***a* having a box-shaped section with an upper opening and also formed with a lateral pair of ridges **7***b*, **7***b* extending on both the sides of the recess **7***a* in parallel to each other along the longitudinal direction of the outer rail **7**. Each of the ridges **7***b*, **7***b* has an inside surfaces **7***c*, to which a single row of ball rolling groove **11** as a rolling member rolling surface is formed so as to extend along the longitudinal direction thereof as shown in **FIG. 11**. An outer rail side ball circulation passage **14** for circulating the balls **13** rolling between the inner and outer rails **8** and **7** is formed to one (front) end side portion of the outer rail **7**.

[0095] The inner rail **8** is fitted to the recess **7***a* of the outer rail **7** and supported thereby so as to be clamped between the ridges **7***b* of the outer rail **7** through the balls **12** and **13**. The inner rail **8** is also formed with a recess **8***a* having an opening opened downward so as to provide a box-shaped section. The inner rail **7** has outside surfaces **8***c* to which loaded ball rolling grooves **15** are formed as loaded rolling member rolling surfaces which face the ball rolling grooves **11** of the outer rail **7**. An inner rail side ball circulation passage **16** for circulating the balls **12** rolling between the inner and outer rails **8** and **7** is formed to one (rear) end side portion of the outer rail **7** in the longitudinal direction thereof.

[0096] As shown in **FIG. 11**, the outer rail side ball circulation passage **14** is composed of a portion of the ball rolling groove **11**, a ball return passage A as a rolling member return passage extending substantially in parallel to the ball rolling groove **11** and a pair of rolling direction changing passages B communicated with the ball rolling groove **11** and the ball return passage A. On the other hand, the inner rail side ball circulation passage **16** is also composed of a portion of the loaded ball rolling groove **15**, a ball return passage A as a rolling member return passage extending substantially in parallel to the loaded ball rolling groove **15** and a pair of rolling direction changing passages B communicated with the loaded ball rolling groove **15** and the ball return passage A. The ball return passages A are formed through drilling working effected from the end portions of the outer rail body **7***d* and the inner rail body **8***d* in their longitudinal directions. The rolling direction changing passages B of the outer rail side ball circulation passage **14** and the inner rail side ball circulation passage **16** are formed to a deflector **19** which is mounted to the inner rail body **8***d* and the outer rail body **7***d* as independent member.

[0097] Holes **33** are formed to the outer rail body **7***d* by means of end mill, for example, from the longitudinal sides thereof, and the deflector **19** is fitted to these holes **33** and then fastened to the outer rail body **7***d*. Holes **33** are also formed to the inner rail body **8***d* by means of end mill, for example, from the longitudinal sides thereof, and the deflector **19** is fitted to these holes **33** and then fastened to the inner rail body **8***d*. Since these deflectors have substantially the same structures as that mentioned herein before with reference to the rolling guide device, the details thereof are omitted herein by adding the same reference numeral of **19**.

[0098] Two linear motors **51** and **52** are interposed between the inner rail **8** and the outer rail **7**, and the linear motors **51** and **52** in this embodiment are linear induction motors and composed of the movable pieces i and i' and the stationary pieces O and O', the induction motors being driven and operated by passing polyphase alternating current to primary windings of the movable pieces i and i'.

[0099] With reference to **FIG. 10**, the movable piece i of the first linear motor **51** is mounted to a portion near one end (front end) in the longitudinal direction of the upper surface of the outer rail **7**, and the stationary piece O' of the second linear motor **52** is also mounted to the upper surface of the outer rail **7** so as to be continuous to the movable piece i of the first linear motor **51** in the longitudinal direction of the outer rail **7**. On the other hand, the movable piece i' of the second linear motor **52** is mounted to a portion near one end (rear end) in the longitudinal direction of the lower surface of the inner rail **8**, and the stationary piece O of the first linear motor **51** is also mounted to the lower surface of the inner rail **8** so as to be continuous to the movable piece i' of the second linear motor **52** in the longitudinal direction of the inner rail **8**. In such arrangement, the movable piece i of the first linear motor **51** and the outer rail side ball circulation passage **14** have substantially the same positions in the longitudinal direction of the outer rail **7**, and on the other hand, the movable piece i' of the second linear motor **52** and the inner rail side ball circulation passage **16** have substantially the same positions in the longitudinal direction of the inner rail **8**. Further, it is to be noted that the terms "upper", "lower" and the like are used herein in the illustrated state in the figures or usable state of the device or system.

[0100] As shown in **FIG. 12**, the movable piece i of the first linear motor **51** is opposed to the stationary piece O of the first linear motor **51**, and as shown in **FIG. 13**, the movable piece i' of the second linear motor **52** is opposed to the stationary piece O' of the second linear motor **52** so that the first and second linear motors **51** and **52** are disposed in the back-to-back arrangement as shown in **FIG. 14**.

[0101] **FIG. 15** shows a linear induction motor **53** constituting one example of the first and second linear motors **51** and **52**. The linear induction motor **53** is provided with the movable piece i and the stationary piece O which is composed of a non-magnetic conductor plate **54** and a magnetic conductor plate **55** by laminating them vertically as viewed. This linear induction motor **53** is driven in a manner basically identical to that of a cage (rotary type) induction motor having an operational function explained by the Lenz's law and the Fleming's left-hand rule.

[0102] When the polyphase alternating current passes the polyphase primary winding **56**, a traveling (progressive) magnetic field moving timely and spacially is generated, and this traveling field induces an eddy current on the non-magnetic conductor plate **54** constituting the secondary side element. The thus generated eddy current constitutes a thrust generation source in cooperation with the traveling field. Further, in the illustrated example of **FIG. 15**, the movable piece i is disposed only to the upper portion of the stationary piece O, but the movable pieces i may be disposed to both the upper and lower portions thereof.

[0103] **FIG. 16** shows a linear pulse motor **57** as another example of the linear motor **51** (**52**).

[0104] With reference to **FIG. 16**, the movable piece i is, for example, composed of a central permanent magnet **58** and two magnetic core members **59** and **60** opposed to each other with the permanent magnet **58** being interposed therebetween. One **59** of the magnetic cores is formed with first and second magnetic poles **61** and **62** magnetized in N-pole by the permanent magnet **58** and, on the contrary, the other one **60** of the magnetic cores is formed with third and fourth magnetic poles **63** and **64** magnetized in S-pole by the permanent magnet **58**.

[0105] On the other hand, the stationary piece O is formed with stationary teeth **65**, each having, a ⊐-shaped section, extending in a direction normal to the longitudinal direction of the stationary piece O equally with the same pitch. The magnetic poles **61** to **64** are formed with magnetic pole teeth **61***a* to **64***a*, respectively, each having the same pitch as that of the stationary piece O.

[0106] A first coil **66** and a second coil **67** are wound up around the first magnetic pole **61** and the second magnetic pole **62** of the N-pole side and connected in series to each other so as to generate magnetic fluxes opposed to each other in directions at a time when current flows. The first coil **66** and the second coil **67** are electrically connected to a pulse generation source, not shown.

[0107] On the other hand, a third coil **68** and a fourth coil **69** are also wound up around the third magnetic pole **63** and the fourth magnetic pole **64** of the S-pole side and connected to a pulse generation source.

[0108] In the described arrangement, the first and second magnetic poles **61** and **62** are arranged so that the magnetic pole teeth **61***a* and **62***a* thereof are shifted from each other by ½ pitch in their phases, and the third and fourth magnetic poles **63** and **64** are also arranged so that the magnetic pole teeth **63***a* and **64***a* thereof are shifted from each other by ½ pitch in their phases. Furthermore, the magnetic pole teeth **63***a* and **64***a* of the third and fourth magnetic poles **63** and **64** of the S-pole side are shifted, by ¼ pitch in phases, from the first and second magnetic pole teeth **61***a* and **62***a* of the first and second magnetic poles **61** and **62** of the N-pole side.

[0109] The linear pulse motor is driven by the following operation theory with reference to **FIGS. 17A** to **17D**.

[0110] Pulses are inputted to the first and second coils **66** and **67** from terminals a, and pulses are also inputted to the third and fourth coils **68** and **69** from terminals b. That is, the pulses are inputted to the terminal a in a direction to energize the first magnetic pole **61** in the state shown in **FIG. 17A**, to the terminal b in a direction to energize the fourth magnetic pole **64** in the state shown in **FIG. 17**B, to the terminal a in a direction to energize the second magnetic pole **62** in the state shown in **FIG. 17**C, and to the terminal b in a direction to energize the third magnetic pole **63** in the state shown in **FIG. 17**D, respectively.

[0111] When the pulse is inputted to the terminal a in a direction to energize the first magnetic pole **61** in the state shown in **FIG. 17**A, the first magnetic pole **61** maintains its stable state under the application of the magnetic fluxes of the permanent magnet **58** and the first coil **66**. Next, in the state shown in **FIG. 17**B, when the pulse is inputted to the terminal b in a direction to energize the fourth magnetic pole **64**, the fourth magnetic pole **64** is moved to a direction so as to maintain its stable state, that is, in the right direction facing the drawing paper by ¼ pitch. As mentioned above, the movable piece is operated continuously as shown in **FIGS. 17C and 17D** by passing alternately the pulse current.

[0112] **FIG. 18** represents a linear D.C. motor **70** as another example of the linear motor.

[0113] With reference to **FIG. 18, a** movable piece of this example is composed of exciting coils **71** and yokes, and a stationary piece O is composed of magnets **72** and yokes. A plurality of exciting coils **71** constituting the movable piece i are arranged along the longitudinal direction thereof, and a plurality of magnets **72** constituting the stationary piece O are arranged along the longitudinal direction so as to provide alternately N- and S-poles.

[0114] The position of the movable piece i is detected by a sensor, and the direction of the current passing the exciting coil **71** at the detected position is changed sequentially reversely. The exciting coil **71** generates a thrust force in accordance with the Fleming's left-hand rule through the relative reaction between the exciting coils **71** and the magnets **72**.

[0115] In the case where such linear D.C. motor is utilized, two sets of linear motors **51** and **52** are disposed in the back-to-back arrangement, and in an arrangement that a distance between the adjacent secondary side magnets **72**, **72** is short, there causes a fear that an alternating magnetic field is caused between the magnets **72** and **72**, which may cause a defective operation. Accordingly, in the case where two sets of the linear motors **51** and **52** are used in the back-to-back arrangement, the linear induction motor **53** and the linear pulse motor **57**, which do not utilize the secondary side magnets **72**, could be effectively utilized. However, in an arrangement in which a relatively large distance could be maintained on the secondary side, no adverse effect is not caused between the magnets **72** and **72**, so that the linear D.C. motor **70** may be utilized.

[0116] The drive system incorporated with the linear motors **51** and **52** of the structures mentioned above will operate in the following manner.

[0117] When the current is applied to the movable pieces i and i' of the first and second linear motors **51** and **52**, suction (attracting) force acts between the movable pieces i and i' and the stationary pieces O and O' to thereby move the inner rail **8** with respect to the outer rail **7** by a predetermined distance in the longitudinal direction thereof. In this case, the movable piece i of the first linear motor **51** moves forward with respect to the stationary piece O. However, with the second linear motor **52**, a current is applied to the movable piece i' in a backward movement direction with respect to the stationary piece O' because of the movement of the stationary piece O', and as a reaction motion thereto, the stationary piece O' is moved forward. Hence, the inner rail **8** is slid with respect to the outer rail **7**, and therefore, the entire structure of the drive system is expanded and contracted.

[0118] In the structure utilizing the linear motors **51** and **52** as driving source, it is not necessary to utilize a ball screw or like, and hence, the inner rail can be moved at high speed with less noise. Furthermore, there is no need for locating a space for a rotary motor or like, thus making the drive system thin and compact in its structure. Still furthermore, since the two sets of linear motors **51** and **52** are arranged between the inner rail **8** and the outer rail **7**, two times of the thrust force is obtainable and the excitation of the linear motors **51** and **52** is averaged, thus making smooth the movement of the inner rail **7**.

[0119] Still furthermore, the movable piece i of the first linear motor **51** is mounted to a portion near the outer rail side rolling member circulation passage **14** and the movable piece i' of the second linear motor **52** is mounted to a portion near the inner rail side rolling member circulation passage **16**, the points on which the thrust force is applied are always positioned at portions near the the outer rail side rolling member circulation passage **14** and the inner rail side rolling member circulation passage **16** irrespective of the stroke of the inner rail **8**. The inner rail **8** is supported by the outer rail **7** at the positions of the inner rail side rolling member circulation passage **16** and the outer rail side rolling member circulation passage **14**. Accordingly, even if a moment causing pitching or yawing acts on the inner rail **8**, the thrust force can be stably generated for the inner rail **8**.

[0120] **FIG. 19** represents a drive system according to a further embodiment of the present invention. The drive system of this embodiment is incorporated with two sets of rod-type linear motors as first and second linear motors **51** and **52**. This drive system is also composed of, like the drive system mentioned hereinbefore, an outer rail **7**, an inner rail **8** supported by the outer rail **7** to be slidable in the longitudinal direction thereof and first and second linear motors **51** and **52** disposed between the outer rail **7** and the inner rail **8** both having box-shaped sections so that the inner rail **8** is fitted into the outer rail **8**. First and second rod-type linear motors are composed of rods O and O' as stationary pieces and cylindrical coils i and i' as movable pieces.

[0121] The cylindrical coil i of the first rod-type linear motor **51** is mounted to the front end portion of the outer rail **7** and, to this front end portion, is also mounted an outer rail side bearer **75** supporting the rod O' of the second rod-type linear motor to be slidable in an axial direction thereof. On the other hand, the cylindrical coil i of the second rod-type linear motor **52** is mounted to the rear end portion of the inner rail **8** and, to this rear end portion, is also mounted an inner rail side bearer **76** supporting the rod O of the first rod-type linear motor to be slidable in an axial direction thereof. The operation theory due to this arrangement is substantially the same as that of the drive system of the embodiment mentioned hereinbefore, and by operating the first and second rod-type linear motors **51** and **52**, the distance between the outer rail side bearer **75** and the inner rail side bearer **76** are expanded or contracted, thus the inner rail **8** being slid with respect to the outer rail **7**. As mentioned above, the rod-type linear motors are also usable as linear motors for the drive system of the present invention.

[0122] Description will be come back to the rolling guide device hereunder.

[0123] **FIG. 20** is a partial sectional view of a drive system using a rolling guide device of a further embodiment of the present invention. The rolling guide device of this embodiment comprises, like the rolling guide device shown in FIGS. **1** to **3**, an outer rail **7** as track rail and an inner rail **8** as movable rail supported to be slidable in the longitudinal direction of the outer rail **7**, and hence, like reference numerals are added to elements or members corresponding to those shown in FIGS. **1** to **3**. The embodiment of **FIG. 20** is provided with a ball screw **9** for driving the inner rail **8**.

[0124] In the rolling guide device of the aforementioned embodiment, although the outer rail **7** and the inner rail **8** are formed with single ball rolling groove to each side portion thereof, in the rolling guide device of this embodiment, the outer rail **7** and the inner rail **8** are formed with two ball rolling grooves **11, 11** (totally four grooves) to each side portion thereof as shown in **FIG. 20** in section. That is, in the rolling guide device of this embodiment, upper and lower two ball rolling grooves **11, 11** are formed respectively to each of the inside surfaces of the opposing ridges **7***b*, **7***b* of the outer rail **7**, i.e. four ball rolling grooves **11, 11** for the outer rail **7**. On the other hand, upper and lower two loaded ball rolling grooves **15, 15** are formed respectively to each of the outside surfaces of the opposing ridges **8***b*, **8***b* of the inner rail **8**, i.e. four loaded ball rolling grooves **15, 15** for the inner rail **8** so as to oppose to the ball rolling grooves **11, 11** of the outer rail **7**, respectively.

[0125] An outer rail side ball circulation passage **14** for circulating the balls rolling between the inner rail **8** and the outer rail **7** is provided to one end side in the longitudinal direction of the outer rail **7** as like as that of the rolling guide device mentioned hereinbefore. This outer rail side ball circulation passage **14** is composed of upper and lower two passages, and more concretely, is composed of portions of the ball rolling grooves **11, 11**, ball return passages A, A as rolling member return passages substantially parallel to the ball rolling grooves **11, 11** and a pair of rolling direction changing passages communicated with the ball rolling grooves **11, 11** and the ball return passages A, A.

[0126] An inner rail side ball circulation passage **16** for circulating the balls rolling between the inner rail **8** and the outer rail **7** is provided to one end side in the longitudinal direction of the outer rail **7** on the side opposing to the outer rail side ball circulation passage **14**. This inner rail side ball circulation passage **16** is composed of upper and lower two passages, and more concretely, is composed of portions of the loaded ball rolling grooves **15, 15**, ball return passages A, A as rolling member return passages substantially parallel to the loaded ball rolling grooves **15, 15** and a pair of rolling direction changing passages communicated with the ball rolling grooves **11, 11** and the ball return passages A, A.

[0127] In the illustration of **FIG. 20**, although it seems that the outer rail side ball circulation passage **14** and the inner rail side ball circulation passage **16** are positioned on the same sectional surface, in an actual arrangement, the outer rail side ball circulation passage **14** and the inner rail side ball circulation passage **16** are shifted in their positions as shown in **FIG. 1**.

[0128] The rolling direction changing passages, each having a semi-circular shape, constituting portions of the outer rail side ball circulation passage **14** and the inner rail side ball circulation passage **16** are formed to deflectors **79** mounted, as independent members, to the inner rail body **8***d* and the outer rail body **7***d*. The deflector **79** is utilized commonly for the outer rail side ball circulation passage **14** and the inner rail side ball circulation passage **16** and is provided with vertical two rolling direction changing passages. The deflector **79** is composed of three sections **79***a*, **79***b* and **78***c* which are splittable vertically along the rolling direction changing passage for easy formation of the vertical two tolling direction changing passages. These three splittable sections **79***a*, **79***b* and **78***c* are divided vertically at planes including central lines of the rolling direction changing passages. These three sections **79***a*, **79***b* and **78***c* are positioned and assembled with each other through fitting of dowels and holes formed to the respective sections. Furthermore, the deflector **79** is formed with a stepped abutment portion **29** to position the deflector **79** at the time when it is mounted to the inner rail side ball circulation passage **16** and the outer rail side ball circulation passage **14**. Holes **33** are formed to the outer rail body **7***d* and the inner rail body **8***d* from the sides thereof, and stepped portions **33***a* are formed to inside surfaces of these holes **33**. Accordingly, the deflector **79** is positioned with respect to the outer rail body **7***d* and the inner rail body **8***d* through the abutment of the stepped abutment portion **29** against the stepped portions **33***a* formed to the holes **33**, i.e. outer rail body **7***d* and the inner rail body **8***d*.

[0129] The ball screw **9** is screw-engaged with the inner rail **8**. This ball screw **9** is composed of a screw shaft **10** having an outer periphery on which a spiral ball rolling groove is formed, a nut (member) **22** having an inner periphery to which a ball circulation passage including a spiral loaded ball rolling groove corresponding to the ball rolling groove formed to the screw shaft **10** and assembled with the screw shaft **10** to be relatively movable thereto, and a number of balls arranged in the ball circulation passage and circulating in accordance with the relative movement of the nut member **22** with respect to the screw shaft **10**.

[0130] **FIG. 21** illustrates a contacting state of the ball rolling groove **11**, the loaded ball rolling groove **15** and the ball **12** or **13**. The ball rolling groove **11** is formed as a single circular groove, so-called, circular arc groove, having a diameter slightly larger than a diameter of the ball so that the ball **12 (13)** contacts the ball rolling groove **11** at one point P1. On the other hand, the loaded ball rolling groove **15** is formed as a single circular groove, so-called, circular arc groove, having a diameter slightly larger than a diameter of the ball so that the ball **12 (13)** contacts the loaded ball rolling groove **15** at one point P2. Further, it is to be noted that a line L connecting the contact point P1 at which the ball **12 (13)** and the ball rolling groove **11** are contacted and the contact point P2 at which the ball **12 (13)** and the loaded ball rolling groove **11** are contacted is defined herein as contact angle line L. In this meaning, the contact angle lines L1, L2, L3 and L4 will be defined as shown in **FIG. 20**.

[0131] That is, with reference to **FIG. 20**, the mutually opposing two ball rolling grooves **11, 11** and the two loaded ball rolling grooves **15, 15** are offset from each other so that the vertical two lines L1 and L2 are inclined towards the horizontal line H passing the center of the screw shaft **10** while reducing a distance therebetween.

[0132] Further, it is desired that a contact angle constituted by the contact angle line L1 (L2) and the horizontal line H is approximately 45°. The center of the screw shaft **10** is positioned on the line passing the intermediate portion between the ball rolling grooves **11, 11** and on the central line of a span of the loaded ball rolling grooves **15, 15**. Furthermore, it is desired that the center of the screw shaft **10** (center of the thrust force of the ball screw **9**) is also positioned on a line connecting a point P3 of the left side contact angle lines L1 and L2 and a point P4 of the right side contact angle lines L1 and L2.

[0133] The moment load as shown in **FIG. 8** will be easily loaded on the rolling guide device of the present invention, and accordingly, the vertical load will be also easily born by the balls **12** and **13**. However, the contact angle lines L1 and L2 between the balls **12, 13** and the ball rolling grooves **11, 11** and between the balls **12, 13** and the loaded ball rolling grooves **15, 15** are inclined with respect to the horizontal line H, thus the vertical load acting on the inner rail **7** being effectively born by the balls **12, 13**. For this reason, the moment load as shown in **FIG. 8** can be surely loaded. Particularly, by setting the inclination angle to 45°, loads acting on the inner rail **7** from vertical and lateral four directions can be effectively supported by the balls **12** or **13**. Furthermore, the ball screw **9** may be smoothly operated by positioning the center of the thrust force of the ball screw **9** on the line connecting the crossing point P3 of the left side contact angle lines L1 and L2 and the crossing point P4 on the right side contact angle lines L1 and L2.

[0134] **FIG. 22** illustrates a contacting state of a ball rolling groove **11***b*, a loaded ball rolling groove **15***b* and the ball **12 (13)** in a rolling guide device in which one ball rolling groove **11***b* and one loaded ball rolling groove **15***b* are formed laterally as like as the rolling guide device shown in **FIGS. 1 and 3**. The ball rolling groove **11***b* and the loaded ball rolling groove **15***b* are each formed as a Gothic arch groove. That is, by forming so-called Gothic arch groove in combination of the ball rolling groove **11***b* and the loaded ball rolling groove **15***b* into two circular arcs, two contact angle lines L3 and L4 inclined from the horizontal line H can be obtained to thereby effectively support the vertical load by the ball **12, 13**.

[0135] **FIG. 23** is an illustration of one embodiment, partially in section, of an essential portion of a drive system utilizing a rolling guide device using rollers **80** as rolling members. In this embodiment, the rollers **80** are utilized in place of the balls **12, 13** in the former embodiments. In this embodiment of **FIG. 23**, the outer rail **7** is provided with ridges **7***b*, **7***b* as mentioned before having opposing inside surfaces **7***c*, **7***c* to which roller rolling grooves **81**, each having a V-shaped section with opening angle of 90°, are formed, respectively. On the other hand, the inner rail **8** has the opposing outside surfaces **8***c*, **8***c* to which loaded roller rolling grooves **82**, each having a V-shaped section with opening angle of 90°, are formed, respectively. Therefore, a roller rolling passage having substantially square cross section is defined between the roller rolling groove **81** and the loaded roller rolling groove **82**. Within this roller rolling passage, a plurality of rollers **80, 80**, - - - are arranged in shape of cross (cross arrangement) so that axes of the adjacent two rollers **80** cross each other.

[0136] The structure of this embodiment other than the above mentioned structure is substantially the same as that of the rolling guide device mentioned with reference to FIGS. **1** to **3**, so that the description thereof is omitted herein by adding the same reference numerals to the corresponding portions or elements.

[0137] According to this embodiment, in which the rollers **80, 80**, - - - are arranged in crossing shape, the rollers **80** can effectively support the vertical load.

[0138] **FIG. 24** is an illustration of another embodiment, partially in section, of an essential portion of a drive system utilizing a rolling guide device using rollers **83, 84** as rolling members. In this embodiment, the outer rail **7** is provided with ridges **7***b*, **7***b* having opposing inside surfaces **7***c*, **7***c* each to which vertical two roller rolling grooves **81, 81** each having a V-shaped section with opening angle of 90°, are formed, respectively. On the other hand, the inner rail **8** has the opposing outside surfaces **8***c*, **8***c* each to which two loaded roller rolling grooves **82, 82** each having a V-shaped section with opening angle of 90°, are formed, respectively. Therefore, vertical two roller rolling passages each having substantially square cross section are defined between the roller rolling grooves **81, 81** and the loaded roller rolling grooves **82, 82**. Within these roller rolling passages, a plurality of rollers **83, 84** are arranged in parallel to each other (parallel arrangement) so that axes of the adjacent two rollers are parallel to each other.

[0139] The rollers **83** disposed in the upper side roller rolling passage are arranged so as to support the load acting in the direction shown by the line L5 (different from the horizontal line H), and on the other hand, the rollers **84** disposed in the lower side roller rolling passage are arranged so as to support the load acting in the direction shown by the line L6 (different from the horizontal line H). Angles constituted by the line L5 and the horizontal line H and by the line L6 and the horizontal line H are defined approximately 45°, respectively. The structure of this embodiment of **FIG. 24** other than the above-mentioned structure is substantially the same as that of the rolling guide device mentioned with reference to **FIG. 20** so that the description thereof is omitted herein by adding the same reference numerals to the corresponding portions or elements.

[0140] According to this embodiment of **FIG. 24**, in which the rollers **83** and **84** are arranged in the vertical two roller rolling passages and the directions along which the rollers **83** and **84** can bear the loads are inclined with respect to the horizontal line H, so that the rollers **83** and **84** can effectively support the vertical loads.

[0141] According to the various preferred embodiments or examples of the present invention mentioned above, the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage, in which the rolling members rolling between the track rail and the movable rail circulate, are formed to the track rail and the movable rail, respectively. Therefore, when the movable rail is slid with respect to the track rail, the rolling members arranged between the track rail and the movable rail endlessly circulate in the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage while rolling therealong. As mentioned, since the rolling members circulate in the endless manner, even if the rolling member be slid during the rolling motion, there is no causing of a case that a cage is shifted from the initial position as in the conventional structure, and hence, a large expansion (contraction) stroke can be realized. Furthermore, in an optional expanded (contracted) attitude, there remains a relatively large distance between the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage, so that a rolling guide device, which can bear even the moment load, can be realized.

[0142] Furthermore, according to the present invention, since the linear motor means is incorporated between the track rail and the movable rail, no specific ball screw or like mechanism is needed, so that the movable rail can be moved at high speed with reduced noise.

[0143] It is further to be noted that the present invention is not limited to the described embodiments and many other changes and modifications may be made without departing from the scopes of the appended claims.

What is claimes is:

1. A rolling guide device comprising:

a track rail formed with a rolling member rolling surface extending along a longitudinal direction thereof;

a movable rail formed with a loaded rolling member rolling surface extending along a longitudinal direction thereof so as to oppose to the rolling member rolling surface of the track rail;

a track rail side rolling member circulation passage formed to the track rail so as to circulate the rolling members rolling between the track rail and the movable rail;

a movable rail side rolling member circulation, passage formed to the movable rail so as to circulate the rolling members rolling between the track rail and the movable rail; and

a number of rolling members disposed and arranged in the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage.

2. A rolling guide device according to claim 1, wherein said track rail side rolling member circulation passage is formed to one longitudinal end side of the track rail and said movable rail side rolling member circulation passage is formed to one longitudinal end side, opposing to said one end side of the track rail, of the movable rail.

3. A rolling guide device according to claim 1, wherein said track rail has an opened recess having a ⊐-shaped section and has inside surfaces to which said rolling member rolling surfaces are formed, said movable rail is fitted into the recess of the track rail, and said movable rail has outside surfaces to which the loaded rolling member rolling surfaces are formed so as to oppose to the rolling member rolling surfaces formed to the track rail inside surfaces.

4. A rolling guide device according to claim 3, wherein said track rail side rolling member circulation passage is provided with a rolling member return passage substantially parallel to said rolling member rolling surface and a rolling direction changing passage communicating the rolling member rolling surface and the rolling member return passage, said movable rail side rolling member circulation passage is provided with a rolling member return passage substantially parallel to said loaded rolling member rolling surface and a rolling direction changing passage communicating the rolling member rolling surface and the rolling member return passage, said rolling direction changing passages of the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage are formed to a deflector which is formed independently from a track rail body and a movable rail body, and said deflector is fitted to holes formed to the track rail body and movable rail body from side portions thereof.

5. A rolling guide device according to claim 4, wherein said return passages are drilled to the track rail body and the movable rail body from longitudinal end portions thereof.

6. A rolling guide device according to claim 4, wherein said deflector is composed of a plurality of sections splittable along the rolling direction changing passages.

7. A rolling guide device according to claim 4, wherein said deflector is made of a synthetic resin.

8. A drive system comprising:

a track rail formed with a rolling member rolling surface extending along a longitudinal direction thereof;

a movable rail formed with a loaded rolling member rolling surface extending along a longitudinal direction thereof so as to oppose to the rolling member rolling surface of the track rail;

a track rail side rolling member circulation passage formed to the track rail so as to circulate the rolling members rolling between the track rail and the movable rail;

a movable rail side rolling member circulation passage formed to the movable rail so as to circulate the rolling members rolling between the track rail and the movable rail;

a number of rolling members disposed and arranged in the track rail side rolling member circulation passage and the movable rail side rolling member circulation passage; and

a linear motor means having a primary side mounted to either one of the track rail and the movable rail and a secondary side mounted to another one of the track rail and the movable rail.

9. A drive system according to claim 8, wherein said track rail side rolling member circulation passage is formed to one longitudinal end side of the track rail and said movable rail side rolling member circulation passage is formed to one longitudinal end side, opposing to said one end side of the track rail, of the movable rail, and said linear motor means comprises first and second linear motors, said first linear motor having a primary side mounted to a portion near the track rail side rolling member circulation passage of the track rail, said second linear motor having a secondary side mounted to the track rail along the longitudinal direction thereof so as to be continuous to the primary side of the first linear motor, and said second linear motor having a primary side mounted to a portion near the movable rail side rolling member circulation passage of the movable rail, said first linear motor having a secondary side mounted to the movable rail along the longitudinal direction thereof so as to be continuous to the primary side of the second linear motor.

10. A drive system according to claim 9, wherein said first and second linear motors are linear induction motors having secondary sides being opposed to each other.

11. A drive system according to claim 9, wherein said first and second linear motors are linear pulse motors having secondary sides being opposed to each other.

12. A drive system according to claim 8, wherein said track rail has an opened recess having a ⊐-shaped section and has inside surfaces to which said rolling member rolling surfaces are formed, said movable rail is fitted into the recess of the track rail, and said movable rail has outside surfaces to which the loaded rolling member rolling surfaces are formed so as to oppose to the rolling member rolling surfaces formed to the track rail inside surfaces.

* * * * *

US 20010016089A1

(19) United States
(12) Patent Application Publication (10) Pub. No.: US 2001/0016089 A1
Mochizuki (43) Pub. Date: Aug. 23, 2001

(54) MOTION GUIDE DEVICE

(75) Inventor: **Hiroaki Mochizuki**, Tokyo-to (JP)

Correspondence Address:
ARMSTRONG,WESTERMAN, HATTORI, MCLELAND & NAUGHTON, LLP
1725 K STREET, NW, SUITE 1000
WASHINGTON, DC 20006 (US)

(73) Assignee: **THK Co., Ltd.**, Tokyo (JP)

(21) Appl. No.: **09/781,991**

(22) Filed: **Feb. 14, 2001**

(30) **Foreign Application Priority Data**

Feb. 18, 2000 (JP) 2000-46756

Publication Classification

(51) **Int. Cl.**^{7} **F16C 29/06**
(52) **U.S. Cl.** **384/45**

(57) **ABSTRACT**

A motion guide device generally comprises a track member having a horizontal surface and two side surfaces continuous to the horizontal surface, a movable member mounted to the track member to be relatively movable with respect to the track member along a longitudinal direction thereof, and a cover member covering the horizontal surface of the track member along an entire width direction thereof. The track member is formed with undercut portions formed to side edge portions of the side surfaces of the track member on the horizontal surface sides, and the undercut portions are recessed towards a central side of the track member in the width direction thereof. The cover member comprises a central flat portion and engaging portions formed at both end portions in the width direction thereof to be engaged with the undercut portions, respectively, so as to clamp the track member therebetween in the width direction. Each of the engaging portions comprises an intermediate section to be engaged with the undercut portion of the track member and a front end section bent outward from the intermediate section so as to be opened outward in the width direction of the track member.

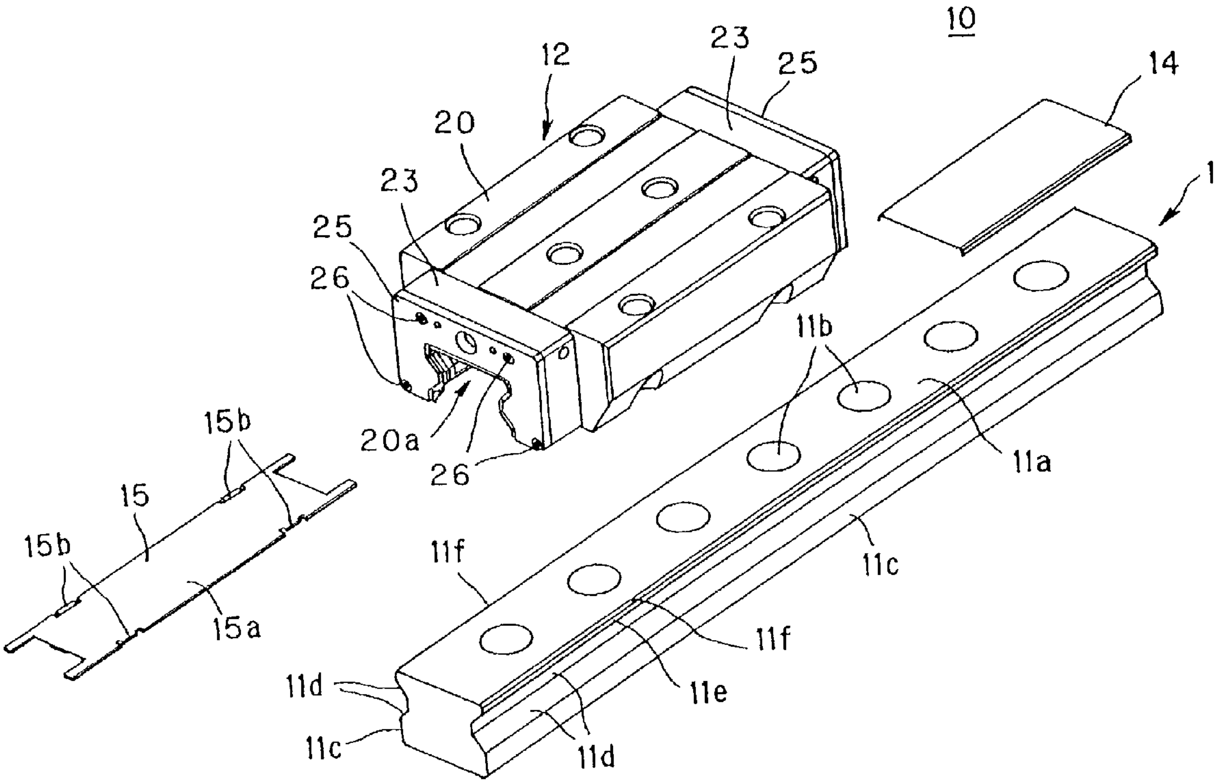


FIG. 1

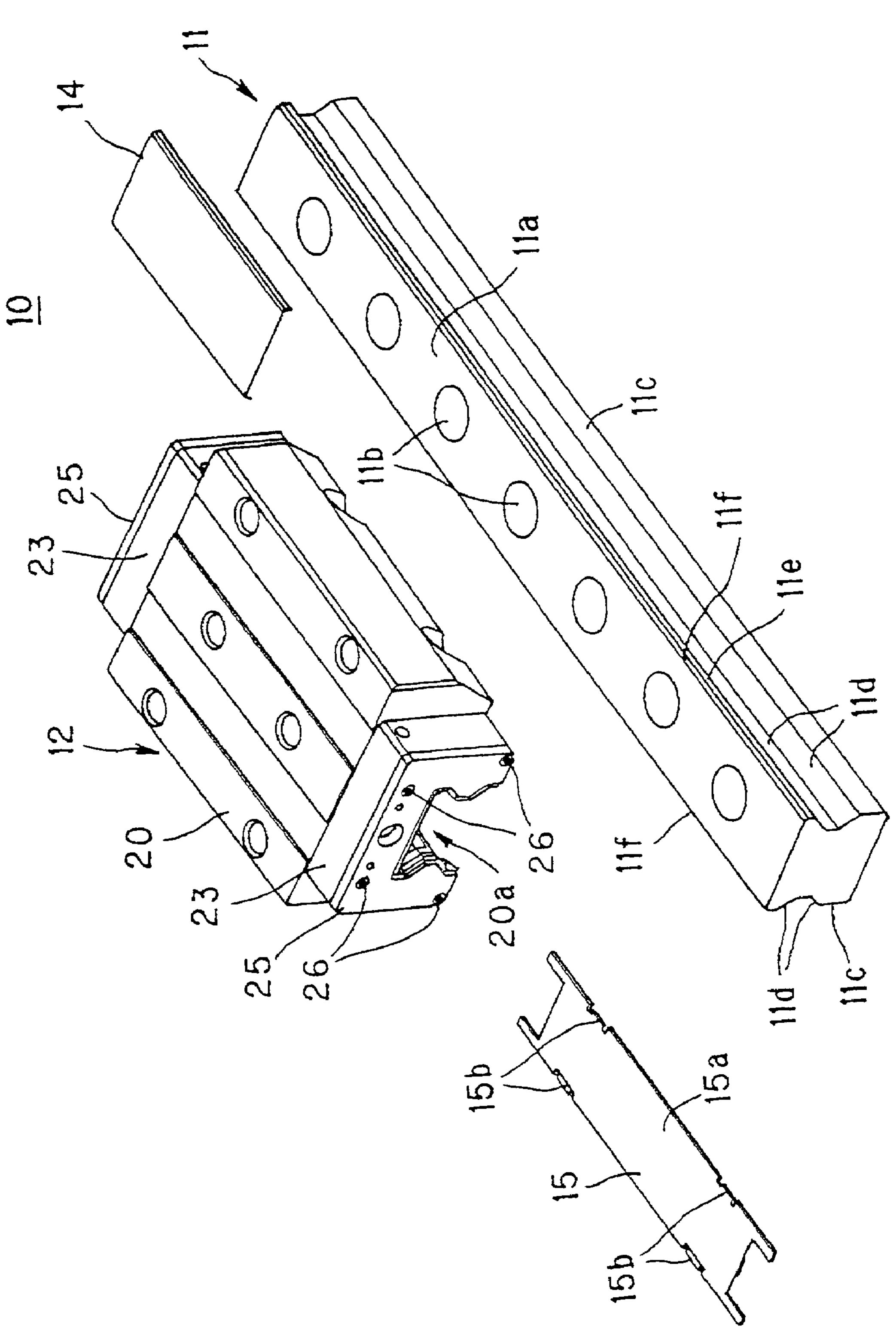


FIG. 2

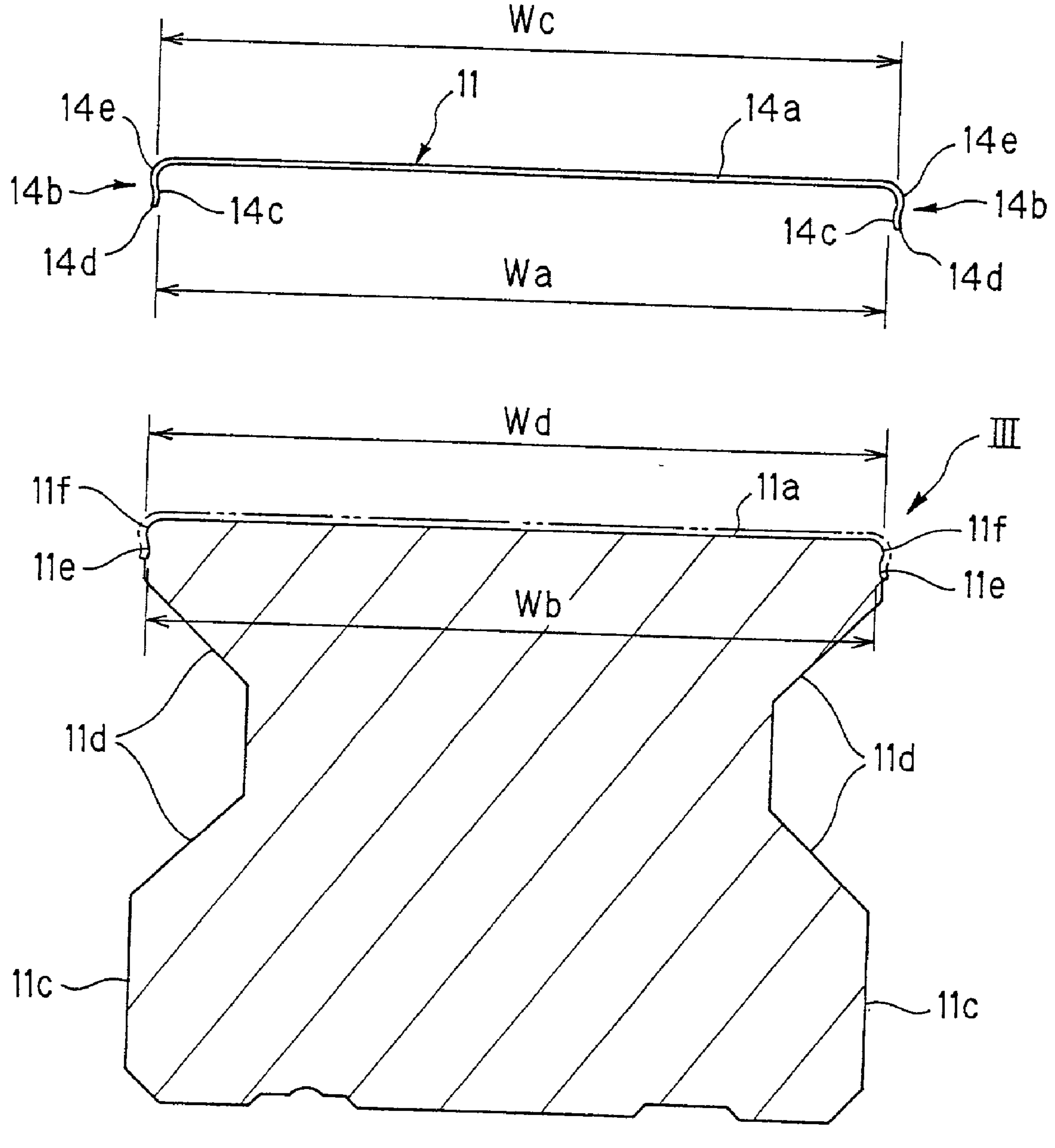

Wc
11
14a
14e
14e
14b
14b
14c
14c
14d
14d
Wa
Wd
III
11f
11a
11f
11e
11e
Wb
11d
11d
11c
11c

FIG. 3

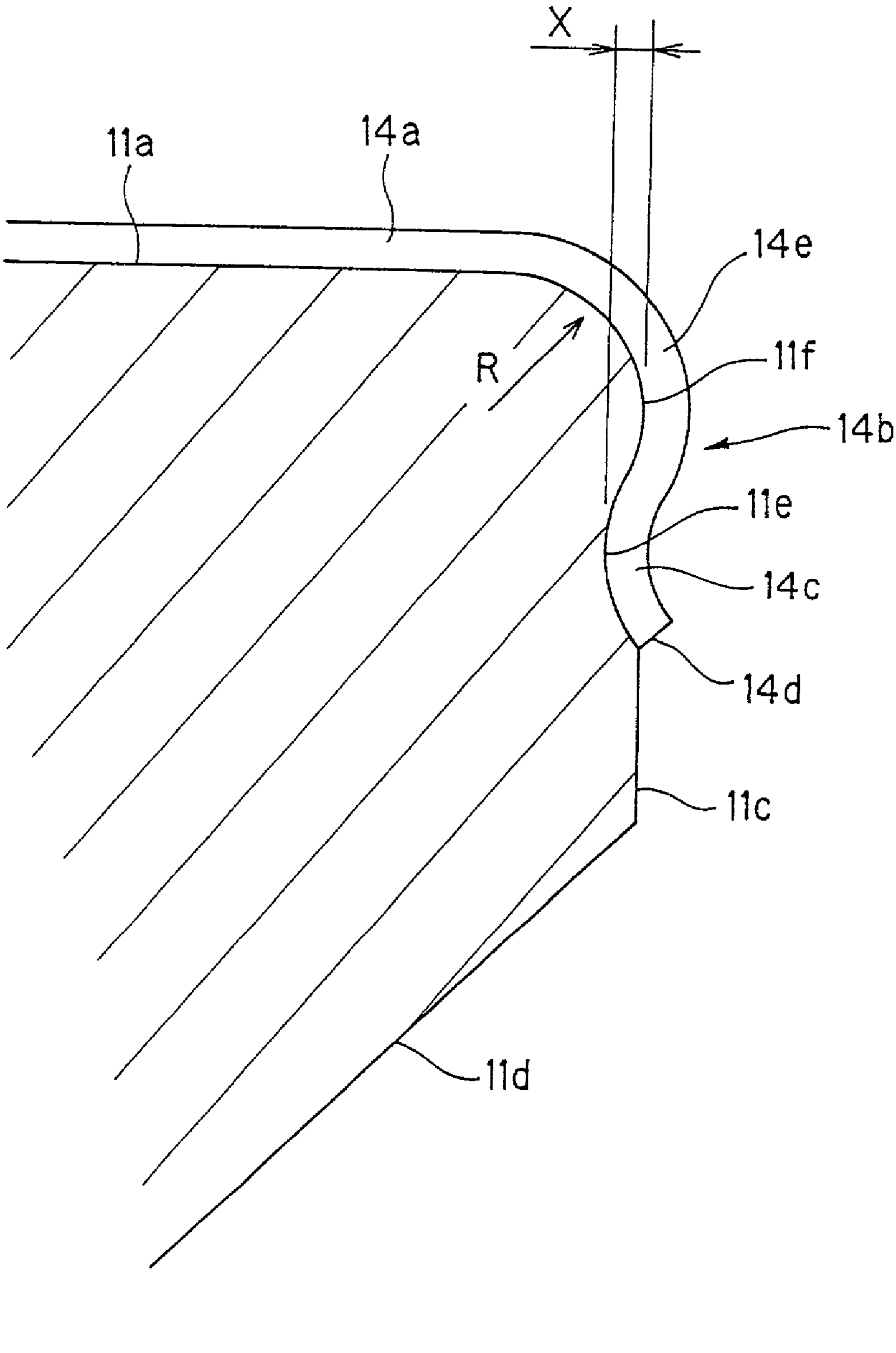


FIG. 4A

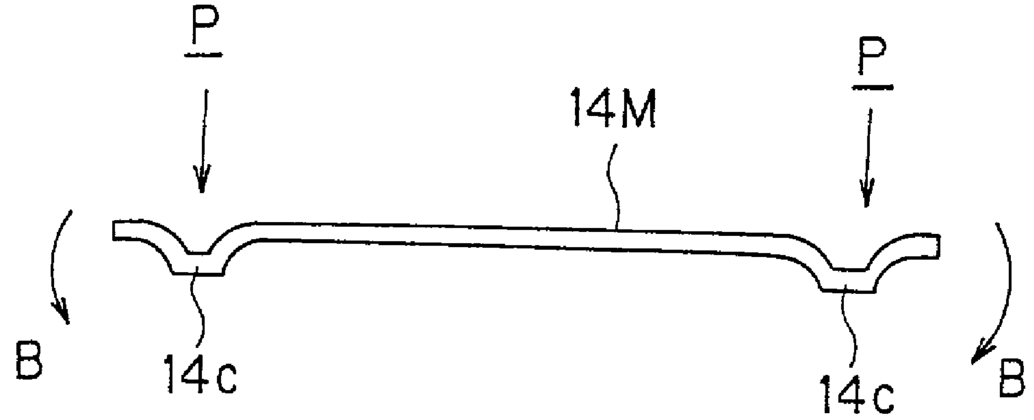


FIG. 4B

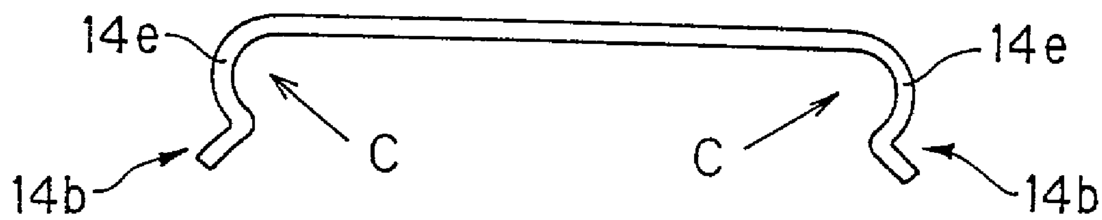


FIG. 5A
PRIOR ART

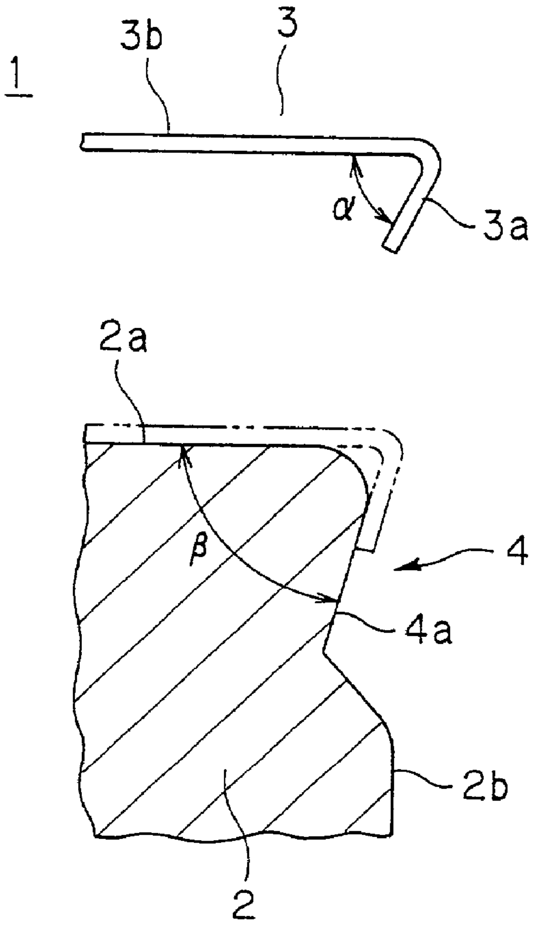
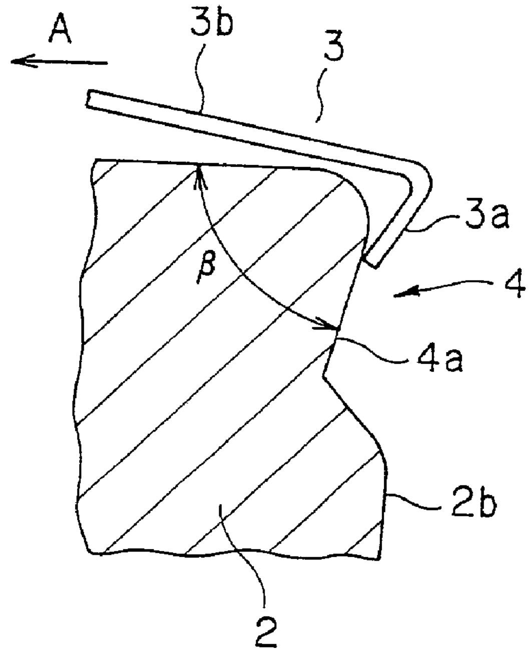


FIG. 5B
PRIOR ART



MOTION GUIDE DEVICE

[0001] The present application claims priority under 35 U.S.C § 119 to Japanese Patent Application No.2000-46756, filed Feb. 18, 2000 entitled "MOTION GUIDE DEVICE" The contents of that application are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to a motion guide device for guiding a movable member along a predetermined track member, and more particularly, to a motion guide device capable of covering an opening for attachment formed on an upper surface of the track member by a cover covering an entire area in a width direction of the upper surface thereof.

[0003] As a device for guiding a movable member such as table of a machine tool in a predetermined direction, there is known a motion guide device constituted by mounting a movable member to a track member by means of a number of rolling members. In such device, the track member or movable member is fixed to a stationary portion of a machine, or the movable member or track member is fixed to a movable portion of the machine. The track member is formed with a plurality of bolt mounting holes for fixing the same so as to penetrate vertically the track member. However, according to a use of such guide device, there is a case where foreign bodies invade in the bolt-mounting hole and is bitten by a seal of the movable member, thus causing a trouble.

[0004] In order to solve such trouble or problem, there has been proposed a device in which a track member is entirely covered by a cover to also cover the bolt mounting holes. **FIG. 5 (FIGS. 5A and 5B)** shows a cover mounting structure, as one example of such device, in a motion guide device disclosed in the Japanese Patent Publication No. 2719985. In a device **1** shown in **FIG. 5, a** cover **3** is disposed for covering a track member **2** at an entire area in the width direction (lateral direction as viewed) of an upper surface **2***a* of the track member **2**, undercut portions **4** are formed to both side surface portions **2***a* of the track member **2** at portions continuous to the upper surface **2***a* of the track member **2** through a round corner portions, and engaging portions **3***a* are formed to both the edge portions of the cover **3** to be tightly contacted to contact surfaces **4***a* of the undercut portions **4**.

[0005] Furthermore, in the structure shown in **FIG. 5**, an angle α constituted by a central portion **3***b* of the cover **3** and the engaging portion **3***a* thereof is set to be smaller than an angle β constituted by the contact surface **4***a* of the undercut portion **4** and the upper surface **2***a* of the track member **2**. Accordingly, at a time when the cover **3** is applied to the track member **2**, if the cover **3** is forcibly pushed to the track member **2** such that the central portion **3***b* of the cover **3** is contacted to the upper surface **2***a* of the track member **2** with the engaging portion **3***a* of the cover **3** being engaged with the contact surface **4***a* of the undercut **4**, the engaging portion **3***a* of the cover is elastically deformed so as to be opened outward, and hence, the engaging portion **3***a* is closely contacted to the contact surface **4***a* of the undercut **4** by its elastic restoring force, thus firmly holding the cover **3** on the track member **2**. Further, it is noted that, in **FIG. 5**, although only one end side in the width direction of the track member **2** is shown, the other one end side thereof is also formed symmetrically with the mentioned one end side.

[0006] In the structure mentioned above, the engaging portion **3***a* gets into most inward, at its front (lower) end portion, in the width direction of the track member **2**, and therefore, it is impossible to engage both the lateral pair of engaging portions **3***a* at the same time with the undercut portions **4**.

[0007] Accordingly, the cover **3** is mounted to the track member **2** in the following manner.

[0008] First, as shown in **FIG. 5**B, the cover **3** is inclined (tilted) from the horizontal surface so that one engaging piece **3***a* is engaged with a corresponding one undercut portion **4**. Under this state, the cover **3** is pulled towards the opposite side engaging portion **3***a* as shown with an arrow A and forcibly fitted to the upper surface of the track member **2** to thereby engage the opposite side engaging portion **3***a* with a corresponding undercut portion **4**.

[0009] In such mounting structure, although the come-off of the cover **3** may be surely prevented, it is required to largely elastically deform the one side engaging portion **3***a* at the mounting time, and accordingly, this engaging portion **3***a* may be plastically deformed in a case when this mounting working is not well performed. Furthermore, when the cover **3** is removed, there is a case where the engaging portion **3***a* of the cover **3** tightly contacts the contacting surface **4***a* of the undercut portion **4** and the cover **3** is hence not easily peeled therefrom. In such case, it is obliged to gradually peel off (remove) the engaging portion **3***a* from both the longitudinal end portions of the track member **2**, which requires much working time and labor for a worker, and moreover, at a time of peeling off the engaging portion **3***a,* there may cause an unnatural twisting force which may plastically deform the engaging portion **3***a*.

SUMMARY OF THE INVENTION

[0010] An object of the present invention is to substantially eliminate defects or drawbacks encountered in the prior art mentioned above and to provide a motion guide device capable of easily mounting or dismounting (removing) a cover covering an upper surface of a track member without giving any damage to the cover during the mounting (dismounting) working time.

[0011] This and other objects can be achieved according to the present invention by providing a motion guide device comprising:

[0012] a track member having an upper surface and two side surfaces continuous to the upper surface;

[0013] a movable member mounted to the track member to be relatively movable with respect to the track member along a longitudinal direction thereof; and

[0014] a cover member covering the upper surface of the track member across an entire width direction thereof,

[0015] the track member being formed with undercut portions formed to side edge portions of the side surfaces of the track member on the upper surface side thereof, the undercuts being recessed towards a central side of the track member in the width direction thereof and

[0016] the cover member comprising a central flat portion and engaging portions formed at both end portions in the width direction thereof to be engaged with the undercut portions, respectively, so as to clamp the track member therebetween in the width direction, each of the engaging portions comprising an intermediate section to be engaged with the undercut portion of the track member and a front end section bent outward from the intermediate section so as to be opened outward in the width direction of the track member.

[0017] In the above aspect, it is to be noted that the term "upper" surface of the track member means a surface opposite to a lower surface in a case of providing that a mounting (mount) surface of the track member with respect to an object member is considered to be "lower" surface. Therefore, it is not absolute for this surface to direct the "upper" direction in an actual use, and in claims of the subject application, this term of "upper" surface is referred to as "horizontal" surface with reference to two side surfaces of the track member.

[0018] Furthermore, the movable member is mentioned as a member to be relatively movable with respect to the track member, and the motion guide device of the present invention is not limited to the structure in which the movable member is itself moved in use.

[0019] In a preferred embodiment of the aspect mentioned above, an outline of the intermediate section and the front end section is curved in a circular shape towards the central side of the track member in the width direction thereof. The engaging portion of the cover member has an elasticity so that both the engaging portions are simultaneously engaged with the undercut portions of the track member. That is, the cover member is formed of a plate member having an elasticity so that the central portion of the cover member is engaged with the upper surface of the track member and both the engaging portions of the cover member are simultaneously engaged with the undercut portions of the track member by depressing the flat portion of the cover member to the upper surface of the track member.

[0020] The cover member has a longitudinal dimension substantially equal to that of the track member.

[0021] The upper surface and the side surfaces of the track member are continuous to each other through round portions and each of the engaging portions of the cover member further comprises a base section curved outward from the intermediate section so as to coincide in shape with the round portion of the track member.

[0022] The track member is formed with openings to the upper surface thereof.

[0023] According to the present invention of the structures mentioned above, the front end sections of the engaging portions of the cover member are opened outward from the intermediate portions thereof, so that, by placing the engaging portions to the end edges of the upper surface of the track member and then pushing the cover member towards the upper surface of the track member, the engaging portions are elastically deformed outward and slid over the continuous round portion connecting the upper surface of the track member and the side surfaces thereof and the intermediate sections of the engaging portions are engaged with the recessed undercut portions of the track member. On the other hand, when the cover member is removed from the track member, the outward opened front end sections of the engaging portions are grasped and pulled upward, thus being easily removed. Since such working can be done without applying a large force locally, the cover member cannot be deformed.

[0024] The circularly curved shape of the intermediate section and the front end sections of the engaging portions can allow the engaging portions to be easily elastically deformed at the time of being attached to or removed from the track member and the working efficiency can be improved. The deformation of the cover member can be also prevented.

[0025] The cover member can be easily fitted to the track member by simultaneously fitting the engaging portions to the undercut portions of the track member.

[0026] The nature and further characteristic features of the present invention will be made more clear from the following descriptions made with reference the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] In the accompanying drawings:

[0028] **FIG. 1** is a developed perspective view showing an entire structure of the motion rolling guide device according to the one embodiment of the present invention;

[0029] **FIG. 2** is a cross sectional view of a track shaft member of a motion rolling guide device according to one embodiment of the present invention;

[0030] **FIG. 3** is a partial enlarged view of a portion III in **FIG. 2**;

[0031] **FIG. 4** includes views of **FIGS. 4A and 4B** showing one example of a cover forming process for the motion rolling guide device; and

[0032] **FIG. 5** includes views for showing mounting processes of the cover of the motion rolling guide device in a prior art in which **FIG. 5A** is a view showing a cover before the mounting to a track shaft (member) of the motion rolling guide device and **FIG. 5B** is a view showing the cover which is mounting to the track shaft.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0033] FIGS. **1** to **4** represent one preferred embodiment of the present invention.

[0034] First, with reference to **FIG. 1, a** motion rolling guide device **10** of the present invention will be described. The motion rolling guide device comprises a track member **11**, a movable member **12** mounted to the track member **11** to be relatively movable in a longitudinal direction of the track member **11**, a plate cover (cover plate) **14** covering an upper surface of the track member **11** and an inner seal **15** disposed between the movable member **12** and the plate cover **14**. The movable member **12** is mounted to the track member **11** with a number of rollers as rolling members, not shown, being interposed therebetween. In the illustration of **FIG. 1**, although the plate cover **14** has a length shorter than that of the track member **11** in the longitudinal direction thereof, in an actual structure, the plate cover **14** has substantially the same longitudinal length as that of the track member **11**.

[0035] The track member **11** is formed of a material having a high rigidity such as steel, and a number of bolt mounting holes **11***b*, **11***b*, - - - , **11***b* are formed to the upper surface **11***a* of the track member **11** so as to vertically penetrate it for mounting or attaching the track member **11** to a machine part, machine tool or the like. Two rows of roller rolling surfaces, i.e. raceways, along which the rollers travel, are formed to each of side surfaces **11***c*, **11***c* of the track member **11**.

[0036] The movable member **12** comprises a block body **20**, a pair of end plates **23, 23** attached to both longitudinal end portions of the block body **20** and end seals **25, 25** mounted to outer surfaces of the end plates **23, 23** by means of screws **26, 26**, - - - , **26**.

[0037] The block body **20** is formed, as like as the track member **11**, of a material having a high rigidity such as steel and has a lower surface (in an illustrated state) to which a recessed portion **20***a* is formed so as to receive the track member **11**. The recessed portion **20***a* has an inner wall section to which lateral two roller rolling surfaces, not shown, are formed respectively so as to oppose to the rolling surfaces **11***d* of the track member **11**, and loaded rolling passages for the rollers are formed along these rolling surfaces. Inside the block body **20**, a return passage for returning the rollers from one end portion of the loaded rolling passage to the other end portion thereof, and rolling direction changing passages are formed inside the end plates, respectively, so that each connects the return passage and the loaded rolling passage. Accordingly, an endless circulation passage is composed of a pair of loaded rolling passages, the return passage and a pair of rolling direction changing passages connecting the loaded rolling passages and the return passage, and two such endless circulation passages are formed to each of the lateral side portions of the track member **11**, that is, four endless circulation passages are formed in total.

[0038] The inner seal **15** in shape of plate, as shown in **FIG. 1**, is composed of a base member **15***a* formed of a steel plate, for example, lips, not shown, formed to a lower surface thereof and lips **15***b*, **15***b*, - - - , **15***b* for buffer function formed to an upper surface thereof. In an assembling process, both end portions of the inner seal **15** are inserted into recessed portions, not shown, formed to inner surfaces of the end plates **23** and held between both the end plates **23, 23** in the longitudinal direction of the track member **11** so as to prevent the inner seal **15** from coming off in its longitudinal direction. Further, each of the recessed portions formed to the end plates **23, 23** has a vertical thickness (direction normal to the upper surface **11***a* of the track member **11**) larger than a thickness of the end portion of the inner seal plate **15** so that the inner seal plate **15** is idly movable in the vertical direction between the end plates **23, 23**. The lips formed to the lower surface of the inner seal **15** contact the plate cover **14** to thereby prevent foreign bodies from entering into the loaded rolling passage and prevent lubricant such as grease from leaking from the loaded rolling passage.

[0039] The structure and the mounting manner of the cover plate **14** will be explained hereunder with reference to FIGS. **1** to **3**.

[0040] With reference to **FIG. 2** as a sectional view, undercuts **11***e*, **11***e* are formed to side edge portions (upper end portions) of both the side surfaces **11***c*, **11***c* of the track member **11** so as to be recessed in a width direction of the track member **11**. The plate cover **14** has a width approximately the same as the upper surface **11***a* of the track member **11** and has a flat central surface **14***a* in its width direction. The plate cover **14** also has both end portions to which engaging portions **14***b*, **14***b* are engaged with the undercuts **11***e*, **11***e* so as to embrace the track member **11** in the width direction thereof.

[0041] As shown in **FIG. 3**, in an enlarged scale, a connecting portion between the upper surface **11***a* of the track member **11** and the side surface **11***c* thereof is formed as a curved portion **11***f* (i.e. round portion having a radius of curvature R) so as to describe a circular curve bulged outward, and accordingly, the undercut **11***e* is formed so as to be hollowed out like a groove towards the central side in the width direction of the track member **11** from the lower end portion of the curved portion **11***f*. The undercuts **11***e* and the curved portions **11***f* are symmetrically formed at both the end portions in the width direction of the track member **11** so as to extend along the entire longitudinal direction thereof.

[0042] As best shown in **FIG. 3** as a cross sectional view of the track member **11**, the engaging portion **14***b* of the plate cover **14** comprises an intermediate (central) section **14***c* curved inside towards the central portion in the width direction of the track member **11** so as to be coincident with the recessed shape of the undercut **11***e*, a front end section **14***d* curved outward from the intermediate section **14***c* so as to be opened outward and a base section **14***e* curved outward from the intermediate section **14***c* so as to provide a shape coincident with the curved round portion **11***f* of the track member **11**. The flat upper surface **11***a* is continuous to the undercuts **11***e* through round portions **11***f* to which the base sections **14***e* of the engaging portions **14***b* are tightly contacted. And an outline of the intermediate section **14***c* and the front end section **14***d* is curved in a circular shape towards the central side of the track member **11** in the width direction thereof.

[0043] According to the structure mentioned above, the front end section **14***d* of the engaging portion **14***b* of the plate cover **14** is opened outward from the intermediate section **14***c* in the width direction of the track member **11**. Therefore, the plate cover **14** is fitted and secured to the track member **11** by abutting the respective engaging portions **14***b* against the respective curved portions **11***f* and pushing down the plate cover **14** under the mentioned state directly towards the upper surface **11***a* of the track member **11** so that the lateral paired engaging portions **14***b*, **14***b* are elastically deformed and the intermediate sections **14***c*, **14***c* of the engaging portions **14***b*, **14***b* are both simultaneously engaged with the undercuts **11***e*, **11***e* over the curved portions **11***f*, **11***f*, and the plate cover **14** is thereby secured to the track member **11**. On the other hand, when the plate cover **14** is removed from the track member **11**, the plate cover **14** will be moved upward by engaging any means with the projected (outward opened) front end sections **14***d*, **14***d* of the plate cover **14** and forcibly pulling up the plate cover **14** to thereby remove the engaging portions **14***b*, **14***b* at the same time from the undercuts **11***e*, **11***e*, that is, the plate cover **14** can be removed from the track member **11**.

[0044] With reference to **FIG. 3**, the character "X" denotes an amount to be removed from the curved portion **11***f* of the undercut **11***e*, and the value of this amount is set to be within a range in which an internal stress exceeding an elastical limit of the plate cover **14** is never caused at a time when the engaging portions **14***b* are removed over the curved portions **11***f*. For example, in one embodiment in which the track member **11** has a width of 45 mm, the value X will be set to be about 0.25 mm.

[0045] Further, the radius of curvature R of the curved portion **11***f* is set to be more than 1 mm, for example, so that the curved portion **11***f* surely remains even if a working error is caused. Furthermore, although the undercuts **11***e*, **11***e* can be formed by various working methods or processes, a grinding working may be most preferred in viewpoint of working performance.

[0046] With reference to **FIG. 2**, the width Wa between the inside surfaces of the bilateral intermediate sections **14***c*, **14***c* of the engaging portions **14***b*, **14***b* of the plate cover **14** and the width Wb between the undercuts **11***e*, **11***e* of the track member **11** are set such that the intermediate sections **14***c*, **14***c* of the engaging portions **14***b*, **14***b* tighten or clamp the track member **11** in the width direction of the track member with a suitable force at the time when the plate cover **14** is fitted to the track member **11**. Furthermore, it is desired that the width Wc between the base sections **14***e*, **14***e* of the engaging portions **14***b*, **14***b* of the plate cover **14** is set to be larger than the width Wd between the inside surfaces of the curved portions **11***f*, **11***f* of the track member **11** so as not to adversely affect on the clamping force of the plate cover **14** to the track member **11**. However, the difference between these widths Wc and Wd will also have to be set to be slight. The radius of curvature of the base section **14***e* will have to be set to be smaller than that of the curved portion **11***f*.

[0047] **FIGS. 4A and 4B** represent one example for forming the plate cover **14**. According to this example, in the step of **FIG. 4**A, both end portions of a flat steel plate **14M** as a material of the plate cover **14** are subjected to press working as shown by arrows P so as to form intermediate sections **14***c*, **14***c* of the engaging portions **14***b*, **14***b*. Both the end portions of such steel plate **14M** are then bent as shown by arrows B to thereby form the engaging portions **14***b*, **14***b* as shown in **FIG. 4B**. In this process, a mold is placed to portions (shown with arrows C), which form the base sections **14***e*, **14***e* of the engaging portions **14***b*, **14***b*, so as to work these portions to provide the radius of curvature of the base section and the widths Wa, Wc with desired or predetermined performance. The plate cover **14** may be formed by a roll forming method in place of the manufacturing method mentioned above, and other many working methods or processes may be adopted as far as the excellent working precision can be attained.

[0048] Further, it is to be noted that the present invention is not limited to the described embodiment and many other changes and modifications may be made without departing from the scopes of the appended claims.

[0049] For example, the plate cover **14** may be formed from a material other than a metal material as far as the material has an elasticity capable of being repeatedly mounted to and dismounted from the track member **11** and has a friction withstanding property against the inner seal **15**. Balls may be utilized in place of the rollers as rolling members. Moreover, the present invention may be applicable to a slide guide device provided with no rolling member. Furthermore, the openings formed to the upper surface of the track member include various openings such as holes, grooves, recesses, etc. formed for various purposes other than the bolt fastening holes in the described embodiment.

What is claimed is:

1. A motion guide device comprising:

a track member having a horizontal surface and two side surfaces continuous to the horizontal surface;

a movable member mounted to the track member to be relatively movable with respect to the track member across a longitudinal direction thereof; and

a cover member covering the horizontal surface of the track member along an entire width direction thereof,

said track member being formed with undercut portions formed to side edge portions of the side surfaces of the track member, said undercut portions being recessed towards a central side of the track member in the width direction thereof and

said cover member comprising a central flat portion and engaging portions formed at both end portions in the width direction thereof to be engaged with the undercut portions, respectively, so as to clamp the track member therebetween in the width direction, each of said engaging portions comprising an intermediate section to be engaged with the undercut portion of the track member and a front end section bent outward from the intermediate section so as to be opened outward in the width direction of the track member.

2. A motion guide device according to claim 1, wherein an outline of said intermediate section and said front end section is curved in a circular shape towards the central side of the track member in the width direction thereof.

3. A motion guide device according to claim 1, wherein said engaging portions of the cover member has an elasticity so that both the engaging portions are simultaneously engaged with the undercut portions of the track member.

4. A motion guide device according to claim 3, wherein said cover member is formed of a plate member having an elasticity so that the central portion of the cover member is engaged with the horizontal surface of the track member and both the engaging portions of the cover member are simultaneously engaged with the undercut portions of the track member.

5. A motion guide device according to claim 1, wherein said cover member has a longitudinal dimension substantially equal to that of the track member.

6. A motion guide device according to claim 1, wherein the horizontal surface and the side surfaces of said track member are continuous to each other through round portions and each of said engaging portions of the cover member further comprises a base section curved outward from the intermediate section so as to coincide in shape with the round portion of the track member.

7. A motion guide device according to claim 1, wherein said track member is formed with openings to the horizontal surface thereof.

* * * * *

US 20010016088A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2001/0016088 A1

Teramachi (43) Pub. Date: Aug. 23, 2001

(54) LINEAR ROLLER GUIDE DEVICE

(75) Inventor: **Hiroshi Teramachi**, Tokyo (JP)

Correspondence Address:
ARMSTRONG,WESTERMAN, HATTORI, MCLELAND & NAUGHTON, LLP
1725 K STREET, NW, SUITE 1000
WASHINGTON, DC 20006 (US)

(73) Assignee: **THK CO., LTD.,**, Tokyo (JP)

(21) Appl. No.: **09/771,966**

(22) Filed: **Jan. 30, 2001**

Related U.S. Application Data

(62) Division of application No. 09/029,322, filed on Nov. 25, 1998, now Pat. No. 6,217,217, which is a 371 of international application No. PCT/JP97/01606, filed on May 13, 1997.

(30) **Foreign Application Priority Data**

May 13, 1996 (JP) 142253/96
May 13, 1996 (JP) 142256/96

Publication Classification

(51) **Int. Cl.**[7] **F16C 29/06**
(52) **U.S. Cl.** **384/44**

(57) **ABSTRACT**

A first invention of the subject application aims to smoothly circulate the rollers by integrally molding at least one member of the roller returning passage, the roller end surface guide wall and the direction changing portion with the block body.

Namely, at least one member of the roller returning passage forming member **91** for forming the roller returning passage **9,** the roller end surface guide wall **13** and the direction changing passage inner periphery portion forming member **12** for forming the direction changing passage inner periphery portion **10***b* is integrally molded by inserting the block body into a molding die.

A second invention of the subject application aims to realize a smooth circulation and movement of the rollers, and to prevent the running-out of the roller chain during the circulation of the roller.

Namely, the roller returning passage and the direction changing passage inner periphery guide portion are provided with a roller chain guide portion for guiding a track of the roller chain onto a predetermined track, and at least one member of roller returning passage forming member for forming the roller returning passage and direction changing passage inner periphery portion forming member for forming the direction changing passage inner periphery portion is integrally molded by inserting the block body into a molding die.

A linear roller guide device in which the rollers smoothly circulate by integrally molding at least one member of the roller returning passage, the roller end surface guide wall and the direction changing portion with the block body. The roller returning passage and the direction changing passage inner periphery guide portion are provided with a roller chain guide portion for guiding a track of the roller chain onto a predetermined track. At least one of the roller returning passage forming member for forming the roller returning passage and the direction changing passage inner periphery portion forming member for forming the direction changing passage inner periphery portion is integrally molded by inserting the block body into a molding die.

(a)

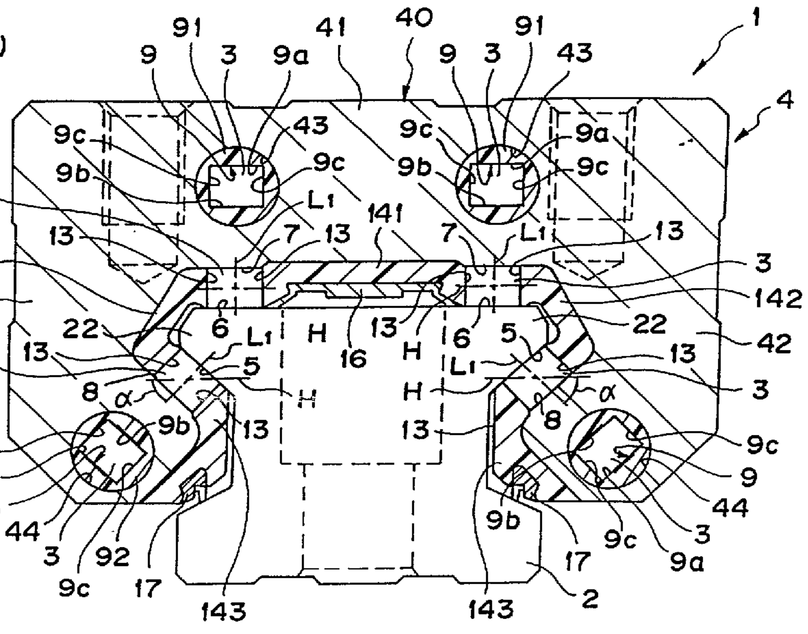


FIG. 1

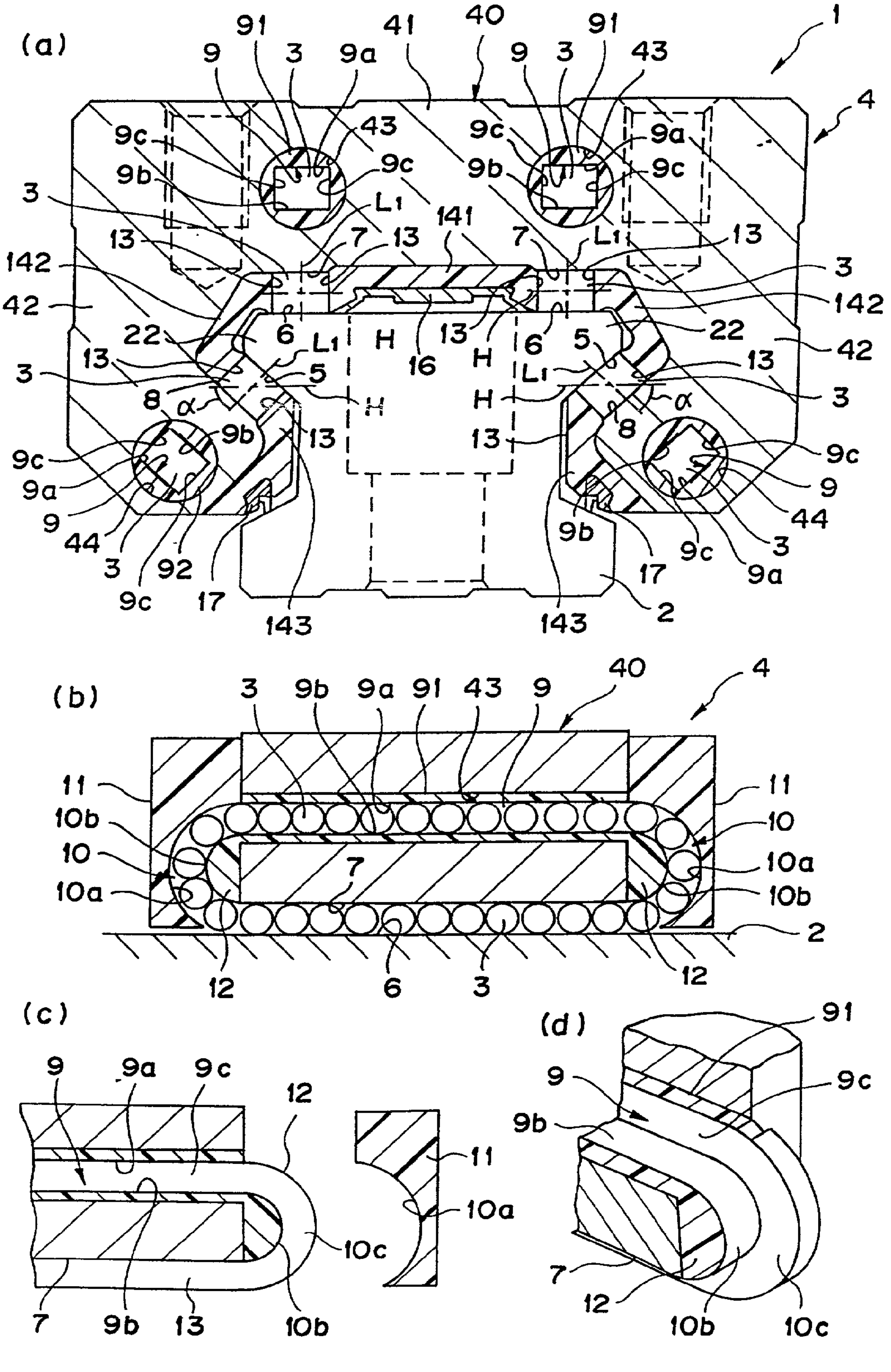


FIG. 2

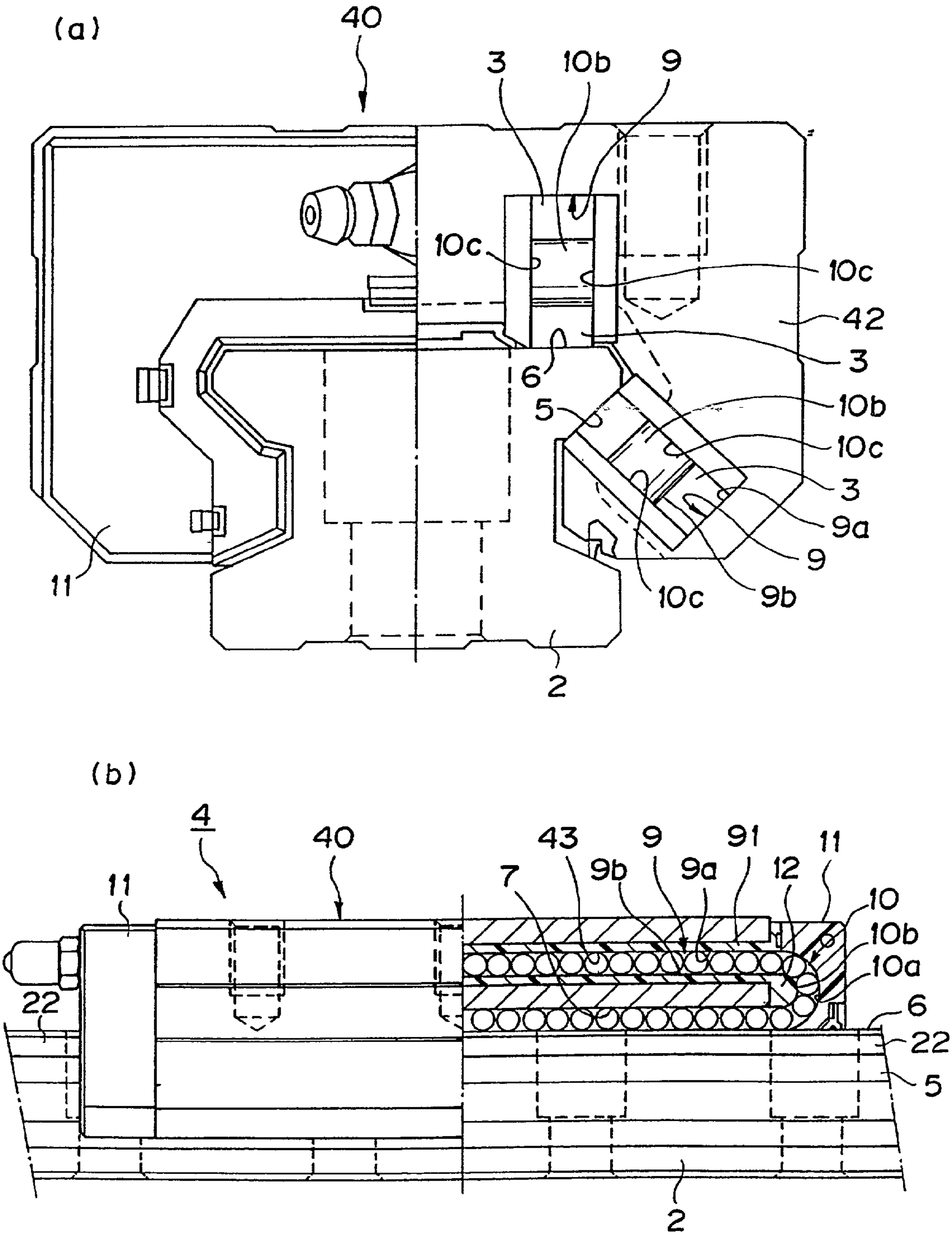

(a)
40
3
10b
9
10c
10c
42
3
6
5
10b
10c
3
9a
9
10c
9b
11
2
(b)
4
40
11
43
9
91
11
7
9b
9a
12
10
10b
10a
22
6
22
5
2

FIG. 3

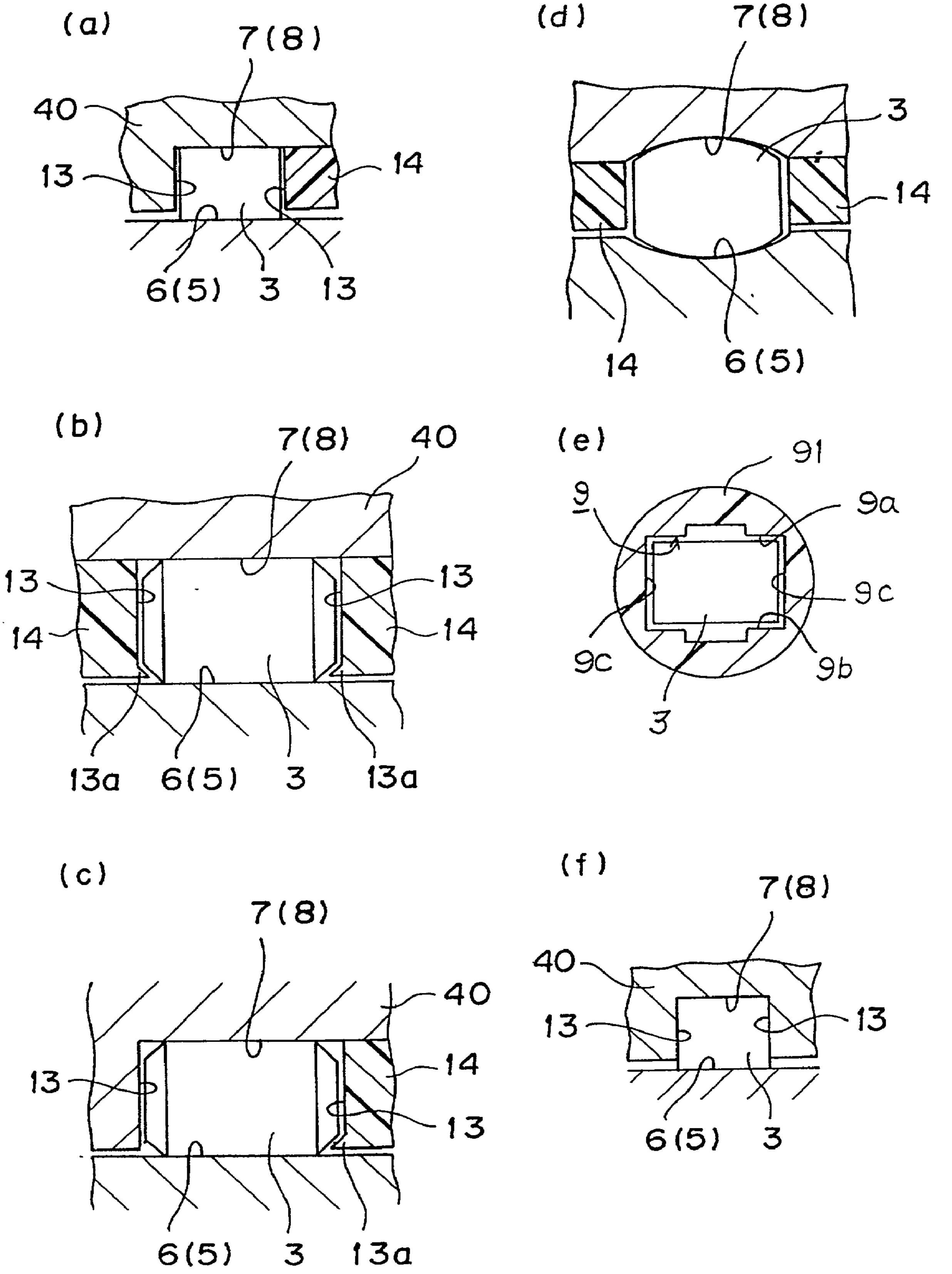

(a)
7(8)
40
13
14
6(5)
3
13
(d)
7(8)
3
14
14
6(5)
(b)
7(8)
40
13
13
14
14
13a
6(5)
3
13a
(e)
91
9
9a
9c
9c
9b
3
(c)
7(8)
40
13
14
13
6(5)
3
13a
(f)
7(8)
40
13
13
6(5)
3

FIG. 4

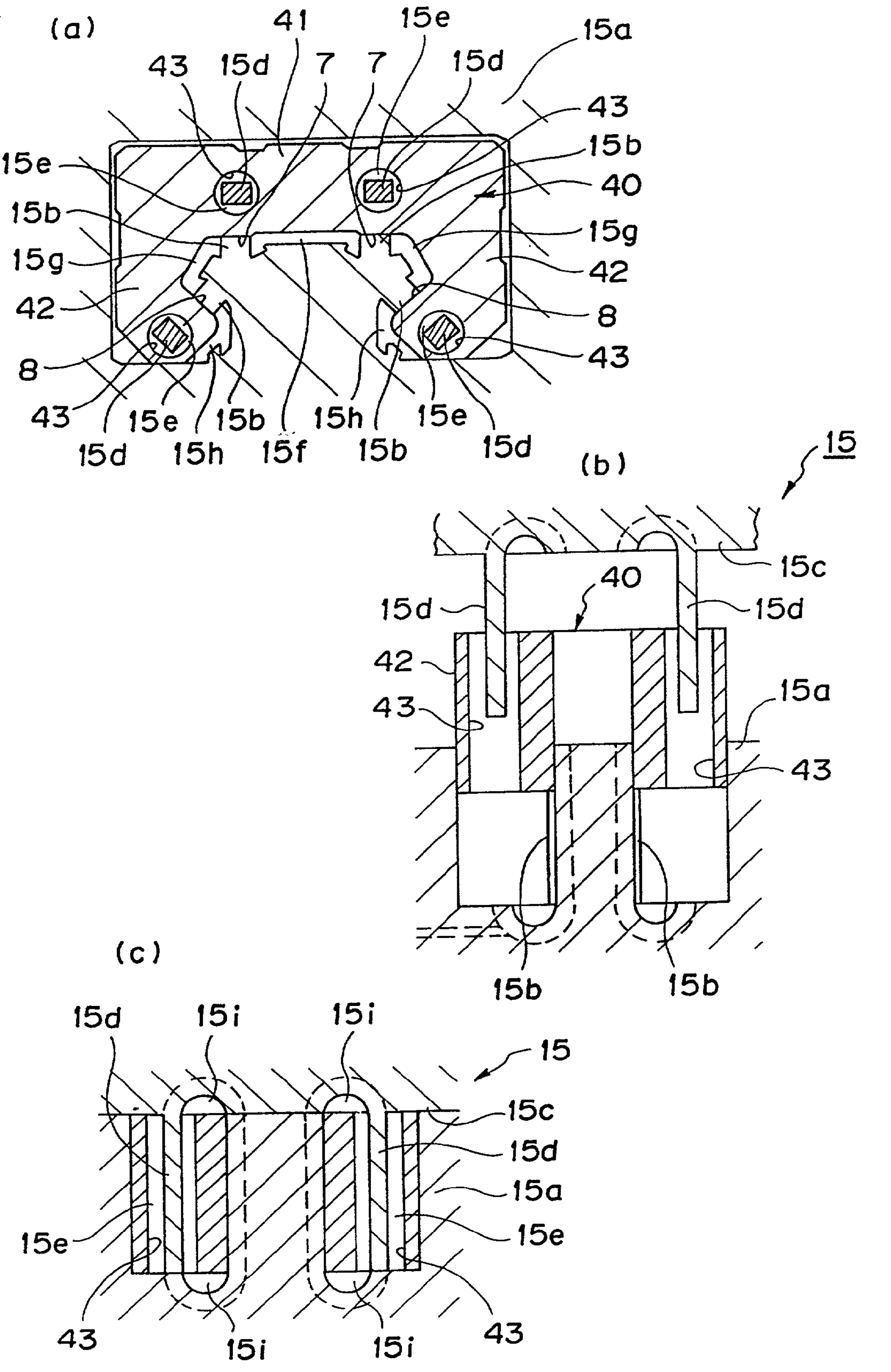

(a)
41
15e
15a
43
15d
7
7
15d
43
15b
15e
40
15b
15g
15g
42
42
8
8
43
43
15e
15b
15h
15e
15d
15h
15f
15b
15d
(b)
15
15c
40
15d
15d
42
15a
43
43
15b
15b
(c)
15d
15i
15i
15
15c
15d
15a
15e
15e
43
15i
15i
43

FIG. 5

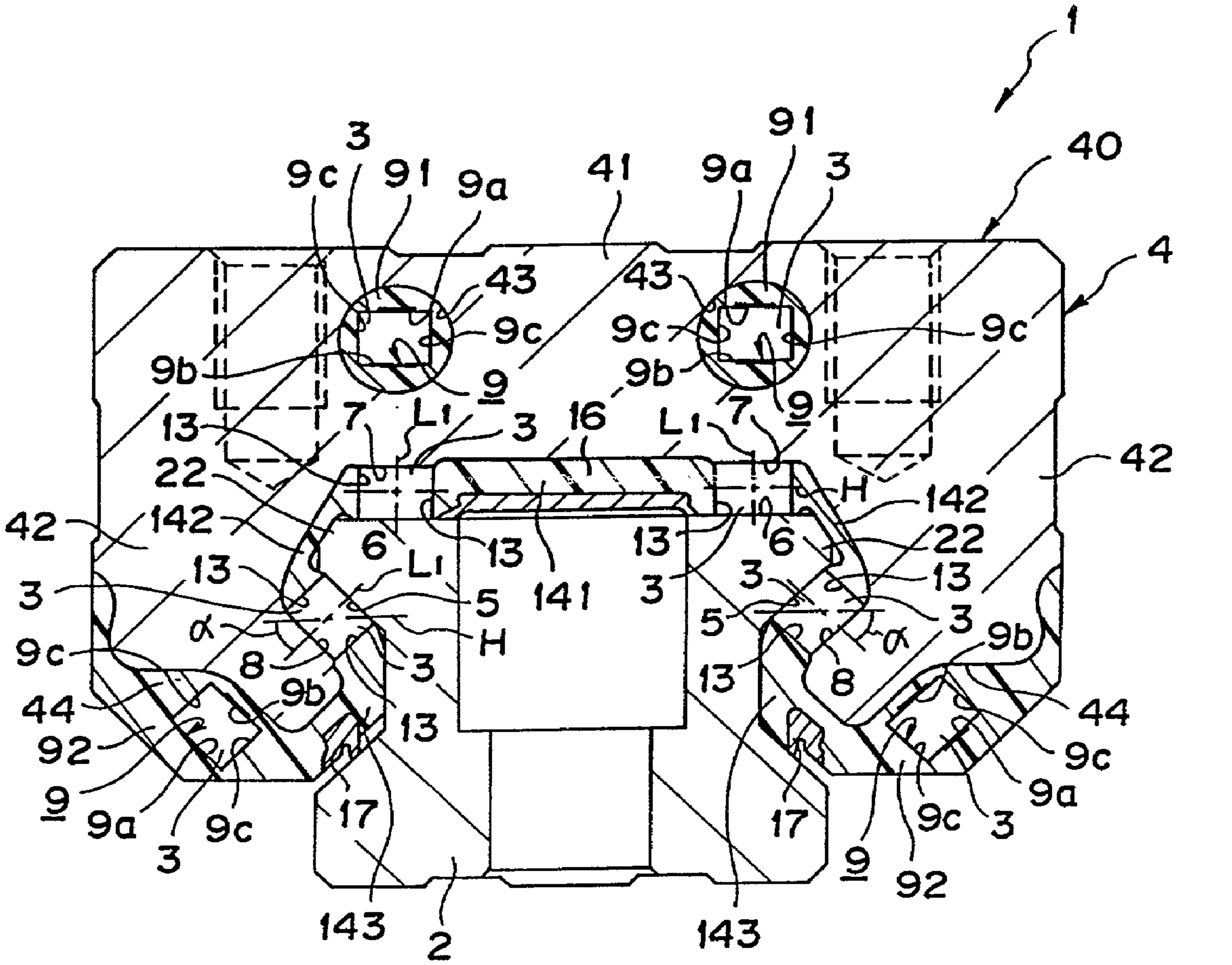

1
40
4
3
9c
91
9a
41
43
9b
9
13
7
L1
16
22
142
42
6
141
5
α
H
8
44
92
9a
3
17
143
2

FIG. 6

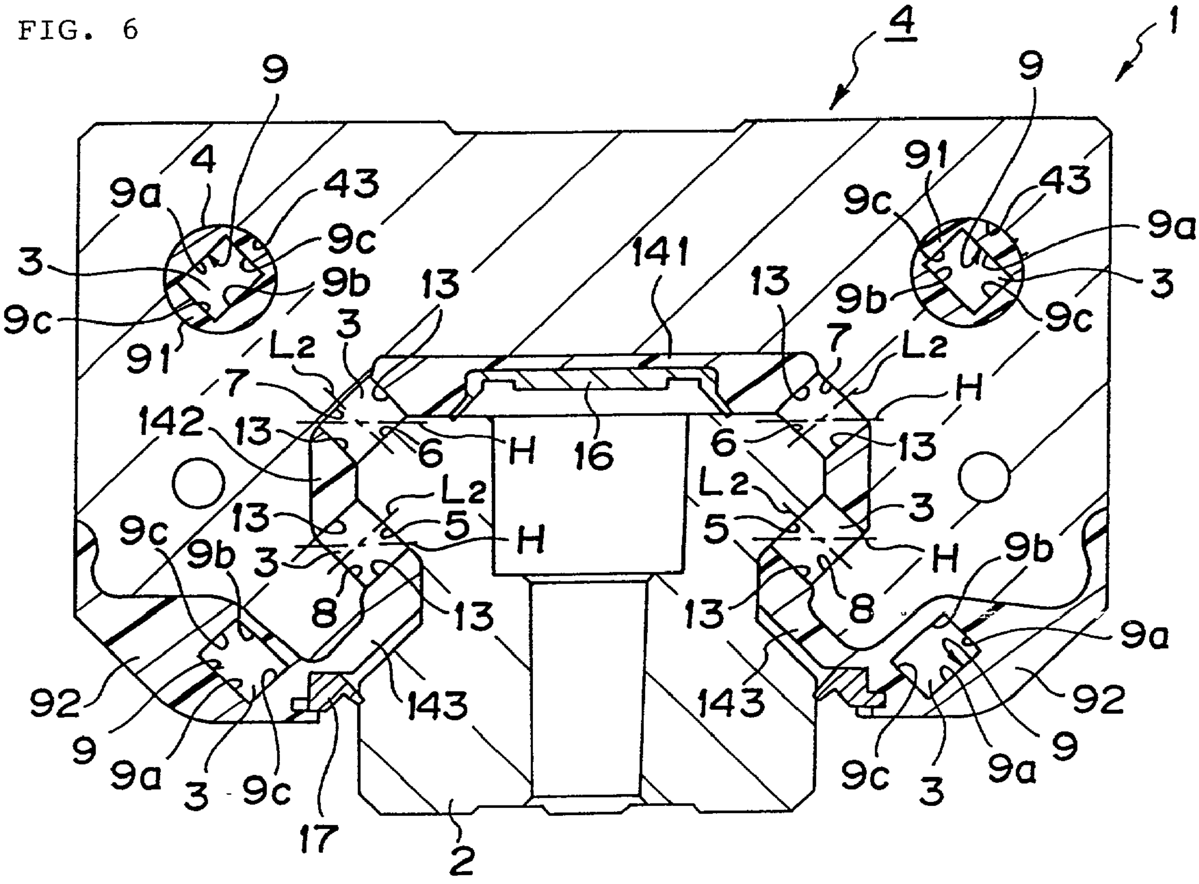
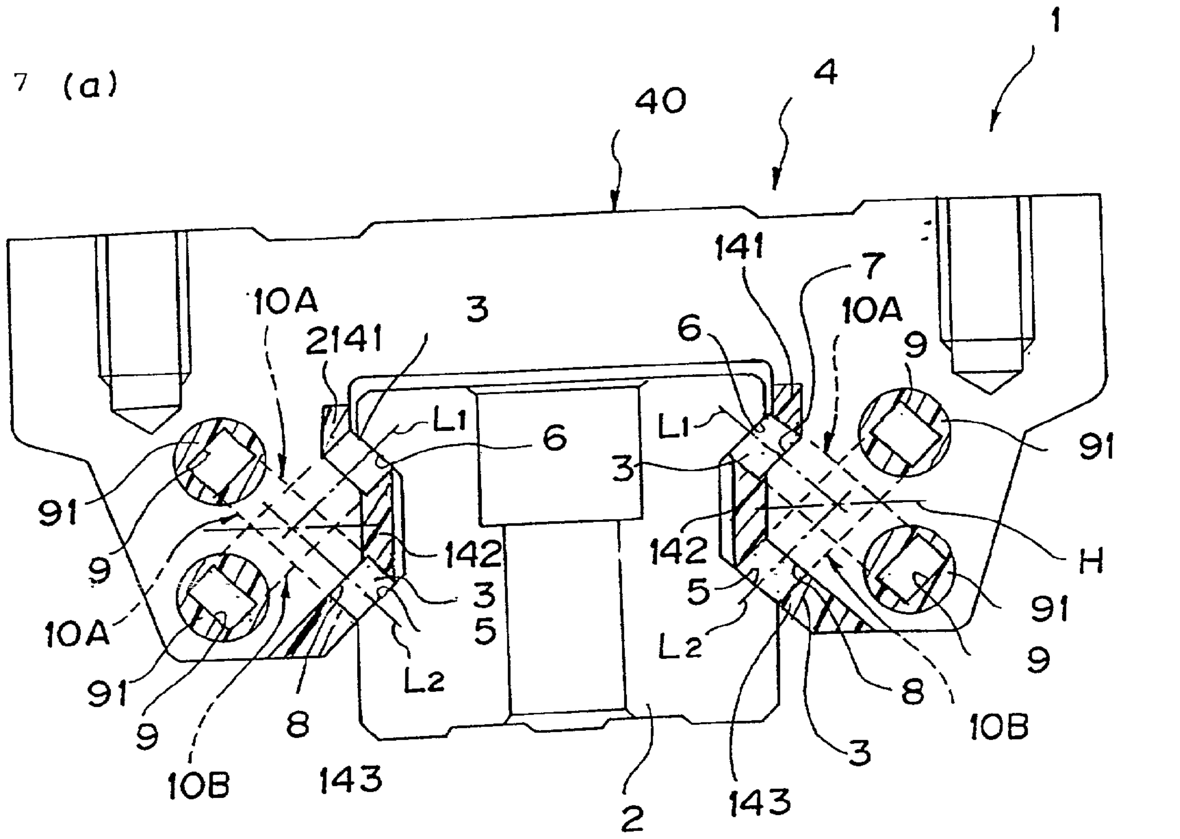


FIG. 7 (a)


1
4
40
141
7
10A
3
2141
6
L1
3
9
91
142
H
5
L2
8
10B
143
2

(b)

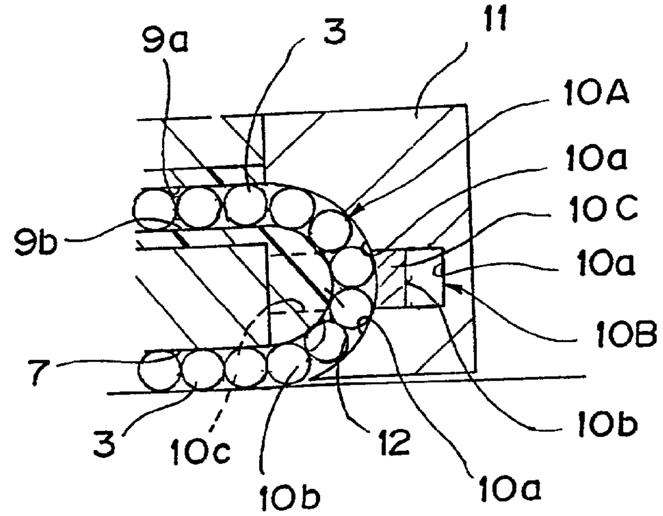
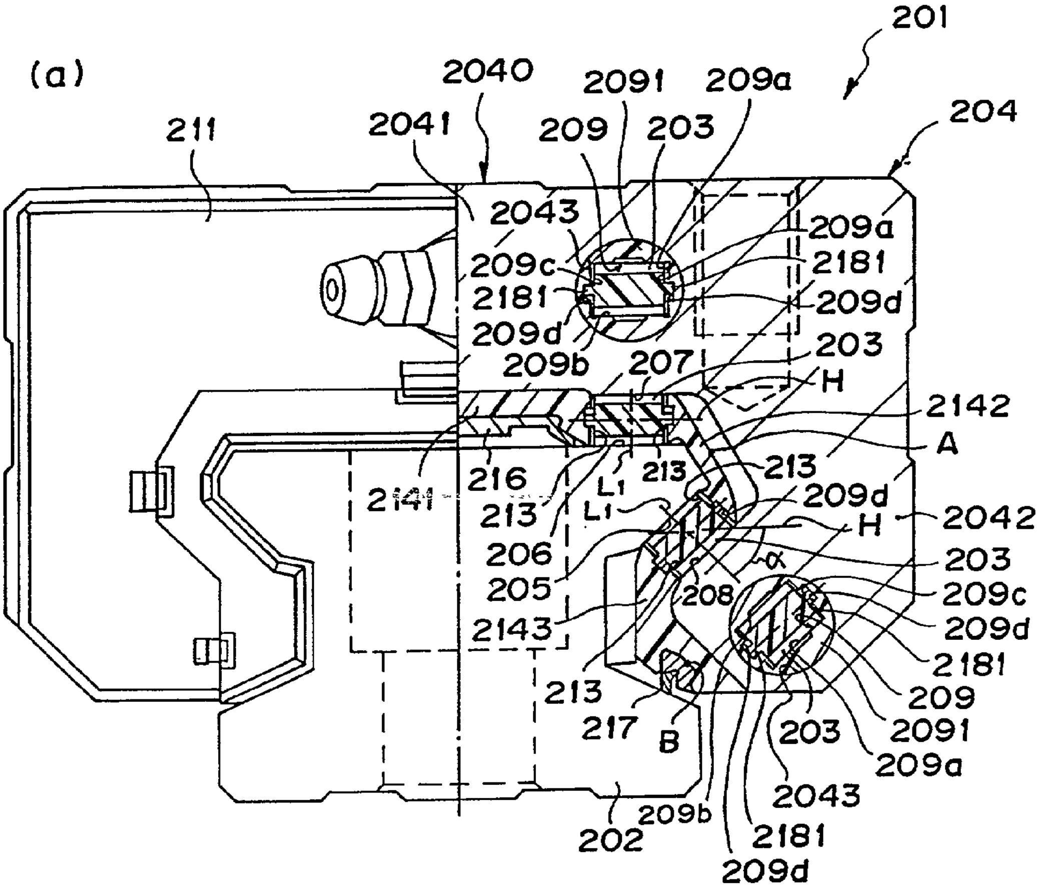

9a
3
11
10A
10a
10C
9b
10B
7
10b
3
10c
12
10b
10a

FIG. 8

(a)


201
2040
2091
209a
204
211
2041
209
203
2043
209a
209c
2181
2181
209d
209d
209b
207
203
H
2142
A
2141
216
213
L1
213
213
209d
L1
2042
H
206
203
205
208
α
209c
2143
209d
2181
213
209
217
B
203
2091
209a
2043
209b
202
2181
209d

(b)

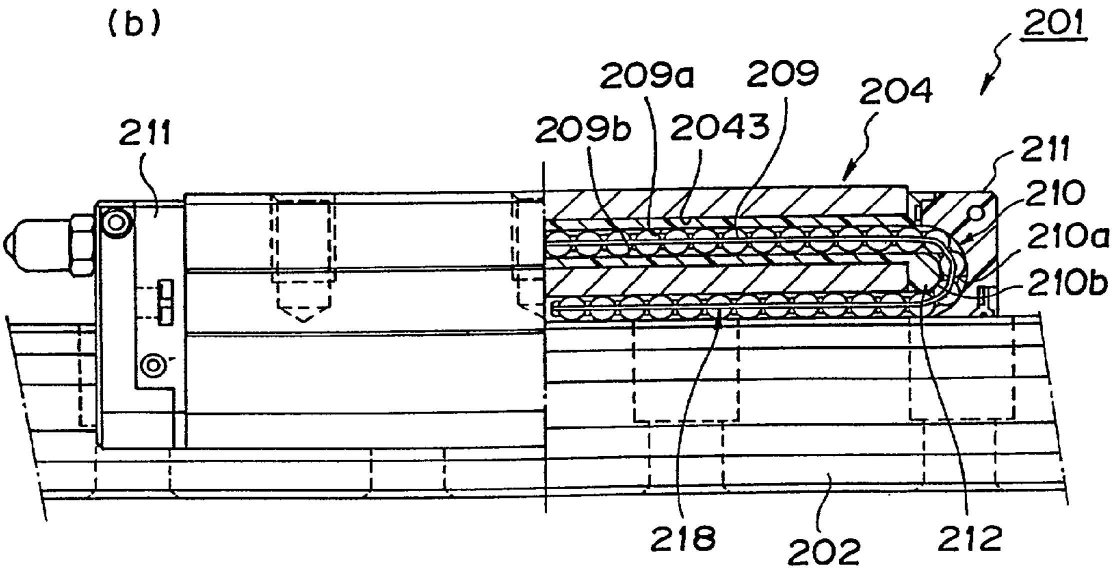

201
209a
209
204
211
209b
2043
211
210
210a
210b
218
202
212

FIG. 9

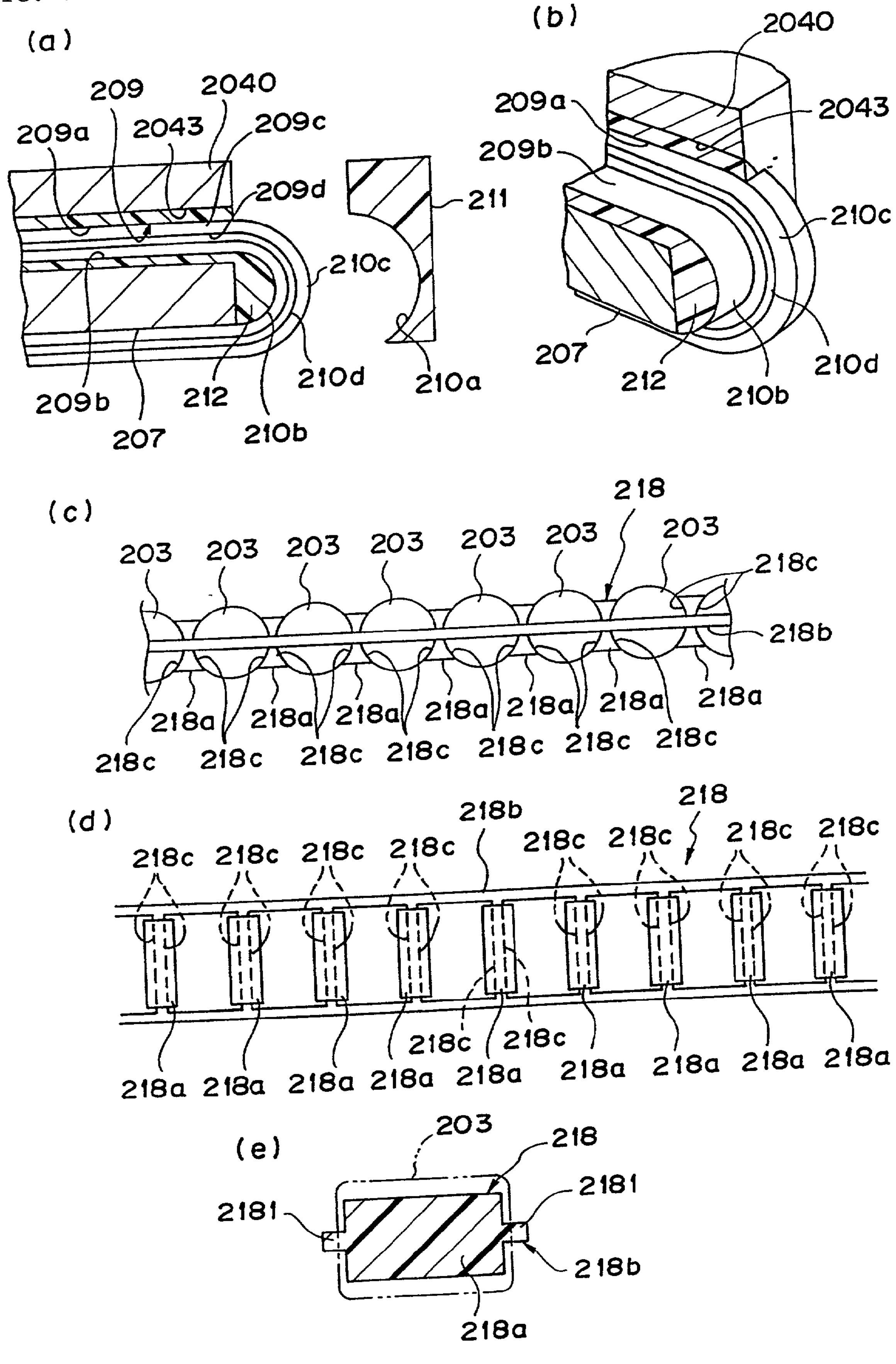

(a)
209
2040
209a
2043
209c
209d
211
210c
209b
207
212
210b
210d
210a
(b)
2040
209a
2043
209b
210c
207
212
210b
210d
(c)
218
203
218c
218b
218a
(d)
218b
218
218c
218a
(e)
203
218
2181
218b
218a

FIG. 10

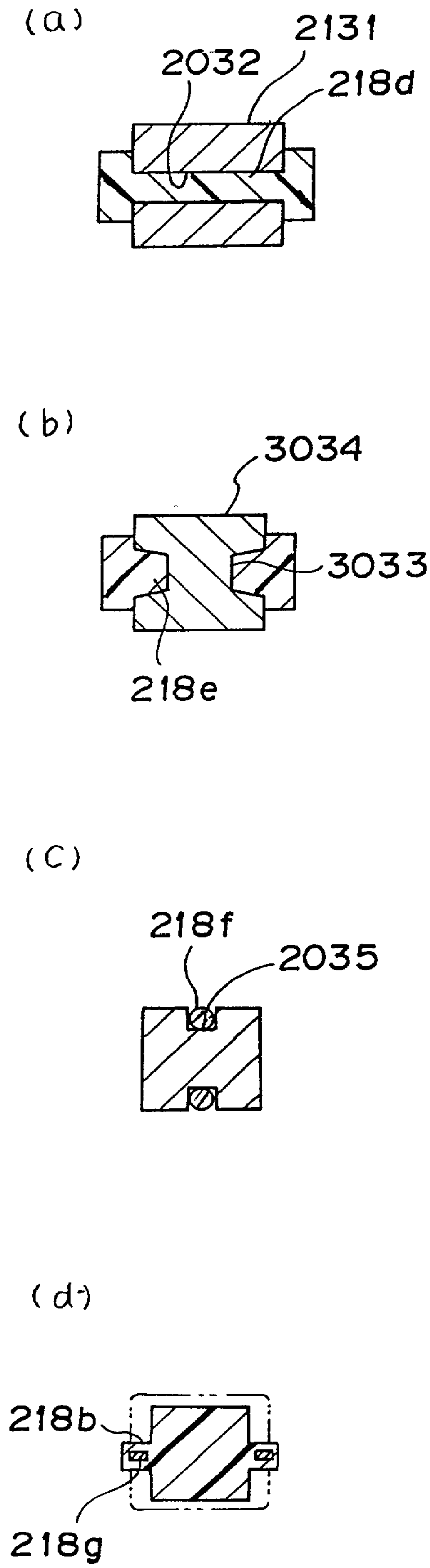


FIG. 11

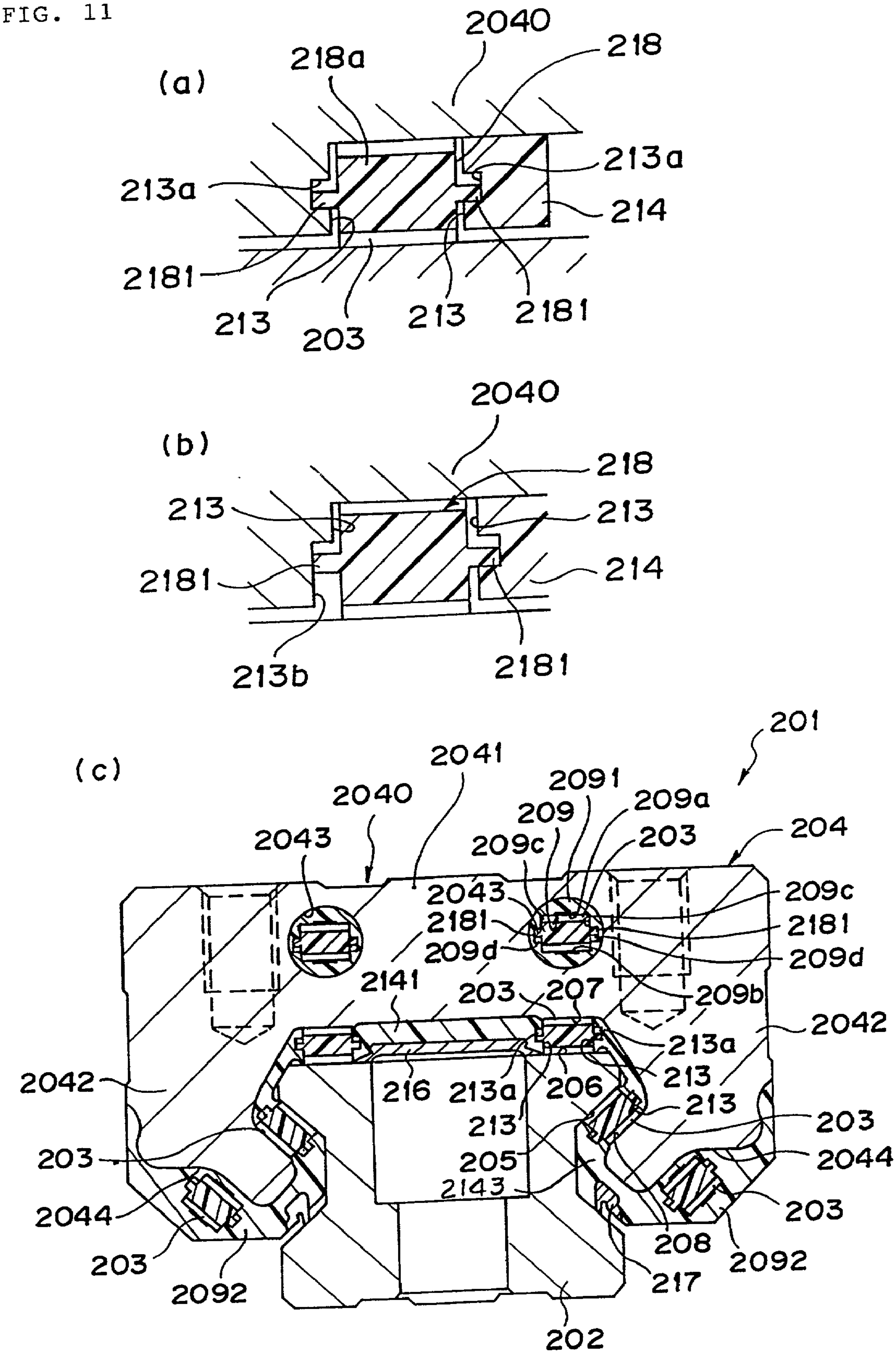

(a)
2040
218a
218
213a
213a
214
2181
213
203
213
2181
(b)
2040
218
213
213
2181
214
213b
2181
(c)
201
2041
2091
2040
209a
209
2043
203
209c
204
2043
209c
2181
2181
209d
209d
2141
203
207
209b
2042
213a
2042
216
213a
206
213
213
213
203
203
205
2044
2143
2044
203
208
2092
203
217
2092
202

FIG. 12

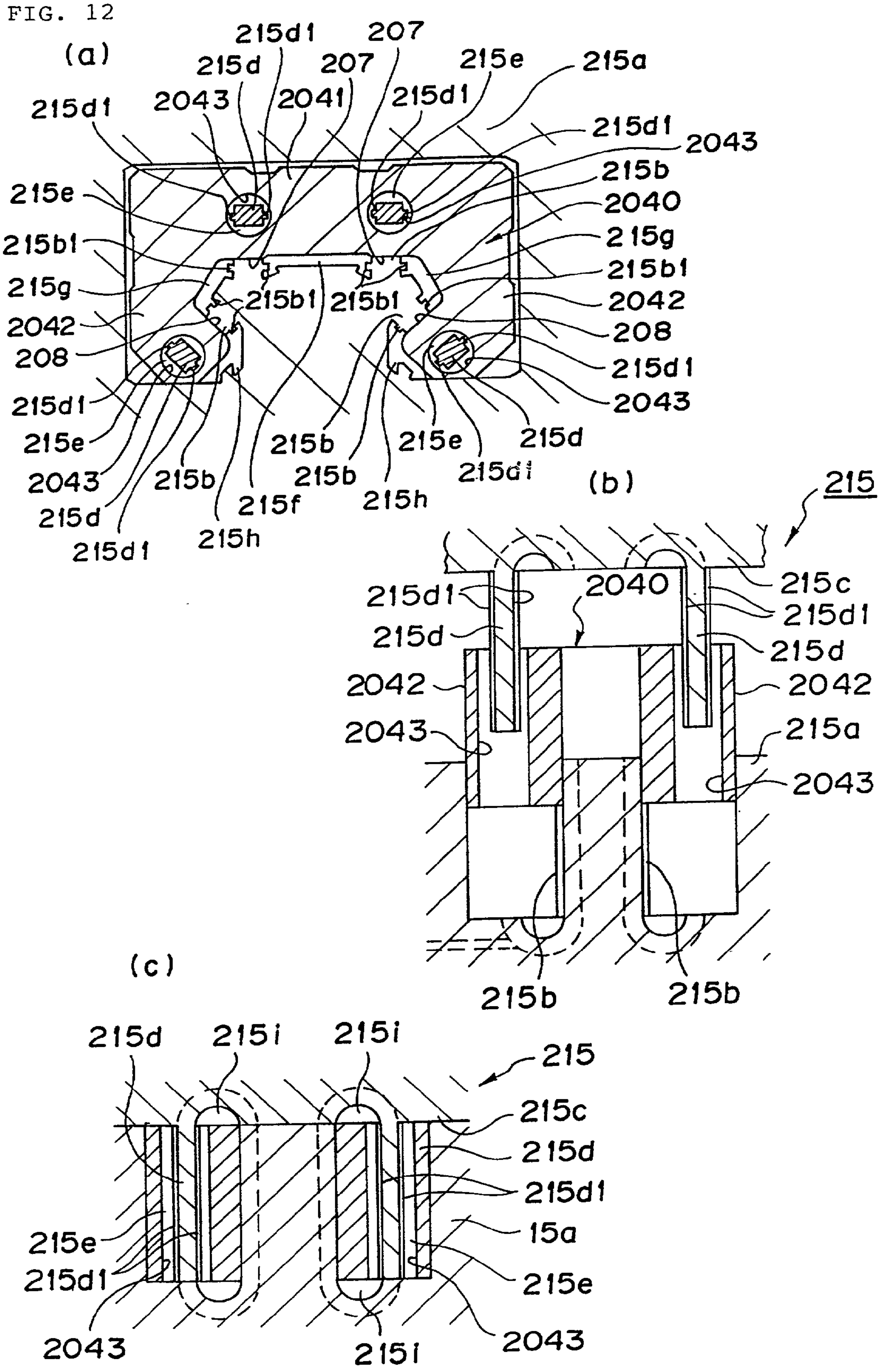

(a)
215d1
207
215d
207
215e
215a
2043
2041
215d1
215d1
215d1
2043
215e
215b
2040
215b1
215g
215b1
215g
215b1
215b1
2042
2042
208
208
215d1
215d1
2043
215e
215b
215e
215d
2043
215b
215b
215f
215h
215d1
215d
215d1
215h
(b)
215
215c
215d1
2040
215d1
215d
215d
2042
2042
2043
215a
2043
215b
215b
(c)
215d
215i
215i
215
215c
215d
215d1
215e
15a
215d1
215e
2043
215i
2043

FIG. 13

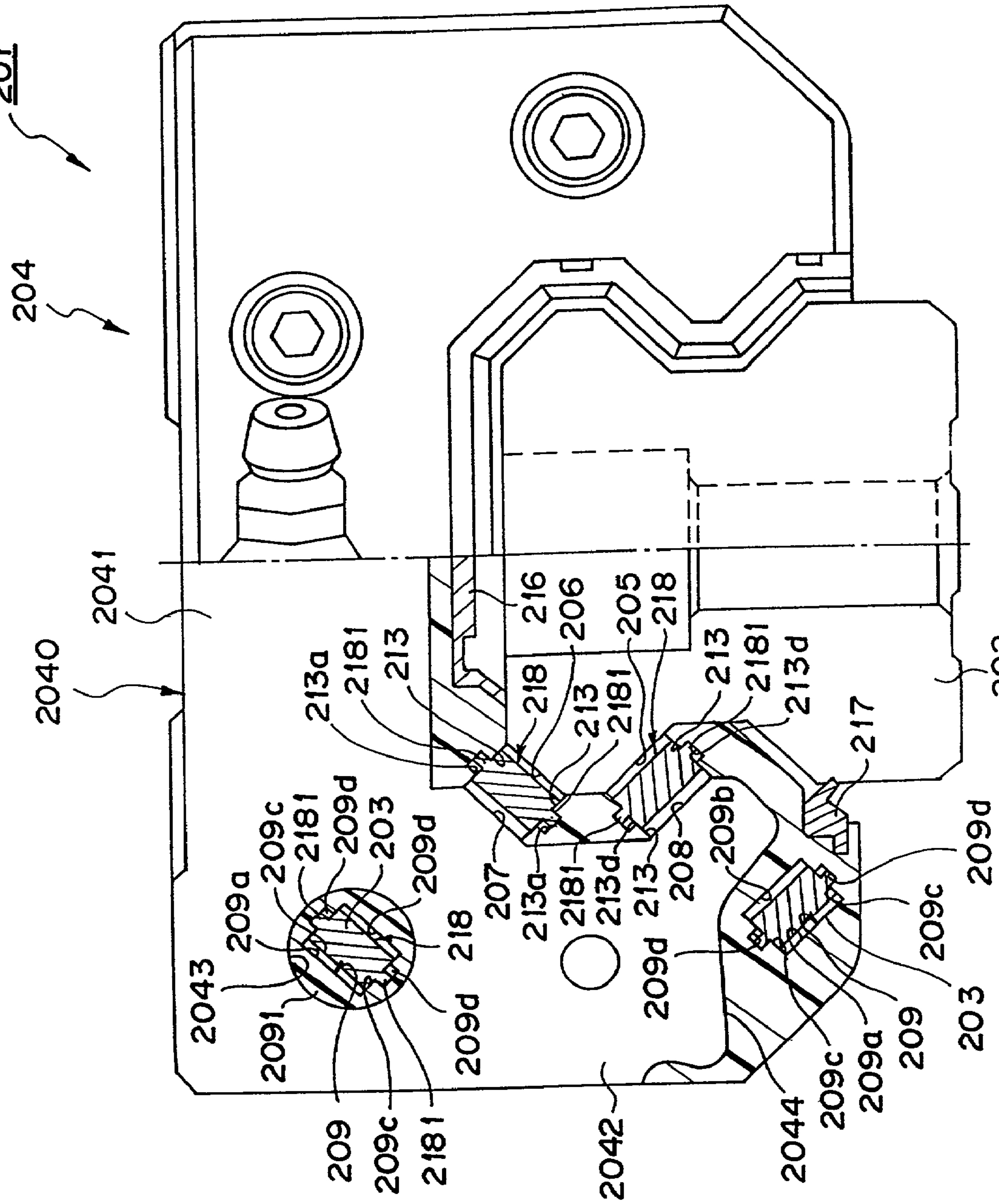

201
204
2040
2041
2042
2043
2044
2091
202
203
205
206
207
208
209
209a
209b
209c
209d
213
213a
213d
216
217
218
2181

FIG. 14

(a)

(b)

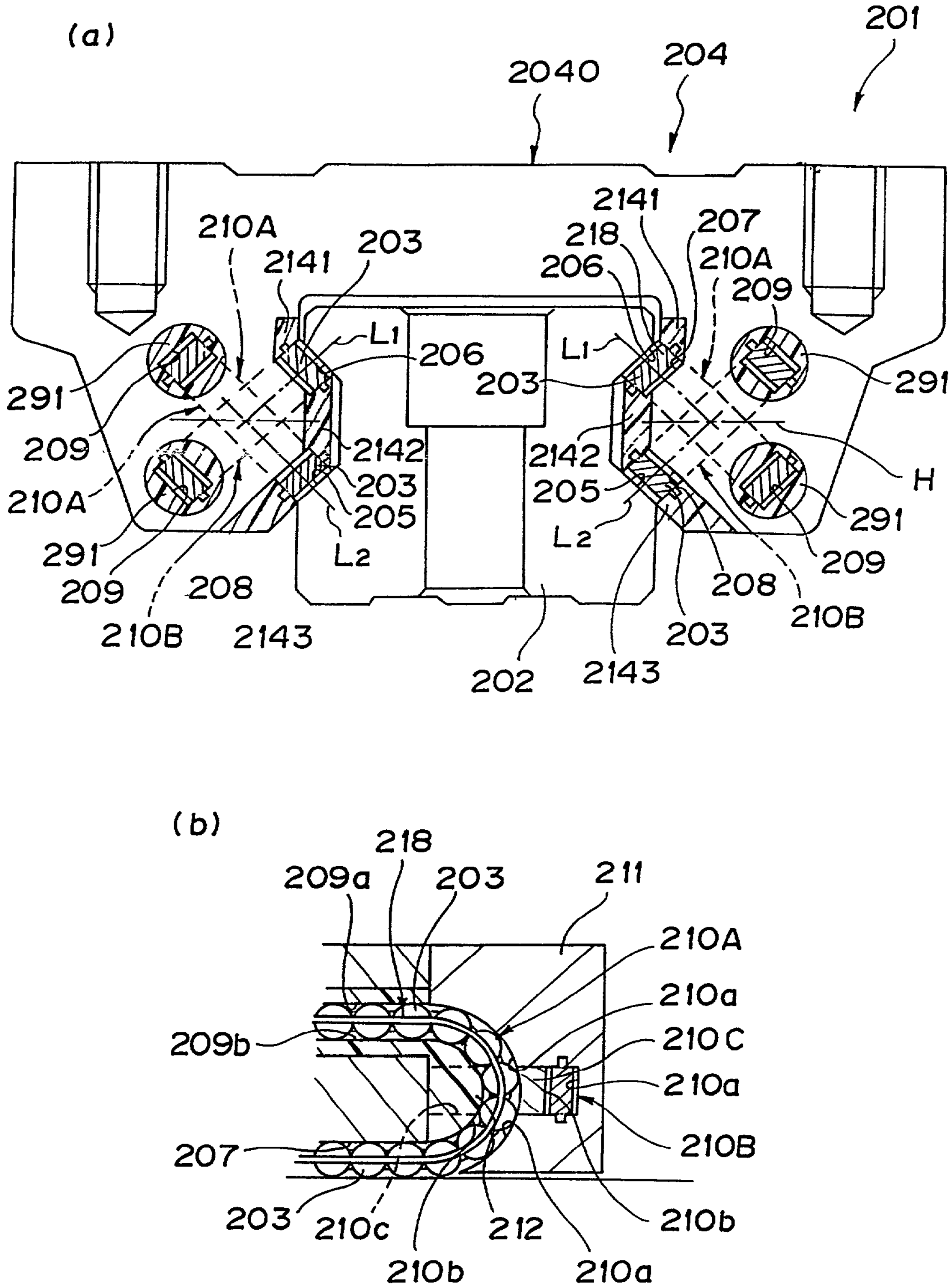
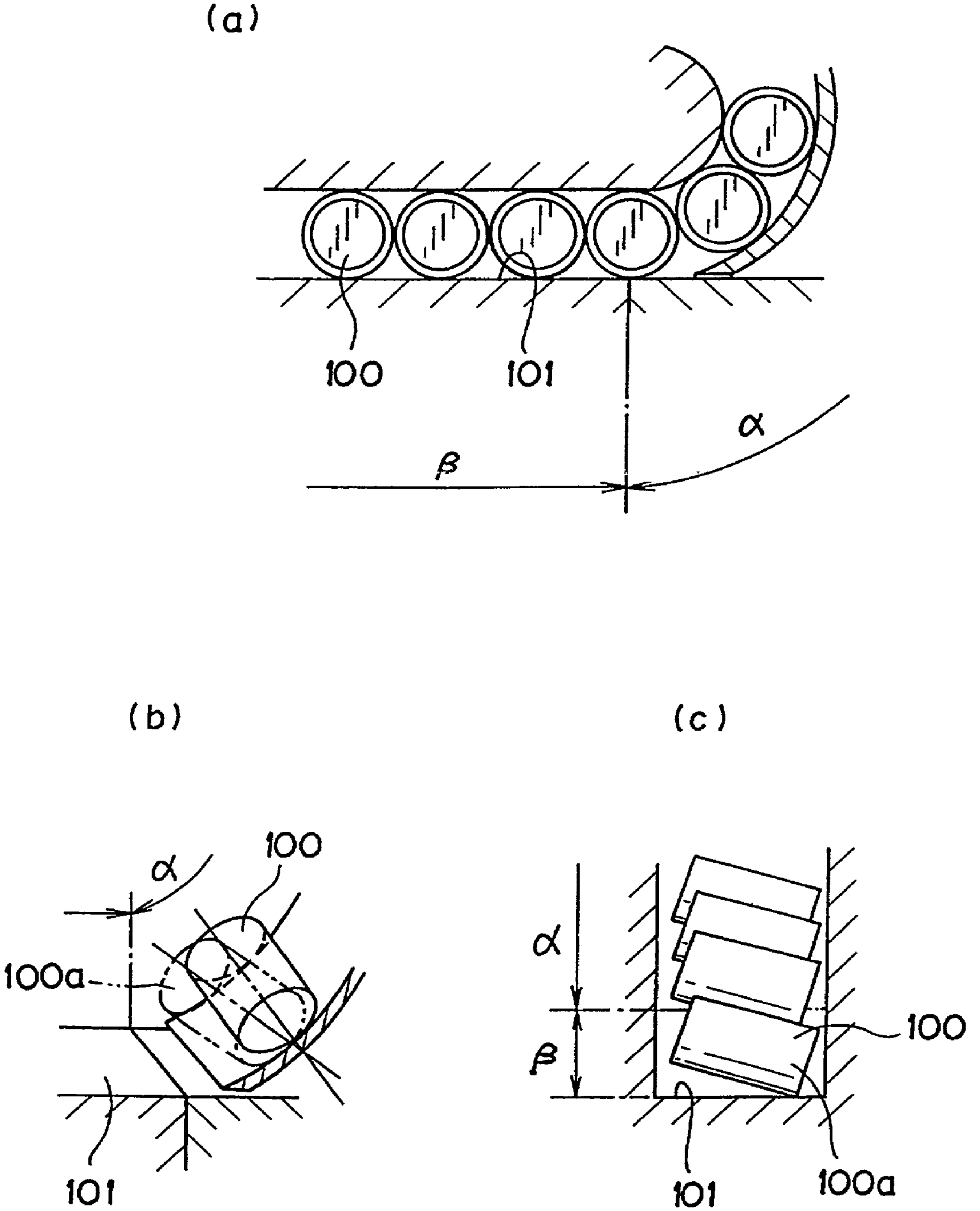

201
204
2040
210A
2141
203
L1
206
2142
205
L2
291
209
208
210B
2143
202
218
207
H
209a
209b
211
210a
210C
210c
210b
212

FIG. 15



LINEAR ROLLER GUIDE DEVICE

TECHNICAL FIELD

[0001] The present invention relates to a linear motion guide device, and more particularly, to a linear roller guide device using rollers as rolling elements.

BACKGROUND ART

[0002] The conventional linear roller guide device of this type generally has a structure in which a movable block is movably supported on a track rail through a number of rollers. The guide device using rollers has an advantage of high rigidity and high load bearing ability in comparison with the guide device using balls. The movable block comprises a block body and side covers to be attached to both end portions of the block body. The block body is provided with a roller rolling surface and a roller returning passage for endlessly circulating a roller row, and the side cover is provided with a direction changing passage for connecting the roller rolling surface side to the roller returning passage.

[0003] Both sides of the roller rolling surface of the movable member are provided with a roller end surface guide wall for guiding an end surface of the roller, and each of the roller returning passage and the direction changing passage is also provided with a guide wall which is formed to be continuous to the roller end surface guide wall, whereby the end surfaces of the roller are guided in entire circulating passage so as to orderly circulate the rollers.

[0004] Conventionally, as to structural members such as the roller returning passage, the side cover and the roller end surface guide wall or the like, an attempt to reduce a manufacturing cost has been made by employing resin moldings as the structural members.

[0005] However, the above conventional linear roller guide devices entail drawbacks as described hereunder:

[0006] ①The manufacturing process is complicated.

[0007] That is, each of the resin molded members is a molded member which is formed separately from the block body, so that a process of assembling the respective resin molded members is required after separately forming the respective members.

[0008] ②The circulating defects of the roller at the roller rolling surface are liable to occur.

[0009] Namely, when assembled the resin molded members, irregularities are liable to occur at a connecting portion between the roller returning passage and the direction changing passage, and at a connecting portion between the roller rolling surface and the direction changing passage, so that there may be posed a problem, for example, that a smooth circulation of the rollers is obstructed and a problem of generation of an abnormal noise.

[0010] ③The circulating defects of the roller at the roller end surface are liable to occur.

[0011] In particular, in case of the roller, it is required to prevent skew of the roller (i.e. blurring of a rotational axis of the roller). In order to prevent the skew, it is required to guide the end surface of the roller not only in a range of a loaded area of the roller rolling surface but also in all around of an endlessly circulating passage ranging from the direction changing passage to the non-loaded area of the roller returning passage.

[0012] FIG. 15(*a*) shows a state that the roller **100** changes a rolling direction thereof form an unloaded area α to a loaded area β of the direction changing passage. At the time of direction changing of the roller **100**, for example, as schematically shown in FIGS. **15**(*b*) and **15**(*c*), when the roller **100** moves from the loaded area α, and then enters into the loaded area β in a skewed state, one end portion of the roller **100***a* of the roller **100** will firstly collide against the roller rolling surface **101** in the loaded area, so that the smooth movement of the roller **100** is obstructed. In addition, an edge load may occur at the end portion **100***a* of the roller **100** entering into the loaded area β, so that the roller **100** per se and the roller rolling surface **101** are damaged thereby to deteriorate durability of the guide device. Further, vibration of the roller and changes in rolling resistance during the circulation of the rollers will occur thereby to obstruct the smooth circulation of the rollers.

[0013] In order to prevent such problems, hitherto, the end surface of the roller is formed so as to be guided by the roller end surface guide wall provided at both sides of the roller rolling surface and passage walls provided at the direction changing passage and the roller returning passage. However, since the guide system is formed by connecting the discontinuous roller end surface guide wall, direction changing passage and roller returning passage, a sticking of the roller is liable to occur due to non-uniformity in a width of the respective passages and the irregularities of the connected portions thereby to also obstruct the smooth circulation of the rollers.

[0014] ④A falling-out of the roller is required to be prevented.

[0015] On the other hand, hitherto, in order to prevent the roller from failing out from the movable block when the movable block is detached from the track rail, there is a well known structure in which a chamfered portion is provided at end portion of the roller and an engaging projection with which the chamfered portion is engaged is provided at the roller end surface guide wall formed along the roller rolling surface.

[0016] However, in case of such roller retaining system, when the engaging projection interferes with the roller during the circulation of the roller, the smooth circulation of the roller is obstructed. Therefore, when assembling the guide device, it is required to provide a small gap or clearance between the roller and the engaging projection so as not to interfere the engaging projection with the roller. However, it was difficult to provide the engaging projection to an accurate position.

[0017] In addition, the chamfered portion is required to be provided, so that an effective length for bearing the load is disadvantageously shortened in a length corresponding to the length of the chamfered portion, thereby to lower the load bearing ability.

[0018] On the other hand, there is also another well-known roller retaining system in which a number of rollers are retained in form of a chain by linking the rollers in a roller chain. However, in the case of such rollers retained in the roller chain, a problem of a running-out of the roller chain will arise during the circulation of the rollers. Therefore, it is necessary to guide the roller chain along the predetermined track. However, it was difficult to accurately guide the roller chain.

[0019] The first invention has been achieved for solving the problems described above, and an object of this invention is to provide a linear roller guide device enabling to reduce the assembling processes, to accurately position the structural members to a predetermined positions of the block body, and to secure the smooth circulation of the rollers by integrally forming at least one of the roller returning passage, roller end surface guide wall and direction changing passage with the block body.

[0020] An object of the second invention is, in addition to the object described above, to provide a linear roller guide device enabling to securely prevent the roller chain from running-out during the circulation of the rollers linked by the roller chain.

DISCLOSURE OF THE INVENTION

[0021] In order to achieve the afore-mentioned object, the first invention provides a linear roller guide device comprising a track rail and a movable block assembled to the track rail through a number of rollers,

[0022] the movable block comprising:

[0023] a roller rolling surface on which the rollers roll;

[0024] a block body having a roller returning passage corresponding to the roller rolling surface;

[0025] a direction changing passage inner periphery portion formed to both end surfaces of the block body:

[0026] a pair of roller end surface guide walls formed to both sides of the roller rolling surface of the block body and adapted to guide both the end surfaces of the roller; and

[0027] side covers each having a direction changing passage outer periphery portion for forming a direction changing passage by fitting the side cover into the direction changing passage inner periphery portion formed to both end surfaces of the block body,

[0028] the track rail including a roller rolling surface extending in an axial direction corresponding to the roller rolling surface of the block body, and

[0029] the rollers circulating in an endless circulating passage constituted by a loaded area between the roller rolling surface of the block body and the roller rolling surface corresponding to the track rail, the direction changing passage and the roller returning passage,

[0030] wherein at least one of a roller returning passage forming member for forming the roller returning passage, a roller end surface guide wall forming member for forming at least one of the paired roller end surface guide wall and a direction changing passage inner periphery portion forming member for forming the direction changing passage inner periphery portion is formed as a molded body integrally formed with the block body by inserting the block body into a molding die.

[0031] According to the structure described above, the assembling of the roller end surface guide wall forming member, the roller returning passage forming member and the direction changing passage inner periphery portion forming member is not required, thus eliminating the assembling process for the members.

[0032] In addition, the roller end surface guide wall, the roller returning passage and the direction changing passage inner periphery portion can be formed at accurate positions with respect to the block body.

[0033] After the rollers are rolled from a starting end to a terminal end of the roller rolling surface of the block body, the rollers are rolled and moved to the roller returning passage through the direction changing passage, moved along the roller returning passage, and thereafter, supplied to the starting end side of the roller rolling surface through the direction changing passage formed at the other side of the roller rolling surface.

[0034] When the direction changing passage inner periphery portion forming member is integrally formed with the block body, it becomes possible to eliminate the irregularities to be formed at the connected portion between the roller rolling surface and the direction changing passage inner periphery portion. In addition, as to the roller returning passage forming member, when it is integrally formed with the block body, it also becomes possible to eliminate the irregularities to be formed at the connected portion between the direction changing passage inner periphery portion and the roller returning passage.

[0035] Further, in one aspect of this invention, the device may have a structure in which the roller returning passage and the direction changing passage inner peripheral portion are provided with guide walls for guiding the end surface of the roller, the guide wall being continuous to the roller end surface guide wall, and the roller returning passage, the roller end surface guide wall of at least one of the paired roller end surface guide walls and the direction changing passage inner peripheral portion are integrally formed with the block body.

[0036] According to the structure described above, the roller end surface guide walls of the roller returning passage and the direction changing passage in an unloaded area and the roller end surface guide wall to be formed along the roller rolling surface in loaded area can be continuously molded, so that the irregularities are not formed at the connected portions in all around the endless circulating passage, thus enables the end surface of the roller to smoothly move.

[0037] In addition, the gap or clearance between the guide wall and the roller end surface can be formed with high accuracy in all around the endless circulating passage, so that the generation of the skew of the roller can be securely prevented.

[0038] In another aspect of this invention, the device may have a structure in which a chamfered portion is provided at least one end portion of the roller and an engaging projection with which the chamfered portion of the roller is engaged is provided at the roller end surface guide wall integrally molded with the block body so as to prevent the roller from falling out.

[0039] As described above, when such engaging projection is provided at the roller end surface guide wall to be integrally molded with the block body, the engaging projection can be accurately positioned with respect to the block body, so that the falling-out of the roller can be securely prevented even if the bearing block is detached from the track rail. In addition, there is not the slightest fear of interference of the block body with the roller during the circulation of the roller.

[0040] The guide device has a structure having four rows of rollers in total in which a pair of right and left rows of rollers are disposed to be rollable between the upper surface of the track rail and a lower surface of a horizontal portion of the block body and other two rows of the rollers each is disposed between the right and left side surfaces of the track rail and an inside surfaces of a suspending portion of the block body, respectively.

[0041] In this case, it is preferable that a contact angle line constituted by a line connecting two contact points of the roller disposed between the corresponding roller rolling surfaces formed to the upper surface of the track rail and the horizontal portion of the block body is set to vertically extend with an inclination angle of about 90° with respect to a horizontal line, while a contact angle line of the roller disposed between the corresponding roller rolling surfaces formed to the right and left side surfaces of the track rail and the inside surfaces of the suspending portion of the block body is set to obliquely extend downwards and is formed so as to incline with an inclination angle of 30° with respect to a horizontal line.

[0042] In still another aspect of this invention, the guide device has a structure having four rows of rollers in total in which two rows of rollers are vertically disposed to be rollable between a right side surface of the track rail and a right inside surface of the suspending portion of the block body, and vertically disposed to be rollable between a left side surface of the track rail and a left inside surface of the suspending portion of the block body, respectively.

[0043] Among the two rows of the rollers arranged vertically at upper and lower portions, it is preferable that the upper row of rollers is formed so that a contact angle line of the roller is set to obliquely extend upwards from a side of the track rail to sides of the right and left suspending portions of the block body, and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line, while the lower row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards, and is formed so as to incline with an inclination angle of almost 45°, or that the upper row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards from a side of the track rail to sides of the right and left suspending portions of the block body, and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line, while the lower row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards, and is formed so as to incline with an inclination angle of almost 45°.

[0044] In particular, at a time of an insert molding, when a block supporting portion corresponding to the roller rolling surface of the block body is provided to an inner periphery of a molding die and the roller rolling surface is contacted to the block supporting portion, the block body can be effectively positioned in the molding die.

[0045] According to such structure, a pair of right and left roller rolling grooves (surfaces) of the block body will contact to the block supporting portion. As a result, the block body is supported by the paired right and left block supporting portions so that the block body is clamped from every four directions and supported by four points. Therefore, even if an injection pressure of a molding material is applied to the block body from every directions, the block body can be held unmoved, and the burr is not formed at a portion between the roller rolling surface and the block supporting portion.

[0046] In a second invention, there is provided a linear roller guide device comprising a track rail and a movable block assembled to the track rail through a number of rollers,

[0047] the movable block comprising:

[0048] a block body having a roller rolling surface and a roller returning passage corresponding to the roller rolling surface:

[0049] a direction changing passage inner periphery portion formed to both end surfaces of the block body: and side covers each having a direction changing passage outer periphery portion for forming a direction changing passage by fitting the side cover into the direction changing passage inner periphery portion formed at both end surfaces of the block body,

[0050] the track rail including a roller rolling surface extending in an axial direction corresponding to the roller rolling surface of the block body,

[0051] the rollers circulating in an endless circulating passage constituted by a loaded area between the roller rolling surface of the block body and the roller rolling surface corresponding to the track rail, the direction changing passage and the roller returning passage, and the rollers are linked to each other by a roller chain inserted to be movable in the endless circulating passage,

[0052] wherein the roller returning passage and the direction changing passage inner periphery guide portion are provided with a roller chain guide portion for guiding a track of the roller chain onto a predetermined track,

[0053] wherein at least one of the roller returning passage forming member for forming the roller returning passage and the direction changing passage inner periphery portion forming member for forming the direction changing passage inner periphery portion is integrally molded by inserting the block body into a molding die.

[0054] According to the structure described above, the rollers can be smoothly rolled and moved in the endless circulating passage while being kept in a state where center axes of the respective rollers are retained in parallel to each other and intervals of adjacent rollers are retained in a predetermined distance, thus enabling to prevent the skew-generation.

[0055] In addition, the roller chain is guided onto the predetermined track by the roller chain guide portions formed to the roller returning passage and the direction changing passage, and the rollers shall be accurately guided by the roller chain guided by the roller chain guide portion. Further, a run-out of the roller chain can be prevented by the roller chain guide portion.

[0056] In addition, when the roller returning passage forming member for forming the roller returning passage and the direction changing passage inner periphery portion forming member for forming the direction changing passage inner periphery portion to which the roller chain guide portions are formed are integrally molded with the block body, the roller chain guide portions can be formed on accurate positions of the track.

[0057] In addition, when the direction changing passage inner periphery portion forming member is integrally formed with the block body, it becomes possible to eliminate the irregularities to be formed at the connected portion between the roller rolling surface and the direction changing passage inner periphery portion. Further, as to the roller returning passage, when it is integrally formed with the block body, it also becomes possible to eliminate the irregularities to be formed at the connected portion between the direction changing passage inner periphery portion and the roller returning passage. As a result, the rollers can be further smoothly circulated and moved in cooperation with the guiding function of the roller chain.

[0058] Furthermore, when the roller chain is formed so as to have an endless structure and is provided with a falling-out preventing portion for the rollers, the falling-out of the rollers can be prevented by the roller chain even if the movable block is detached from the track rail.

[0059] Further, the roller chain is preferably provided with a guide projecting portion so as to project from the end surface of the roller in an axial direction of the roller, while the roller returning passage and the direction changing passage inner peripheral portion are preferably provided with guide grooves with which the guide projecting portion is engaged. In addition, at least one side of the roller rolling surfaces formed to the block body is preferably provided with a guide wall having the guide groove extending in parallel to the roller rolling surface for guiding the guide projecting portion in parallel to the roller rolling surface. As to this guide wall, it is also preferable to integrally mold the guide wall with the block body by using an insert molding method and to continuously form the guide groove to the roller returning passage, the direction changing passage inner periphery portion and the guide wall so that the guide groove ranges to all around the endless circulating passage.

[0060] According to the structure described above, when the roller chain is circulated and moved, the guide projecting portion is engaged with the guide groove formed to the roller returning passage and the direction changing passage inner peripheral portion, so that the run-out of the roller chain is suppressed. As a result, the rollers can be rolled and moved in orderly arranged state in all around the endless circulating passage.

[0061] In addition, in a case where the roller chain is formed in a striped-shape having no connected portion at both ends thereof, when the movable block is detached from the track rail, the guide projecting portion is engaged with the guide groove, thus enabling to prevent a sagging or slack of an end portion of the roller chain. Further, also in a case of the roller chain having an endless structure, the sagging or slack of an intermediate portion of the roller chain can be prevented.

[0062] In still another aspect of this invention, the roller chain comprises spacer portions disposed between the adjacent rollers and connecting portions for connecting the respective spacer portions, and the guide projecting portion is provided to the connecting portion.

[0063] Accordingly, each of the rollers is arranged and circulated in a state where the rollers are retained by the spacer portions form back and forth in the arranging direction thereof.

[0064] Further, when a falling-out preventing portion for the roller is provided to the spacer portion so as to prevent the falling-out of the roller from back and forth of the roller, it becomes unnecessary to chamfer the end portion of the roller, so that an effective length of the roller for bearing the load can be increased.

[0065] Furthermore, since only the spacer portion is disposed between the adjacent rollers, a pitch of the rollers can be formed as small as possible, so that a number of the rollers to be disposed per unit length for bearing the load can be increased as many as possible, thus improving the load bearing ability of the roller.

[0066] In still another aspect of this invention, the connecting member and the spacer portion disposed between the adjacent rollers are formed as resin moldings, the roller is formed to have a hollow portion, and the roller is retained by inserting a resin portion into the hollow portion of the roller.

[0067] According to the structure described above, the falling-out of the roller can be surely prevented and a degree of parallelization between the adjacent rollers can be accurately maintained.

[0068] In addition, the roller may be retained in such a manner that a recessed portion is formed to both end portions of the roller and the resin portion is inserted into the recessed portion or in a manner that a grooved portion is formed to a center peripheral portion of the roller and the resin portion is fitted into the grooved portion.

[0069] When the roller chain moves at portion between the roller rolling surfaces and the unloaded roller rolling passage, the roller chain takes a linear shape. In contrast, when the roller chain moves in the direction changing passage, the roller chain is deformed from linear-shape to a curved-shape. As a result, the roller chain is repeatedly deformed in accordance with the movement of the movable block.

[0070] In view of this point, it is preferable to reinforce the roller chain by inserting a wire or thin plate into the connecting member.

[0071] In the guide device of the present invention, the number of rollers and arrangement thereof are optional. However, the following arrangements are more effective.

[0072] That is, the guide device may have a structure having four rows of rollers in total in which a pair of right and left rows of rollers are disposed to be rollable between the upper surface of the track rail and a lower surface of a horizontal portion of the block body, and one row of the roller is disposed between the right and left side surfaces of the track rail and inside surfaces of a suspending portion of the block body, respectively.

[0073] In this case, it is preferable that a contact angle line constituted by a line connecting two contact points of the roller disposed between the corresponding to the roller rolling surfaces formed to the upper surface of the track rail and the horizontal portion of the block body is set to vertically extend with an inclination angle of about 90° with respect to a horizontal line, while a contact angle line of the roller disposed between the corresponding roller rolling surfaces formed to the right and left side surfaces of the track rail and the inside surfaces of the suspending portion of the block body is set to obliquely extend downwards and is formed so as to incline with an inclination angle of 30° with respect to a horizontal line.

[0074] In addition, the guide device may have a structure having four rows of rollers in total in which two rows of rollers are vertically disposed at upper and lower portions to be rollable between a right side surface of the track rail and a right inside surface of the suspending portion of the block body, and vertically disposed to be rollable between a left side surface of the track rail and a left inside surface of the suspending portion of the block body, respectively.

[0075] Among the two rows of the rollers arranged vertically, it is preferable that the upper row of rollers is formed so that a contact angle line of the roller is set to obliquely extend upwards from a side of the track rail to sides of the right and left suspending portions of the block body and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line, while the lower row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards, and is formed so as to incline with an inclination angle of almost 45°; or that the upper row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards from a side of the track rail to sides of the right and left suspending portions of the block body and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line, while the lower row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards and is formed so as to incline with an inclination angle of almost 45°.

[0076] In particular, at a time of an insert molding, when a block supporting portion corresponding to the roller rolling surface of the block body is provided to an inner periphery of a molding die and the roller rolling surface is contacted to the block supporting portion, the block body can be effectively positioned in the molding die.

[0077] According to such structure, a pair of right and left roller rolling grooves (surfaces) of the block body will contact to the block supporting portion. As a result, the block body is supported by the paired right and left block supporting portions so that the block body is clamped from every four directions and supported by four points. Therefore, even if an injection pressure of a molding material is applied to the block body from every directions, the block body can be held unmoved, and the burr is not formed at a portion between the roller rolling surface and the block supporting portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0078] **FIG. 1** is a view showing one embodiment of a linear roller guide device according to the first invention.

[0079] **FIG. 2** is also a view showing one embodiment of the first invention.

[0080] **FIG. 3** is a view showing various modifications of the roller end surface guide walls and roller retaining structures for the linear roller guide device shown in **FIG. 1**.

[0081] **FIG. 4** is an explanatory view showing a molding method of a movable block for the linear roller guide device shown in **FIG. 1**.

[0082] **FIG. 5** is a view showing a modification of a roller returning passage forming member shown in **FIG. 1**.

[0083] **FIG. 6** is a view showing another roller contact angle structure of the embodiment according to the first invention.

[0084] **FIG. 7** is a view showing still another roller contact angle structures of the embodiment according to the first invention in which **FIG. 7**(*a*) is a cross sectional view of the linear roller guide device and **FIG. 7**(*b*) is a cross sectional view showing a direction changing passage.

[0085] **FIG. 8** is a view showing one embodiment of a linear roller guide device according to the second invention in which a roller chain is used.

[0086] **FIG. 9** is a view showing structures of chain guide portions and roller chains in **FIG. 8**.

[0087] **FIG. 10** is a view showing another embodiment of the roller chain shown in **FIG. 9**.

[0088] **FIG. 11** is a view showing a modification of the roller end surface guide wall for the linear roller guide device shown in **FIG. 8** and another structure of the roller returning passage forming member.

[0089] **FIG. 12** is a view showing a molding method of a movable block shown in **FIG. 8**.

[0090] **FIG. 13** is a view showing another roller contact angle structure of the embodiment according to the second invention.

[0091] **FIG. 14** is a view showing another roller contact angle structure of the embodiment according to the second invention.

[0092] **FIG. 15** is an explanatory view showing a state where a roller-skew occurs in a conventional linear roller guide device.

BEST MODE FOR EMBODYING THE INVENTION

The First Invention

[0093] Hereunder, the first invention will be explained with reference to the accompanying drawings.

[0094] **FIGS. 1 and 2** are views showing an embodiment of a linear roller guide device according to the first invention. The linear roller guide device **1** comprises a track rail **2**, four rows of rollers **3** in total of which two rows of rollers are disposed to an upper side surface of the track rail **2** and one row of rollers is disposed to both right and left side surfaces of the track rail **2** respectively, and a movable block **4** assembled to be movable through the four rows of rollers **3**.

[**0095**] The track rail **2** is an elongated member formed to have a rectangular shape in section, an upper portion of both the side surfaces of the track rail being formed to have tapered surfaces which gradually expand outwardly in upward direction, and each of the right and left tapered surfaces is provided with one row of roller rolling surface **5**, respectively. In addition, the upper surface of the track rail **2** is formed to be a plain surface of which both right and left end portions are provided with one row of roller rolling surface **6**, respectively, i.e., two rows of the roller rolling surfaces **6** in total.

[**0096**] The movable block **4** comprises a block body **40** formed of metal, and side covers **11** to be attached to both end surfaces of the block body **40**.

[**0097**] The block body **40** has a U-shaped cross section and high rigidity, and comprises a horizontal portion **41** opposing to the upper surface of the track rail **2**, a pair of suspending portions **42** and **42** suspending from the right and left end portions of the horizontal portion **41** so as to clamp both the right and left side surfaces of the track rail **2**. A lower surface of the horizontal portion **41** is provided with a pair of roller rolling surfaces **7**, **7** corresponding to the paired roller rolling surfaces **6**, **6** formed to the upper surface of the track rail **2**, while each of inner side surfaces of the right and left suspending portions **42**, **42** is provided with a roller rolling surface **8** corresponding to the respective roller rolling surfaces **5**, **5** formed to the right and left side surfaces of the track rail **2**.

[**0098**] A number of rollers **3** are disposed between four pairs of roller rolling surfaces **5**, **8**; **6**, **7**, corresponding to each other, that are formed to opposing surfaces between the track rail **2** and the movable block **4**, whereby roller rows for bearing a load to be applied to portions between the track rail **2** and the movable block **4** are assembled. A predetermined pre-load is applied to respective rollers **3**. The roller **3** is formed as a cylindrical roller. However, as shown in **FIG. 3**(*d*), a barrel-shaped roller having a circular-arc shaped cross section in axial direction can be also available as the roller **3**.

[**0099**] Each of the rollers **3** linearly contacts to the roller rolling surfaces **5**, **8**; **6**, **7**. A contact angle line L1 constituted by a line connecting two contact portions of the roller disposed between the corresponding to the roller rolling surfaces **5**, **8**; **6**, **7** formed to the upper surface of the track rail **2** and the horizontal portion **41** of the block body **40** is set to vertically extend with an inclination angle of about 90° with respect to a horizontal line passing through a center of the roller **3**, while a contact angle line of the roller **3** disposed between the corresponding to the roller rolling surfaces formed to the right and left side surfaces of the track rail **2** and the inside surfaces of the right and left suspending portions **42**, **42** of the block body **40** is set to obliquely extend toward a center of the track rail **2** and is formed so as to upwardly incline with a predetermined angle of α with respect to a horizontal line H passing through a center of the roller **3**, thereby to form a structure in which both the right and left corner portions **22**, **22** of an upper portion of the track rail **2** are clamped by the two rows of rollers **3**, **3** disposed to the right and left sides of the track rail **2** and by the two rows of rollers **3**, **3** disposed to the upper surface side of the track rail **2**. In the embodiment shown in Figure, the angle of α is set to about 30°.

[**0100**] The block body **40** is provided with four rows of the roller returning passages **9** for circulating and guiding the four rows of rollers **3**. The roller returning passage **9** linearly extend in parallel to the respective roller rolling surfaces **5**, **6** formed to the block body **40**. Two rows of the roller returning passages **9** are provided to the horizontal portion **41**, while two rows of the roller returning passages **9** are respectively provided to the right and left suspending portions of the block body **40**. The roller returning passage **9** is formed from a roller returning passage forming member **91** composed of resin.

[**0101**] The roller returning passage forming member **91** is integrally bonded to an inner peripheral portion of a penetration bore **43** penetrating through the horizontal portion **41** and the suspending portion **42** of the block body **40**. An outer peripheral shape of the roller returning passage forming member **91** is formed to have a cylindrical shape which conforms to an inner peripheral shape of the penetration bore **43**. The inner periphery of the roller returning passage forming member **91** is provided with a roller returning passage **9** having a rectangular cross section for guiding the roller **3**.

[**0102**] The roller returning passage **9** comprises a pair of unloaded roller guide surfaces **9***a*, **9***b* extending in parallel to each other for guiding a cylindrical outer periphery surface of the roller **3**, and a pair of unloaded roller end surface guide surfaces **9***c*, **9***c* extending in parallel to each other for guiding end surfaces of the roller **3**.

[**0103**] A gap or clearance between the paired unloaded roller guide surfaces **9***a*, **9***b* is set to slightly larger than a diameter of the roller **3** so as to form a small gap therebetween, while a gap or clearance between the paired unloaded roller end surface guide surfaces **9***c*, **9***c* is set to slightly larger than a length of the roller **3** so as to form a small gap therebetween, thus resulting in a structure enabling to smoothly move the rollers **3** (see **FIG. 3**(*e*)).

[**0104**] **FIG. 5** shows another embodiment of a roller returning passage forming member **92** to be formed to the suspending portion **42** of the block body **40**. Namely, the roller returning passage forming member **92** is integrally bonded to a recessed portion **44** formed to a lower end portion of the right and left suspending portions **42** of the block body **40**. The roller returning passage forming member **91** is integrally connected to a third loaded roller end surface guide wall forming member **143** provided to the inner peripheral side of the suspending portion **42**.

[**0105**] According to the structure described above, the block body **40** is required to be provided with only two penetration bores **43** to be formed to the horizontal portion **41**, thus enabling to simplify the manufacturing of the device.

[**0106**] In addition, as shown in FIGS. **1**(*b*), (*c*) and **2**, both end portions of the block body **40** are provided with side covers **11** constituting a direction changing passage **10** for changing the rolling direction of the roller **3** to the roller returning passage **9**, the roller **3** being disposed between the loaded roller rolling surfaces **5**, **8**; **6**, **7** formed to the track rail **2** and the block body **40**.

[0107] The direction changing passage **10** is formed to be a pipe having a U-shape. The side cover **11** is formed with only a direction changing passage inner periphery portion **10***a* of the direction changing passage **10**, while a direction changing passage inner periphery portion forming member **12** is integrally bonded to both end portions of the block body **40**.

[0108] This direction changing passage **10** has a rectangular shaped cross section, and both side portions of the direction changing passage outer periphery portion **10***a* and the inner periphery portion **10***b* for guiding the outer periphery surface of the roller **3** are provided with direction changing roller end surface guide walls **10***c*, **10***c* for guiding the end surfaces of the roller **3**. This direction changing roller end surface guide walls **10***c* together with the direction changing passage inner periphery portion **10***b* are formed to the direction changing passage inner periphery portion forming member **12**. Then, when the side cover **11** formed with the direction changing passage outer periphery portion **10***a* is fitted into the end surface of the block body **40** formed with the direction changing passage inner periphery portion **10***b* and the direction changing roller end surface guide walls **10***c*, the direction changing passage **10** having a U pipe shape is formed.

[0109] In this regard, the direction changing roller end surface guide walls **10***c*, **10***c* together with the direction changing passage outer periphery portion **10***a* may be provided to the side cover **11**. In another way, one direction changing roller end surface guide wall **10***c* together with the direction changing passage inner periphery portion **10***b* may be provided to a side of the direction changing passage inner periphery portion forming member **12**, while the other direction changing roller end surface guide walls **10***c* together with the direction changing passage outer periphery portion **10***a* may be provided to the side cover **11**.

[0110] In still another way, the direction changing roller end surface guide wall **10***c* is divided into two portions i.e., an inner periphery side portion and an outer periphery side portion, and then, the outer periphery side portion may be formed to the side cover **11**, while the inner periphery side portion may be provided to the direction changing passage inner periphery portion forming member **12**.

[0111] Further, as shown in **FIG. 1**(*a*) , along the respective four rows of roller rolling surfaces **7**, **8** of the block body **40**, there is provided with a loaded roller end surface guide wall **13** for guiding the end surfaces of the roller in the loaded area. In order to form the loaded roller end surface guide wall **13**, the block body **40** comprises a first end surface guide wall forming member **141** to be integrally bonded to a lower surface of the horizontal portion **40**, right and left second end surface guide wall forming members **142** to be integrally bonded to recessed corner portions between the horizontal portion **41** and the right and left suspending portions **42**, and right and left third end surface guide wall forming members **143** to be integrally bonded to a lower portion of inner side surface of the right and left suspending portions **42**.

[0112] The both end portions of the first end surface guide wall forming member **141** and an upper end portion of the second end surface guide wall forming members **142** are provided with loaded roller end surface guide walls **13**, **13**; **13**, **13** for guiding the end surfaces of the roller **3** rolling on the roller rolling surfaces **7**, **7** formed to the lower surface of the horizontal portion **41** of the block body **40**.

[0113] In addition, the lower end portions of the right and left second end surface guide wall forming member **142** and an upper end portion of the third end surface guide wall forming members **143** are provided with loaded roller end surface guide walls **13**, **13**; **13**, **13** for guiding the end surfaces of the roller **3** rolling on the roller rolling surfaces **8**, **8** formed to the suspending portion **42** of the block body **40**.

[0114] A gap or clearance between the paired loaded roller end surface guide walls **13**, **13** is set to slightly larger than a length of the roller **3** so as to form a small gap between the end surface of the roller **3** and the guide wall **13**.

[0115] Further, a first seal member **15** for sealing the gap formed between the horizontal portion **41** of the block body **40** and the upper surface of the track rail **2** is attached to the first end surface guide wall forming member **141**, while a second seal member **16** for sealing the gap formed between the suspending portion **42** of the block body **40** and the right and left side surfaces of the track rail **2** is attached to the third end surface guide wall forming member **143**.

[0116] In this embodiment, the loaded roller end surface guide walls **13** for guiding both end surfaces of the roller **3** is formed by the first to third end surface guide wall forming members **141**-**143** that are all composed of resin.

[0117] However, as shown in **FIG. 3**(*a*), the loaded roller end surface guide walls **13** for guiding one end surface of the roller **3** may be formed by the block body **40** per se, while the loaded roller end surface guide wall **13** for guiding the other end surface of the roller **3** may be formed by the loaded roller end surface guide wall forming member **14**. In another way, as shown in **FIG. 3**(*f*), both side of the loaded roller end surface guide walls **13** can be also formed by the block body **40**.

[0118] In this first embodiment, all of the roller returning passage forming member **91**, the roller end surface guide wall forming members **141**-**143** and the direction changing passage inner periphery portion forming member **12** are formed by integrally molding with the movable block.

[0119] Accordingly, the unloaded roller guide surfaces **9***a*, **9***b* of the roller returning passage **9** and both the inner and outer periphery portions **10***a*, **10***b* of the direction changing passage can be continuously and integrally molded. Further, the direction changing passage inner periphery portion **10***b* and the roller rolling surfaces **7**, **8** in the loaded area can be also integrally molded.

[0120] In addition, the roller end surface guide wall **9***c* of the roller returning passage **9**, the direction changing roller end surface guide wall **10***c* of the direction changing passage **10** and the loaded area roller end surface guide wall **13** are continuously formed by being integrally molded, so that the roller end surface guide wall can be continuously formed in all around the endless circulating passage.

[0121] According to the linear roller guide device of this invention, the assembling of the loaded roller end surface guide wall forming member **14**, the roller returning passage forming member **91** and the direction changing passage inner periphery portion forming member **12** is not required, thus enabling to omit the assembling process for the members.

[0122] In addition, the roller end surface guide wall **13**, the roller returning passage **9** and the direction changing passage inner periphery portion **10***b* can be provided at accurate positions with respect to the block body **40**.

[0123] As a result, after the rollers **3** are rolled from a starting end to a terminal end of the roller rolling surfaces **7**, **8** in the loaded area of the block body **40**, the rollers **3** are moved to the roller returning passage **9** through the direction changing passage **10**, then moved along the roller returning passage **9**, and thereafter, supplied to the starting end side of the roller rolling surfaces **7**, **8** through the direction changing passage **10** formed at the other end of the roller rolling surfaces **7**, **8**.

[0124] When the direction changing passage inner periphery portion forming member **12** is integrally formed with the block body **40**, it becomes possible to eliminate the irregularities to be formed at the connected portion between the roller rolling surfaces **7**, **8** and the direction changing passage inner periphery portion **10***b*. In addition, as to also the roller returning passage forming member **91**, when the member **91** is integrally formed with the block body **40**, it also becomes possible to eliminate the irregularities to be formed at the connected portion between the direction changing passage inner periphery portion **10***b* and the roller returning passage **9**.

[0125] Further, when the roller returning passage forming member **91** and the direction changing passage inner peripheral portion forming member **12** are provided with unloaded roller end surface guide wall **9***c* and the direction changing roller end surface guide wall **10***c* for guiding the end surface of the roller, the guide walls being continuous to the loaded roller end surface guide wall **13** and these roller end surface guide walls are integrally formed with the block body **40**, the loaded roller end surface guide wall **13**, the direction changing roller end surface guide wall **10***c* and the unloaded roller end surface guide wall **9***c* can be continuously molded in all around the endless circulating passage without forming the irregularities at the connected portions of the guide walls, thus enabling the end surface of the roller to smoothly move.

[0126] In addition, the gaps or clearances between the the loaded roller end surface guide wall **13**, the direction changing roller end surface guide wall **10***c*, the unloaded roller end surface guide wall **9***c* and the roller end surfaces can be accurately maintained to constant values, so that the gaps or clearances can be limited to a small value, and the skew of the roller **3** can be securely prevented.

[0127] In addition, as shown in FIGS. **3**(*b*) and **3**(*c*), the device may have a structure in which a chamfered portion **3***a* is provided at least one end portion of the roller **3** while an engaging projection **13***a*, with which the chamfered portion **3***a* of the roller **3** is engaged, is provided at the loaded roller end surface guide wall **13** integrally molded with the block body **40** so as to prevent the roller **3** from falling out when the movable block **4** is detached from the track rail **2**. A small gap is formed between the engaging projection **13***a* and the roller **3** so that the engaging projection **13***a* would not interfere with the roller **3** when the rollers **3** roll and move between the roller rolling surfaces **6**, **7**; **5**, **8**.

[0128] As described above, when the engaging projection **13***a* is provided at the roller end surface guide wall **13** to be integrally molded with the block body **40**, the engaging projection **13***a* can be accurately positioned with respect to the block body **40**, and the gap between the engaging projection **13***a* and the chamfered portion **3***a* of the roller **3** can be accurately maintained to a constant value, whereby there is no fear of interference of the engaging projection **13***a* with the roller during the circulation of the roller **3**.

[0129] The integrally molding of the roller returning passage forming member **91**, the direction changing passage inner peripheral portion forming member **12** and the loaded roller end surface guide wall **13** with the block body **40** is performed in accordance with an insert molding method comprising the steps of disposing the block body **40** into a molding die **15** on the basis of the roller rolling surfaces **7**, **8** formed to the block body **40**, forming cavities corresponding to the respective resin molded portions to be formed between an inner wall of the molding die **15** and the block body **40**, and injecting a molding material into the respective cavities to form the resin molded portions.

[0130] **FIG. 4** is a schematic view showing the block body **40** and states where the molding dies **15** are clamped or opened at the time of the insert molding. Namely, a fixed molding die **15***a* is provided with block supporting portions **15***b* to which the roller rolling surfaces **7**, **7**; **8**, **8** are fitted for positioning, while a movable molding die **15***c* is provided with pins **15***d* for forming the roller returning passage.

[0131] The block supporting portions **15***b* have plain shapes corresponding to the roller rolling surfaces **7**, **7**; **8**, **8** and linearly extend in parallel to each other. In this regard, FIGS. **4**(*b*) and **4**(*c*) show only a circumference of the roller returning passage **9** of a side of the suspending portion **42**.

[0132] Cavities **15***e* for forming the roller returning passage forming member **91** are provided to inside the penetration bores **43** formed in the horizontal portion **41** and the suspending portion **42** of the block body **40**, respectively. Further, cavities **15***f*-**15***h* for forming the first to third loaded roller end surface guide wall forming members **141**-**143** are provided to inner periphery portions of the horizontal portion **41** and the suspending portion **42**, respectively. Furthermore, cavities **15***i* for forming the direction changing passage inner periphery portion forming members **12** are provided to both front and back end portions of the block body **40**, respectively.

[0133] In this embodiment, the paired right and left roller rolling surfaces **7**, **7**: **8**, **8** of the block body **40** are supported at four points by the block supporting portions **15***b* of the molding die **15**. As a result, the block body **40** can be supported unmoved by the block supporting portions **15***b*, even if an injection pressure of a molding material is applied to the block body **40** from every directions, whereby the roller returning passage **9**, the direction changing inner periphery portion **10***b* and the first to third loaded roller end surface guide walls **131**-**133** can be accurately formed at predetermined positions.

[0134] In addition, since the block body **40** is stably positioned in the molding die **15**, the burr is not formed at portions between the roller rolling surfaces **7**, **7**: **8**, **8**.

[0135] It is preferable that the block supporting portions **15***b* closely contact to the roller rolling surfaces **7**, **8**. However, even the block supporting portions **15***b* and the roller rolling surfaces **7**, **8** are moved in a small distance due to a small gap formed therebetween, the small gap can be allowed as far as a dimension accuracy is within an allowable range and the resin material would not penetrate through the gap.

Modifications of Roller Contact Angles

[0136] Though the explanation described above has been made by taking an example of a case in which total four rows of rollers are disposed between corresponding portions i.e., the right and left two rows of rollers being disposed between the upper surface of the track rail **2** and the lower surface of the horizontal portion **41** of the block body **40** while one row of rollers being disposed between the right and left side surfaces of the track rail **2** and the inner side surfaces of the right and left suspending portions **42** respectively, a number and an arrangement of the roller rows are optional.

[0137] For example, as shown in **FIGS. 6 and 7**, the device may have a structure having four rows of rollers in total of which right and left two rows of rollers are disposed between the right and left side surfaces of the track rail **2** and the inner side surfaces of the right and left suspending portions **42** of the block body **40**, respectively.

[0138] **FIG. 6** shows an example having a structure in which the upper row of rollers **3** among the two rows of the rollers **3** arranged vertically is formed so that a contact angle line L1 of the roller **3** is set to obliquely extend upwards from a side of the track rail **2** to the right and left suspending portions **42** of the block body **40** and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line H, while the lower row of rollers **3** is formed so that a contact angle line L2 of the roller **3** is set to obliquely extend downwards, and is formed so as to incline with an inclination angle of almost 45°.

[0139] **FIG. 7** shows an example having a structure in which the upper row of rollers **3** among the two rows of the rollers **3** arranged vertically is formed so that a contact angle line L1 of the roller **3** is set to obliquely extend downwards from a side of the track rail to sides of the right and left suspending portions **42, 42** of the block body **40** and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line, while the lower row of rollers **3** is formed so that a contact angle line L2 of the roller **3** is set to obliquely extend upwards, and is formed so as to incline with an inclination angle of almost 45°.

[0140] In the case of this embodiment, the direction changing passages **10**A, **10**B of vertically arranged two rows of rollers **3** disposed to both end portions of the block body **40** are arranged alternately with a predetermined interval in an axial direction so as to intersect to each other. In this case, the direction changing passage inner peripheral portion forming member **12** formed to the end surface of the block body **40** is provided with the direction changing passage inner periphery portion **10***b* of the direction changing passage **10**A of a side close to the block body **40** and the direction changing roller end surface guide wall **10***c*, the inner periphery portion **10***b* and the guide wall **10***c* being integrally molded with the block body **40**.

[0141] As to the direction changing passage **10**B far from the block body **40**, at least one portion of the loaded roller rolling surfaces **7, 8** of an end surface side of the block body **40**, the direction changing passage inner periphery portion **10***b* of a part which is connected to an end portion of the roller returning passage **9** and the direction changing roller end surface guide wall **10***c* are integrally molded with the block body **40**. While, a round piece **10**C formed with the direction changing passage inner periphery portion **10***b* is attached to a part far from the direction changing passage **10**A. An inner periphery of this round piece **10**C is formed with a part of an outer periphery guide portion of the inside direction changing passage **10**A. The side cover **11** is formed with the direction changing passage outer peripheral portions **10***a*, **10***a* for both the direction changing passages **10**A, **10**B arranged vertically.

[0142] According to the first invention described above, the assembling of the roller end surface guide wall, the roller returning passage and the direction changing passage inner periphery portion is not required, thus eliminating the assembling process for the members.

[0143] In addition, the roller end surface guide wall, the roller returning passage and the direction changing passage inner periphery portion can be formed at accurate positions with respect to the block body.

[0144] When the direction changing passage inner periphery portion is integrally formed with the block body, it becomes possible to eliminate the irregularities to be formed at the connected portion between the roller rolling surface and the direction changing passage inner periphery portion. In addition, as to the roller returning passage, when it is integrally formed with the block body, it also becomes possible to eliminate the irregularities to be formed at the connected portion between the direction changing passage inner periphery portion and the roller returning passage.

[0145] Further, when the roller returning passage and the direction changing passage inner peripheral portion are provided with guide walls for guiding the end surface of the roller, the guide wall being continuous to the roller end surface guide wall, and the roller returning passage, the roller end surface guide wall of at least one the paired roller end surface guide walls and the direction changing passage inner peripheral portion are integrally formed with the block body, so that the roller returning passage, the guide walls of the direction changing passage inner periphery portions and the roller end surface guide walls can be continuously molded, whereby irregularities are not formed at the connected portions, thus enabling the end surface of the roller to smoothly move.

[0146] In addition, the guide walls for the roller end surfaces can be integrally formed in continuous in all around the endless circulating passage and a gap between the guide wall and the end surface of the roller can be formed with a high accuracy, so that the skew of the roller can be securely prevented.

[0147] In addition, when the engaging projection for preventing the roller from falling out by engaging with the chamfered portion of the roller is provided at the roller end surface guide wall to be integrally molded with the block body, the engaging projection can be accurately positioned with respect to the block body, so that the falling-out of the roller can be surely prevented even if the bearing blocks is detached from the track rail. In addition, there is no fear of interference of the block body with the roller during the circulation of the roller.

[0148] In addition, at a time of an insert molding, when a block supporting portion having a shape obtained by cutting an outer peripheral portion of the roller with a cross section passing through a center axis of the roller is provided to an inner periphery of a molding die so as to correspond to the roller rolling surface of the block body and the block body is positioned in the molding die by contacting the roller rolling surface to the block supporting portion, the burr would not occur at the roller rolling surfaces.

[0149] In particular, when the paired right and left roller rolling surfaces of the block body are supported by the block supporting portions of the molding die, the block body is clamped from every four directions and supported by the paired right and left block supporting portions at four points. Therefore, even if an injection pressure of a molding material is applied to the block body from every directions, the block body can be held unmoved, and the block body can be accurately positioned.

Second Invention

[0150] Next, an embodiment of a second invention will be explained hereunder with reference to the accompanying drawings.

[0151] **FIGS. 8 and 9** disclose embodiments of linear roller guide devices according to the second invention, respectively.

[0152] The linear roller guide device **201** comprises a track rail **202** and a movable block **204** assembled to be movable on an upper surface of the track rail **202** through four rows of rollers **203** in total of which two rows of rollers are disposed on an upper surface side of the track rail **202** and one row of rollers is disposed on the right and left side surface sides of the track rail **202**, respectively.

[0153] Each of the four rows of the rollers **203** circulates in an endless circulating passage constituted by the loaded area between the roller rolling surfaces **206**, **207**; **205**, **208** of the block body **2040** and corresponding to the track rail **202**, the direction changing passage **210** and the roller returning passage **209**. In this regard, the embodiment of this second invention is different form that of the first invention in a point where the rollers **203** are linked to each other by a roller chain **218** inserted to be movable in the endless circulating passage.

[0154] The roller chain **218** is a resin molded product, as shown in **FIG. 9**(*c*)-(*e*), and comprises spacer portions **218***a* disposed between the adjacent rollers **203** and connecting bands (plates) **218***b* as connecting members for connecting the respective spacer portions **218***a*, the connecting bands **218***b* being flexible and having a thin plate-shape.

[0155] Both side surfaces of the spacer portion **218** is provided with a retaining recessed portion **218***c* for constituting the falling-out preventing portion having a circular-arc shape corresponding to a cylindrical surface of the roller **203**. The connecting plates **218***b* are positioned on a virtual surface connecting the center axes of the respective rollers **203**.

[0156] The spacer portion **218***a* is a member having a rectangular parallelepiped shape and a predetermined thickness so as to be disposed between the rollers **203** and has almost the same length in axial direction as that of the roller **203** and a width shorter than a diameter of the roller **203**. In addition, side surfaces in a thickness direction of the spacer portion **218***a* to which the roller **203** contacts are formed with retaining recessed portions **218***c* having a circular-arc shape corresponding to the shape of the roller **203**.

[0157] Both side end portions in axial direction of the roller of the connecting band **218***b* of the roller chain **218** project from the end surfaces of the roller in axial direction of the roller thereby to form guide projecting portions **2181**.

[0158] Each of the rollers **203** is retained from back and forth in an arranging direction by the respective spacer portions **218***a* of the roller chain **218**, so that it becomes unnecessary to form the chamfered portion to the end portion of the roller. As a result, a load can be supported by an entire length of the roller **203**, and an effective length of the roller **203** for bearing the load can be increased.

[0159] Furthermore, since only the spacer portion **218***a* is disposed between the adjacent rollers **203**, a pitch of the rollers **203** can be formed as small as possible, so that a number of the rollers **203** to be disposed per unit length for bearing the load can be increased as many as possible, thus improving the load bearing ability of the roller **203**.

[0160] **FIG. 10**(*a*) shows an example of the roller chain **218** of a case where the roller **2031** has a hollow structure having a penetration bore **2032**. In the case of the roller **203** having the hollow structure, a pre-load can be easily applied in comparison with a case of a solid roller **203**, thus resulting in advantage.

[0161] A shaft portion **218***d* to be inserted into the penetration bore **2032** is formed to the roller chain **218**, whereby the roller chain **218** is integrated with the roller **203**. According to the structure described above, the falling-out of the roller **203** can be securely prevented, and the degree of parallelization between the respective rollers **203** can be accurately maintained.

[0162] **FIG. 10**(*b*) shows an example of the roller chain **218** of a case where the roller **2034** has a structure having recessed portions **2033** at its both ends.

[0163] The roller chain **218** is provided with convex portions **218***e* to be rotatively inserted into the recessed portions **2033** formed to both the end portions of the roller **203**. According to this structure, the falling-out of the roller **2034** can be surely prevented, and the degree of parallelization between the respective rollers **2034** can be accurately maintained.

[0164] **FIG. 10**(*c*) shows an example of the roller chain **218** of a case where the roller **2036** has a structure having a circular groove **2035** at a center of outer periphery of the roller **2036**.

[0165] The roller **203** is retained by fitting a ring member **218***f* formed to the roller chain **218** into the circular groove **2035** of the roller chain **218**.

[0166] On the other hand, **FIG. 10**(*d*) shows an example of the roller chain **218** of a case where the connecting plate **218***b* of the roller chain **218** is reinforced. Namely, the roller **218** is moved in the endless circulating passage having a track shape in accordance with the movement of the movable block **204**, and the roller chain **218** is repeatedly subjected to deformations from a linear-shape to a curved-shape, so that it is required to increase a fatigue strength of the roller chain **218**.

[0167] In view of this point, it is preferable to reinforce the connecting plate **218***b* for linking the roller **203** by inserting reinforcing members **218***g* such as wire, thin plate or the like into the connecting plate **218***b*.

[0168] The track rail **202** is an elongated member formed to have a rectangular shape in section, an upper portion of both the side surfaces of the track rail being formed to have tapered surfaces which gradually expand outwardly in upward direction, and each of the right and left tapered surfaces is provided with one row of roller rolling surface **205**, respectively. In addition, the upper surface of the track rail **202** is formed to be a plain surface of which both right and left end portions are provided with one row of roller rolling surface **206**, respectively, i.e., two rows of the roller rolling surfaces **206** in total.

[0169] The movable block **204** comprises a block body **2040** formed of metal, and side covers **211** to be attached to both end surfaces of the block body **2040**.

[0170] The block body **2040** has a U-shaped cross section and high rigidity and comprises a horizontal portion **2041** opposing to the upper surface of the track rail **202**, a pair of suspending portions **2042, 2042** suspending from the right and left end portions of the horizontal portion **2041** so as to clamp both the right and left side surfaces of the track rail **202**. A lower surface of the horizontal portion **2041** is provided with a pair of roller rolling surfaces **207, 207** corresponding to the paired roller rolling surfaces **206, 206** formed to the upper surface of the track rail **202**, while each of inner side surfaces of the right and left suspending portions **2042, 2042** is provided with roller rolling surface **208, 208** corresponding to the respective roller rolling surfaces **205, 205** formed to the right and left side surfaces of the track rail **202**.

[0171] A number of rollers **203** are disposed between four pairs of roller rolling surfaces **205, 208**; **206, 207** corresponding to each other, that are formed to opposing surfaces between the track rail **202** and the movable block **204**, whereby roller rows for bearing a load to be applied to portions between the track rail **202** and the movable block **204** are assembled. A predetermined pre-load is applied to respective rollers **203**.

[0172] Each of the rollers **203** linearly contacts to the roller rolling surfaces **205, 208**; **206, 207**. A contact angle line L1 constituted by a line connecting two contact portions of the roller disposed between the corresponding roller rolling surfaces **205, 208**; **206, 207** formed to the upper surface of the track rail **202** and the horizontal portion **2041** of the block body **2040** is set to vertically extend with an inclination angle of about 90° with respect to a horizontal line passing through a center of the roller **203**, while a contact angle line of the roller **203** disposed between the corresponding to the roller rolling surfaces formed to the right and left side surfaces of the track rail **202** and the inside surfaces of the right and left suspending portions **2042, 2042** of the block body **2040** is set to obliquely extend toward a center of the track rail **202** and is formed so as to upwardly incline with a predetermined angle of α with respect to a horizontal line H passing through a center of the roller **203**, thereby to form a structure in which both the right and left corner portions **2022, 2022** of an upper portion of the track rail **202** are clamped by the two rows of rollers **203, 203** disposed to the right and left sides of the track rail **202** and by the two rows of rollers **203, 203** disposed to the upper surface side of the track rail **202**. In the embodiment shown in Figure, the inclination angle of α is set to about 30°.

[0173] The block body **2040** is provided with four rows of the roller returning passages **209** for circulating and guiding the four rows of rollers **203**. The roller returning passage **209** linearly extend in parallel to the respective roller rolling surfaces **205, 206** formed to the block body **2040**. Two rows of the roller returning passages **209** are provided to the horizontal portion **2041**, while two rows of the roller returning passages **209** are respectively provided to the right and left suspending portions **2042** of the block body **2040**. The roller returning passage **209** is formed of a roller returning passage forming member **2091** composed of resin.

[0174] The roller returning passage forming member **2091** is integrally bonded to an inner peripheral portion of a penetration bore **2043** penetrating through the horizontal portion **2041** and the suspending portion **2042** of the block body **2040**. An outer peripheral shape of the roller returning passage forming member **2091** is formed to have a cylindrical shape which conforms to an inner peripheral shape of the penetration bore **2041**. The inner periphery of the roller returning passage forming member **2091** is provided with a roller returning passage **209** having a rectangular cross section for guiding the roller **203**.

[0175] The roller returning passage **209** comprises a pair of unloaded roller guide surfaces **209***a*, **209***b* extending in parallel to each other for guiding a cylindrical outer periphery surface of the roller **203**, and a pair of unloaded roller end surface guide surfaces **209***c*, **209***c* extending in parallel to each other for guiding end surfaces of the roller **203**.

[0176] A gap or clearance between the paired unloaded roller guide surfaces **209***a*, **209***b* is set to slightly larger than a diameter of the roller **203** so as to form a small gap therebetween, while a gap or clearance between the paired roller end surface guide walls **209***c*, **209***c* is set to slightly larger than a length of the roller **203** so as to form a small gap therebetween, thus resulting in a structure enabling to smoothly move the rollers **3**.

[0177] The unloaded roller end surface guide walls **209***c*, **209***c* are formed with guide grooves **209***d* with which the guide projecting portions **2181** of the roller chain **218** are engaged.

[0178] **FIG. 11** shows another embodiment of a roller returning passage forming member **2092** to be formed to the suspending portion **2042** of the block body **2040**. Namely, the roller returning passage forming member **2092** is integrally bonded to a recessed portion **2044** formed to a lower end portion of the right and left suspending portions **2042** of the block body **2040**. The roller returning passage forming member **2091** is integrally connected to a third loaded roller end surface guide wall forming member **2143** provided to the inner peripheral side of the suspending portion **2042**.

[0179] According to the structure described above, the block body **2040** is required to be provided with only two penetration bores **2043** to be formed to the horizontal portion **2041**, thus making simple the manufacturing of the device.

[0180] In addition, as shown in FIGS. **8**, **9**(*a*) and **9**(*b*), both end portions of the block body **2040** are provided with side covers **211** constituting a direction changing passage **210** for changing the rolling direction of the roller **203** to the roller returning passage **209**, the roller **203** being disposed between the loaded roller rolling surfaces **205**, **208**; **206**, **207** formed to the track rail **202** and the block body **2040**.

[0181] The direction changing passage **210** is formed to be a pipe having a U-shape. The side cover **211** is formed with only a direction changing passage inner periphery portion **210***a* of the direction changing passage **210**, while a direction changing passage inner periphery portion forming member **212** is integrally bonded to both end portions of the block body **2040**.

[0182] This direction changing passage **210** has a rectangular shaped cross section, and both side portions of the direction changing passage outer periphery portion **210***a* and the inner periphery portion **210***b* for guiding the outer periphery surface of the roller **203** are provided with direction changing roller end surface guide walls **210***c*, **210***c* for guiding the end surfaces of the roller **203**. This direction changing roller end surface guide walls **210***c* together with the direction changing passage inner periphery portion **210***b* are formed to the direction changing passage inner periphery portion forming member **212**. Then, when the side cover **211** formed with the direction changing passage outer periphery portion **210***a* is fitted into the end surface of the block body **2040** formed with the direction changing passage inner periphery portion **210***b* and the direction changing roller end surface guide walls **210***c*, the direction changing passage **210** having a U pipe shape is formed.

[0183] The direction changing roller end surface guide walls **210***c*, **210***c* are formed with guide grooves **210***d* with which the guide projecting portions **2181** of the roller chain **218** are engaged.

[0184] In this regard, the direction changing roller end surface guide walls **210***c*, **210***c* together with the direction changing passage outer periphery portion **210***a* may be provided to the side cover **211**. In another way, one direction changing roller end surface guide wall **210***c* together with the direction changing passage inner periphery portion **210***b* may be provided to a side of the direction changing passage inner periphery portion forming member **212**, while the other direction changing roller end surface guide walls **210***c* together with the direction changing passage outer periphery portion **210***a* may be provided to the side cover **211**.

[0185] In still another way, the direction changing roller end surface guide wall **210***c* is divided into two portions i.e., an inner periphery side portion and an outer periphery side portion, and then, the outer periphery side portion may be formed to the side cover **211**, while the inner periphery side portion may be provided to the direction changing passage inner periphery portion forming member **212**.

[0186] Further, as shown in **FIG. 8**(*a*) along the respective four rows of roller rolling surfaces **207**, **208** of the block body **240**, there is provided with a loaded roller end surface guide wall **213** for guiding the end surfaces of the roller in the loaded area.

[0187] The loaded roller end surface guide walls **213** are formed with guide grooves **213***a* with which the guide projecting portions **2181** of the roller chain **218** are engaged. In order to form the loaded roller end surface guide wall **213**, the block body **240** comprises a first end surface guide wall forming member **2141** to be integrally bonded to a lower surface of the horizontal portion **2040**, the right and left second end surface guide wall forming members **2142** to be integrally bonded to recessed corner portions between the horizontal portion **2041** and the right and left suspending portions **2042**, and right and left third end surface guide wall forming members **2143** to be integrally bonded to a lower portion of inner side surface of the right and left suspending portions **2042**.

[0188] Both the end portions of the first end surface guide wall forming member **2141** and an upper end portion of the second end surface guide wall forming members **2142** are provided with loaded roller end surface guide walls **213**, **213**; **213**, **213** for guiding the end surfaces of the roller **203** rolling on the roller rolling surfaces **207**, **207** formed to the lower surface of the horizontal portion **2041** of the block body **2040**.

[0189] In addition, the lower end portions of the right and left second end surface guide wall forming members **2142** and an upper end portion of the third end surface guide wall forming members **2143** are provided with loaded roller end surface guide walls **213**, **213**; **213**, **213** for guiding the end surfaces of the roller **203** rolling on the roller rolling surfaces **208**, **208** formed to the suspending portion **2042** of the block body **2040**.

[0190] A gap or clearance between the paired loaded roller end surface guide walls **213**, **213** is set to slightly larger than a length of the roller **203** so as to form a small gap between the end surface of the roller **203** and the guide wall **213**.

[0191] Further, a first seal member **216** for sealing the gap formed between the horizontal portion **2041** of the block body **2040** and the upper surface of the track rail **202** is attached to the first end surface guide wall forming member **2141**, while a second seal member **217** for sealing the gap formed between the suspending portion **2042** of the block body **2040** and the right and left side surfaces of the track rail **202** is attached to the third end surface guide wall forming member **2143**.

[0192] In this embodiment, the loaded roller end surface guide walls **213** for guiding both end surfaces of the roller **203** is formed by the first to third end surface guide wall forming members **2141**-**2143** that are all composed of resin.

[0193] However, as shown in **FIG. 11**(*a*), the loaded roller end surface guide walls **213** for guiding one end surface of the roller **203** may be formed by the block body **2040** per se, while the loaded roller end surface guide wall **213** for guiding the other end surface of the roller **203** may be formed by the loaded roller end surface guide wall forming member **214**. In this case, the loaded roller end surface guide walls **213** may be formed with guide grooves with which the guide projecting portions **2181** of the roller chain **218** are engaged. In another way, as shown in **FIG. 11**(*b*), a cutout **213***b* can be also formed in place of the guide groove.

[0194] In this second embodiment, all of the roller returning passage forming member **2091**, the roller end surface guide wall forming members **2141**-**2143** and the direction changing passage inner periphery portion forming member **212** is formed by integrally molding with the movable block **2040**.

[0195] Accordingly, the unloaded roller guide surfaces **209***a*, **209***b* of the roller returning passage **209** and both the inner and outer periphery portions **210**_a_, **210**_b_ of the direction changing passage can be continuously and integrally molded. Further, the direction changing passage inner periphery portion **210**_b_ and the roller rolling surfaces **207**, **208** in the loaded area can be also integrally molded.

[**0196**] In addition, the roller end surface guide wall **209**_c_ of the roller returning passage **209**, the direction changing roller end surface guide wall **210**_c_ of the direction changing passage **210** and the loaded area roller end surface guide wall **213** are continuously formed by being integrally molded, so that the roller end surface guide wall can be continuously formed in all around the endless circulating passage. In addition, the guide groove for engaging with the guide projecting portion **2181** of the roller chain **218** can be continuously formed in all around the endless circulating passage.

[**0197**] According to the linear roller guide device of this invention, the roller returning passage forming member **2091** and the direction changing passage inner periphery portion forming member **212** are not required, thus enabling to omit the assembling process for the members. In addition, the roller returning passage **209** and the direction changing passage inner periphery portion **210**_a_ can be provided at accurate positions with respect to the block body **2040**.

[**0198**] When the direction changing passage inner periphery portion forming member **212** is integrally formed with the block body **2040**, it becomes possible to eliminate the irregularities to be formed at the connected portion between the roller rolling surfaces **207**, **208** and the direction changing passage inner periphery portion **210**_b_. In addition, as to the roller returning passage **209**, when the member **91** is integrally formed with the block body **2040**, it becomes also possible to eliminate the irregularities to be formed at the connected portion between the direction changing passage inner periphery portion **210**_b_ and the unloaded roller guide surface **209**_b_ of the roller returning passage **209**.

[**0199**] On the other hand, the rollers **203** can be smoothly rolled and moved from the roller returning passage **209** in the unloaded area and the direction changing passage **210** to the loaded area between the roller rolling surfaces **206**, **207**; **205**, **208** while being held in a state where the center axes of the respective rollers **203** are retained in parallel to each other and intervals of adjacent rollers **203** are retained in a predetermined distance by the roller chain **218**.

[**0200**] In particular, when the roller chain **218** is circulated and moved, the guide projecting portions **218**_a_ formed to the roller chain **218** are guided in all around the circulating passage by the guide grooves **209**_d_, **210**_d_ and **213**_a_ formed to the guide walls **213** provided to both sides of the roller returning passage **209**, the direction changing inner periphery portion **210**_b_ and the roller rolling surfaces **207**, **208**, so that the run-out of the roller chain **218** during the circulation can be suppressed in all around the circulating passage. Accordingly, the roller chain **218** can circulate and move on a predetermined track in all around the endless circulating passage. As a result, the rollers **203** can accurately roll and move, thus preventing the skew-generation of the rollers **203**.

[**0201**] Furthermore, in this embodiment, the gaps between the guide walls **213**, the direction changing roller end surface guide wall **210**_c_ in the loaded area and the unloaded roller end surface guide wall **209**_c_ and the roller end surfaces can be accurately maintained to a predetermined value, so that the gap can be reduced to a sufficiently small value. As a result, the skew of the rollers **203** can be securely prevented in cooperation with the retaining function of the roller chain **218**.

[**0202**] Furthermore, when the movable block **204** is detached from the track rail **202**, the rollers **203** are retained by the roller chain **218**.

[**0203**] The integrally molding of the roller returning passage forming member **2091**, the direction changing passage inner peripheral portion forming member **212** and the loaded roller end surface guide wall **213** with the block body **2040** is performed in accordance with an insert molding method comprising the steps of disposing the block body **2040** into a molding die **215** on the basis of the roller rolling surfaces **207**, **208** formed to the block body **2040**, forming cavities corresponding to the respective resin molded portions to be formed between an inner wall of the molding die **215** and the block body **2040**, and injecting a molding material into the cavities to form the resin molded portions.

[**0204**] **FIG. 12** is a schematic view showing the block body **2040** and states where the molding dies **215** are clamped or opened at the time of the insert molding. Namely, a fixed molding die **215**_a_ is provided with block supporting portions **215**_b_ to which the roller rolling surfaces **207**, **207**; **208**, **208** are fitted for positioning, while a movable molding die **215**_c_ is provided with pins **215**_d_ for forming the roller returning passage. The block supporting portions **215**_b_ and the pins **215**_d_ are formed with projecting portions **215**_b_**1**, **215**_d_**1** corresponding to the guide projecting portion **2181** of the roller chain **218**.

[**0205**] The block supporting portions **215**_b_ have plain shapes corresponding to the roller rolling surfaces **207**, **207**; **208**, **208** and linearly extend in parallel to each other. In this regard, FIGS. 12(_b_) and 12(_c_) shows only a circumference of the roller returning passage **209** of a side of the suspending portion **2042**.

[**0206**] Cavities **215**_d_ for forming the roller returning passage forming member **2091** are provided inside the penetration bores **2043** formed in the horizontal portion **2041** and the suspending portion **2042** of the block body **2040**, respectively. Further, cavities **215**_e_ for forming the first to third loaded roller end surface guide wall forming members **213** are provided to inner periphery portions of the horizontal portion **2041** and the suspending portion **2042**, respectively. Furthermore, cavities **215**_f_ for forming the direction changing passage inner periphery portion forming members **212** are provided to both front and back end portions of the block body **2040**, respectively.

[**0207**] In this embodiment, the paired right and left roller rolling surfaces **207**, **207**; **208**, **208** of the block body **2040** are supported at four points by the block supporting portions **215**_b_ of the molding die **215**. As a result, the block body **2040** can be supported unmoved by the block supporting portions **215**_b_, even if an injection pressure of a molding material is applied to the block body **2040** from every directions, whereby the roller returning passage **209**, the direction changing inner periphery portion **210**_b_ and the first to third loaded roller end surface guide walls **2131-2133** can be accurately formed at predetermined positions.

[0208] In addition, since the block body **2040** is stably positioned in the molding die **215**, the burr is not formed at portions between the roller rolling surfaces **207**, **207**; **208**, **208**.

[0209] It is preferable that the block supporting portions **215***b* closely contact to the roller rolling surfaces **207**, **208**. However, even the block supporting portions **215***b* and the roller rolling surfaces **207**, **208** are moved in a small distance due to a small gap formed therebetween, the small gap shall be allowed as far as a dimension accuracy is within an allowable range and the resin material would not penetrate through the gap.

Modifications of Roller Contact Angles

[0210] Though the explanation described above has been made by taking into consideration an example of a case in which total four rows of rollers are disposed between corresponding portions i.e., the right and left two rows of rollers being disposed between the upper surface of the track rail **202** and the lower surface of the horizontal portion **2041** of the block body **2040** while one row of rollers being disposed between the right and left side surfaces of the track rail **202** and the inner side surfaces of the right and left suspending portions **2042** respectively, a number and an arrangement of the roller rows are optional.

[0211] For example, as shown in **FIGS. 13 and 14**, the device may have a structure having four rows of rollers in total in which right and left two rows of rollers are disposed between the right and left side surfaces of the track rail **202** and the inner side surfaces of the right and left suspending portions **2042** of the block body **2040**, respectively.

[0212] **FIG. 13** shows an example having a structure in which the upper row of rollers **203** among the two rows of the rollers **203** arranged vertically is formed so that a contact angle line of the roller **203** is set to obliquely extend upwards from a side of the track rail **202** to the right and left suspending portions **2042** of the block body **2040** and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line, while the lower row of rollers **203** is formed so that a contact angle line of the roller **203** is set to obliquely extend downwards and is formed so as to incline with an inclination angle of almost 45°.

[0213] **FIG. 14** shows an example having a structure in which the upper row of rollers **203** among the two rows of the rollers **203** arranged vertically is formed so that a contact angle line **L1** of the roller **203** is set to obliquely extend downwards from a side of the track rail to sides of the right and left suspending portions **2042**, **2042** of the block body **2040** and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line H, while the lower row of rollers **203** is formed so that a contact angle line **L2** of the roller **203** is set to obliquely extend upwards and is formed so as to incline with an inclination angle of almost 45°.

[0214] In the case of this embodiment, the direction changing passages **210**A, **210**B of vertically arranged two rows of rollers **3** disposed to both end portions of the block body **2040** are arranged alternately with a predetermined interval in an axial direction so as to intersect to each other. In this case, the direction changing passage inner peripheral portion forming member **212** formed to the end surface of the block body **2040** is provided with the direction changing passage inner periphery portion **210***b* of the direction changing passage **210**A of a side close to the block body **2040** and the direction changing roller end surface guide wall **210***c*, the inner periphery portion **210***b* and the guide wall **210***c* being integrally molded with the block body **2040**.

[0215] As to the direction changing passage **210**B far from the block body **2040**, at least one portion of the loaded roller rolling surfaces **207**, **208** of an end surface side of the block body **2040**, the direction changing passage inner periphery portion **210***b* of a part which is connected to an end portion of the roller returning passage **209** and the direction changing roller end surface guide wall **210***c* are integrally molded with the block body **2040**. While, a round piece **210**C formed with the direction changing passage inner periphery portion **210***b* is attached to a part far from the direction changing passage **210**A. An inner periphery of this round piece **210**C is formed with a part of an outer periphery guide portion of the inside direction changing passage **210**A. The side cover **211** is formed with the direction changing passage outer peripheral portions **210***a*, **210***a* for both the direction changing passages **210**A, **210**B arranged vertically.

[0216] According to the second invention described above, since the rollers are circulated in a state of being retained by the roller chain, the rollers are rolled and moved in a state where center axes of the respective rollers are retained in parallel to each other by the roller chain. Therefore, the generation of skew can be prevented and the rollers can be smoothly rolled and moved.

[0217] In addition, since the roller chain is guided on a predetermined track through the roller chain guide portions formed to the roller returning passage and the direction changing passage, the rollers retained by the roller chain can be also accurately guided.

[0218] In addition, the running-out of the roller chain can be prevented by the roller chain guide portions.

[0219] In particular, when the roller returning passage to be formed with the roller chain guide portions, the roller returning passage forming member to be formed with the direction changing inner periphery portion and the direction changing passage inner periphery portion forming member are integrally molded with the block body, the roller chain guide portions can be accurately formed on the track.

[0220] In addition, when the direction changing passage inner periphery portion forming member is integrally formed with the block body, it becomes possible to eliminate the irregularities to be formed at the connected portion between the roller rolling surface and the direction changing passage inner periphery portion. In addition, as to the roller returning passage, when it is integrally formed with the block body, it also becomes possible to eliminate the irregularities to be formed at the connected portion between the direction changing passage inner periphery portion and the roller returning passage, whereby the rollers can be further smoothly circulated and moved in cooperation with the guiding function of the roller chain.

[0221] Furthermore, when the roller chain is formed so as to have an endless structure and is provided with a falling-out preventing portion for the rollers, the falling-out of the rollers can be prevented by the roller chain even if the movable block is detached from the track rail.

[0222] In addition, the roller chain is provided with a guide projecting portion, while the roller returning passage and the direction changing passage inner peripheral portion are provided with guide grooves. In addition, a side of the roller rolling surface in the loaded area is provided with a guide wall having the guide groove, and the guide wall is integrally molded with the block body by using an insert molding method, so that the roller chain can be accurately guided in all around the endless circulating passage, thus enabling the rollers to further smoothly circulate and move.

[0223] According to the structure described above, when the roller chain is circulated and moved, the guide projecting portion is engaged with the guide groove formed to the roller returning passage and the direction changing passage inner peripheral portion, so that the run-out of the roller chain during the circulation is suppressed. As a result, the rollers can be rolled and moved in orderly arranged state in all around the endless circulating passage.

[0224] In addition, in a case where the roller chain is formed in a striped-shape having no connected portion at both ends thereof, when the movable block is detached from the track rail, the guide projecting portion is engaged with the guide groove, thus enabling to prevent a sagging or slack of an end portion of the roller chain. Further, also in the case of the roller chain having an endless structure, the sagging or slack of an intermediate portion of the roller chain can be prevented.

[0225] When the roller chain comprises spacer portions disposed between the adjacent rollers and connecting members for connecting the respective spacer portions, each of the rollers is arranged and circulated in a state where the rollers are retained by the spacer portions from back and forth in the arranging direction thereof.

[0226] Further, when a falling-out preventing portion for the roller is Provided to the spacer portion so as to prevent the roller falling-out from back and forth of the roller, it becomes unnecessary to chamfer the end portion of the roller, so that an effective length of the roller for bearing the load can be increased, thus enabling to improve the load bearing ability.

[0227] Furthermore, since only the spacer portion is disposed between the adjacent rollers, a pitch of the rollers can be formed as small as possible, so that a number of the rollers required to be disposed per unit length for bearing the load can be increased as many as possible, thus further improving the load bearing ability of the roller.

[0228] In addition, when the roller is formed to have a hollow structure and the roller is retained by inserting a resin portion into the hollow portion of the roller, the falling-out of the roller can be securely prevented and a degree of parallelization between the adjacent rollers can be accurately maintained.

[0229] In addition, as an example of a case where the hollow portion does not penetrate, the roller may be retained in such a manner that a recessed portion is formed to both end portions of the roller and the resin portion is inserted into the recessed portion or in a manner that a grooved portion is formed to a center peripheral portion of the roller and the resin portion is fitted into the grooved portion.

[0230] In addition, when the roller chain is reinforced by inserting a wire or thin plate into the connecting member for linking the rollers, a fatigue strength and life duration of the roller chain can be increased.

[0231] In addition, at a time of the insert molding, when a block supporting portion having a shape obtained by cutting an outer peripheral portion of the roller with a cross section passing through a center axis of the roller is provided to an inner periphery of a molding die so as to correspond to the roller rolling surface of the block body, and the block body is positioned in the molding die by contacting the roller rolling surface to the block supporting portion, the burr would not occur at the roller rolling surfaces.

[0232] In particular, when the paired right and left roller rolling surfaces of the block body are supported by the block supporting portions of the molding die, the block body is clamped from every four directions and supported by the paired right and left block supporting portions at four points. Therefore, even if an injection pressure of a molding material is applied to the block body from every directions, the block body can be held unmoved, thus the block body can be accurately positioned.

INDUSTRIAL APPLICABILITY

[0233] As described above, the linear roller guide device according to the present invention is widely applicable to linear guide mechanisms for various industrial equipments such as machine tool, robot operating system, measuring apparatus or the like.

1. A linear roller guide device comprising a track rail and a movable block assembled to the track rail through a number of rollers,

said movable block comprising:

a roller rolling surface on which said rollers roll;

a block body having a roller returning passage corresponding to the roller rolling surface;

a direction changing passage inner periphery portion formed to both end surfaces of the block body;

a pair of roller end surface guide walls formed to both sides of the roller rolling surface of the block body and adapted to guide both the end surfaces of the roller; and

side covers each having a direction changing passage outer periphery portion for forming a direction changing passage by fitting the side cover into the direction changing passage inner periphery portion formed to both end surfaces of the block body,

said track rail including a roller rolling surface extending in an axial direction corresponding to the roller rolling surface of the block body, and

said rollers circulating in an endless circulating passage constituted by a loaded area between the roller rolling surface of the block body and the roller rolling surface corresponding to the track rail, the direction changing passage and the roller returning passage,

wherein at least one of a roller returning passage forming member for forming the roller returning passage, a roller end surface guide wall forming member for forming at least one of the paired roller end surface guide wall and a direction changing passage inner periphery portion forming member for forming the direction changing passage inner periphery portion is formed as a molded body integrally formed with the block body by inserting the block body into a molding die.

2. A linear roller guide device according to claim 1, wherein said roller returning passage forming member and said direction changing passage inner peripheral portion forming member are provided with guide walls for guiding the end surfaces of the rollers, the guide walls being continuous to the roller end surface guide wall, and said roller returning passage forming member, said roller end surface guide wall forming member of at least one of the paired roller end surface guide wall forming members and said direction changing passage inner peripheral portion forming member are integrally molded with the block body.

3. A linear roller guide device according to claim **1**, wherein said roller is provided with a chamfered portion formed to at least one end portion of the roller, and an engaging projection with which said chamfered portion of the roller is engaged is provided at the roller end surface guide wall integrally molded with the block body so as to prevent the roller from falling-out.

4. A linear roller guide device according to any one of claims **1**, **2** and **3**, wherein said device has a structure having four rows of rollers in total in which a paired right and left rows of rollers are disposed to be rollable between the upper surface of the track rail and a lower surface of a horizontal portion of the block body and two rows of the rollers each is disposed between the right and left side surfaces of the track rail and inside surfaces of a suspending portion of the block body, respectively.

5. A linear roller guide device according to claim 4, wherein a contact angle line constituted by a line connecting two contact points of said roller disposed between the roller rolling surfaces formed to the upper surface of the track rail and the horizontal portion of the block body is set to vertically extend with an inclination angle of approximately 90° with respect to a horizontal line, while a contact angle line of the roller disposed between the roller rolling surfaces formed to the right and left side surfaces of the track rail and the inside surfaces of the suspending portion of the block body is set to obliquely extend downwards and is formed so as to incline with an inclination angle of approximately 30° with respect to a horizontal line.

6. A linear roller guide device according to any one of claims **1**, **2** and **3**, wherein said guide device has a structure having four rows of rollers in total in which two rows of rollers are vertically disposed to be rollable at upper and lower portions between a right side surface of the track rail and a right inside surface of the suspending portion of the block body, respectively, while the remaining two rows of rollers are vertically disposed to be rollable at upper and lower portions between a left side surface of the track rail and a left inside surface of the suspending portion of the block body, respectively.

7. A linear roller guide device according to claim 6, wherein said upper row of rollers is formed so that a contact angle line of the roller is set to obliquely extend upwards from a side of the track rail to sides of the right and left suspending portions of the block body and is formed so as to incline with an inclination angle of approximately 45° with respect to a horizontal line, while said lower row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards and is formed so as to incline with an inclination angle of approximately 45° with respect to a horizontal line.

8. A linear roller guide device according to claim 6, wherein said upper row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards from a side of the track rail to sides of the right and left suspending portions of the block body, and is formed so as to incline with an inclination angle of approximately 45° with respect to a horizontal line, while the lower row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line.

9. A linear roller guide device according to any one of claims 1 to 7, wherein a block supporting portion having a shape obtained by cutting an outer peripheral portion of the roller with a cross section passing through a center axis of the roller is formed to an inner periphery of a molding die so as to correspond to the roller rolling surface of the block body at a time of an insert molding, and the block body is positioned in the molding die by contacting the roller rolling surface to the block supporting portion.

10. A linear roller guide device comprising a track rail and a movable block assembled to the track rail through a number of rollers,

said movable block comprising:

a block body having a roller rolling surface and a roller returning passage corresponding to the roller rolling surface;

a direction changing passage inner periphery portion formed to both end surfaces of the block body: and

side covers each having a direction changing passage outer periphery portion for forming a direction changing passage by fitting the side cover into the direction changing passage inner periphery portion formed at both end surfaces of the block body,

said track rail including a roller rolling surface extending in an axial direction corresponding to the roller rolling surface of the block body,

said rollers circulating in an endless circulating passage constituted by a loaded area between the roller rolling surface of the block body and the roller rolling surface corresponding to the track rail, the direction changing passage and the roller returning passage, and the rollers are linked to each other by a roller chain inserted to be movable in the endless circulating passage,

wherein said roller returning passage and said direction changing passage inner periphery guide portion are provided with a roller chain guide portion for guiding a track of the roller chain onto a predetermined track,

wherein at least one of the roller returning passage forming member for forming the roller returning passage and the direction changing passage inner periphery portion forming member for forming the direction changing passage inner periphery portion is integrally molded by inserting the block body into a molding die.

11. A linear roller guide device according to claim 10, wherein said roller chain is provided with a guide projecting portion so as to project from the end surface of the roller in an axial direction of the roller, while said roller returning passage and the direction changing passage are provided with guide grooves with which said guide projecting portion is engaged, at least one side of the roller rolling surfaces formed to the block body is provided with a guide wall having the guide groove with which said guide projecting portion is engaged, and said guide wall is integrally molded with the block body by inserting the block body into a molding die to thereby continuously form the guide groove to the roller returning passage forming member, the direction changing passage inner periphery portion forming member and the guide wall so that the guide groove ranges to all around the endless circulating passage.

12. A linear roller guide device according to claim 11, wherein said roller chain comprises spacer portions disposed between the adjacent rollers and connecting members for connecting the respective spacer portions, and said guide projecting portion is provided to the connecting member.

13. A linear roller guide device according to claim 11 or 12, wherein said connecting member and said spacer portion disposed between the adjacent rollers are formed as resin moldings, said roller is formed to have a hollowed portion, and the roller is retained by inserting a resin portion into said hollowed portion of the roller.

14. A linear roller guide device according to claim 11 or 12, wherein said roller is retained in such a manner that a recessed portion is formed to both end portions of said roller and the resin portion is inserted into the recessed portion.

15. A linear roller guide device according to claim 11 or 12, wherein said roller is retained in such a manner that a grooved portion is formed to a center peripheral portion of the roller and the resin portion is fitted into the grooved portion.

16. A linear roller guide device according to any one of claims **11**, **12**, **13**, **14** and **15** wherein said connecting member for linking the rollers is reinforced by inserting a wire or thin plate into the connecting member.

17. A linear roller guide device according to any one of claims 10 to 16, wherein said device has a structure having four rows of rollers in total in which a paired right and left rows of rollers are disposed to be rollable between the upper surface of the track rail and a lower surface of a horizontal portion of the block body and two rows of the rollers each is disposed between the right and left side surfaces of the track rail and inside surfaces of a suspending portion of the block body, respectively.

18. A linear roller guide device according to claim 17, wherein a contact angle line constituted by a line connecting two contact points of said roller disposed between the roller rolling surfaces formed to the upper surface of the track rail and the horizontal portion of the block body is set to vertically extend with an inclination angle of approximately 90° with respect to a horizontal line, while a contact angle line of the roller disposed between the roller rolling surfaces formed to the right and left side surfaces of the track rail and the inside surfaces of the suspending portion of the block body is set to obliquely extend downwards and is formed so as to incline with an inclination angle of approximately 30° with respect to a horizontal line.

19. A linear roller guide device according to any one of claims 10 to 16, wherein said device has a structure having four rows of rollers in total in which two rows of rollers are vertically disposed to be rollable at upper and lower portions between a right side surface of the track rail and a right inside surface of the suspending portion of the block body, while the remaining two rows of rollers are vertically disposed to be rollable at upper and lower portions between a left side surface of the track rail and a left inside surface of the suspending portion of the block body, respectively.

20. A linear roller guide device according to claim 19, wherein said upper row of rollers of the two rows of rollers is formed so that a contact angle line of the roller is set to obliquely extend upwards from a side of the track rail to sides of the right and left suspending portions of the block body and is formed so as to incline with an inclination angle of approximately 45° with respect to a horizontal line, while said lower row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards and is formed so as to incline with an inclination angle of approximately 45° with respect to a horizontal line.

21. A linear roller guide device according to claim 19, wherein said upper row of rollers of the two rows of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards from a side of the track rail to sides of the right and left suspending portions of the block body and is formed so as to incline with an inclination angle of approximately 45° with respect to a horizontal line, while the lower row of rollers is formed so that a contact angle line of the roller is set to obliquely extend upwards and is formed so as to incline with an inclination angle of approximately 45° with respect to a horizontal line.

22. A linear roller guide device according to any one of claims 10 to 21, wherein a block supporting portion having a shape obtained by cutting an outer peripheral portion of the roller with a cross section passing through a center axis of the roller is provided to an inner periphery of a molding die so as to correspond to the roller rolling surface of the block body at a time of an insert molding, and the block body is positioned in the molding die by contacting the roller rolling surface to the block supporting portion.

* * * * *

US006609304B1

(12) **United States Patent**
Mishler

(10) **Patent No.: US 6,609,304 B1**
(45) **Date of Patent: Aug. 26, 2003**

(54) **TWO-DIMENSIONAL MOVING SYSTEM**

(75) Inventor: **Mike Mishler**, Schaumburg, IL (US)

(73) Assignees: **TKH Co., Ltd.**, Tokyo (JP); **THK America, Inc.**, Schaumberg, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 115 days.

(21) Appl. No.: **09/634,864**

(22) Filed: **Aug. 8, 2000**

(51) **Int. Cl.**[7] **G01B 5/00**
(52) **U.S. Cl.** .... **33/1 M**; 33/706
(58) **Field of Search** .... 33/1 M, 430, 436, 33/441, 443, 444, 503, 706, 707, 708

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,495,519 A * 2/1970 Alfsen et al. .... 33/1 M
4,419,823 A * 12/1983 Thorban .... 33/1 M
4,995,277 A * 2/1991 Yanagisawa .... 33/1 M
5,326,335 A * 7/1994 Takei .... 33/1 M
5,363,774 A * 11/1994 Anada et al. .... 33/1 M
6,049,988 A * 4/2000 Shirai .... 33/1 M
6,327,929 B1 * 12/2001 Yanagisawa .... 33/1 M
6,495,935 B1 * 12/2002 Mishler 310/12

FOREIGN PATENT DOCUMENTS

JP 58-198369 11/1983

* cited by examiner

Primary Examiner—Diego Gutierrez
Assistant Examiner—Madeline Gonzalez
(74) *Attorney, Agent, or Firm*—Armstrong, Westerman & Hattori, LLP.

(57) **ABSTRACT**

A two-dimensional moving system for moving a table in a plane comprises a table, a guide mechanism for guiding the table to be movable in the plane, first and second belts which are connected to the table so as to intersect to each other at substantially right angles, first driving mechanism for driving the first belt so as to move the table in a longitudinal direction of the first belt and to allow the first belt to be movable in a longitudinal direction of the second belt, and a second driving mechanism for driving the second belt so as to move the table in the longitudinal direction of the second belt and to allow the second belt to be movable in the longitudinal direction of the first belt.

9 Claims, 10 Drawing Sheets

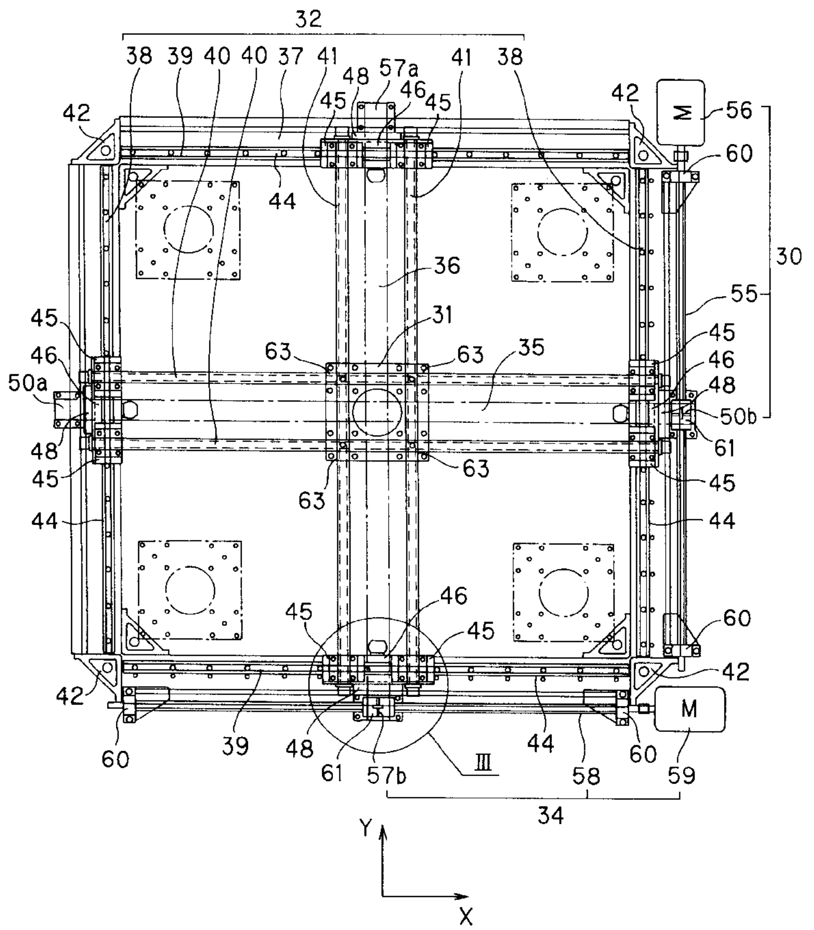


FIG. 1

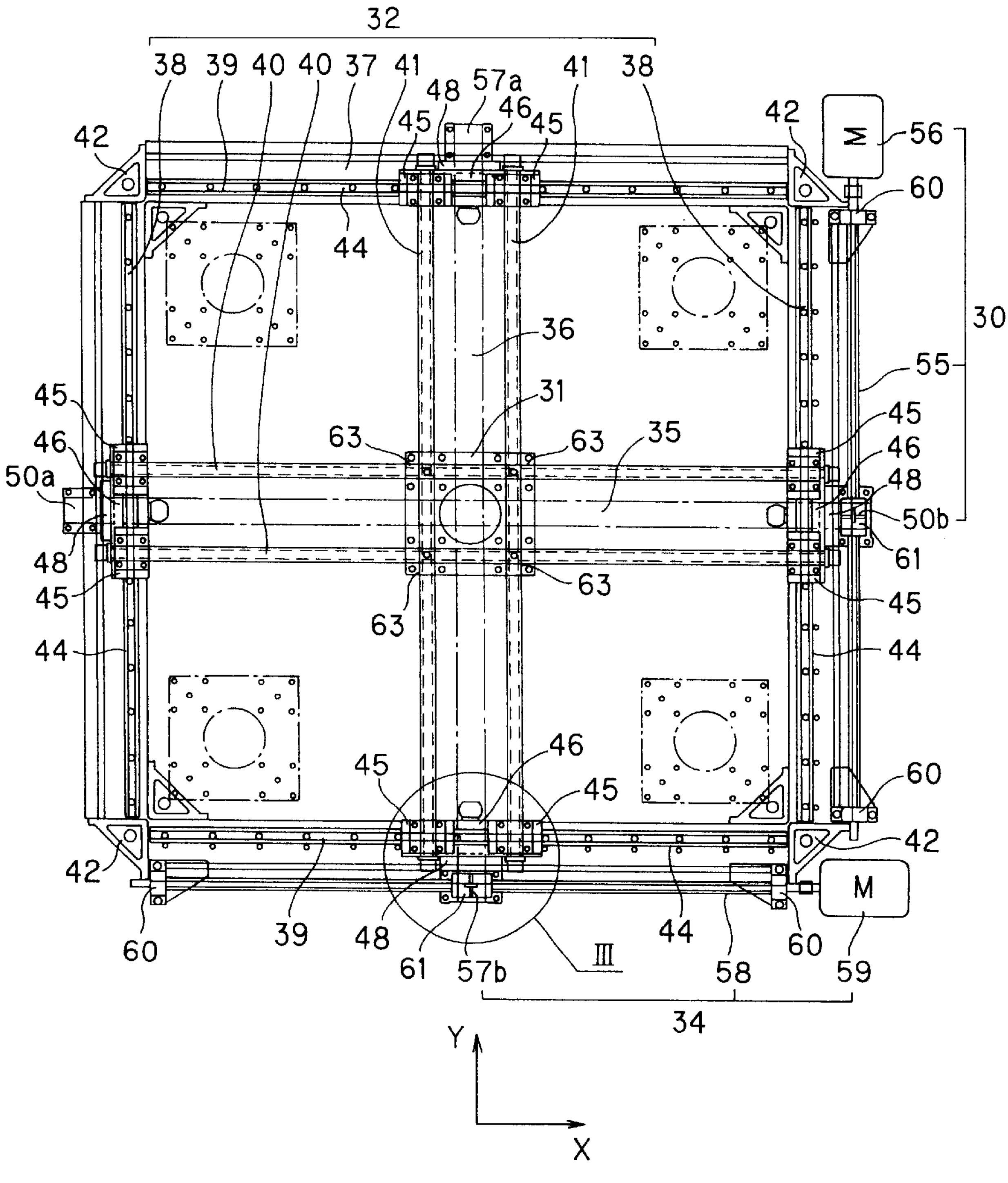

32
38
39
40
40
37
41
48
57a
46
45
45
41
38
42
M
56
60
30
42
44
36
55
45
31
45
46
63
63
35
46
50a
48
50b
48
61
45
63
45
63
44
44
45
46
60
45
42
42
39
48
44
60
59
60
61
57b
III
58
34
Y
X

FIG. 2

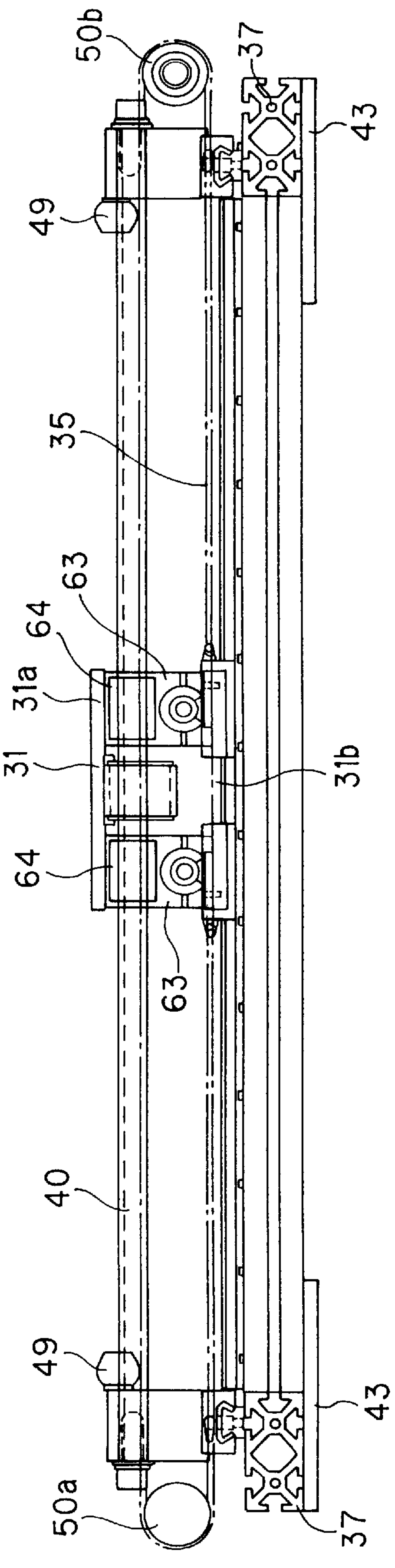


FIG. 3

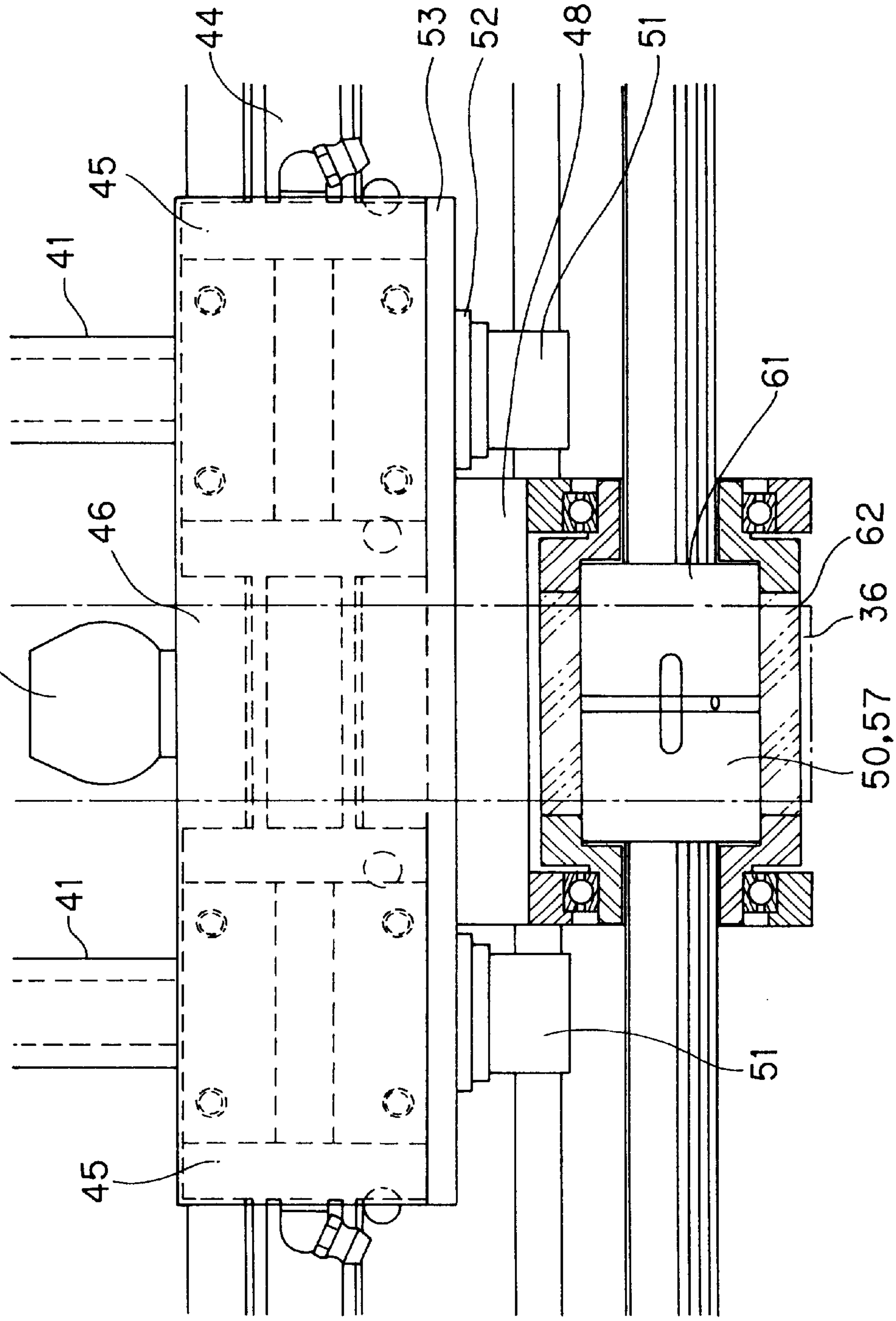


FIG. 4

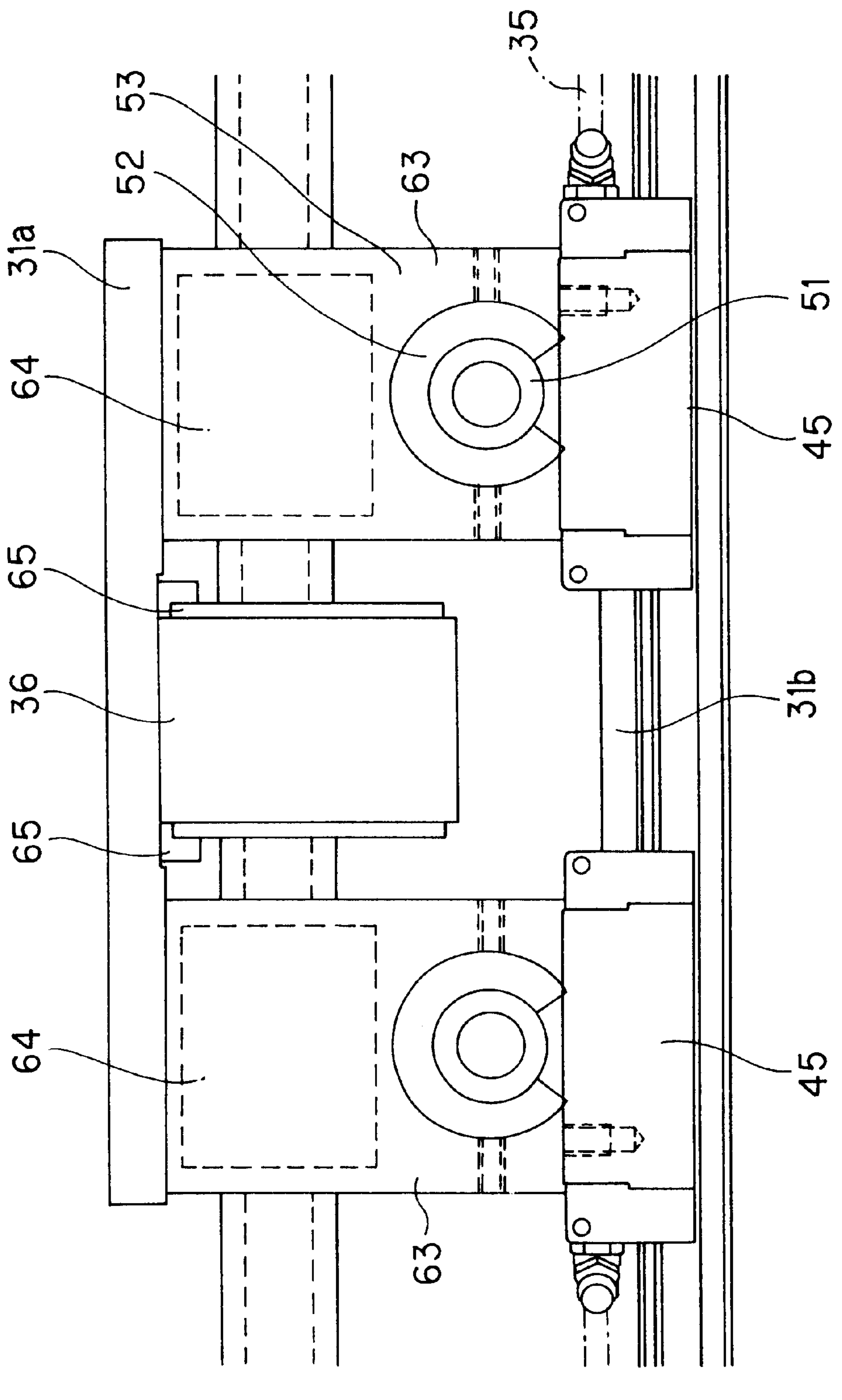


FIG. 5

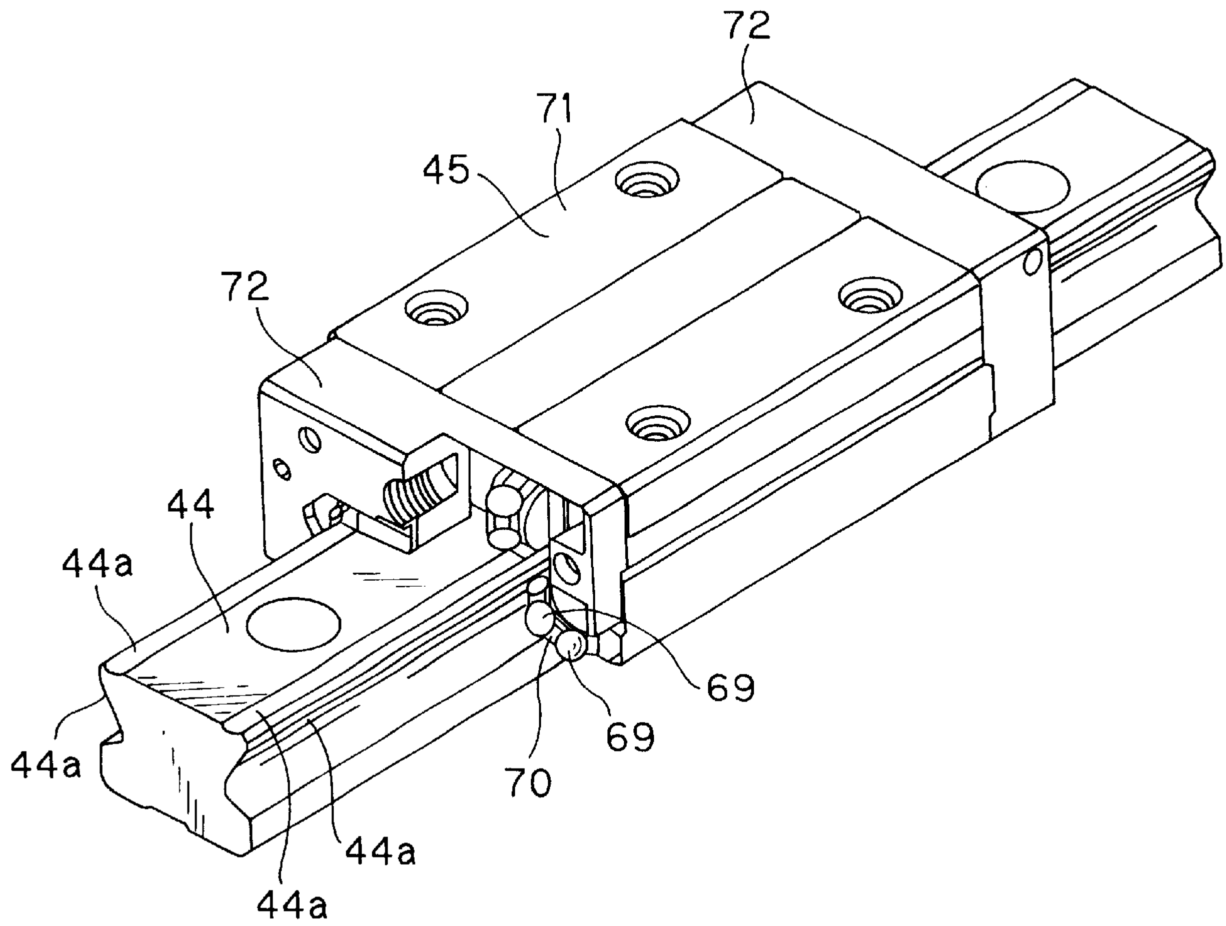


FIG. 6

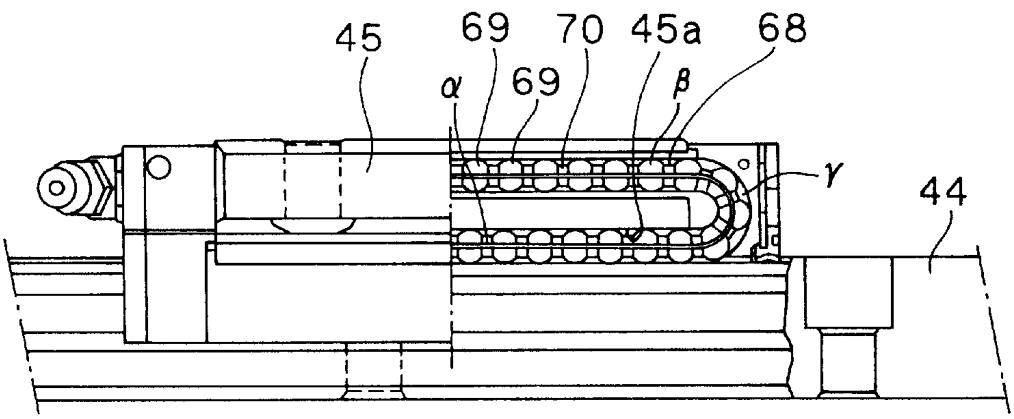


FIG. 7

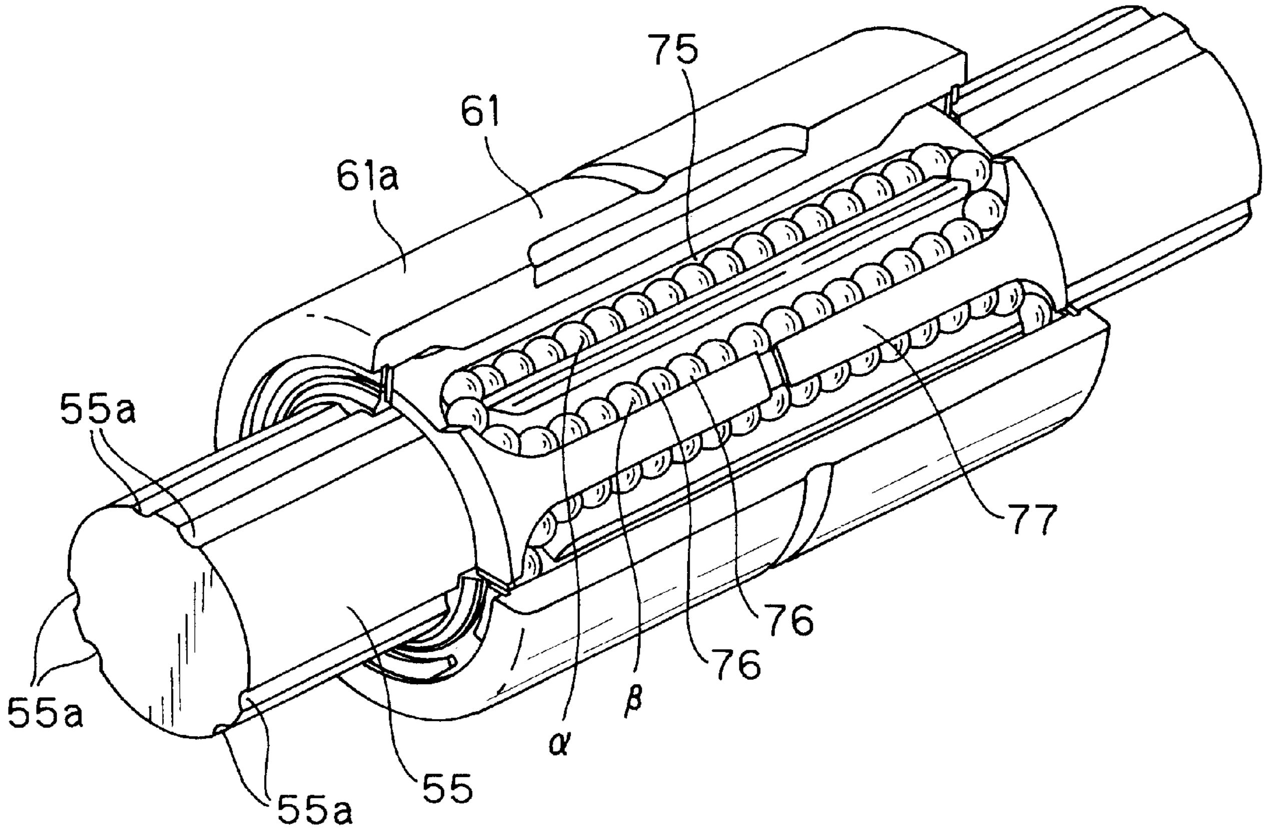


FIG. 8

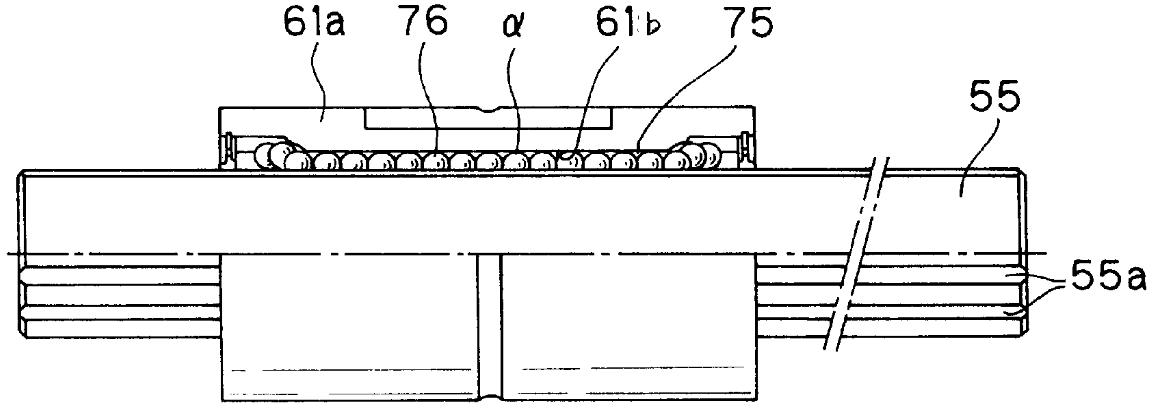


FIG. 9

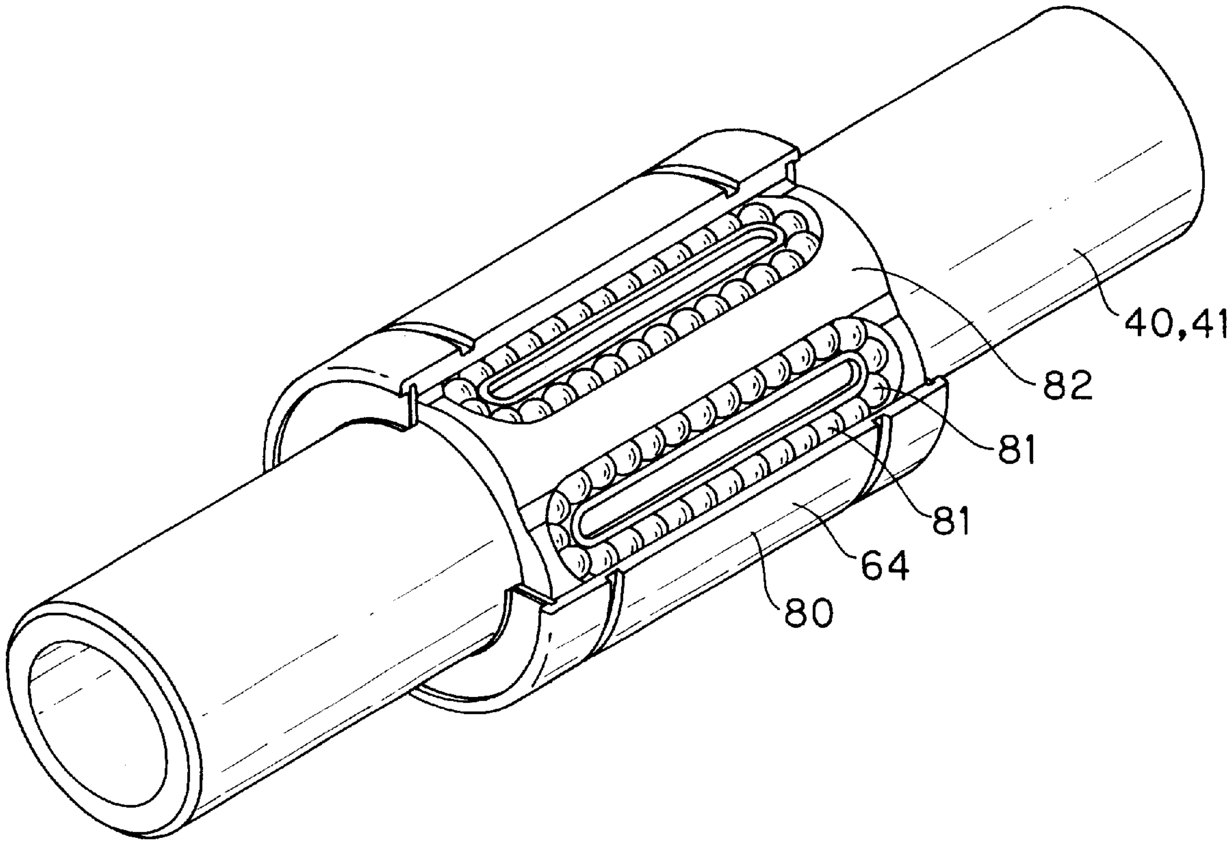


FIG. 10

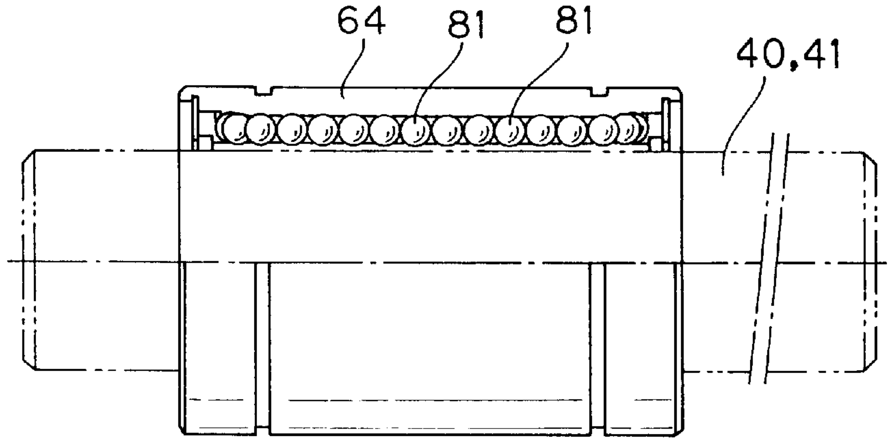


FIG. 11
PRIOR ART

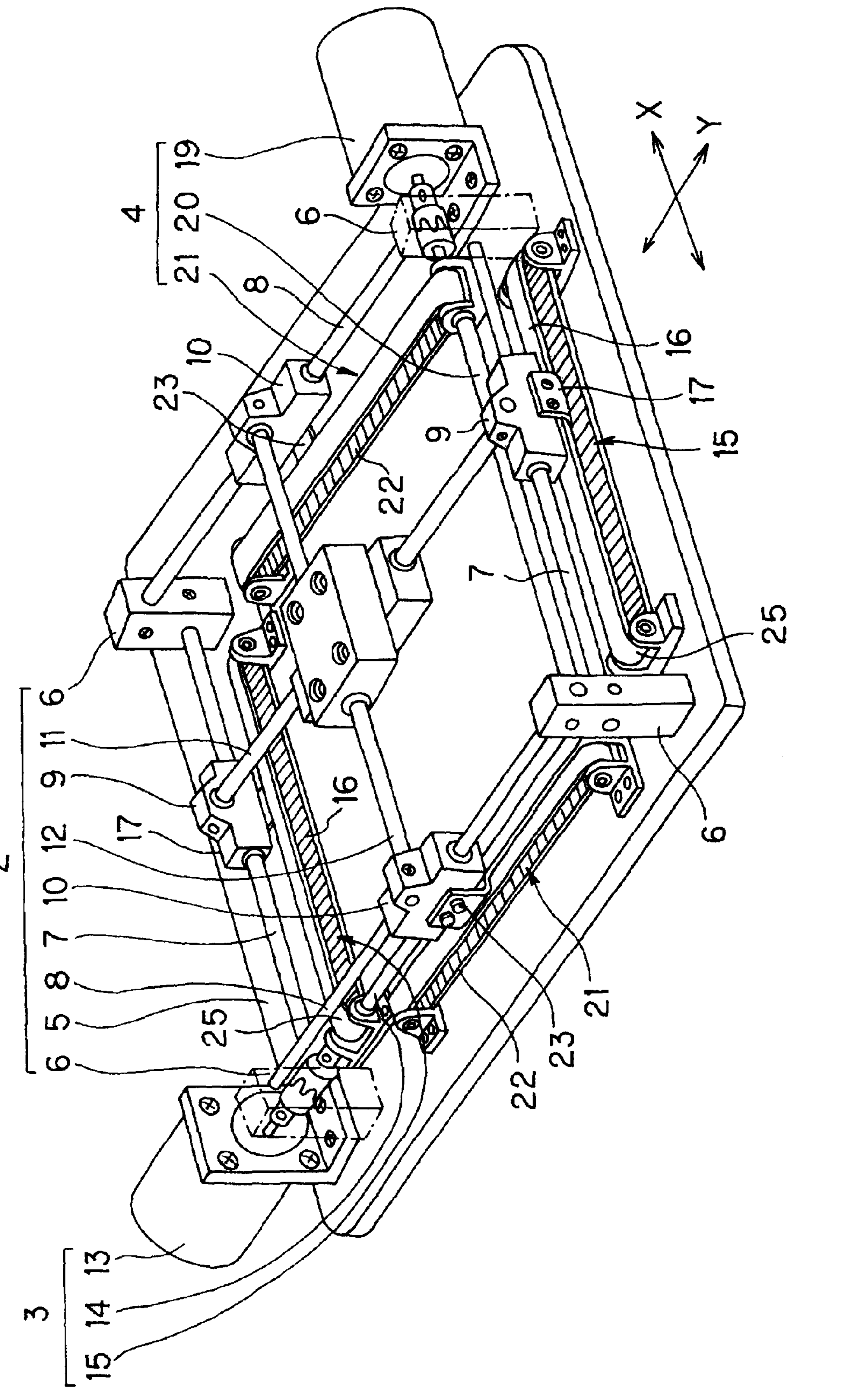


FIG. 12
PRIOR ART

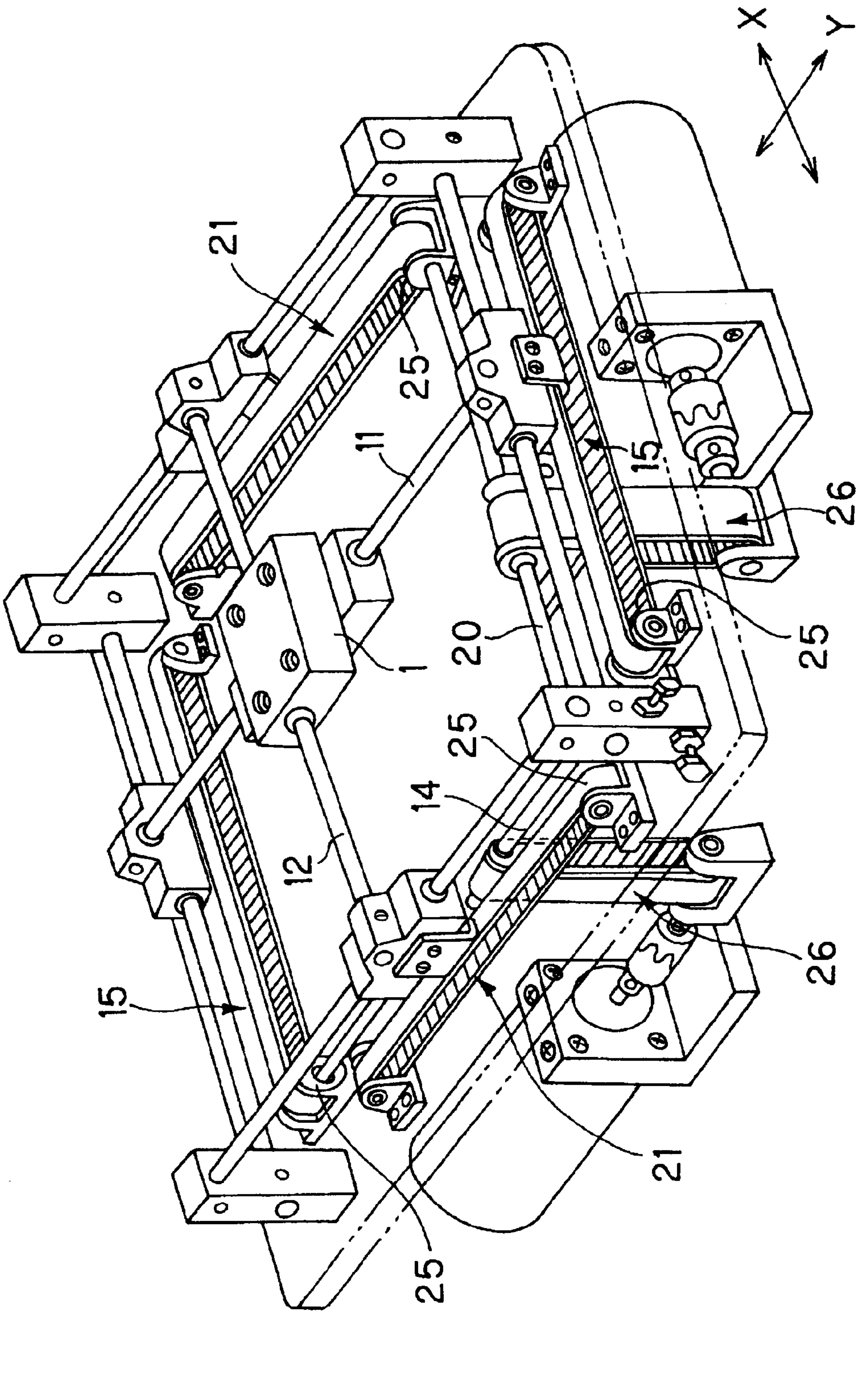
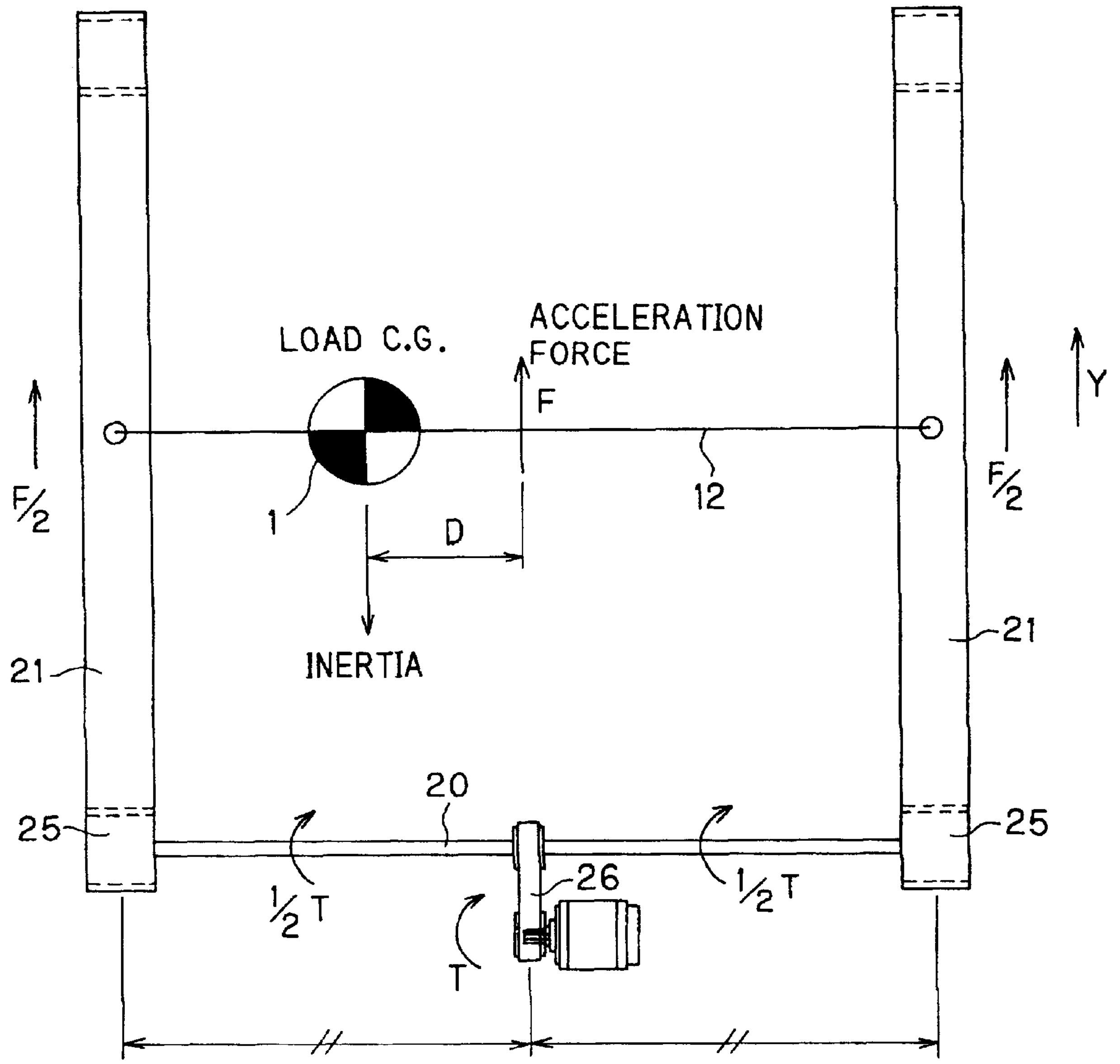


FIG. 13
PRIOR ART



TWO-DIMENSIONAL MOVING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a two-dimensional moving system for moving a table two dimensionally in a plane, such as X-Y table, in which a table is movable in an X (lateral) direction and a Y (longitudinal) direction, or a X-Z table in which a table is movable in the X direction and a Z (vertical) direction.

2. Related Art

FIG. **11** shows a known plane-type X-Y table, having a conventional structure, a two-dimensional moving system for moving a table in a plane (for example, as disclosed in Japanese Patent Publication No. SHO 63-9477). Such X-Y table comprises a table **1**, a guide mechanism **2** for guiding the table to be movable in a plane, an X-axis driving mechanism **3** and a Y-axis driving mechanism **4**.

Further, it is to be noted that the terms "X-axis "Y-axis " and "Z-axis " used herein may be substituted with terms "X-directional", "Y-directional " and "Z-directional", in which X, Y and Z mean the axial directions (axes) normal to each other.

The guide mechanism **2** includes a base plate **5**, columns (posts) **6**, - - - , **6** disposed at four corner portions of the base plate **5**, two X-axis slider shafts **7**, **7** arranged in parallel between opposed two columns **6**, **6**, two Y-axis slider shafts **8**, **8** arranged in parallel between other opposed two columns **6**, **6**, X-axis sliders **9**, **9** mounted to the X-axis slider shafts **7**, **7** to be slidable, Y-axis sliders **10**, **10** mounted to the Y-axis sliders **8**, **8** to be slidable, a Y-axis guide shaft **11** arranged between the X-axis sliders **9**, **9**, and an X-axis guide shaft **12** arranged between the Y-axis sliders **10**, **10**. Both the X-axis guide shaft **11** and Y-axis guide shaft **12** penetrate the table **1** so as to intersect to each other at right angles.

The X-axis driving mechanism **3** includes a Y-axis motor **13**, a Y-axis driving shaft **14** connected to the Y-axis motor **13** and a pair of X-axis belt transmission devices **15**, **15** fixed to the Y-axis driving shaft **14**. Each of the X-axis belt transmission devices **15**, **15** includes an X-axis belt **16**, which is coupled to the X-axis slider **9** by means of bracket **17**.

The Y-axis driving mechanism **4** includes an X-axis motor **19**, an X-axis driving shaft **20** connected to the X-axis motor **19** and a pair of Y-axis belt transmission devices **21**, **21** fixed to the X-axis driving shaft **14**. Each of the Y-axis belt transmission devices **21**, **21** includes an Y-axis belt **22**, which is coupled to the Y-axis slider **10** by means of bracket **23**.

Then, when the Y-axis motor **13** is driven to be rotated, the Y-axis driving shaft **14** is rotated, the X-axis belts **16**, **16** are moved in the longitudinal direction thereof, and the X-axis sliders **9**, **9** and the Y-axis guide shaft **11** are moved in the X-axis direction. According to such movement, the table **1** is moved in the X-axis direction. On the other hand, when the X-axis motor **19** is driven to be rotated, the X-axis driving shaft **20** is rotated, the Y-axis belts **22**, **22** are moved in the longitudinal direction thereof, and the Y-axis sliders **10**, **10** and the X-axis guide shaft **12** are moved in the Y-axis direction. According to such movement, the table **1** is moved in the Y-axis direction.

In the X-Y table of the structure mentioned above, the Y-axis guide shaft **11** is disposed between the X-axis belts **16**, **16** extending in the X-axis direction, and when the Y-axis driving shaft **14** is driven to be rotated, the Y-axis guide shaft **11** is moved in the X-axis direction, and thereby, the table **1** is moved in the X-axis direction. On the other hand, the X-axis guide shaft **12** is disposed between the Y-axis belts **22**, **22** extending in the Y-axis direction, and when the X-axis driving shaft **20** is driven to be rotated, the X-axis guide shaft **12** is moved in the Y-axis direction, and thereby, the table **1** is moved in the Y-axis direction.

However, in the conventional X-Y table of the structures mentioned above and shown, for example, in FIG. **11**, there is a possibility that rotational angles of tandem pulleys **25**, **25** of the belt transmission devices **15**, **15** are changed at the driving time due to twisting (torsion) force of the Y-axis driving shaft **14**, and the motion of one of the X-axis belts **16** disposed apart from the Y-axis motor **13** always delays from the motion of the other one of the X-axis belts **16** disposed near the Y-axis motor **13**. Such delay of the motion also occurs on the Y-axis belts **22**, **22**. When the table **1** is moved at a highly accelerated speed, the twisting of the Y-axis driving shaft **14** and the X-axis driving shaft **20** is made large. Therefore, in the conventional X-Y table, it is impossible to move the table **1** at a highly accelerated speed.

In order to solve such problem, the Japanese Patent Publication mentioned hereinbefore provides an X-Y table having structure, as shown in FIG. **12**, that the Y-axis driving shaft **14** or X-axis driving shaft **20** is driven at a central portion between the tandem pulleys **25**, **25** so as to make equal the twisting amounts thereof and, hence, to substantially eliminate variation or change of the rotational angles of the tandem pulleys **25**, **25**. In such X-Y table, central driving devices **26**, **26** are arranged at a central portion between the parallel paired X-axis belt transmission devices **15**, **15** and a central portion between the parallel paired Y-axis belt transmission devices **21**, **21**, respectively.

However, in the X-Y table in which the rotational angle variation between the tandem pulleys **25**, **25** are eliminated, the central driving devices **26**, **26** merely serve to distribute a driving force to or between the tandem belt transmission assemblies (including a pair of X-axis belt transmission devices **15**, **15** and a pair of Y-axis belt transmission devices **21**, **21**), and in an actual arrangement, the driving force is applied to the central position between the tandem belt transmission assemblies. That is, the driving force is focused and concentrated on the central portion in the longitudinal direction between the X- and Y-axis guide shafts **12** and **11**. For this reason, when the table **1** is shifted from the central portion between the tandem belt transmission assemblies, it is impossible to position the driving force on the central portion of the table **1**. Therefore, in the case where the table **1** is not accurately positioned on the central portion of the tandem belt transmission assemblies, there will cause a yawing (YAW) moment to the peripheral support bearings, which will be described hereunder in detail.

FIG. **13** shows a schematic arrangement of the X-Y table in which the rotational angle variation between the tandem pulleys **25**, **25** is eliminated. With reference to FIG. **13**, when the central driving device **26** drives the X-axis driving shaft **20**, the tandem belt transmission assemblies **21**, **21**, and the X-axis guide shaft **12** is moved in the Y-axis direction. As shown in FIG. **13**, the equally divided X-axis driving shaft **20** distributes a torque (T) equally to ½ torque (T/2) which equally balances a force of F/2 at both sides of the X-Y table. Finally, a composed force F is positioned on the central portion of the tandem belt transmission assemblies at both the sides of the X-Y table. When the table **1** is shifted from the central position by a distance D, since no means for controlling the supply of the torque exists on the closer side, the force F for acceleration is always applied to the central portion of the X-axis guide shaft **12**. As a result, the yawing moment equal to F×D is caused. In the case where such yawing moment is caused, it becomes difficult to move the table **1** at the highly accelerated speed.

SUMMARY OF THE INVENTION

An object of the present invention is to substantially eliminate defects or drawbacks encountered in the prior art mentioned above and to provide a two-dimensional moving system capable of moving a table or like at a highly accelerated speed without causing any moment such as yawing moment and achieving a high moving (motion) performance, that is, capable of effectively concentrating the accelerated speed on the table regardless of the position of the table when moved.

This and other objects can be achieved according to the present invention by providing a two-dimensional moving system for moving a table in a plane comprising:

a table;

a guide mechanism for guiding the table to be movable in the plane;

first and second belt members which are connected to the table so as to intersect to each other at substantially right angles;

a first driving mechanism for driving the first belt members so as to move the table in a longitudinal direction of the first belt members and to allow the first belt members to be movable in a longitudinal direction of the second belt members; and

a second driving mechanism for driving the second belt members so as to move the table in the longitudinal direction of the second belt members and to allow the second belt members to be movable in the longitudinal direction of the first belt members.

In the present invention, the first and second belt members each preferably comprises an annular endless member including, for example, timing belt, V-belt, chain or rope.

According to the present invention of the structure mentioned above, since the table is moved by driving the first and second belt members, the accelerated force can be effectively concentrated to the table regardless of the position of the table. Further, the moving load including the weight of the table and the load applied thereto is larger than a moving load preliminarily applied to a movable portion of the guide mechanism. However, according to the structure of the present invention, since any yawing moment is not caused, the table can be moved at a high acceleration speed, thus achieving the improved moving performance.

In a preferred embodiment of the present invention, the first driving mechanism comprises a pair of first pulleys provided for both end portions of the first belt members, a first spline shaft extending in parallel to the longitudinal direction of the second belt members so as to penetrate one of the first pulleys and a first driving source for driving the first spline shaft to be rotated, this one of the first pulleys being movable in an axial direction of the first spline shaft and being rotated thereby, and the second driving mechanism comprises a pair of second pulleys provided for both end portions of the second belt members, a second spline shaft extending in parallel to the longitudinal direction of the first belt members so as to penetrate one of the second pulleys and a second driving source for driving the second spline shaft to be rotated, this one of the second pulleys being movable in an axial direction of the second spline shaft and being rotated thereby.

According to this embodiment, the first belt member is rotated and the first belt member can be moved in the longitudinal direction of the second belt member. Furthermore, the second belt member is rotated and the second belt member can be moved in the longitudinal direction of the first belt member. The use of the spline shaft makes simple the structures of the first and second driving mechanisms, improving the reliability. Moreover, even if the driving sources are disposed at corner portions of the X-Y table for the sake of easy usage, the acceleration force can be concentrated to substantially the central portion of the table without using, for example, wrapping transmission member.

The pulleys may be timing pulleys and the belt members may be timing belts.

According to the use of the timing belt having less slip or noise, the table can be smoothly moved at a high acceleration speed and backlash is eliminated, thus improving the positioning performance.

In a further embodiment, the guide mechanism comprises a pair of first guide shafts extending in parallel to the longitudinal direction of the first belt members so as to guide the table to be movable, a pair of second guide shafts extending in parallel to the longitudinal direction of the second belt members so as to guide the table to be movable, a pair of first linear motion guides provided for both end portions of the first guide shafts and adapted to guide the linear motion of the first guide shafts in the longitudinal direction of the second belt members, and a pair of second linear motion guides provided for both end portions of the second guide shafts and adapted to guide the linear motion of the second guide shafts in the longitudinal direction of the first belt members, a pair of the first guide shafts being arranged on both sides of the first belt members and a pair of the second guide shafts being arranged on both sides of the second belt members.

According to this embodiment, since the paired first guide shafts are arranged on both sides of the first belt members and the paired second guide shafts are arranged on both sides of the second belt member, the table can be smoothly guided in a balanced state even if the table is moved at the highly accelerated speed.

In a further embodiment, each of the first pulleys is guided by each of the first linear motion guides so as to be linearly moved in the longitudinal direction of the second belt member and each of the second pulleys is guided by each of the second linear motion guides so as to be linearly moved in the longitudinal direction of the first belt members.

According to this embodiment, the motion of the table can accord with the motions of the first and second belt members, and hence, the table can be moved at the highly accelerated speed.

In a further embodiment, the first and second spline shafts are formed with ball rolling grooves extending in axial directions thereof, the above-mentioned one of the first pulleys and the above-mentioned one of the second pulleys are formed with ball circulation passages including ball rolling grooves corresponding respectively to the ball rolling grooves formed to the first and second spline shafts, and an outer sleeve is assembled to each of the first and second spline shafts to be linearly movable thereto and a number of balls housed and arranged in the ball circulation passage of the outer sleeve so as to circulate in accordance with the linear motion of the outer sleeve with respect to each of the first and second spline shafts.

According to this embodiment, the pulleys can be smoothly moved in the axial direction of the spline shafts through the rolling motion guide, and as a result, the table can be moved at the highly accelerated speed.

In a further embodiment, the linear motion guides each comprises a track shaft having a rolling member rolling surface, a slider member formed with a rolling member circulation passage including a loaded rolling member rolling surface corresponding to the rolling member rolling surface of the track shaft and assembled with the track shaft to be relatively movable, and a number of rolling members arranged in the rolling member circulation passage so as to circulate therein in accordance with the relative motion of the slider member with respect to the track shaft.

According to this embodiment, the motion of the linear motion guide device can be made smooth through the rolling motion of the rolling members, and hence, the guide shafts and the table can be moved at the highly accelerated speed.

In a further embodiment, the first and second belt members are coupled to substantially a central portion of the table in the plane.

According to such structure, the accelerated force can be more effectively concentrated to the central portion of the table, so that the table can be moved at the more highly accelerated speed.

In a further embodiment, the table comprises an upper table section and a lower table section which are shifted from each other in positions in a direction normal to the plane, and one of the first and second belt members is coupled to the upper table section and the other one thereof is coupled to the lower table section.

According to this embodiment, the belt attaching positions are shifted in the vertical direction, so that the interference between the first and second belt members can be prevented even if they intersect to each other.

The nature and further characteristic features of the present invention will be made more clear from the following descriptions made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** is a plan view of a two-dimensional moving system according to one embodiment of the present invention;

FIG. **2** is a side view of the two-dimensional moving system of FIG. **1**;

FIG. **3** is a view, in an enlarged scale, of an encircled portion III shown in FIG. **1**;

FIG. **4** is a side view of FIG. **3**;

FIG. **5** is a perspective view, partially including a sectional portion, of a linear guide;

FIG. **6** is a side view of the linear guide including a longitudinal sectional view of a guide rail;

FIG. **7** is a perspective view, partially including a sectional portion, of X-axis or Y-axis spline shaft and an outer sleeve thereof;

FIG. **8** is a side view of the X-axis or Y-axis spline shaft, partially including an axial sectional view of the spline shaft;

FIG. **9** is a perspective view, partially including a sectional portion, of X-axis or Y-axis guide shaft and a ball bush;

FIG. **10** is a side view, partially including an axial sectional portion, of the ball bush;

FIG. **11** is a perspective view of one example of an X-Y table having a conventional structure;

FIG. **12** is a perspective view of another example of an X-Y table having a conventional structure; and

FIG. **13** a schematic view of an X-Y table of a further example of a conventional structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will be described hereunder with reference to the accompanying drawings.

FIGS. **1** to **4** represents a two-dimensional moving system according to one embodiment of the present invention. This two-dimensional moving system is used as X-Y table which moves a table in an X-direction (lateral direction in FIG. **1**, for example,) and a Y-direction (vertical direction therein). As shown in FIG. **1**, the two-dimensional moving system includes a table **31**, a guide mechanism **33** for guiding the table **31** to be movable in a plane, an X-axis (directional) driving mechanism **33** for driving, i.e., moving, the table in the X direction and a Y-axis (directional) driving mechanism **34**. At substantially the central portion in the plane of the table **1**, an X-axis belt as first belt **35** and a Y-axis belt as second belt **36**, which intersect at right angles to each other, are coupled together. In the two-dimensional moving system of this embodiment, the table **31** is directly driven and moved by such X-axis belt **35** and the Y-axis belt **36** so that an acceleration force can be effectively concentrated to substantially the central portion of the table **31** even if the table **31** is positioned at any portion. It is preferred that such X-axis belt **35** and the Y-axis belt **36** are formed from annular timing belts.

The guide mechanism **32** for guiding the table **31** to be movable in a plane comprises a frame **37** formed so as to provide a rectangular frame shape, Y-axis linear guides **38**, **38** as first linear motion guide means fixed to two side portions in the Y-direction of the upper surface of the frame **37**, X-axis linear guides **39**, **39** as second linear motion guide means fixed to two side portions in the X-direction of the upper surface of the frame **37**, a pair of X-axis guide shafts **40**, **40** as first guide shafts disposed between the Y-axis linear guides **38**, **38** so as to be parallel to the longitudinal direction of the X-axis belt **35**, and a pair of Y-axis guide shafts **41**, **41** as first guide shafts disposed between the X-axis linear guides **39**, **39** so as to be parallel to the longitudinal direction of the Y-axis belt **36**. The table **31** is guided to be movable in the X-direction by the paired X-axis guide shafts **40**, **40** and in the Y-direction by the paired Y-axis guide shafts **41**, **41**.

The frame **37** is fabricated by arranging frame pieces, which are formed as aluminum product through extrusion molding, into substantially a square shape and connecting four corner portions of the square frame pieces by means of gussets **42**, - - - , **42**, for example. As shown in FIG. **2**, the frame **37** is fixed on a frame mounting bracket **43**.

With reference to FIGS. **1** and **2**, the X-axis linear guides **39**, **39** and the Y-axis linear guides **38**, **38** are each provided with a track rail **44** as a track shaft having a long scale and two slider members **45**, **45** sliding along the track rail **44**. Further, as shown in FIG. **3**, two slider members **45**, **45** are coupled together by means of connection (coupling) plate **46**. The details of the structures of such track rail **44** and slider members **45**, **45** will be mentioned hereinlater. A pulley **50** is mounted to the outside portion of the connection plate **46** through a pulley mounting plate **48** also mentioned hereinlater, and a shock absorber cushion **49** for absorbing an impact energy of the table **31** is also mounted to the inside portion of the connection plate **46**.

Referring to FIG. **1**, a pair of X-axis guide shafts **40**, **40** extending in parallel to the longitudinal direction of the

X-axis belt **35** have both end portions to which a pair of Y-axis linear guides **38, 38** are mounted so as to guide the linear motion in the Y-direction of the X-axis guide shafts **40, 40**. Furthermore, a pair of Y-axis guide shafts **41, 41** extending in parallel to the longitudinal direction of the Y-axis belt **36** have both end portions to which a pair of Y-axis linear guides **39, 39** are mounted so as to guide the linear motion in the X-axis direction of the Y-axis guide shafts **41, 41**.

The paired X-axis guide shafts **40, 40** are on both the side portions of the X-axis belt **35** with equal distance in the Y-axis direction, and the paired Y-axis guide shafts **41, 41** are on both the side portions of the Y-axis belt **36** with equal distance in the X-direction. These X-axis guide shafts **40, 40** and Y-axis guide shafts **41, 41** are composed of hollow shafts having inner hollow structures and attached to the connection plates **46, 46** so as to adjust a tension. That is, as shown in FIGS. **3** and **4**, each of both the end portions of these X-axis guide shafts **40, 40** and Y-axis guide shafts **41, 41** is attached to the connection plate **46** through tension adjusting bolts **51, 51**, a split bush **52** and a tension adjusting bracket **53**. According to this structure, the tensions of the X-axis guide shafts **40, 40** and the Y-axis guide shafts **41, 41** can be adjusted by the tension adjusting bolts **51, 51**, respectively.

With reference to FIG. **1**, the X-axis driving mechanism **33** as the first driving mechanism comprises a pair of X-axis pulleys **50***a*, **50***b* mounted to both end portions of the X-axis belt **35**, a Y-axis spline shaft **55** as a first spline shaft extending in the Y-axis direction and a Y-axis motor **56** such as stepping motor or like as a first driving source for rotating the Y-axis spline shaft **55**, which penetrates one **50***b* of the X-axis pulleys **50***a*, **50***b*. This one X-axis pulley **50***b* is made movable in the axial direction of the Y-axis spline shaft **55** to be rotatable thereby.

The Y-axis driving mechanism **34** as the second driving mechanism comprises a pair of Y-axis pulleys **57***a*, **57***b* mounted to both end portions of the Y-axis belt **36**, a X-axis spline shaft **58** as a second spline shaft extending in the X-axis direction and an X-axis motor **59** such as stepping motor or like as a second driving source for rotating the X-axis spline shaft **58**, which penetrates one **57***b* of the Y-axis pulleys **57***a*, **57***b*. This one Y-axis pulley **57***b* is made movable in the axial direction of the X-axis spline shaft **58** to be rotatable thereby.

The X-axis driving mechanism **33** drives the X-axis belt **35** to be rotated to allow the table **31** to move in the longitudinal direction (X-axis direction) of the X-axis belt **35** and also allow the X-axis belt **35** to move in the longitudinal direction (Y-axis direction) of the Y-axis belt **36**. Further, the Y-axis driving mechanism **34** drives the Y-axis belt **36** to be rotated to allow the table **31** to move in the longitudinal direction of the Y-axis belt **36** and also allow the Y-axis belt **36** to move in the longitudinal direction of the X-axis belt **35**.

The X-axis spline shaft **58** and the Y-axis spline shaft **55** are supported to be rotatable at both ends thereof by support brackets **60, 60** through radial bearings. The support brackets **60, 60** are mounted to the corner portions of the frame **37**.

As shown in FIGS. **1** and **3**, a pair of X-axis pulleys **50***a*, **50***b* and a pair of Y-axis pulleys **57***a*, **57***b* comprises timing pulleys, which are mounted to pulley mounting plates **48**, - - - , **48** mounted and supported to the side surfaces of the connection plates **46, 46** so as to be rotatable through radial bearings, respectively.

The respective X-axis pulleys **50***a*, **50***b* are guided by the Y-axis linear guides **38, 38** to be linearly movable in the Y-axis direction, and the respective Y-axis pulleys **57***a*, **57***b* are guided by the X-axis linear guides **39, 39** to be linearly movable in the X-axis direction. The X-axis pulley **50***b* and the Y-axis pulley **57***b* are formed in combination of outer sleeves **61, 61** and gears **62, 62**, respectively.

As shown in FIGS. **1, 2** and **4**, the table **31** is provided with an upper side table section **31***a* and a lower side table section **31***b* which are shifted from each other in positions in a direction (Z-axis direction) normal to the X-Y plane. The upper side table section **31***a* and the lower side table section **31***b* are coupled together through bush housings **63**, - - - , **63** arranged to four corners of the table **31**. The paired X-axis guide shafts **40, 40** and the paired Y-axis guide shafts **41, 41** penetrate the bush housings **63**, - - - , **63**. Furthermore, ball bushes **64**, - - - , **64** are provided for the X-axis guide shafts **40, 40** and the Y-axis guide shafts **41, 41** at portions penetrating the bush housings **63**, - - - , **63** so as to enable the table to be smoothly movable with respect to the X-axis guide shafts **40, 40** and the Y-axis guide shafts **41, 41**, respectively.

As shown in FIG. **4**, the Y-axis belt **36** is fastened at its upper end side to the lower surface of the upper table section **31***a* by the belt mounting plates **65, 65**, and further, the X-axis belt **35** is also fastened at its lower end side to the upper surface of the lower table section **31***b* by the belt mounting plates, not shown. Further, the upper side of the annular X-axis belt **35** passes through the annular Y-axis belt **36**.

FIGS. **5** and **6** show the track rail **44** and the slider member **45** constituting the linear guides **38, 39**. The linear guides **38** and **39** are disposed on the frame **37** and each comprises the track rail **44** (track shaft) formed with a ball rolling groove **44***a* as a rolling member rolling surface so as to extend in the longitudinal direction thereof, the slider member **45** assembled to the track rail **44** to be relatively movable and a number of balls **69**, - - - , **69** as rolling members. The slider member **45** is formed with a ball circulation passage **68** (rolling member circulation passage) including a loaded ball rolling groove **45***a* as a loaded rolling surface corresponding to the ball rolling groove **44***a* formed to the track rail **44**, and the balls **69** endlessly circulate in the ball circulation passage **68** in association with the relative motion of the slider member **45** with respect to the track rail **44**. According to the endless circulation of the balls **69**, the slider member **45** supporting the table **31** moves linearly along the track rail **44**. The respective balls **69** are held to be rotatable and slidable by retainer means **70**. The balls may be substituted with rollers as rolling members.

The track rail **44** is composed of a linear long member and has substantially a rectangular sectional shape. The ball rolling grooves **44***a* are formed on the upper surface and to both side surfaces of the track rail **44** so as to extend in its longitudinal direction along which the balls **69** are rolled. Two ball rolling grooves **44***a*, totally, four grooves, are formed on left and right side portions of the track rail **44**, respectively. That is, for example, on the left side, one ball rolling groove **44***a* is formed on the left side upper surface of the track rail **44** and one ball rolling groove is formed on the left side side surface thereof.

The slider member **45** comprises a block body **71** and a pair of end covers **72, 72** disposed to both end sides of the block body **71** and fastened thereto by means of bolts. The block body **71** is formed with four loaded rolling member rolling grooves **45***a* opposing to the ball rolling grooves **44***a*, respectively, and the opposing ball rolling grooves **44***a* and **45***a* constitute, when they are assembled, a loaded ball rolling passage α, that is, four loaded ball rolling passages are formed between the track rail **44** and the slider member **45**. Furthermore, four ball return passages β are formed to the movable member so as to extend in parallel to the corresponding loaded ball rolling passages α, and rolling direction changing passages γ connecting the loaded ball rolling passages α and the ball return passages β, respectively, are also formed to the movable member, and one ball circulation passage **68** is constituted by one loaded ball rolling passage α, one return passage β and two rolling direction changing passages γ.

FIGS. **7** and **8** show an example of the X-axis spline shaft **58** and the outer sleeve **61** mounted thereto. Although only the X-axis spline shaft **58** is explained herein, the Y-axis spline shaft **55** has substantially the same structure.

The X-axis spline shaft **58** is formed with, for example, six ball rolling grooves **55***a* extending in the axial direction thereof. The outer sleeve **61** is assembled to the X-axis spline shaft **58** to be linearly movable and comprises a sleeve body **61***a* formed with ball circulation passages **75** including ball rolling grooves **61***a* opposing to the ball rolling grooves **55***a* formed to the spline shaft **58**, a number of balls **76**, - - - , **76** which are housed and arranged in the ball circulation passage **75** and circulate therein in accordance with the relative linear motion of the outer sleeve **61** with respect to the X-axis spline shaft **58**, and retainers **77** assembled to the sleeve body **61***a* so as to align and hold the balls **76** in the ball circulation passages **75**.

Further, a ball rolling groove **61***b* is formed to the inner peripheral surface of the sleeve body **61***a*, as the track for the balls **76**, so as to extend in the axial direction thereof, and the loaded ball rolling groove α is formed by the combination of the ball rolling groove **55***a*formed to the X-axis spline shaft **55** and the ball rolling groove **61***b* formed to the sleeve body **61***a*. A non-loaded ball return passage β, in which the balls **76** released from the load are circulated, is formed adjacent to the loaded ball rolling passage α.

According to the structure mentioned above, when the outer sleeve **61** is moved relatively to the X-axis spline shaft **55**, the balls **76** roll in the loaded rolling passage a under the loaded state and, then, return to the non-loaded return passage β disposed adjacent to the loaded rolling passage α thus endlessly circulating in the circulation passage in shape of circuit.

FIGS. **9** and **10** show the X-axis guide shaft **40** (Y-axis guide shaft **41**) and the ball bush **64** in an assembled state. The ball bush **64** is assembled with the X-axis guide shaft **40** or Y-axis guide shaft **41** to be relatively linearly movable thereto. The ball bush **64** comprises an outer sleeve **80** formed with a ball circulation passage, a number of balls **81**, - - - , **81**, as rolling members which are housed and arranged in the ball circulation passage **75** and circulate therein in accordance with the relative linear motion of the outer sleeve **80** with respect to the X-axis guide shaft **40** or Y-axis guide shaft **41**, and retainers **82** assembled to the outer sleeve **80** so as to align and hold the balls **81** in the ball circulation passages. When the ball bush **64** is relatively linearly moved with respect to the X-axis guide shaft **40** or Y-axis guide shaft **41**, the balls **81** circulate in the ball circulation passage, including the loaded ball rolling passage, between the surface of the X-axis guide shaft **40** (Y-axis guide shaft **41**) and the outer sleeve **80**.

As shown in FIG. **1**, when the Y-axis motor **56** is driven, the X-axis spline shaft **55** is rotated, then, the X-axis belt **35** is driven to be rotated and the table **31** fixed to the X-axis belt **35** is moved in the X-axis direction. In this operation, the Y-axis belt **36** connected to the table **31** is also moved in the X-axis direction under the guidance of the X-axis linear guide. On the other hand, when the X-axis motor **59** is driven, the Y-axis spline shaft **58** is rotated, then, the Y-axis belt **36** is driven to be rotated and the table **31** fixed to the Y-axis belt **36** is moved in the Y-axis direction. In this operation, the X-axis belt **35** connected to the table **31** is also moved in the Y-axis direction under the guidance of the Y-axis linear guide. According to such structure and operation of the present invention, the table is moved in the X and/or Y directions.

Furthermore, according to the present invention, since the table **31** is driven through the driving of the X-axis belt **35** and the Y-axis belt **36**, which are directly connected to the table **31**, the acceleration force can be effectively concentrated to the central portion of the table **31** regardless of the position of the table **31**.

Therefore, according to such structure, no yawing moment is caused, and hence, the table can be moved at a highly accelerated speed with high performance.

It is to be noted that the present invention is not limited to the described embodiments and many other changes and modifications may be made without departing from the scopes of the appended claims.

What is claimed is:

1. A two-dimensional moving system for moving a table in a plane comprising:

a table;

a guide mechanism for guiding the table to be movable in the plane;

a first and second belt means which are connected to the table so as to intersect to each other at substantially right angles;

a first driving mechanism for driving the first belt means so as to move the table in a longitudinal direction of the first belt means and to allow the first belt means to be movable in a longitudinal direction of the second belt means; and

a second driving mechanism for driving the second belt means so as to move the table in a longitudinal direction of the second belt means and to allow the second belt means to be movable in a longitudinal direction of the first belt means,

wherein mechanical force for driving the first and second belt means is provided by motors, and wherein movement of the table does not require translational movement of the motors.

2. A two-dimensional moving system according to claim **1**, wherein said first driving mechanism comprises a pair of first pulleys provided for both end portions of the first belt means, a first spline shaft extending in parallel to the longitudinal direction of the second belt means so as to penetrate one of the first pulleys and a first driving source for driving the first spline shaft to be rotated, said one of the first pulleys being movable in an axial direction of the first spline shaft and being rotated thereby, and wherein said second driving mechanism comprises a pair of second pulleys provided for both end portions of the second belt means, a second spline shaft extending in parallel to the longitudinal direction of the first belt means so as to penetrate one of the second pulleys and a second driving source for driving the second spline shaft to be rotated, said one of the second pulleys being movable in an axial direction of the second spline shaft and being rotated thereby.

3. A two-dimensional moving system according to claim **2**, wherein said pulleys are timing pulleys and said belt means are timing belts.

4. A two-dimensional moving system according to claim **2**, wherein said guide mechanism comprises a pair of first guide shafts extending in parallel to the longitudinal direction of the first belt means so as to guide the table to be movable, a pair of second guide shafts extending in parallel to the longitudinal direction of the second belt means so as to guide the table to be movable, a pair of first linear motion guide means provided for both end portions of the first guide shafts and adapted to guide the linear motion of the first guide shafts in the longitudinal direction of the second belt means, and a pair of second linear motion guide means provided for both end portions of the second guide shafts and adapted to guide the linear motion of the second guide shafts in the longitudinal direction of the first belt means, a pair of said first guide shafts being arranged on both sides of the first belt means and a pair of said second guide shafts being arranged on both sides of the second belt means.

5. A two-dimensional moving system according to claim **4**, wherein each of said first pulleys is guided by each of said first linear motion guide means so as to be linearly moved in the longitudinal direction of the second belt means and each of said second pulleys is guided by each of said second linear motion guide means so as to be linearly moved in the longitudinal direction of the first belt means.

6. A two-dimensional moving system according to claim **4**, wherein said first and second spline shafts are formed with ball rolling grooves extending in axial directions thereof, said one of the first pulleys and said one of the second pulleys are formed with ball circulation passages including ball rolling grooves corresponding respectively to the ball rolling grooves formed to the first and second spline shafts, and wherein an outer sleeve is assembled to each of the first and second spline shafts to be linearly movable thereto and a number of balls housed and arranged in the ball circulation passage of the outer sleeve so as to circulate in accordance with the linear motion of the outer sleeve with respect to each of the first and second spline shafts.

7. A two-dimensional moving system according to claim **4**, wherein said linear motion guide means each comprises a track shaft having a rolling member rolling surface, a slider member formed with a rolling member circulation passage including a loaded rolling member rolling surface corresponding to the rolling member rolling surface of the track shaft and assembled with the track shaft to be relatively movable, and a number of rolling members arranged in the rolling member circulation passage so as to circulate therein in accordance with the relative motion of the slider member with respect to the track shaft.

8. A two-dimensional moving system according to claim **1**, wherein said first and second belt means are coupled to substantially a central portion of the table in the plane.

9. A two-dimensional moving system according to claim **1**, wherein said table comprises an upper table section and a lower table section which are shifted from each other in positions in a direction normal to the plane, and one of said first and second belt means is coupled to the upper table section and the other one thereof is coupled to the lower table section.

* * * * *

US006495935B1

(12) **United States Patent**
Mishler

(10) **Patent No.: US 6,495,935 B1**
(45) **Date of Patent: Dec. 17, 2002**

(54) **LINEAR MOTOR DRIVE UNIT**

(75) Inventor: **Mike Mishler**, Schaumburg, IL (US)

(73) Assignees: **THK Co., LTD**, Tokyo (JP); **THK America, Inc.**, Schaumburg, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 55 days.

(21) Appl. No.: **09/692,159**

(22) Filed: **Oct. 20, 2000**

(51) **Int. Cl.**[7] **H02K 41/00**
(52) **U.S. Cl.** **310/12**; 384/59
(58) **Field of Search** 310/12, 42, 90; 384/45, 59

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,707,924 A	* 1/1973	Barthalon et al.	....	104/290
4,879,482 A	* 11/1989	Murofushi	....	310/12
5,225,725 A	* 7/1993	Shiraki et al.	....	310/12
5,924,518 A	* 7/1999	D'Onofrio	....	310/12 X
6,054,783 A	* 4/2000	Philipp et al.	....	310/12
6,326,708 B1	* 12/2001	Tsuboi et al.	....	310/12
6,336,744 B1	* 1/2002	Rehm et al.	....	384/59

FOREIGN PATENT DOCUMENTS

JP	355083452 A	* 6/1980
JP	405252725 A	* 9/1993

OTHER PUBLICATIONS

Abstract of Japanese Patent Publ. No. 03007055A; dated Jan. 14, 1991.
Abstract of Japanese Patent Publ. No. 07–083228; dated Mar. 28, 1995.

* cited by examiner

Primary Examiner—Nestor Ramirez
Assistant Examiner—Judson H. Jones
(74) *Attorney, Agent, or Firm*—Arent Fox Kintner Plotkin & Kahn PLLC

(57) **ABSTRACT**

A linear motor drive unit which is connected to a movable body supported movably on a stationary portion such as a head, like a work table and the like of a machine table for instance, and which drives such a movable body in reciprocation while giving a predetermined movement amount to it. The linear motor drive unit comprises a base plate, a magnet plate provided on the base plate, a top plate having a face for attaching the movable body, a movable element fixed to the top plate and facing the magnet plate, one pair of track rails provided on the base plate along both sides of the magnet plate, and slide members fixed to the top plate along both sides of the movable element and moving on the track rails, and the track rails and the slide members are constituted so as to be able to freely divide in a direction along which the movable element is separated from the magnet plate.

3 Claims, 6 Drawing Sheets

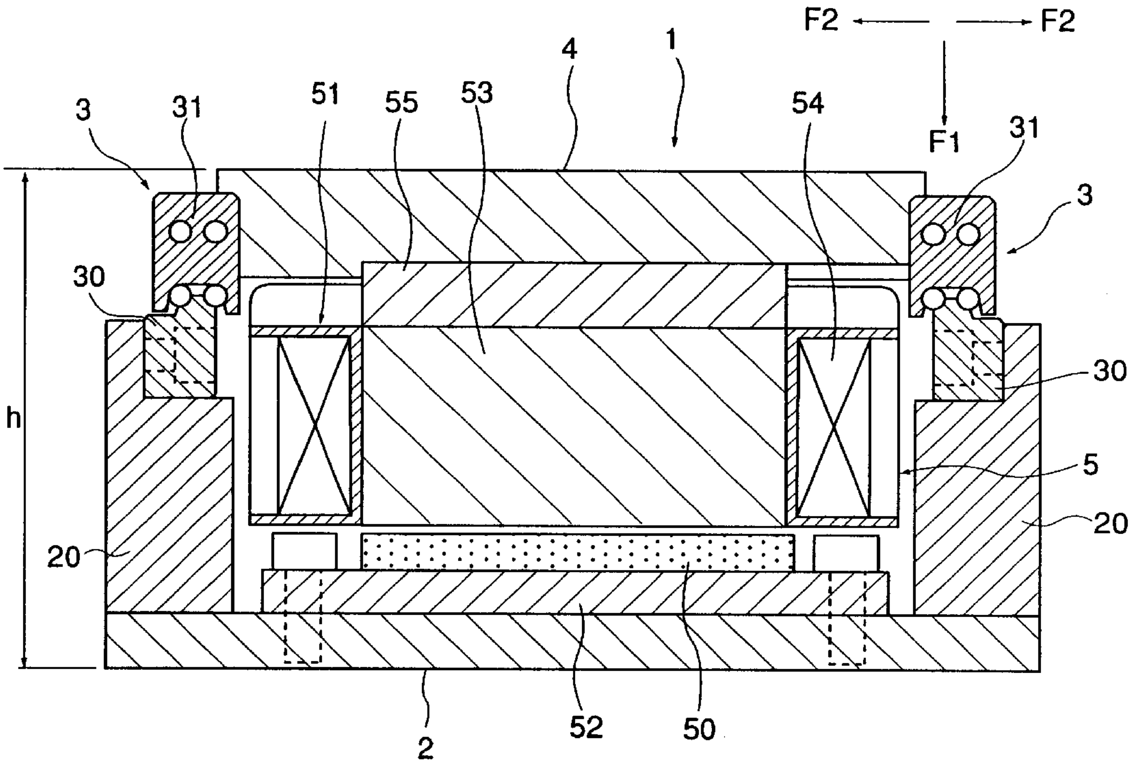
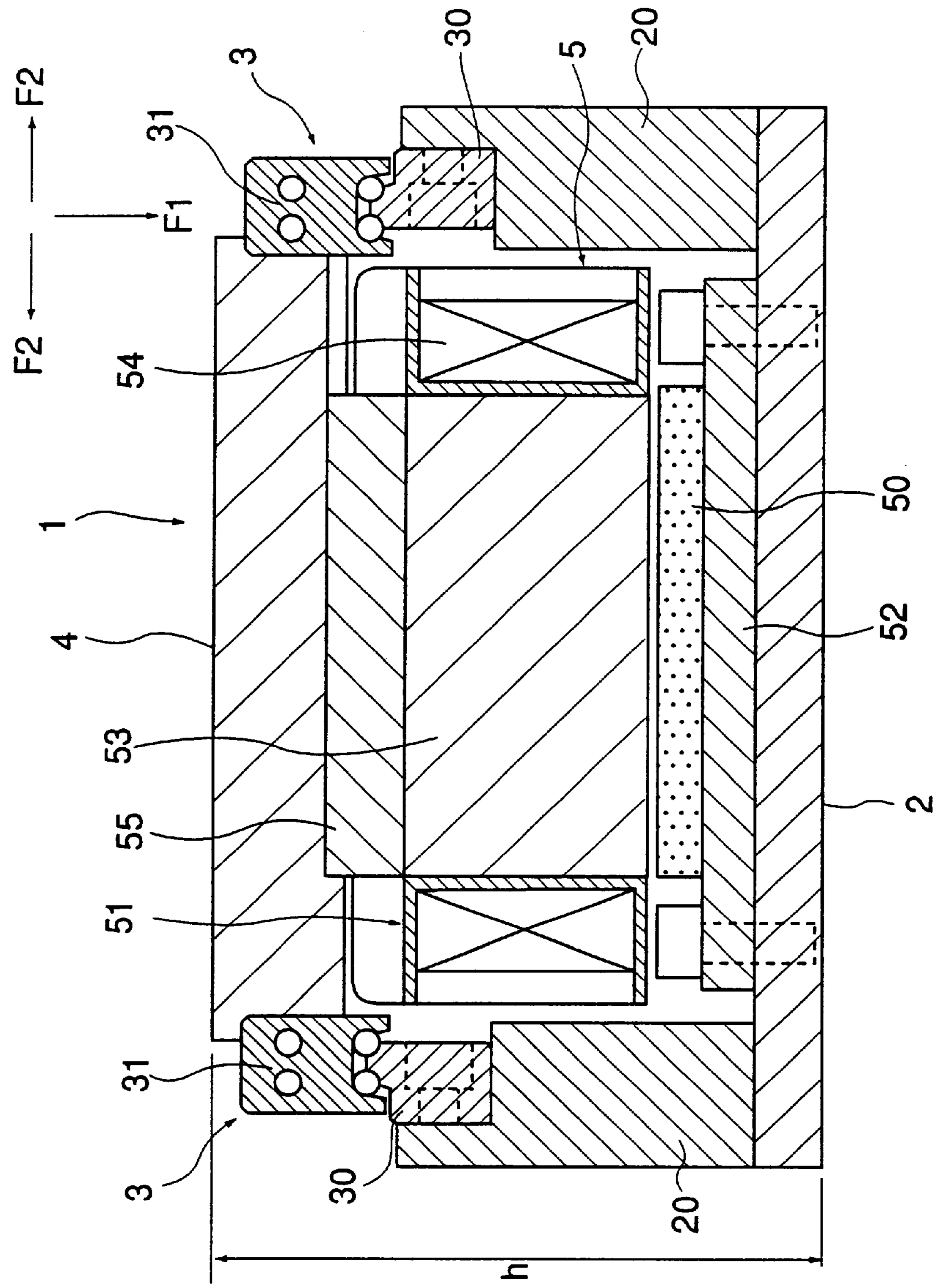
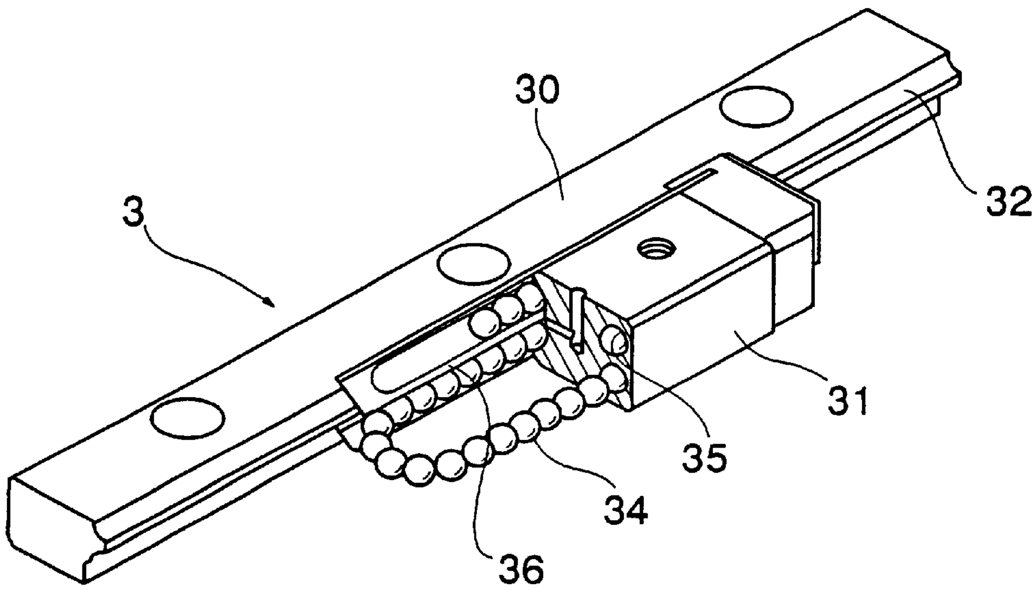


FIG. 1



F I G. 2



F I G. 3

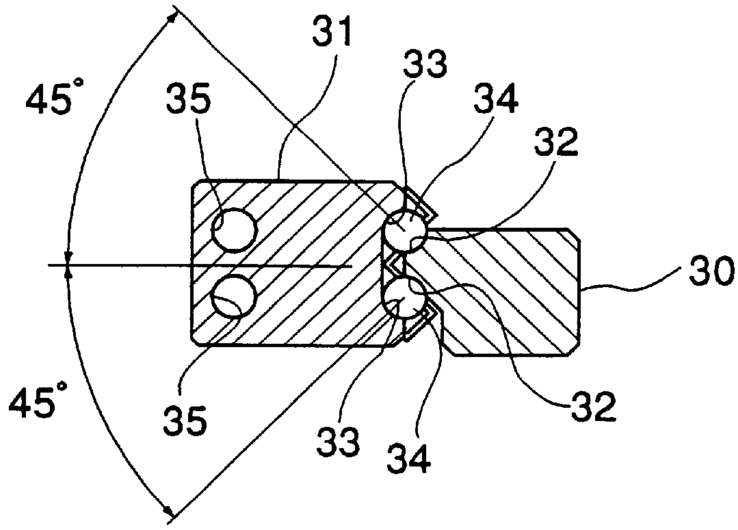


FIG. 4

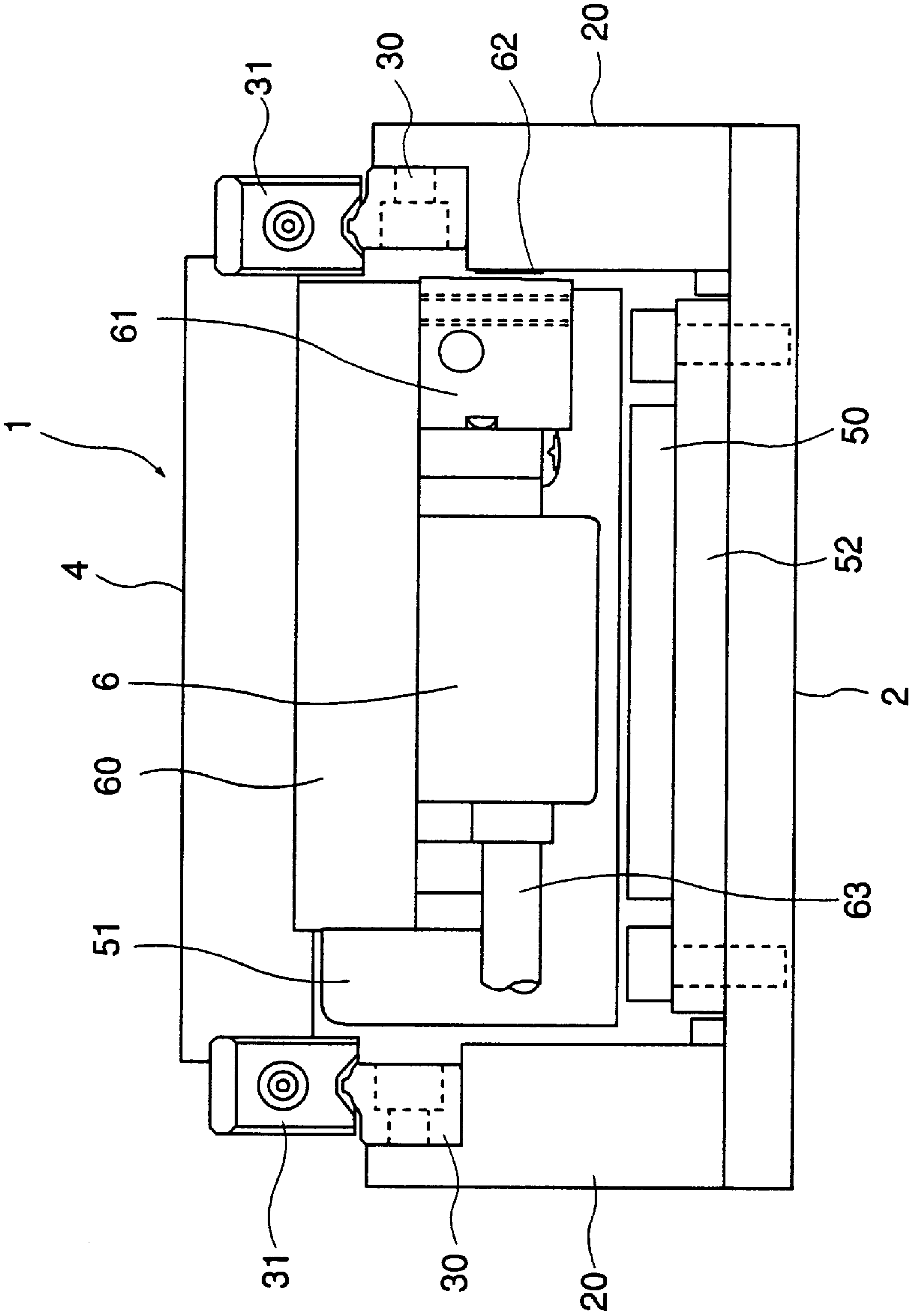
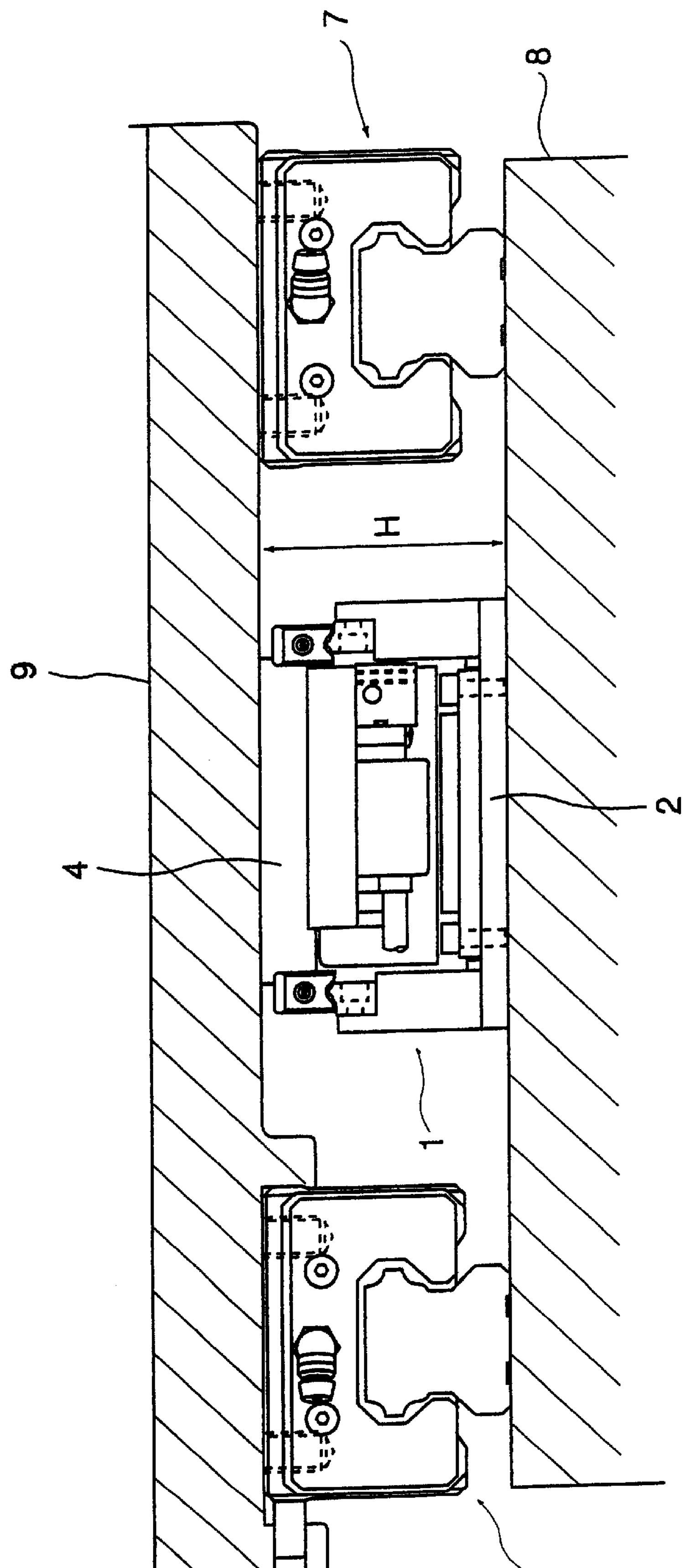
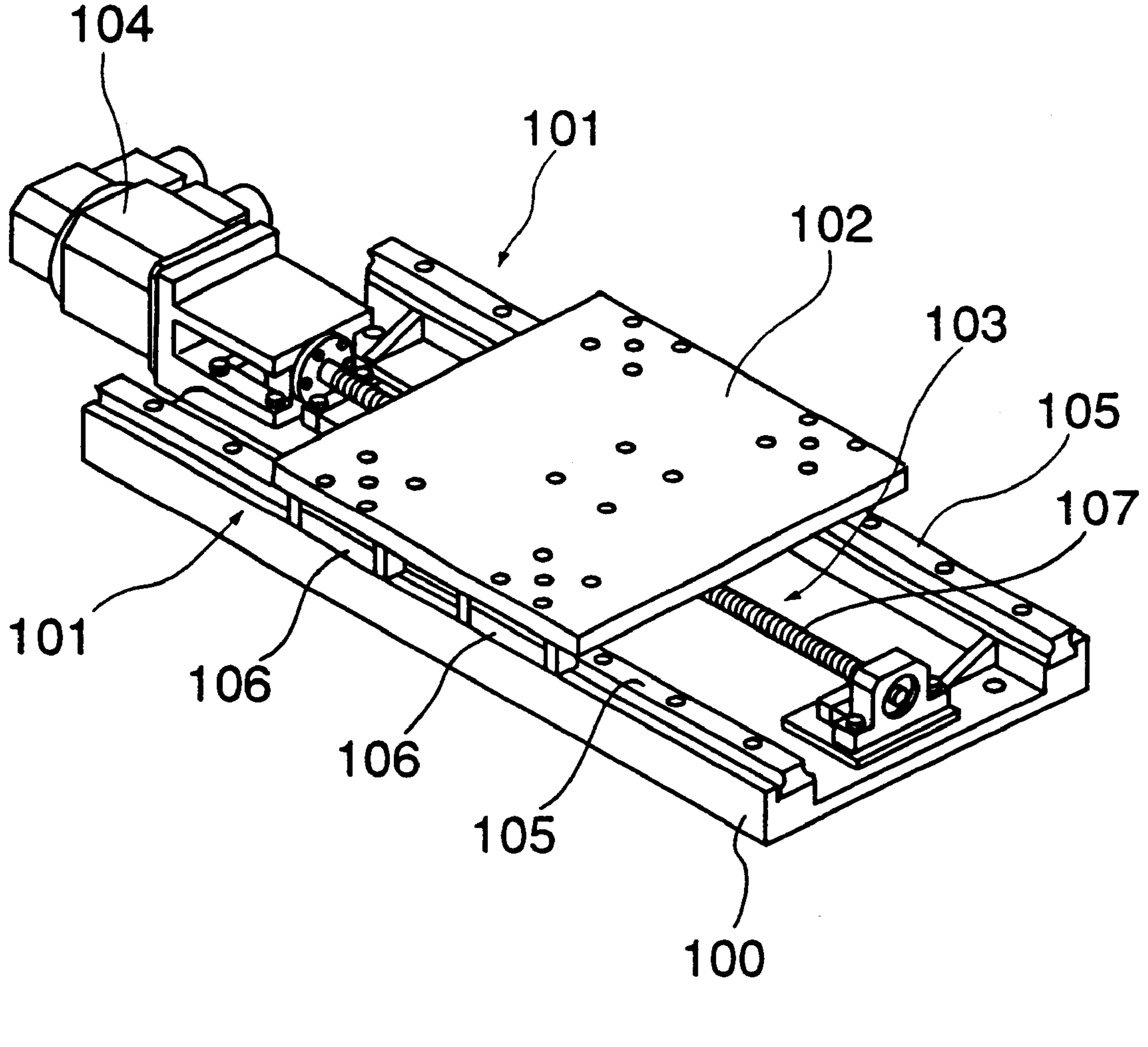


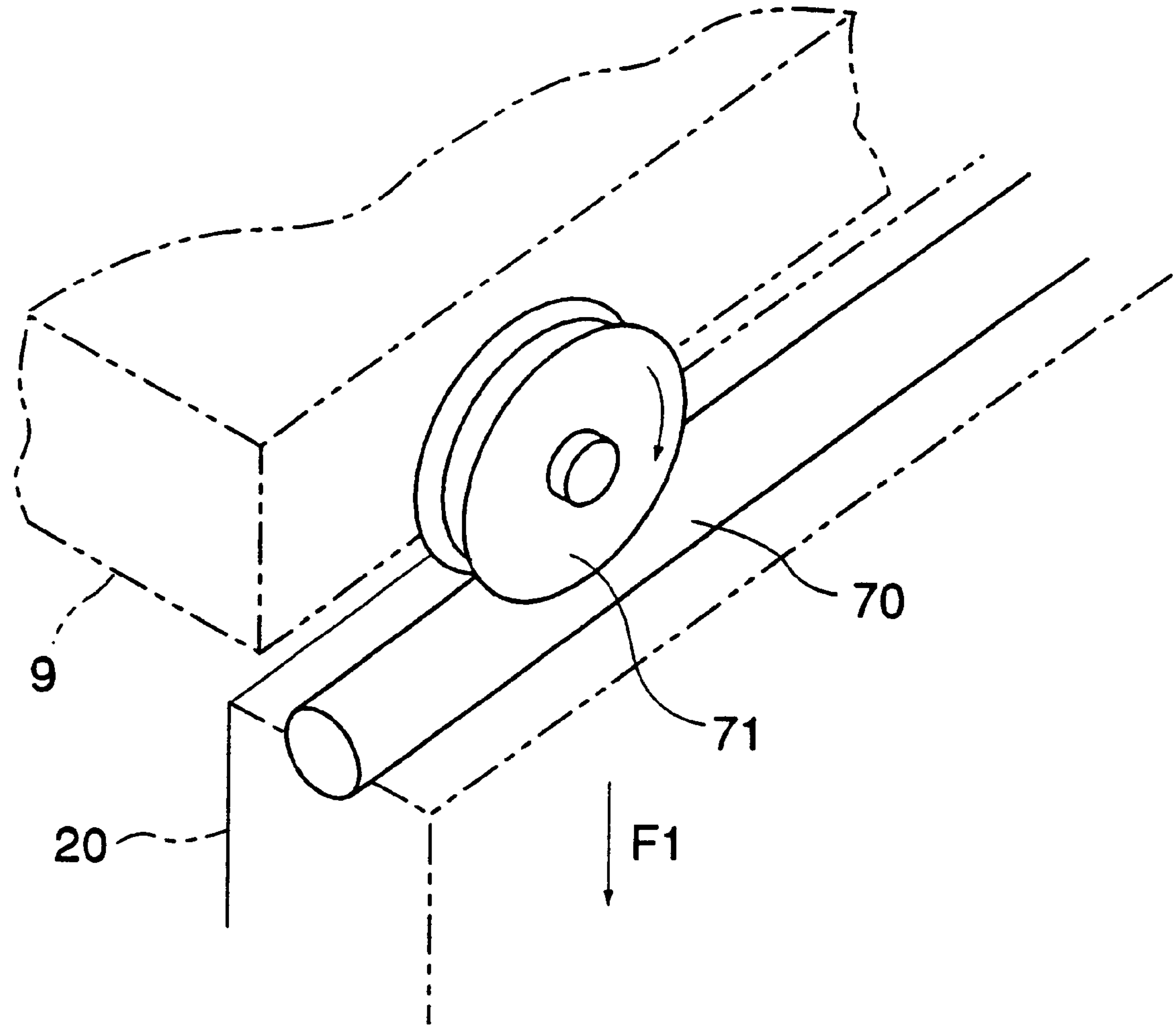
FIG. 5



F I G. 6



F I G. 7



LINEAR MOTOR DRIVE UNIT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a linear motor drive unit which is connected to a movable body supported movably on a stationary portion such as a head, like a work table and the like of a machine tool for instance, and which drives such a movable body in reciprocation while giving a predetermined movement amount to it.

2. Description of the Related Art

In various tables of the machine tool, a travelling portion of an industrial robot, various carrier apparatuses and the like, it is required to linearly guide the movable body on the stationary portion such as head and column, and position it to a predetermined position. Hitherto, as such a guide structure of the movable body, one shown in FIG. **6** is generally well known. Concretely, it is constituted such that a movable body **102** is supported by arranging one pair of linear guide units **101**, **101** on a stationary portion **100**, a ball screw **103** is disposed below the movable body **102**, and the ball screw **103** is driven by a rotary motor **104**. The linear guide unit **101** is composed of a track rail **105** incorporated through balls, and slide blocks **106**. Accordingly, by fixing the track rails **105** to the stationary portion **100** and the slide blocks **106** to the movable body **102**, it becomes possible to freely guide the movable body **102** on the stationary portion **100** along the track rails **105**. Further, the ball screw **103** is one in which a screw shaft **107** meshes with a nut member (not shown in the drawing) through balls and the nut member is fixed to the movable body **102**, while the screw shaft **107** is provided rotatively and parallel to the track rails **105** of the linear guide units **101**. Therefore, it is adapted such that if the screw shaft **107** is rotated by the rotary motor **104**, the nut member is moved on the screw shaft **107** in compliance with rotations of the rotary motor **104** to thereby give a thrust in a direction along the track rails **105** to the movable body **102** and, further, the movable body **102** can be stopped at a predetermined position.

In order to accurately position the movable body on the stationary portion by using the ball screw in this manner, it is required to suitably control a rotational speed and a rotational amount of the rotary motor. However, a precision rotary motor unitized with an encoder being stored and a feedback control function being provided is supplied in a market in various kinds. Accordingly, a person who intends to construct the aforesaid guide structure can very easily construct it merely by purchasing that precision rotary motor, installing it to the stationary portion, and connecting it to the screw shaft through a coupling.

On the other hand, in recent years, also a guide structure in which the movable body is directly driven by using a linear motor without using the ball screw becomes increased. However, different from the rotary motor in which a stator and a rotor are integrated within a casing, magnet plates and coils are under a separated state in the linear motor, so that there arises a necessity to individually fix the magnet plates to the stationary portion and the coils to the movable body. That is, the linear motor is not traded under a state that the magnet plates and the coils are integrated, so that a handling after the purchase is very troublesome. Especially, since it is required that the magnet plate and the coil are faced each other with a very small predetermined gap, in case where these magnet plate and coil are individually handled, a work for attaching them requires much labor, and such a trouble that the magnet plate is brought into contact with the coil to thereby damage them and such an accident that a hand is nipped between the magnet plate and the coil are liable to occur.

Further, also a linear encoder for detecting a movement amount of the coil with respect to the magnet plate is completely separately traded and, in order to realize the feedback control function, it is necessary to purchase the linear encoder separately from the linear motor and incorporate it to the stationary portion and the movable body. And, when completely individually incorporating the magnet plate, the coil and the linear encoder in this manner, a constant accuracy is required for every attaching work, so that the work becomes very troublesome.

Also a linear motor in which these magnet plate, coil and linear encoder are completely unitized exists in the market, but such a linear motor is directed to a specified use, so that a room for improving it in compliance with required conditions scarcely exists.

SUMMARY OF THE INVENTION

The invention has been made in view of such problems, and its object is to provide a linear motor drive unit capable of being easily and safely attached as a drive source of various guide structures, and capable of being flexibly applied to required uses.

In order to achieve the above object, the invention provides a linear motor drive unit attached to a movable body linearly movable with respect to a stationary portion and used for the purpose of giving a thrust to the movable body, comprising: a long base plate; a magnet plate which is provided on the base plate, and in which plural magnetic poles are arranged at a predetermined pitch along a longitudinal direction of the base plate; a top plate having a face for attaching the movable body; a movable element fixed to the top plate and facing the magnet plate; one pair of track rails provided on the base plate along both sides of the magnet plate; and slide members fixed to the top plate along both sides of the movable element and moving on the track rails while keeping an un-contact state between the movable element and the magnet plate; characterized in that the track rails and the slide members are constituted so as to be able to freely divide in a direction along which the movable element is separated from the magnet plate.

According to such a technical means, since the magnet plate is fixed to the base plate, while the movable element is fixed to the top plate and, moreover, since the top plate is incorporated to the base plate through the slide members and the track rails, it becomes possible to handle the magnet plate and the movable element as an integrated one in which they are unitized. Therefore, a work for attaching the magnet plate and the movable element to the stationary portion and the movable body can be easily performed, so that it become possible to avoid such troubles that, during such a work, the magnet plate is damaged and a hand is nipped between the magnet plate and the movable element. That is, since the track rails and the slide members are constituted so as to be able to divide in a direction along which the movable element is separated from the magnet plate, by inserting the linear motor drive unit of the invention to a lower side of the movable body supported movably by linear guide units, and fixing respectively the base plate to the stationary portion and the top plate to the movable body, the magnet plate and the movable element can be easily faced with a predetermined gap.

Further, it is also possible to incorporate a linear encoder between the base plate and the top plate and, in case of being constituted in such a manner, since the linear motor and the linear encoder can be handled as an integrated one in which they are unitized, it becomes also possible to construct easily and within a short time a guide structure having a feedback control function.

Accordingly, the linear motor drive unit of the invention can be easily applied to a wide use, and it becomes possible to intend to reduce a cost by mass production.

Further, in regard to a limited use, it is also possible to use the top plate as a table as it is. In this case, since it results in the fact that a magnetic force applied between the magnet plate and the movable element gives a pre-load between the track rail and the slide member, it becomes possible, in a range not impairing such a pre-load, to use the top plate as the table.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front sectional view showing an embodiment of a linear motor drive unit of the invention;

FIG. **2** is a perspective view showing one example of a linear guide used in the linear motor drive unit according to the embodiment;

FIG. **3** is a sectional view showing one example of the linear guide used in the linear motor drive unit according to the embodiment;

FIG. **4** is a front view of the linear motor drive unit according to the embodiment;

FIG. **5** is a front view showing a guide structure in which the linear motor drive unit according to the embodiment is used as drive means of a movable body;

FIG. **6** is a perspective view showing one example of a conventional guide structure in which a rotary motor is used as drive means; and

FIG. **7** is a perspective view showing another example of the linear guide.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Hereunder, a linear motor drive unit of the invention is explained in detail on the basis of the attached drawings.

FIG. **1** is a front sectional view showing a linear motor drive unit **1** to which the invention is applied. The linear drive unit **1** is constituted such that a top plate **4** is movably supported on a long base plate **2** through one pair of linear guides **3** and a linear servomotor **5** is provided between the base plate **2** and the top plate **4** to thereby give a thrust to the top plate **4**.

FIG. **2** and FIG. **3** are a perspective view and a front sectional view, respectively showing details of a constitution of the linear guide **3**. The linear guide **3** is composed of a track rail **30** arranged along a longitudinal direction of the base plate **2**, and a slide member **31** moving along the track rail **30** and fixed to the top plate **4**. The track rail **30** is formed in an approximately rectangular shape in its section perpendicular to a longitudinal direction and, in its one side face along the longitudinal direction, two ball rolling faces **32** are formed toward a direction mutually diverging at 90°. On the other hand, in a side face of the slide member **31**, two load rolling faces **33** facing the ball rolling faces **32** of the track rail **30** are formed, and it is adapted such that many balls **34** roll between the ball rolling faces **32** of the track rail **30** and the load rolling faces **33** of the slide member **31** while bearing a load. Further, it is constituted such that a ball endless track **35** for circulating the balls **34** having finished rolling on the load rolling face **33** is formed in the slide member **31**, so that the slide member **31** can be continuously moved by the fact that the balls **34** are endlessly circulated. Incidentally, in FIG. **2** and FIG. **3**, a reference numeral **36** denotes a retainer, and it prevents the balls **34** from rolling down from the load rolling faces **33** of the slide member **31** when the slide member **31** is separated from the track rail **30**.

As shown in FIG. **1**, one pair of standoffs **20**, **20** are provided in both side edge portions of the base plate **2** along the longitudinal direction, and the track rails **30** are respectively fixed to each standoff **20** by bolts. On the other hand, the slide members **31** are fixed to both side edge portions of the top plate **4** while corresponding to each track rail **30**, and the top plate **4** is provided so as to span between the one pair of standoffs **20**, **20**. Here, each track rail **30** is fixed to the standoff **20** with its face formed with the ball rolling faces **32** being directed upward, while each slide member **31** is fixed to the top plate **4** with its side face formed with the load rolling faces **33** being directed downward, and the slide member **31** is incorporated to the track rail **30** from above (upper side of a paper of FIG. **1**). Accordingly, the ball rolling faces **32** of the track rail **30** contact with the balls **34** at 45° upwardly with respect to a horizontal direction (left and right direction of the paper of FIG. **1**), while the load rolling faces **33** of the slide member **31** contact with the balls **34** at 45° downwardly with respect to the horizontal direction, and it is adapted such that the linear guide **3** constituted by the track rail **30** and the slide member **31** bears only a vertically downward load F1 applied to the top plate **4** and a load F2 applied in the horizontal direction. That is, the top plate **4** is supported on the base plate **2** by the linear guides **3** and freely movable while bearing the loads F1 and F2, whereas it is adapted so as to be able to separate from the base plate **2** when a vertically upward load is applied thereto.

Further, the linear servomotor motor **5** is provided between the top plate **4** and the base plate **2**, and it is constituted such that the top plate **4** is moved on the base plate **2** by the thrust and a holding force, which are generated by the linear servomotor **5**, and can be stopped at a predetermined position on the base plate **2**. The linear servomotor **5** is composed of a magnet plate **50** fixed to the base plate **2** side, and a movable element **51** fixed to the top plate **4** side. A bolster **52** is fixed onto the base plate **2** so as to be put between the standoffs **20**, and the magnet plate **50** is disposed on the bolster **52**. Further, in the magnet plate **50**, plural magnetic poles are magnetized at a predetermined pitch along the longitudinal direction of the base plate **2**, and these magnetic poles are arranged such that an N pole and an S pole exist alternately. On the other hand, the movable element **51** is constituted by repeatedly arranging plural coil assemblies along a moving direction of the top plate **4**, and each coil assembly is constituted by winding a coil **54** around an exciting core **53**. And, each coil assembly is fixed to a lower face of the top plate **4** through a yoke **55**, and an arrangement pitch between the mutually adjoining coil assemblies is the same as that between the magnetic poles in the magnet plate **50**.

Further, as shown in FIG. **4**, in the linear motor drive unit **1**, a Hall sensor **6** is fixed to the top plate **4** through a bracket **60**, and it faces the magnet plate **50** fixed to the base plate **2** with a predetermined interval being kept between them. Since the Hall sensor **6** generates a signal complying with a change in magnetic flux density, if the top plate **4** moves on the base plate **2** along the track rails **30**, it generates a signal in compliance with the intensity of a magnetic field generated by the magnetic pole of the magnet plate **50**. Accordingly, by controlling, on the basis of this signal of the Hall element **6**, a timing of power supply for each coil assembly, a magnetic attraction force is generated between a tip of the exciting core **53** and the magnetic pole of the magnet plate **50**, so that it becomes possible to continuously give a thrust along the longitudinal direction of the base plate **2** to the top plate **4**, while it becomes possible to give a holding force for binding the top plate **4** to one place on the base plate **2**.

Additionally, a reading section **61** of optical type linear encoder is fixed to the bracket **60**, and the reading section **61** faces an encoder tape **62** adhered on a side face of the standoff **20** along the longitudinal of the track rail **30**. Accordingly, it is adapted such that, if the top plate **4** moves on the base plate **2** along the track rails **30**, the reading section **61** counts light and dark stripes formed in the encoder tape **62** at predetermined pitches and, on the basis of such a counted value, a movement amount of the top plate **4** with respect to the base plate **2** can be grasped. Incidentally, a reference numeral **63** in FIG. **4** denotes a cable for transmitting signals from the Hall sensor **6** and the reading section **61** to a control section outside the drawing and supplying an electric power to the movable element **51**. Further, the linear encoder composed of the reading section **61** and the encoder tape **62** is not limited to the optical type one, and may be a magnetic type one for reading the magnetism of a magnet scale.

And, the linear motor drive unit **1** of this embodiment constituted as mentioned above is arranged, for example as shown in FIG. **5**, in the lower face side of a movable body **9** guided on a stationary portion **8** by another linear guides **7**, **7**, and is used as drive means of the movable body **9**. That is, the linear motor drive unit **1** is used with its base plate **2** being fixed to the stationary portion **8** and its top plate **4** to the movable body **9**. Further, the longitudinal direction of the base plate **2** is set parallel to a moving direction of the movable body **9** by the guide units **7**. And, under this state by supplying the electric power to each coil assembly constituting the movable element **51**, a thrust given to the top plate **4** is transmitted to the movable body **9**, so that it is possible to move the movable body **9** on the stationary portion **8** by an optional amount and, further, hold it to a predetermined position.

In such a using method, if a height H from the stationary portion **8** to the movable body **9** is set slightly larger (for example, by about 0.1 mm) than a height h (refer to FIG. **1**) of the linear motor drive unit **1** of this embodiment, a state in which the slide member **31** slightly floats from the track rail **30** is obtained by the fact that the top plate **4** is fixed to the movable body **9**, so that it follows that the movable body **9** is guided on the stationary portion **8** only by the linear guides **7** supporting the movable body **9**. Therefore, even if a guide direction of the top plate **4** by the linear motor drive unit **1** does not strictly agree with that of the movable body **9** on the stationary portion **8**, it is possible to lightly drive the movable body **9** without applying a large resistance to the movement of the movable body **9**. In other words, if the height H of the movable body **9** is set slightly larger than the height h of the linear motor drive unit **1**, an incorporation of the linear motor drive unit **1** to the stationary portion **8** and the movable body **9** can be performed roughly in some extent, so that it is possible to reduce a labor required for the incorporation.

Further, before the linear motor drive unit **1** is incorporated to the movable body **9**, since the top plate **4** fixed with the movable element **51** is mounted on the base plate **2** by the linear guides **3**, **3**, such a trouble that the movable element **51** is brought into contact with the magnet plate **50** can be prevented and, besides, such an accident that a hand is nipped between the movable element **51** and the magnet plate **50** can be prevented as well.

Additionally, according to the linear motor drive unit **1** of this embodiment, since also the top plate **4** itself fixed with the movable element **51** is supported on the base plate **2** by the linear guides **3**, a vertically upward load (load in a direction reverse to F1) is not applied to the top plate **4** and, further if F1 is a very light load, it is also possible to construct a table guide structure by utilizing the top plate **4** itself as a movable body, even if the movable body **9** supported by the linear guides **7** as shown in FIG. **5** is not provided separately. Since an attraction force of the linear servomotor **5**, i.e., a magnetic attraction force between the movable element **51** and the magnet plate **50**, is applied between the top plate **4** and the base plate **2**, this magnetic attraction force acts as a pre-load for pushing the slide member **31** to the track rail **30** and thus, so long as the vertically upward load applied to the top plate **4** does not exceed this pre-load, the top plate **4** is not separated from the base plate **2**.

Further additionally, in the linear motor drive unit of this embodiment, since the magnet plate and the movable element constituting the linear servomotor is unitized through the linear bearings, and since the hall sensor and the linear encoder necessary for controlling the linear servomotor are integrated with the linear servomotor, if this linear motor drive unit is used when constructing a guide structure of the movable body, it becomes possible to construct easily and within a short time the guide structure having a feedback control function.

Incidentally, the linear guide **3** is not limited to one shown in FIG. **2** and FIG. **3** and, so long as it is one capable of bearing the vertically downward load F1 applied to the top plate **4**, its constitution can be suitably changed. However, in case where the fact that it is used with the top plate **4** being fixed to the movable body **9** is taken into consideration, it is necessary that the linear guide **3** has no bearing ability as to a direction reverse to an action direction of the load F1 in order that an interval between the magnet plate **50** fixed to the base plate **2** and the movable element **51** fixed to the top plate **4** can be freely adjusted. For example, as another example of the linear guide **3**, as shown in FIG. **7** there is considered one in which a guide shaft **70** extending along a moving direction of the movable body **9** is arranged on the standoff **20**, while the movable body **9** is provided with rollers **71** travelling on the guide shaft **70**.

Further, the linear motor provided between the top plate **4** and the base plate **2** is not limited to the linear servomotor **5**, and it is also possible to use a linear motor of another type such as a linear pulse motor for instance.

What is claimed is:

1. A linear motor drive unit attached to a movable body linearly movable with respect to a stationary portion and used for the purpose of giving a thrust to the movable body, comprising:

a long base plate;

a magnet plate which is provided on the base plate, and in which plural magnetic poles are arranged at a predetermined pitch along a longitudinal direction of the base plate;

a top plate having a face for attaching the movable body;

a movable element fixed to the top plate and facing the magnet plate;

one pair of track rails provided on the base plate along both sides of the magnet plate; and

slide members fixed to the top plate along both sides of the movable element and moving on the track rails while keeping an un-contact state between the movable element and the magnet plate;

characterized in that the track rails and the slide members are constituted so as to be able to freely divide in a direction along which the movable element is separated from the magnet plate.

2. A linear motor drive unit set forth in claim **1**, characterized in that a linear encoder for detecting a movement distance of the top plate with respect to the base plate is provided.

3. A linear motor drive unit set forth in claim **1**, characterized by having a Hall element for detecting a magnetic flux density between the magnet plate and the movable element.

* * * * *

US006402381B1

(12) United States Patent
Shirai et al.

(10) Patent No.: US 6,402,381 B1
(45) Date of Patent: Jun. 11, 2002

(54) RELATIVE LINEAR MOTION APPARATUS

(75) Inventors: **Takeki Shirai**; **Tadashi Hirokawa**; **Akihiro Teramachi**, all of Tokyo-to (JP)

(73) Assignee: **THK Co., Ltd.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/625,966**

(22) Filed: **Jul. 26, 2000**

(30) **Foreign Application Priority Data**

Jul. 29, 1999 (JP) 11-215794
Jun. 5, 2000 (JP) 2000-167616

(51) **Int. Cl.**[7] **F16C 29/06**
(52) **U.S. Cl.** **384/45**; 384/57
(58) **Field of Search** 384/43, 45, 57, 384/37, 38

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,672,379 A * 3/1954 McVey 384/45
4,231,621 A * 11/1980 Teramachi 384/45
5,388,913 A * 2/1995 Cawley et al. .... 384/57 X
5,706,581 A * 1/1998 Kato et al. .... 384/45 X
6,019,514 A * 2/2000 Feinstein 384/37

FOREIGN PATENT DOCUMENTS

DE 3834900 * 4/1990 .... 384/57

* cited by examiner

Primary Examiner—Thomas R. Hannon
(74) *Attorney, Agent, or Firm*—Armstrong, Westerman & Hattori, LLP

(57) **ABSTRACT**

A relative linear motion apparatus comprising: a first structure having at least a pair of inner wall surfaces opposing to each other; a second structure arranged between the pair of inner wall surfaces, the second structure being movable in linear motion relative to the first structure; at least two rectilinear guides arranged between the first structure and the second structure; and a displacement absorbing device arranged on at least one of the first structure and the second structure so as to allow at least one of the two rectilinear guides to move in a intersecting direction against the wall surfaces.

15 Claims, 13 Drawing Sheets

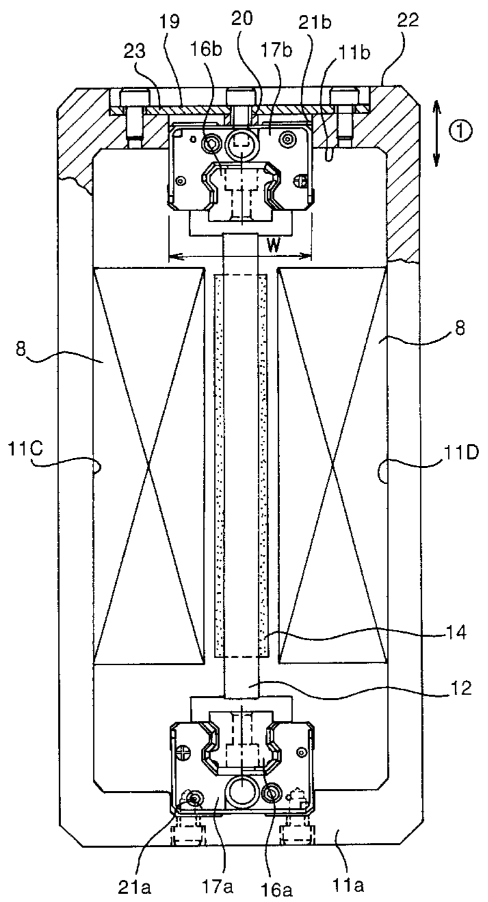


FIG. 1

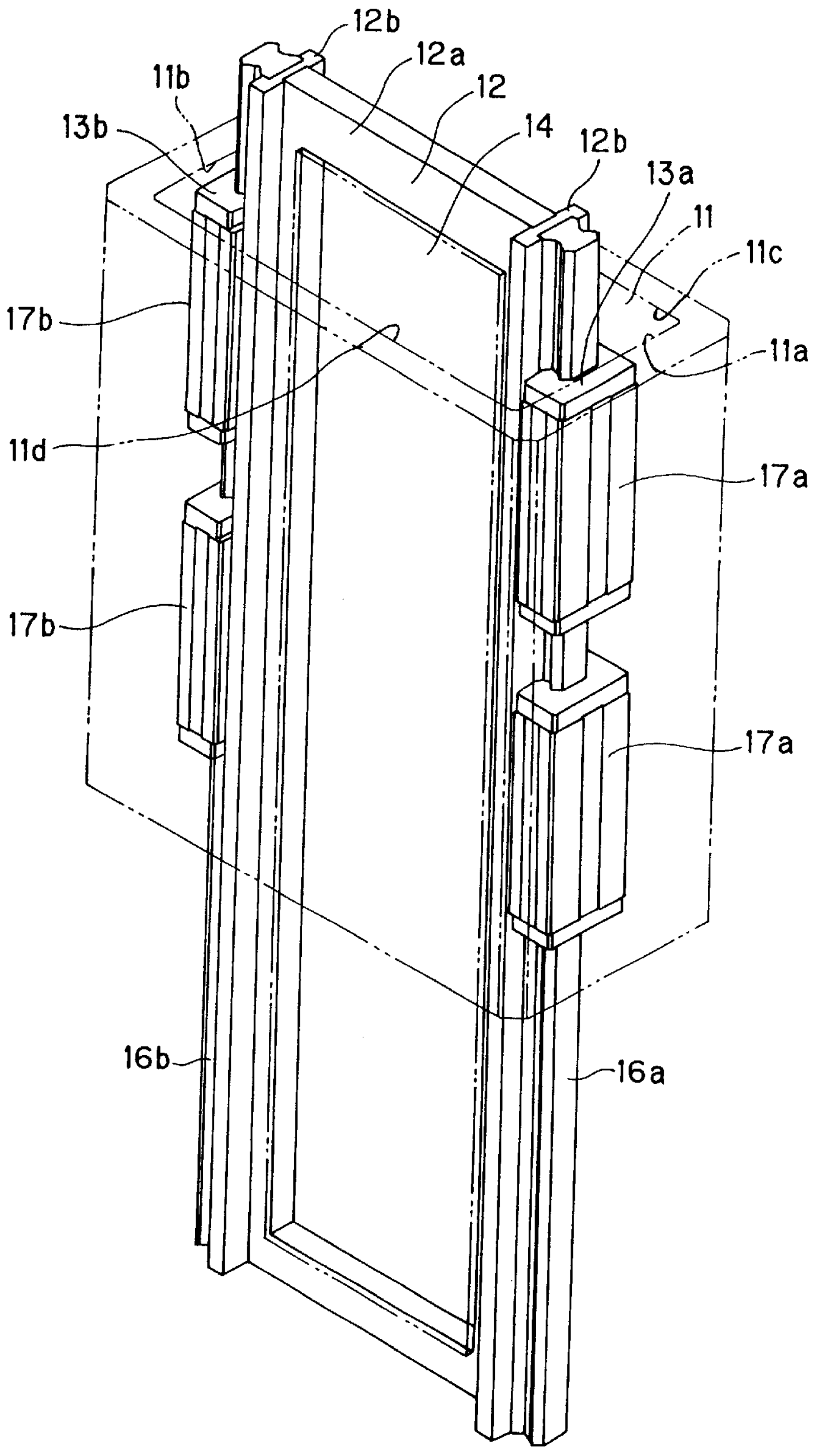
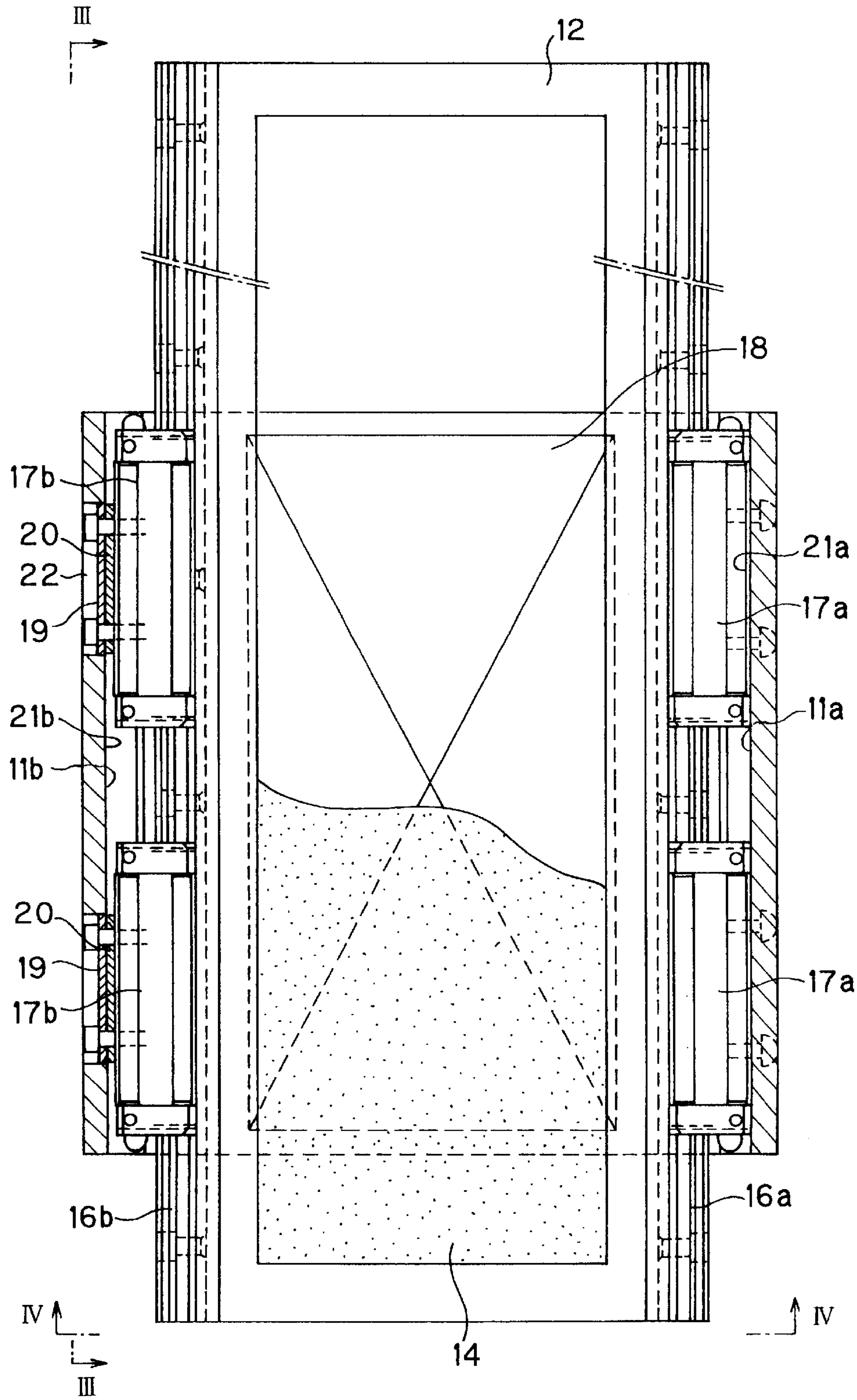

12b
12a
12
11b
14
12b
13b
13a
11
11c
17b
11a
11d
17a
17b
17a
16b
16a

FIG. 2



III
12
18
17b
20
22
19
21a
17a
11a
21b
11b
20
19
17b
17a
16b
16a
IV
IV
III
14

FIG. 3

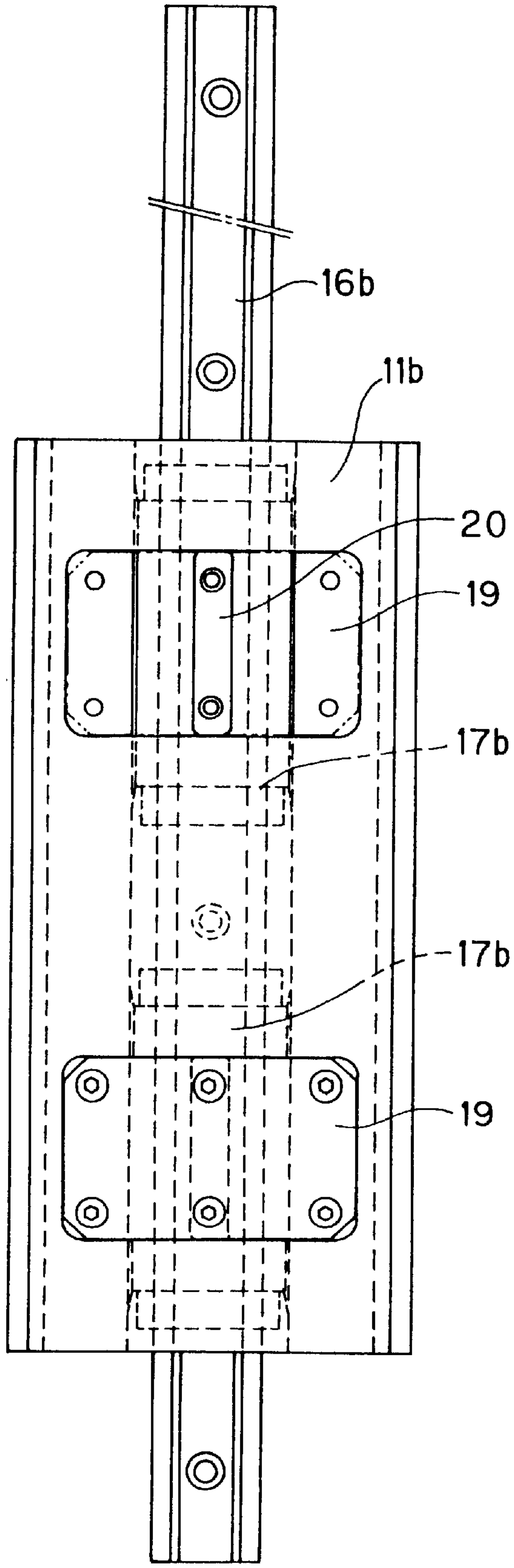


FIG. 4

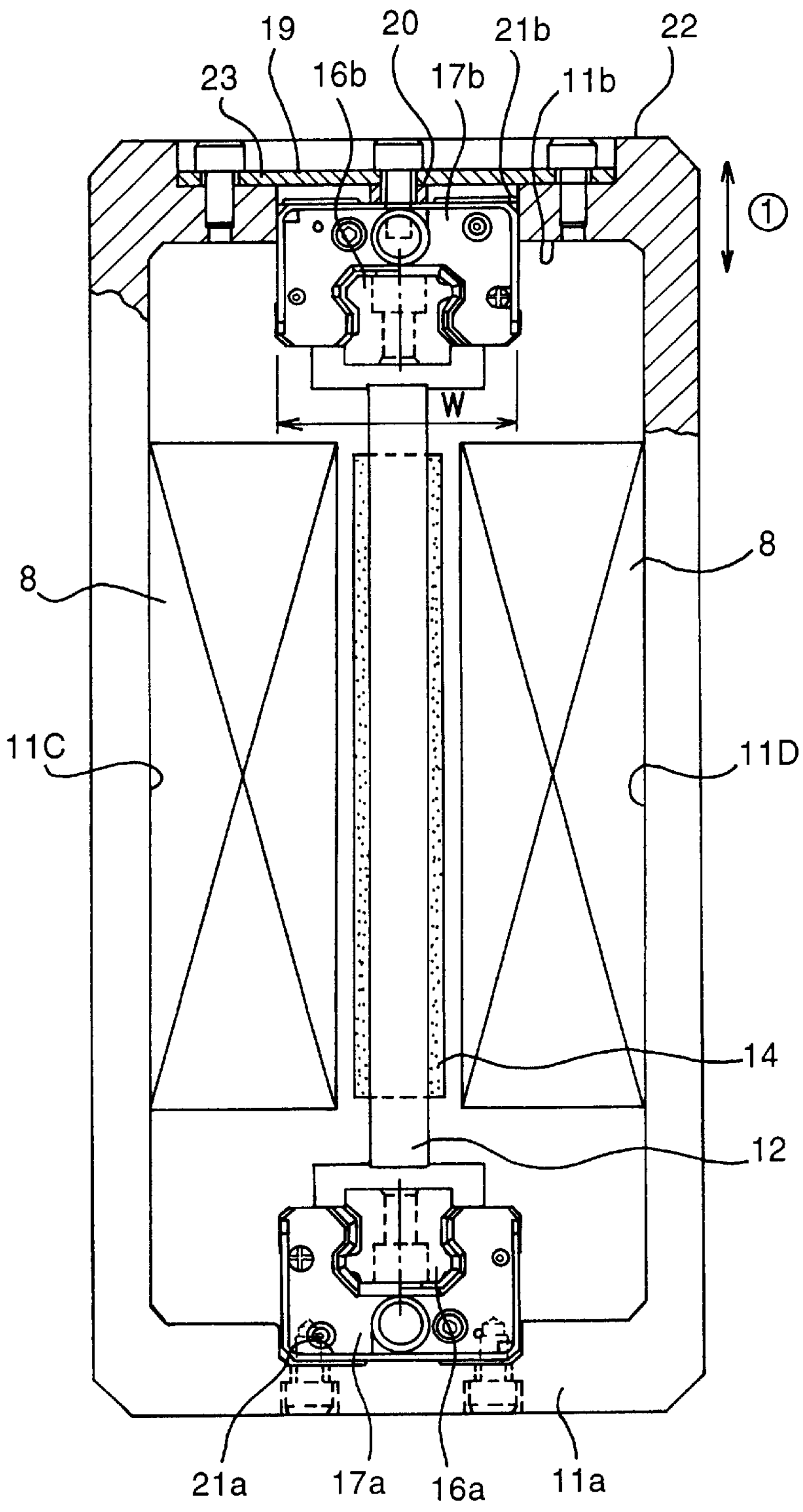


FIG. 5

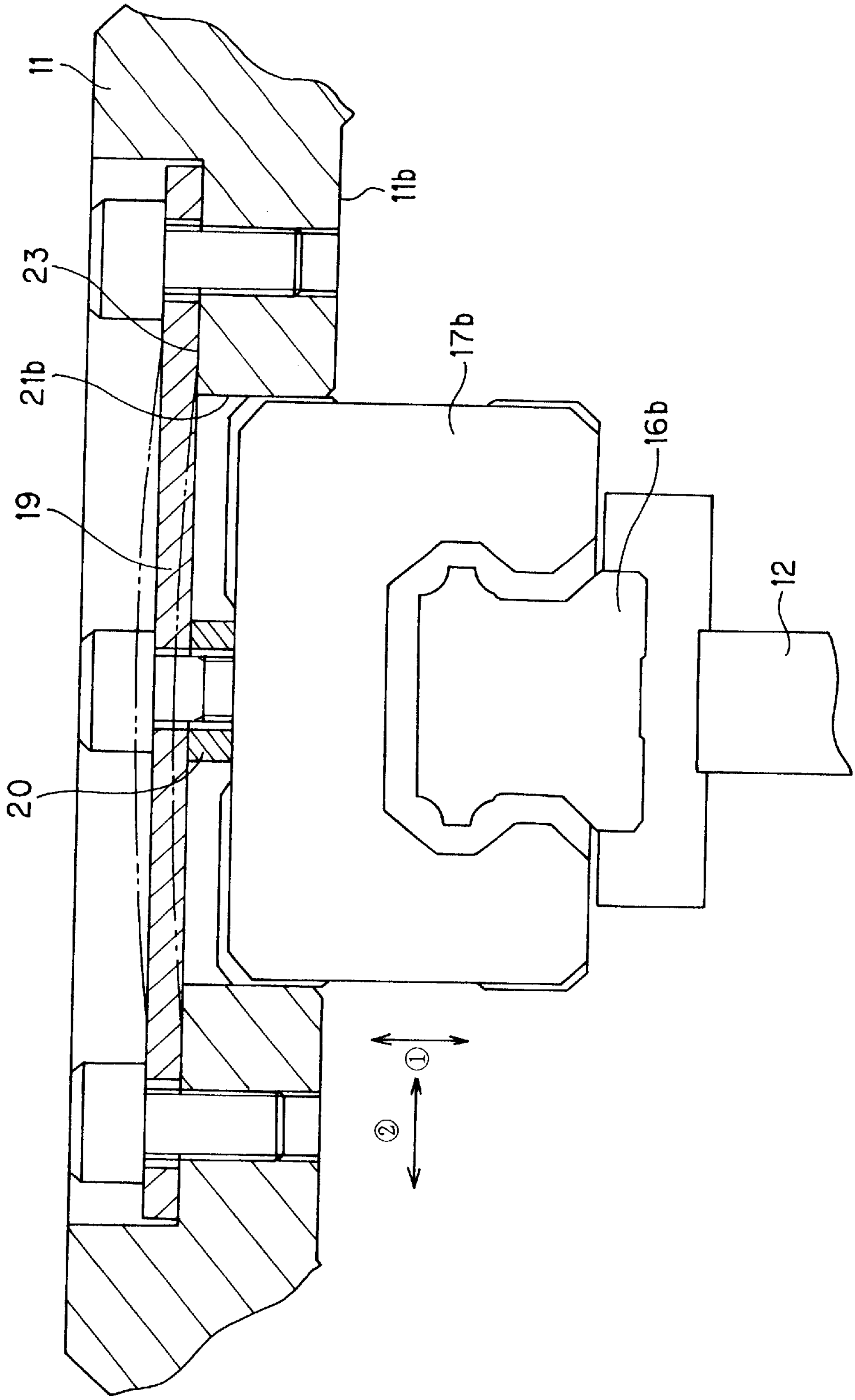


FIG. 6

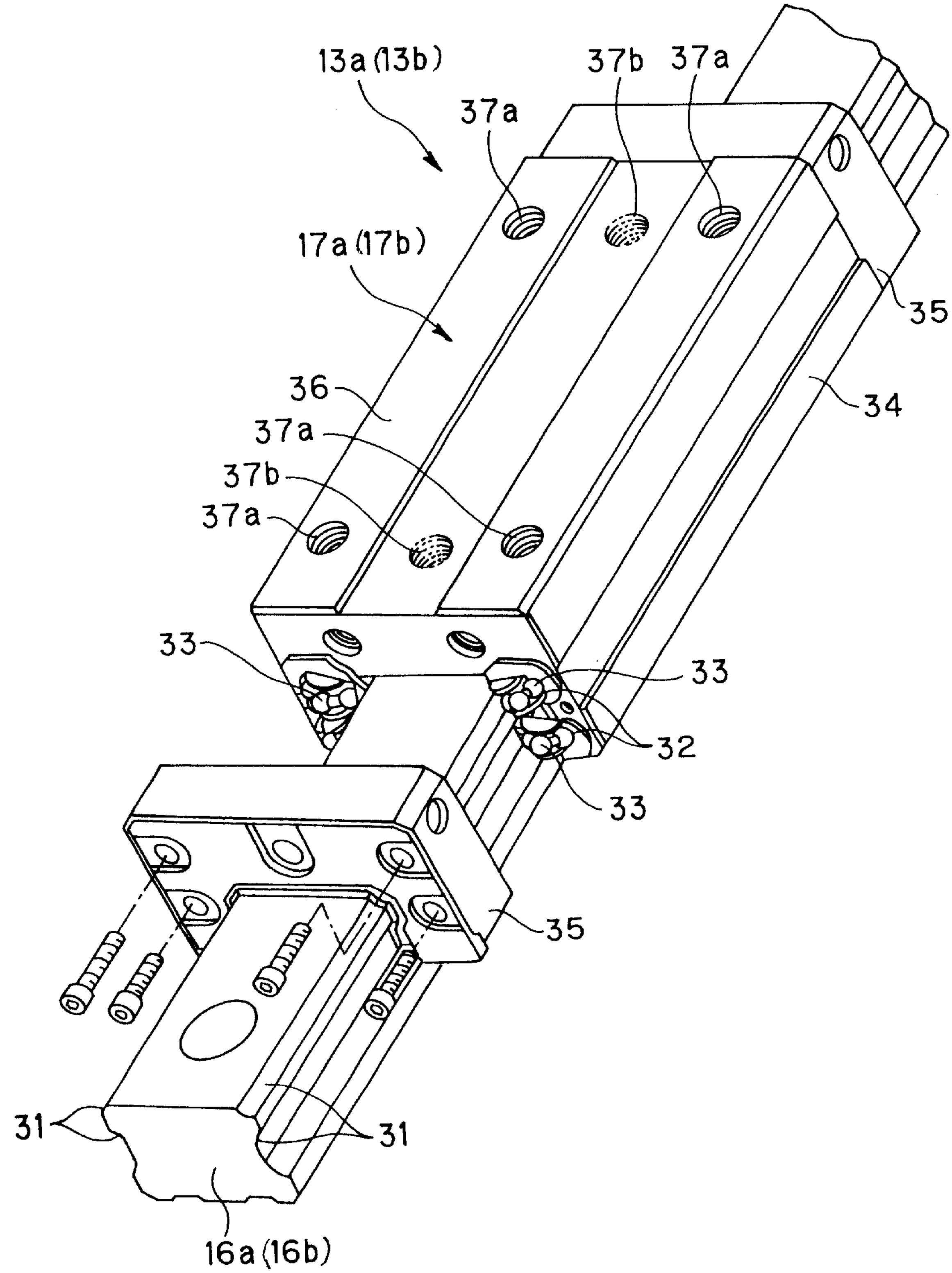

13a(13b)
37b
37a
37a
17a(17b)
35
36
34
37a
37b
37a
33
33
32
33
35
31
31
16a(16b)

FIG. 7

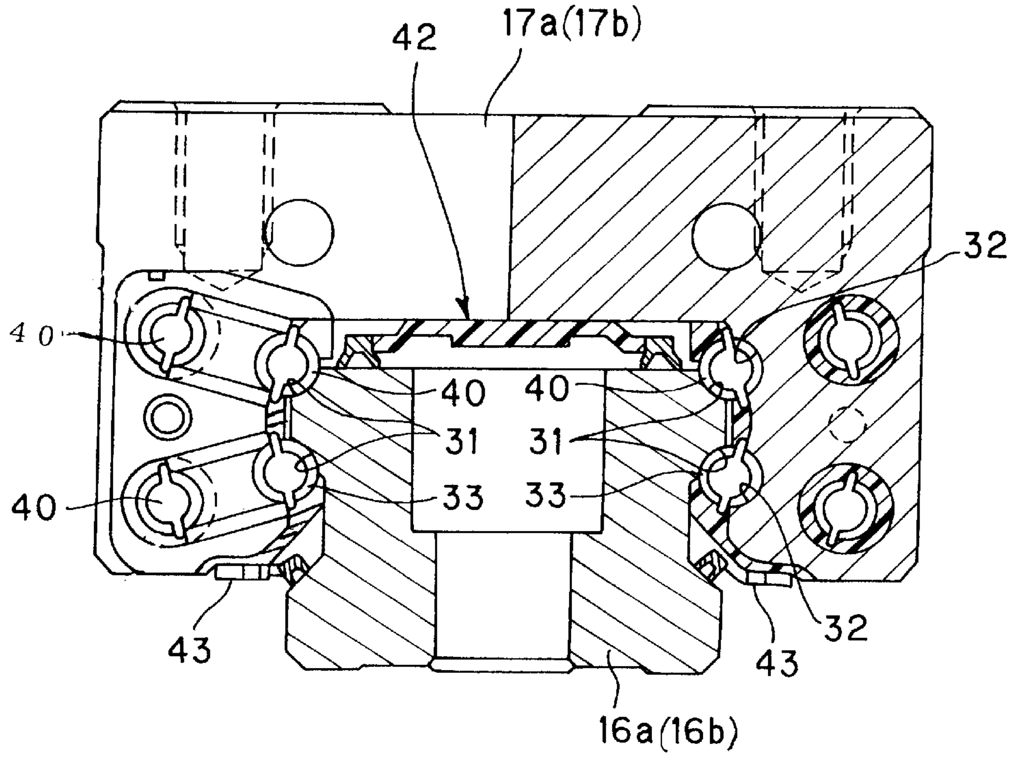

42
17a(17b)
32
40
40
40
40
31
31
33
33
40
32
43
43
16a(16b)

FIG. 8

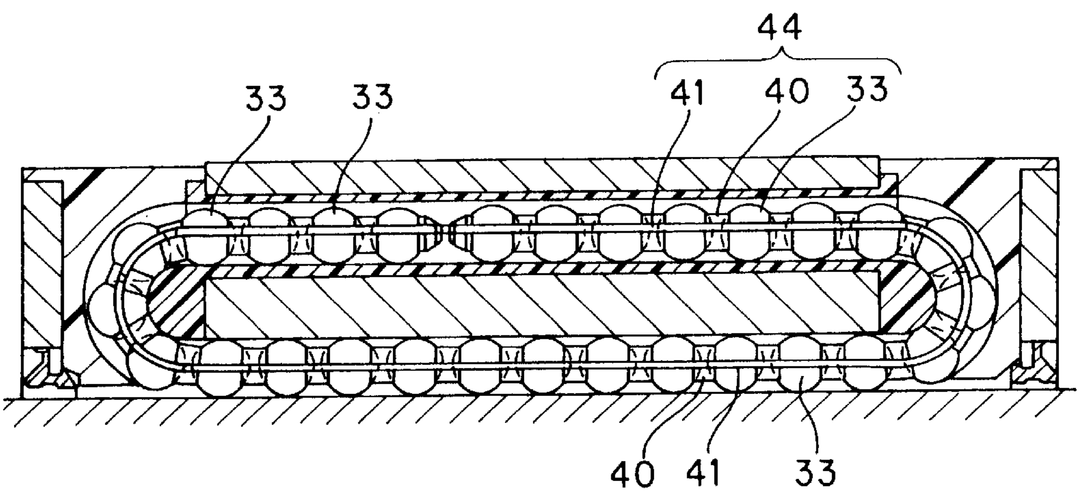

44
33
33
41
40
33
40
41
33

FIG. 9

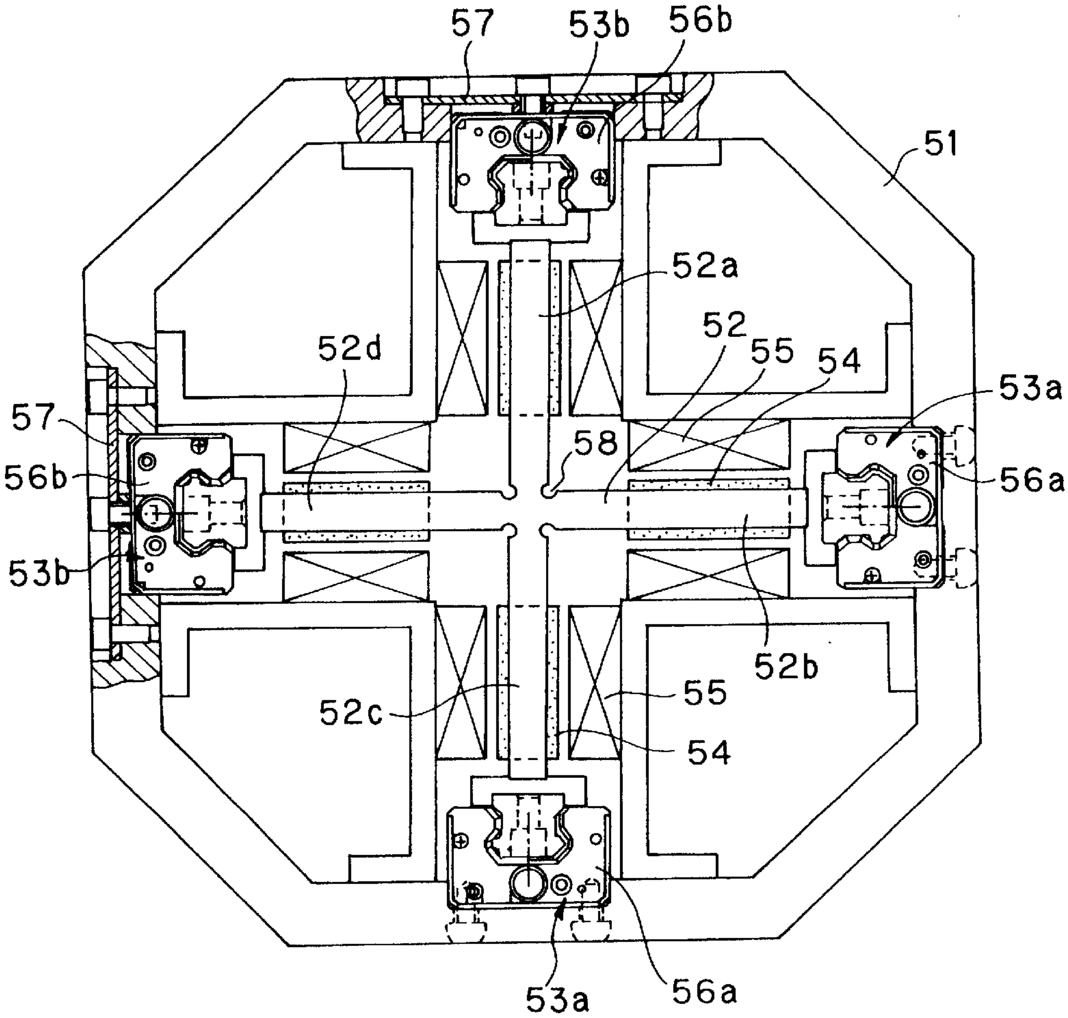

57
53b
56b
51
52a
52d
52
55
54
53a
57
58
56b
56a
53b
52b
55
52c
54
53a
56a

FIG. 10

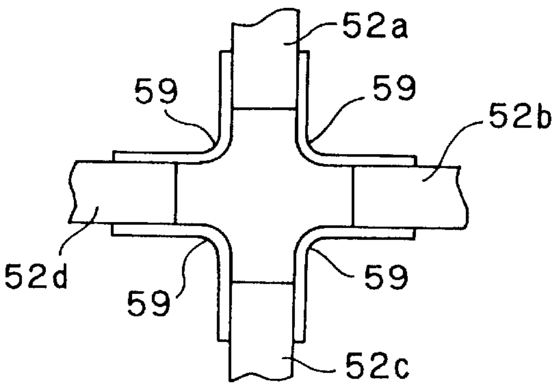

52a
59
59
52b
52d
59
59
52c

FIG. 11

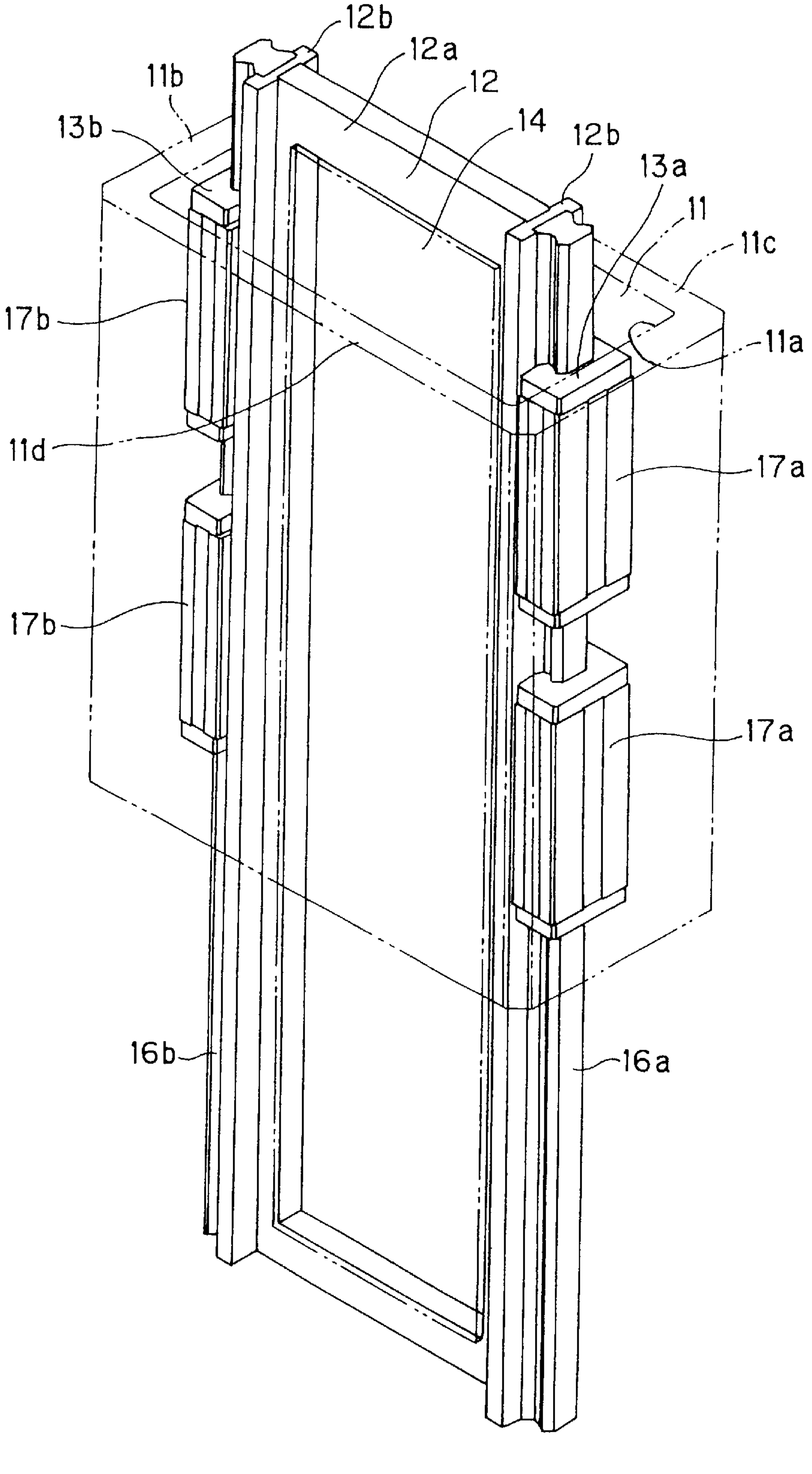

12b
12a
12
11b
13b
14
12b
13a
11
11c
17b
11a
11d
17a
17b
17a
16b
16a

FIG. 12

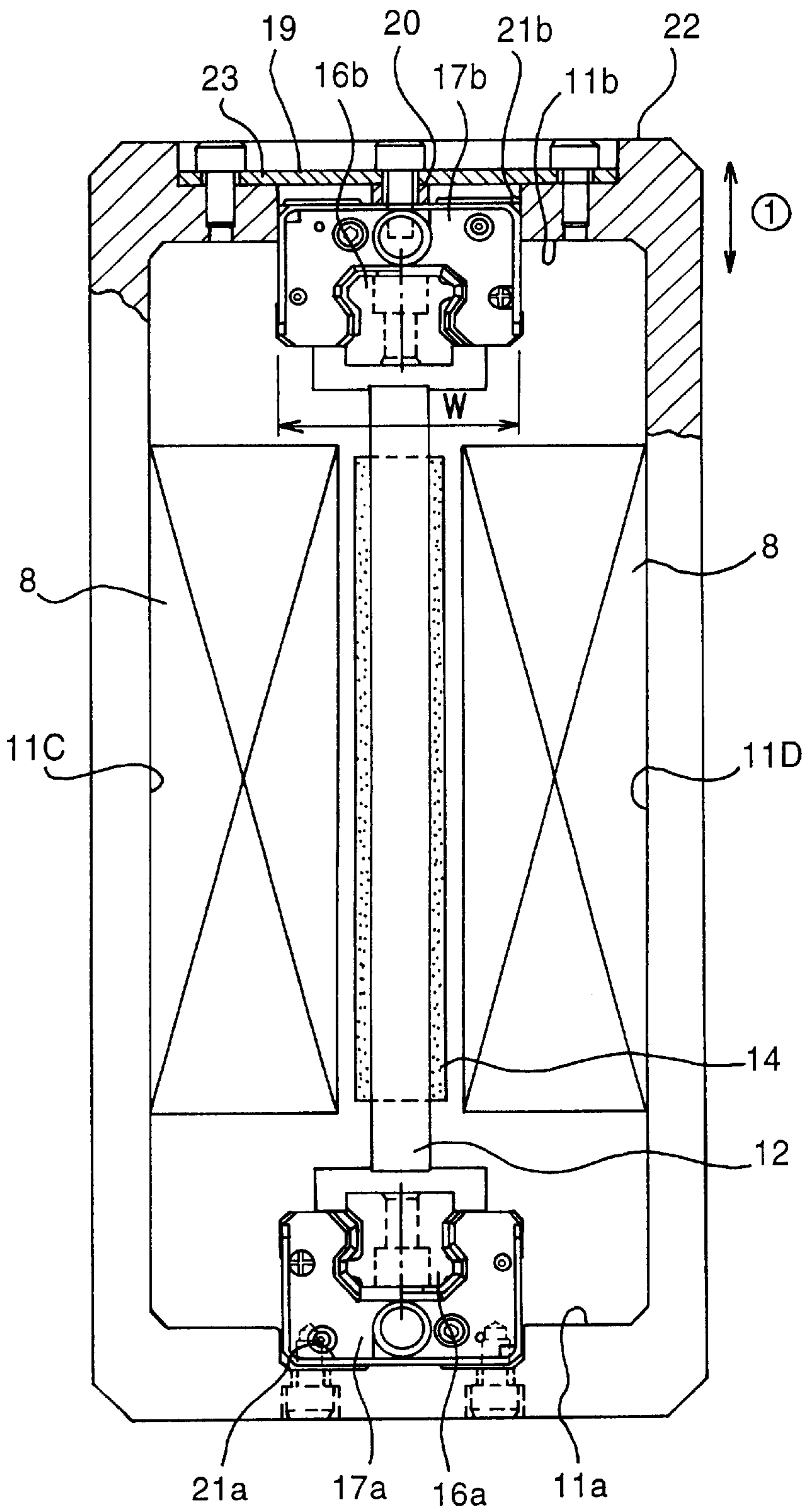


FIG. 13

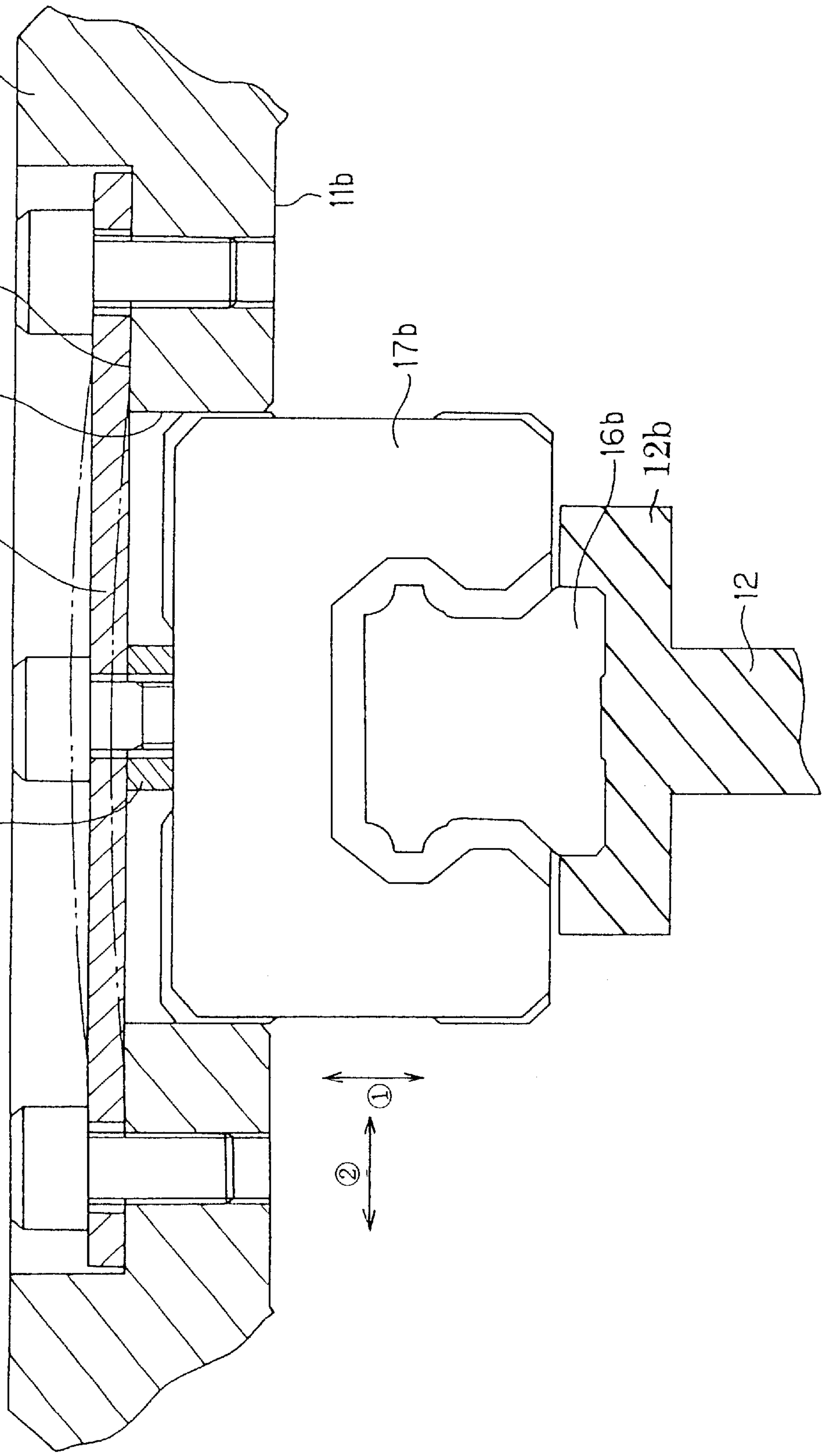


FIG. 14A

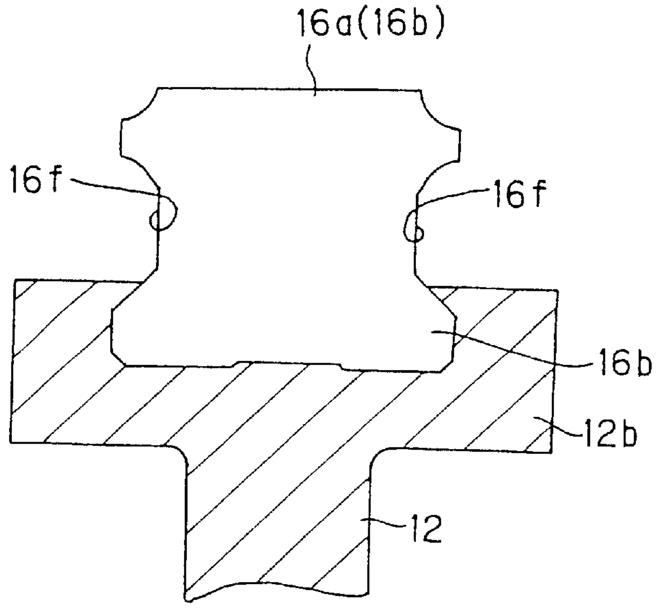


FIG. 14B

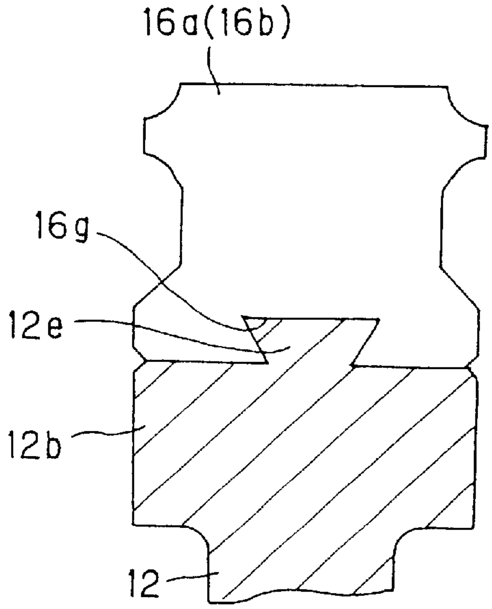


FIG. 14C

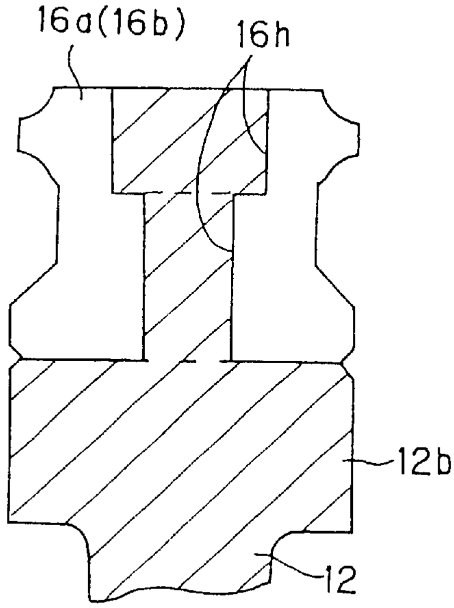
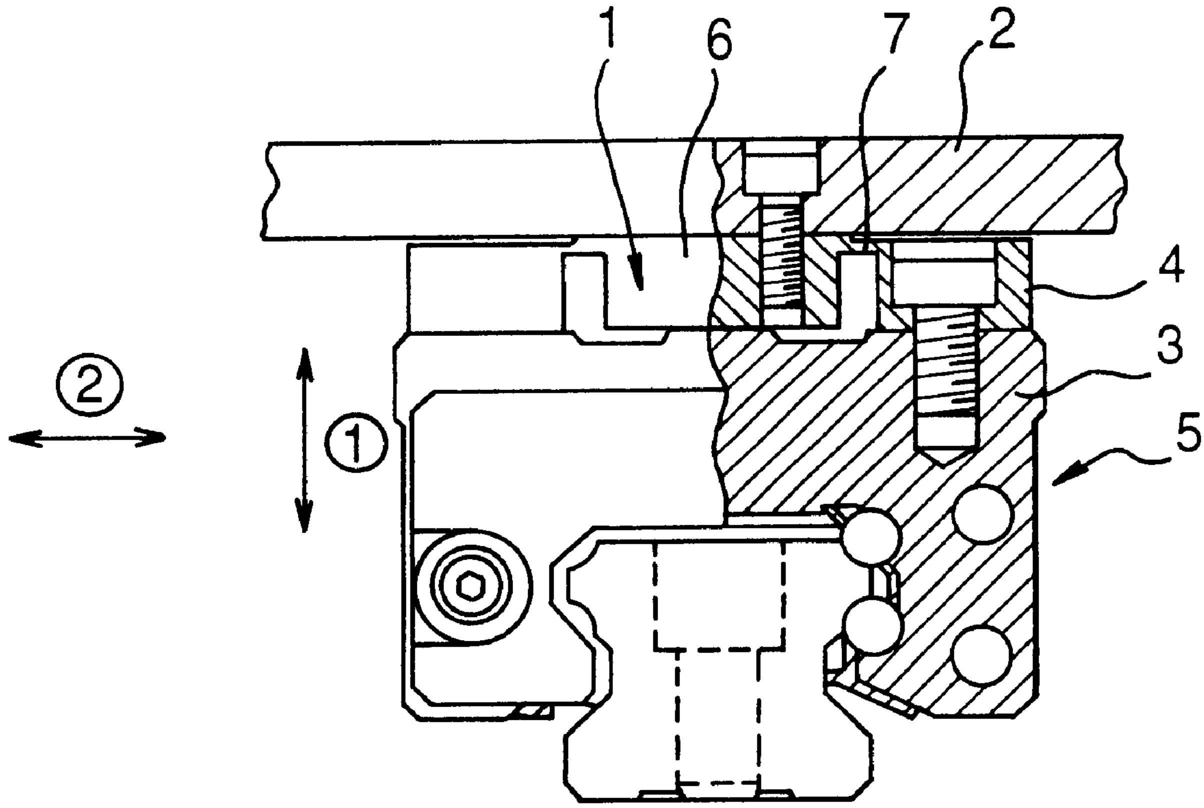


FIG. 15
PRIOR ART



RELATIVE LINEAR MOTION APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a relative linear motion apparatus in which a second structure is movable in linear motion relative to a first structure, for example in which the second structure formed like a plate is put in the first structure formed like a frame, plurality of rectilinear guides are arranged between the first structure and the second structure so that the second structure is movable relative to the first structure.

In a known art, the Japanese Patent Laid-open Publication No. HEI 7-190053 discloses a mounting plate for a rectilinear guide in order to allow misalignment such as an installation error caused when rectilinear guide is installed. FIG. **15** shows this mounting plate. The mounting plate **1** is put between the rectilinear guide **5** and a fixed member **2**, and allows the rectilinear guide **5** to move in a perpendicular direction 1 against the fixed member **2**. The mounting plate **1** consists of fixed portion **6** mounted to the fixed member **2**, attached portion **4** mounted to a movable block **3** of the rectilinear guide **5**, and thin board portion **7** which connect the fixed portion **6** with the attached portion **4**.

Since the misalignment such as the installation error deforms the thin board portion **7**, the attached portion **4** moves relative to the fixed portion **6** in the perpendicular direction 1 and the mounting plate **1** absorbs the misalignment.

SUMMARY OF THE INVENTION

In some cases, a relative linear motion apparatus comprises a fixed member (first structure) having at least a pair of inner wall surfaces opposing to each other, a movable member (second structure) arranged between the pair of inner wall surfaces, two rectilinear guides arranged between the fixed member and the movable member. The movable member guided by the rectilinear guides slides relative to the fixed member in linear motion to a direction parallel to the inner wall surfaces of the fixed member.

In such a relative linear motion apparatus, when the parallelism of one rectilinear guide to the other rectilinear guide is spoiled by an installation error, or when installing position for the rectilinear guide is under slight error, the movable member can not slide smoothly. Therefore it is necessary to install the rectilinear guides with high accuracy. Also, even if the rectilinear guides are installed with high accuracy, since the rectilinear guides are applied a load caused by thermal expansion and contraction difference between the fixed member and the movable member in a perpendicular direction to the wall, the movable member sometimes can not slide smoothly

In case the conventional mounting plate **1** is used for the relative linear motion apparatus described above, deformation of the thin board portion **7** is small and the mounting plate **1** can not absorb a large error. Therefore, though the mounting plate **1** can absorb small misalignment, the mounting plate **1** can not sufficiently absorb thermal expansion and contraction difference between the fixed member and the movable member.

Also the conventional mounting plate **1** allows the movable member to move slightly not only in the perpendicular direction 1 but also in a horizontal direction 2 (which is parallel to the inner wall surface and perpendicular to a sliding direction of the movable member). So the movable member can not be guided with good rigidity. Further, it is difficult to process the thin board portion **7** on the mounting plate **1**.

An object of the present invention is to provide a relative linear motion apparatus which can sufficiently absorb the installing error of rectilinear guides or thermal expansion and contraction difference between the fixed member and the movable member, and guide the movable member with good rigidity.

In order to achieve the above-mentioned object, the relative linear motion apparatus according to the present invention is constructed so as to comprise: a first structure having at least a pair of inner wall surfaces opposing to each other; a second structure arranged between the pair of inner wall surfaces, the second structure being movable in linear motion relative to the first structure; at least two rectilinear guides arranged between the first structure and the second structure; and a displacement absorbing device arranged on at least one of the first structure and the second structure so as to allow at least one of the two rectilinear guides to move in a intersecting direction against the wall surfaces. The two rectilinear guides make the second structure to be movable in linear motion relative to the first structure.

When the second structure is arranged between the pair of inner wall surfaces of the first structure through the rectilinear guides, and a processing error including an installation error or thermal expansion and contraction difference between the first structure and the second structure occurs, the second structure could not smoothly slide relative to the first structure.

According to the invention described above, even if the processing error including the installation error occurs, or even if the thermal expansion and contraction difference occurs, the displacement absorbing device can absorb the displacement of the rectilinear guide in the intersecting direction against the wall surfaces. Therefore the rectilinear guides are not applied an excessive load and work smoothly, and the second structure smoothly slide relative to the first structure. If the displacement absorbing device allows at least one of the two rectilinear guides to move only in the intersecting direction against the wall surfaces (for example only in the perpendicular direction to the wall surfaces), and restricts the rectilinear guide to move in a horizontal direction (which is parallel to the inner wall surface and perpendicular to a sliding direction of the second structure), it is possible to guide the second structure with good rigidity.

In the relative linear motion apparatus to which the present invention is applied, at least one of the two rectilinear guides moves in the intersecting direction against the wall surfaces due to a processing error including an installation error caused when said at least one of the two rectilinear guides is installed or thermal expansion or thermal contraction difference between the first structure and the second structure.

The relative linear motion apparatus of the invention is effective in absorbing such large displacement.

In a preferred embodiment of the present invention, the displacement absorbing device is arranged between (i) one of said first structure and said second structure and (ii) one of said two rectilinear guides, said displacement absorbing device having an elastic beam which can deflect toward the intersecting direction against the wall surfaces.

According to this embodiment, an elastic beam can deflect and absorb the processing error or the thermal expansion and contraction difference between the first structure and the second structure.

In a further embodiment, said elastic beam has span which is capable of deflection, and the span is longer than width of said one of the two rectilinear guides.

According to this embodiment, the span of the elastic beam become longer, and the deflection of the elastic beam become larger. Therefore the elastic beam can absorb the large processing error or the large thermal expansion and contraction difference.

In a further embodiment, a spacer is arranged between said elastic beam and said one of the two rectilinear guides so that said elastic beam deflects larger, the spacer having width less than the width of said one of the two rectilinear guides.

According to this embodiment, since the load placed on the elastic beam approaches to concentrated load from distributed load, the elastic beam deflects larger.

In a further embodiment, said elastic beam has both longitudinal end portions fixed to said first structure or said second structure, and said one of the two rectilinear guides is arranged in the middle of said elastic beam in a longitudinal direction thereof.

According to this embodiment, the elastic beam deflects with easy construction.

In a further embodiment, said first structure or said second structure has guide surfaces which guide said one of the two rectilinear guides to move in the intersecting direction against the wall surfaces.

According to this embodiment, since the rectilinear guide is guided to move in the intersecting direction against the wall surfaces, the rectilinear guide is prevented from moving in another direction except the intersecting direction. For example it is possible for the rectilinear guide to move only in the perpendicular direction to the wall surfaces so as to absorb the error and not to move in the horizontal direction. Therefore the second structure can be guided with good rigidity.

In a further embodiment, said guide surfaces allows said one of the two rectilinear guides to move only in a perpendicular direction to the wall surfaces without occurrence of change in posture thereof.

According to this embodiment, the rectilinear guide is allowed to move only in the perpendicular direction to the wall surfaces, and is restricted to move in the horizontal direction.

In a further embodiment, each of said rectilinear guides comprises:

- a track member formed with a rolling member rolling surface along a longitudinal direction;
- a movable block mounted to be relatively movable to the track member formed with a rolling member circulation passage including a loaded rolling member rolling surface opposing to the rolling member rolling surface of the track member when mounted;
- and a number of rolling members arranged in the rolling member circulation passage so as to circulate therein in conformity with the relative motion of the movable block with respect to the track rail.

In a further embodiment, each of movable blocks is fixed to said each of said inner wall surfaces of said first structure, and each of track members is fixed to each of edges of said second structure.

In a further embodiment, said track member is integrally formed with said second structure by an inserting mold.

In case the second structure is arranged between the pair of the inner wall surfaces of the first structure through the rectilinear guides, it is necessary to reduce the processing error including the installation error so that the second structure smoothly slides relative to the first structure.

According to this embodiment, since the track rail is inserted in second structure and is integrally molded with the second structure, the processing error is reduced as small as possible. Also, since component parts are reduced too, a relative linear motion apparatus of the invention can be fitted for mass production. On the contrary, if the track rail and the second structure are separately made and the track rail and the second structure are joined together with bolts and so on, the occurrence of the installing error caused by the operator's degree of aging can not be avoided.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** is a perspective view showing a relative linear motion apparatus according to a first embodiment of the present invention.

FIG. **2** is a cross sectional view of the apparatus shown in FIG. **1**, the cross section being taken in a direction parallel to a movable member of the device.

FIG. **3** is a side view of the apparatus of FIG. **2** taken along the line III—III therein.

FIG. **4** is a plan view of the apparatus of FIG. **2** taken along the line IV—IV therein, partially in section.

FIG. **5** is a cross sectional view showing the deflection of the elastic beam.

FIG. **6** is perspective view showing a rectilinear guide put in the apparatus.

FIG. **7** is a cross sectional view showing the rectilinear guide, the cross section being taken in a direction normal to a track rail of the guide.

FIG. **8** is a cross sectional view showing a movable block of the rectilinear guide, the cross section being taken in a direction parallel to a track rail of the guide.

FIG. **9** is a cross sectional view showing a relative linear motion apparatus according to a second embodiment of the present invention, the cross section being taken in a direction normal to a movable member.

FIG. **10** is a cross sectional view showing another crossing portion of the apparatus in FIG. **9**.

FIG. **11** is a perspective view showing a relative linear motion apparatus according to a third embodiment of the present invention.

FIG. **12** is a plan view of the apparatus in FIG. **11**, partially in section.

FIG. **13** is a cross sectional view showing a combination of a movable member and a track rail of the apparatus in FIG. **11**.

FIG. **14** is a cross sectional view showing another variations of the point of apparatus in FIG. **11**, and includes FIG. **14**A showing a first variation, FIG. **14**B showing a second variation, FIG. **14**(C) showing a third variation.

FIG. **15** is a plan view, partially in section, of a mounting plate having a conventional structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. **1** to **4** respectively show a relative linear motion apparatus according to a first embodiment of the present invention.

As shown in FIG. **1**, This relative linear motion apparatus comprises a fixed member **11** formed like a quadrilateral frame as first structure, movable member **12** (a second structure) arranged between a pair of inner wall surfaces

11*a*, 11*b* in short sides of the quadrilateral frame, movable member 12 being formed like a plate, and a pair of rectilinear guides 13*a*, 13*b* arranged between each of the inner wall surfaces 11*a*, 11*b* and each of both edges of the movable member 12. The inner wall surfaces 11*a*, 11*b* are parallel to each other. The movable member 12 arranged between the pair of inner wall surfaces 11*a*, 11*b* is perpendicular to the pair of inner wall surfaces 11*a*, 11*b*. Also the movable member 12 slides relative to the inner wall surfaces 11*a* 11*b* in a direction parallel to the inner wall surfaces 11*a* 11*b*.

This relative linear motion apparatus is used for a linear motor for example. In this case, as shown in FIG. 4 a permanent magnet 14 as a magnetic material is disposed in a frame of the movable member 12. And a pair of coils 8, 8 are disposed on a pair of inner wall surfaces 11*c* 11*d* in long sides of the fixed member 11. And the movable member 12 is put between the pair of coils 8, 8. Producing a magnetic field of the coils 8, 8 slides the movable member 12.

The movable member 12 is composed of a frame 12*a*, the permanent magnet 14 disposed in the frame 12*a*, and rail holding portions 12*b*, 12*b* which are fixed to both edges of the frame 12*a*. Track rails 16*a*, 16*b* are attached to the rail holding portions 12*b*, 12*b*. This movable member 12 slides in a direction parallel to the inner wall surfaces 11*a* 11*b* (in FIG. 1 vertical direction) with the track rails 16*a*, 16*b*.

Each of the rectilinear guides 13*a*, 13*b* comprises the track rail 16*a* (16*b*) as a track member, and the movable block 17*a* (17*b*) as slide member. In this embodiment, two movable blocks 17*a*, 17*a* (17*b*, 17*b*) are put side by side on the track rail 16*a* (16*b*). Each of the track rails 16*a*, 16*b* is arranged on each of both edges of the movable member 12. And the movable blocks 17*a*, 17*a*, 17*b*, 17*b* are arranged on the inner wall surfaces 11*a*, 11*b* of fixed member 11. The track rails 16*a*, 16*b* slide along the movable blocks 17*a*, 17*a*, 17*b*, 17*b* without changing the position of the movable blocks 17*a*, 17*a*, 17*b*, 17*b*.

In this embodiment, although the backs of the movable blocks 17*a*, 17*a*, 17*b*, 17*b* are attached to the inner wall surfaces 11*a*, 11*b* and the movable member 12 is arranged between the track rails 16*a*, 16*b* opposing to each other, the arrangement of the rectilinear guides 13*a*, 13*b* is not restricted to these. For example, it may be possible to turn the rectilinear guides 13*a*, 13*b* over so that the backs of the movable blocks 17*a*, 17*b* are attached to the both edges of the movable member 12 and the track rails 16*a*, 16*b* are attached to the inner wall surfaces 11*a*, 11*b*. Also it may be possible to turn only one of the rectilinear guides 13*a*, 13*b* over. In this case, the track rail 16*b* is attached to the inner wall surface 11*b* in one rectilinear guide 13*b* and the back of movable block 17*a* is attached to the inner wall surface 11*a* in other rectilinear guide 13*a*.

As shown in FIGS. 2 to 4, the fixed member 11 is formed like a quadrilateral frame. And the movable blocks 17*a*, 17*a*, 17*b*, 17*b* are attached to the inner wall surfaces 11*a*, 11*b* in short sides of the quadrilateral frame. The movable blocks 17*a*, 17*a* attached to the inner wall surface 11*a* does not change the position. And the movable blocks 17*b*, 17*b* attached to the inner wall surface 11*b* are allowed to be movable in a perpendicular direction to the inner wall surface 11*b* so as to absorb an installation error caused when said the pair of rectilinear guides 13*a*, 13*b* are installed, or thermal expansion and contraction difference between the fixed member 11 and the movable member 12.

In the inner wall surface 11*a*, a fitting groove 21*a* which has a width equal to the width of the movable blocks 17*a*, 17*a* are formed so as to locate the movable blocks 17*a*, 17*a*. The movable blocks 17*a*, 17*b* are fitted in the fitting groove 21*a* and fixed to the inner wall surface 11*a*. In the inner wall surface 11*b*, fitting groove 21*b* is formed by which the rectilinear guide 13*b* is guided to move in the direction perpendicular to the inner wall surface 11*b*. The width of the fitting groove 21*b* is equal to the width of the movable blocks 17*b*, 17*b* of the rectilinear guide 13*b*. The fitting groove 21*b* has a pair of wall guide surfaces opposing to each other. Being guided by a pair of wall guide surfaces of the fitting groove 21*b*, movable blocks 17*b*, 17*b* move in the perpendicular direction.

The movable blocks 17*b*, 17*b* are attached to the inner wall surface 11*b* of the fixed member 11 through elastic beams 19, 19 as a displacement absorbing device.

As shown in FIG. 4, the elastic beam 19 has both longitudinal end portions fixed to the fixed member 11, the movable block 17*b* is substantially arranged in the middle of the elastic beam 19 in the longitudinal direction thereof. A hollow 23 which has the same area as the elastic beam 19 is formed on an outer wall surface 22, and the elastic beam 19 is fitted in the hollow 23. The hollow 23 is extended to the fitting groove 21*b*. A wall is penetrated by the hollow 23 and the fitting groove 21*b*. The elastic beam 19 has span which is capable of deflection, and the span is longer than the width W of the movable block 17*b*. And a spacer 20 is arranged between the elastic beam 19 and the movable block 17*b* so that the elastic beam 19 deflects larger. The spacer 20 has width less than the width of the movable block 17*b*.

As shown FIG. 5, when a processing error including an installation error caused by the installation of the two rectilinear guides 13*a*, 13*b* occurs, or when thermal expansion and contraction difference between the fixed member 11 and the movable member 12 occurs, or when a deformation of the relative linear motion apparatus caused by a load from the inside or the outside of the apparatus occurs, the elastic beam 19 is deflected by a load applied from the spacer 20 to the elastic beam 19. The elastic beam 19 is deflected by the load, as if a fixed beam is deflected by a concentrated load applied to the middle of the fixed beam. Deflecting the elastic beam 19 to the perpendicular direction allows the movable block 17*b* to move in the perpendicular direction ① and absorbs the installing error or the thermal expansion and contraction difference or the deformation of the relative linear motion apparatus caused by the load. Since the movable block 17*b* is allowed to move only in the direction ① perpendicular to the inner wall surface 11*b* and restricted to move in the horizontal direction ②, it is possible to guide the movable member 12 in good rigidity. Further, In this embodiment, since elastic beam 19 is disposed only on the movable block 17*b* and is not disposed on the movable block 17*a*, the movable member 12 is stably supported by the rectilinear guides 13*a*, 13*b* in the perpendicular direction ①.

In order to absorb the expansion and contraction difference, it is expected that the elastic beam 19 deflect largely. Disposing the spacer between the movable member 17*b* and the elastic beam 19 the load placed on the elastic beam 19 approaches to the concentrated load from the distributed load, and deflects the elastic beam 19 larger. Furthermore, since the span of the elastic beam 19 is longer than the width W of the movable block 17*b*, the deflection of the elastic beam 19 becomes all the more larger.

FIG. 6. Shows the rectilinear guide 13*a* (13*b*). The rectilinear guides 13*a* (13*b*) comprises, a track rail 16*a* (16*b*) as a track member formed with rolling member rolling grooves 31,31 as rolling member rolling surfaces along a

longitudinal direction thereof, a movable block **17**a (**17**b) mounted to be relatively movable to the track rail **16**a (**16**b), the movable block **17**a (**17**b) being formed with rolling member circulation passages including loaded rolling member rolling grooves as loaded rolling member rolling surfaces opposing to the rolling member rolling grooves **31**,**31** of the track rail **16**a (**16**b) when mounted, and a number of balls **33**, - - - , **33** as rolling members arranged in the rolling member circulation passages so as to circulate therein in conformity with the relative motion of the movable block **17**a (**17**b) with respect to the track rail **16**a (**16**b). This rectilinear guides **13**a (**13**b) is constructed so as to bear a load not only in the perpendicular direction but also in the horizontal direction.

The track rail **16**a (**16**b) has a rectangular shape in section. Each of the right and left side surfaces of the track rail **16**a (**16**b) is formed with two lines of loaded ball rolling grooves **31**,**31**. And the total of ball rolling grooves **31**,**31** is four.

The movable block **17**a (**17**b) comprises a body portion **34** and end covers (plates) **35**, **35** disposed on both longitudinal end sides of the body portion **34**, the body portion **34** and the end covers **35**, **35** being secured together by means of bolts. The movable block **17**a (**17**b) straddles the track rail **16**a (**16**b). The movable block **17**a (**17**b) is formed with the loaded ball rolling grooves **32**,**32** and the ball escape bores, while each of the end plates **35**,**35** is formed with the direction changing passages. Each of the ball escape bores linearly passes through the movable block **17**a (**17**b). A fixing surface **36** attached to the inner wall surface **11**a (**11**b) or the spacer **20** is formed on the upper surface of the body portion **34**. Four screw holes **37**a, - - - , **37**a for fixing the inner wall surface **11** a (**11** b) are formed around the fixing surface **36**, and two screw holes **37**b, **37**b for fixing the spacer **20** are formed inside the screw holes **37**a, - - - , **37**a.

The loaded rolling member rolling grooves **32**, **32** are opposing to the rolling member rolling grooves **31**, **31** of the track rail **16**a (**16**b), and the loaded rolling member rolling grooves **32**, **32** and the rolling member rolling grooves **31**, **31** compose loaded ball rolling passages. A number of balls (rolling members) **33**, - - - , **33** are arranged in the ball circulation passages and are put between the loaded rolling member rolling grooves **32**, **32** and the rolling member rolling grooves **31**,**31**. According to the movement of the movable blocks **17**a (**17**b) along the track rail **16**a (**16**b), the balls **33**, - - - , **33** are moved (rolled) from one end to the other end of the loaded ball rolling passages and scooped by the direction changing passages of the end plates **35**, **35** and guided by the ball escape bores, and then returned to the one end of the loaded ball rolling passages through the other one of the direction changing passages. The balls circulate in conformity with the relative motion of the movable block **17**a (**17**b) with respect to the guide rail **16**a (**16**b).

As shown in FIGS. **7** to **8**, a chain of balls are held capable of rotation and slide by retainer **44**. This retainer **44** is composed of a plurality of spacers **40**, - - - , **40** interposed alternately between a plurality of balls **33**, - - - , **33**, and a thin belt **41** connecting the each of the spacers **40**, - - - , **40**.

A seal member **42** is disposed between the movable block **17**a (**17**b) and a upper surface of track rail **16**a (**16**b). Seal members **43**, **43** are disposed between the movable block **17**a (**17**b) and side surfaces of the track rail **16**a (**16**b). This seal members **42**, **43**, **43** seal lubricating oil filled between the ball rolling grooves **31**, **31** and the loaded ball rolling grooves **32**, **32**.

FIG. **9** shows a relative linear motion apparatus according to a second embodiment of the present invention. In this embodiment, a fixed member **51** has a octagonal frame in section, a movable member **52** is cross-shaped in section. Four rectilinear guides **53**a, **53**a, **53**b, **53**b are disposed between tips of a cross and inner wall surfaces opposing to the tips. Four permanent magnets **54**, - - - , **54** are fitted in four plate members **52**a, **52**b, **52**c, **52**d composing the cross. And four coils **55**, - - - , **55** are attached to the fixed member so that the each of permanent magnets **54**, - - - , **54** are put between each of the coils **55**, - - - , **55**. The movable member **52** is moved by producing a magnetic field of the coils **55**, - - - , **55**.

In one direction and in other direction crossing to one direction, rectilinear guides **53**a, **53**a and rectilinear guides **53**b, **53**b are arranged between the fixed member **51** and the plate members **52**a, **52**b, **52**c, **52**d of the movable member **52**. As the relative linear motion apparatus according to the first embodiment, movable blocks **56**b, **56**b are attached to the fixed member **51** through elastic beams **57**, **57**, and are capable of moving in a direction perpendicular to the inner wall surfaces. Also, these movable blocks **56**b, **56**b are guided to move only in the direction perpendicular to the inner wall surfaces and restricted to move in a horizontal direction by guide surfaces.

At the crossing part of the movable member **52**, notches **58**, - - - , **58** are made to reduce a rigidity of the movable member **52** slightly. Since there is a reduction in the rigidity of the crossing part, the crossing part absorbs the displacement caused by the thermal expansion and contraction of the plate members **52**a, **52**c in one direction or the plate members **52**b, **52**d in other direction. And a load which is caused by the thermal expansion and contraction of the plate members **52**a, **52**c is not transmitted to the plate members **52**b, **52**d. Also, a load which is caused by the thermal expansion and contraction of the plate members **52**b, **52**d is not transmitted to the plate members **52**a, **52**c in the same way.

FIG. **10** shows another variation of the crossing part. In this variation, four plate members **52**a, **52**b, **52**c, **52**d which compose the cross are connected with gussets **59**, - - - , **59**. The rigidity of gussets **59**, - - -, **59** are reduced. In this case, the gussets **59**, - - - , **59** absorb the displacement caused by the thermal expansion and contraction of the plate members **52**a, **52**c in one direction or the plate members **52**b, **52**d in other direction. And a load which is caused by the thermal expansion and contraction of the plate members **52**a, **52**c is not transmitted to the plate members **52**b, **52**d. Also, a load which is caused by the thermal expansion and contraction of the plate members **52**b, **52**d is not transmitted to the plate members **52**a, **52**c in the same way.

In this embodiment, making the movable member in the shape of the cross give good rigidity to the movable member **52** itself. Also, since an area of the coils **55**, - - - , **55** and the permanent magnets **54**, - - - , **54** become larger, an output of the primary drive become larger.

Further, in the described embodiment of the relative linear motion apparatus, the elastic beam **57** is arranged on only one side of the rectilinear guides **53**a, **53**b opposing to each other so that only one side of the rectilinear guides **53**a, **53**b moves in the perpendicular direction. However, in an alternation, it may be adopted that the elastic beams **57**, **57** are arranged on both rectilinear guides **53**a, **53**b so that both sides of the rectilinear guides **53**a, **53**b move in the perpendicular direction.

Further, in the described embodiment of the relative linear motion apparatus, the elastic beams (plate) **57** are attached to the fixed member **51**. However, in an alternation, it may be adopted that the elastic beam **57**, **57** are attached to the movable member **52**.

Still furthermore, the shape of the fixed member **51** in cross section is not restricted to a quadrilateral or an octagon, and alternations and many other changes such as a polygon or a circle or a substantially ⊐-shaped cross section of which one side is opened may be adopted. As to the movable member **52**, the shape of the movable member **52** in cross section is not restricted to a plate or an crossing which miniaturize the relative linear motion apparatus, and alternations and many other changes such as a cylinder may be adopted.

FIGS. **11** to **13** show a relative linear motion apparatus according to a third embodiment of the present invention. In this embodiment, the relative linear motion apparatus comprises a fixed member **11** formed like a quadrilateral frame as first structure, movable member **12** arranged between a pair of inner wall surfaces **11***a* **11***b* in short sides of the quadrilateral frame as second structure, the movable member **12** being formed like a plate as a second structure, and a pair of rectilinear guides **13***a*, **13***b* arranged between each of the inner wall surfaces **11***a*, **11***b* and each of both edges of the movable member **12**. The movable member **12** slides relative to the inner wall surfaces **11***a*, **11***b* in a direction parallel to the inner wall surfaces **11***a*, **11***b*.

Each of the rectilinear guides **13***a*, **13***b* comprises the track rail **16***a* (**16***b*) as a track member, and the movable block **17***a* (**17***b*) as slide member. Each of the track rails **16***a*, **16***b* is arranged on each of both edges of the movable member **12**. And the movable blocks **17***a*, **17***a*, **17***b*, **17***b* are arranged on the inner wall surfaces **11***a*, **11***b* of fixed member **11**. The movable blocks **17***a*, **17***a* are attached to the inner wall surface **11***a*, and the movable blocks **17***b*, **17***b* are attached to the inner wall surface **11***b*. And the movable blocks **17***b*, **17***b* are set to be movable only in the direction perpendicular to the inner wall surface **11***b* so as to absorb the installing error of the rectilinear guides **13***a*, **13***b* or the thermal expansion and construction difference between fixed member **11** and movable member **12**.

The arrangements and functions of elements or parts of the relative linear motion apparatus the same as the relative linear motion apparatus shown in FIGS. **1** to **6** are not described herein by adding the same reference numerals to the corresponding elements or parts.

The frame **12***a* and rail holding portions **12***b*, **12***b* fixed to the both edges of the frame **12***a* are integrally formed by a die casting using metal such as aluminum. Further, the track rails **16***a*, **16***b* are inserted in rail holding portions **12***b*, **12***b* of the movable member **12**, and are integrally molded with movable member **12**. In different words, the movable member **12** is integrally formed with the track rails **16***a*, **16***b* by injecting metal such as aluminum into a metal mold in which the track rails **16***a*, **16***b* are placed, i.e. through a so-called insert molding method. Since the track rails **16***a*, **16***b* are affected by heat when the track rails **16***a*, **16***b* are molded, the ball rolling grooves **31**,**31** are formed by machining or grinder after molding the track rails **16***a*, **16***b*. Also, it may be possible to arrange a means for preventing the track rails **16***a*, **16***b* from slipping out of the rail holding portions **12***b*, **12***b* to the axial direction of the track rails **16***a* **16***b*. And forming a difference in level on the track rails **16***a* **16***b* prevents the track rails **16***a*, **16***b* from slipping out of the rail holding portions **12***b*, **12***b*.

When movable member **12** are arranged between the pair of inner wall surfaces **11***a*, **11***b* opposing to each other of the fixed member **11** through the rectilinear guides **13***a*, **13***b*, it is necessary to reduce the processing error including the installing error of the rectilinear guides **13***a*, **13***b*. According to this embodiment, since the track rails **16***a*, **16***b* are inserted in the movable member **12** and are integrally molded with the movable member **12**, it is possible to reduce the processing error as much as possible. Also it is possible to reduce the number of articles.

FIG. **14** shows a variation of the point in the third embodiment. As shown in FIG. **14**(*a*), the rail holding portion **12***b* of the movable member **12** is extended from a base of the track rail **16***a* (**16***b*) to hollows **16***f*, **16***f* formed on side surfaces of the track rail **16***a* (**16***b*). A lower part of the track rail **16***a* (**16***b*) is wrapped by the rail holding portion **12***b*. According to this construction, since combination of the track rail **16***a* (**16***b*) and the rail holding portion **12***b* becomes firmer, both are not separated by added vibration or shock.

In a second variation shown in FIG. **14**(*b*), a dovetail groove **16***g* is formed on the base of the track rail **16***a* (**16***b*), a part **12***e* of the rail holding portion **12***b* is injected into the dovetail groove **16***g*. According to this structure, combination of the track rail **16***a* (**16***b*) and the rail holding portion **12***b* becomes firmer as much as the variation shown in FIG. **14**(*a*). Also, it is possible to narrow down the width of the rail holding portion **12***b* to the width of the track rail **16***a* (**16***b*) and to miniaturize the relative linear motion apparatus.

In a third variation shown in FIG. **14**(*c*), a part **12***f* of the rail holding portion **12***b* is injected into bore **16** for inserting bolt. According to this structure, combination of the track rail **16***a* (**16***b*) and the rail holding portion **12***b* becomes firmer as much as the variations shown in FIG. **14**(*a*) and FIG. **14**(*b*). And it is possible to narrow down the width of the rail holding portion to the width of the track rail **16***a* (**16***b*). Furthermore since the existing bore **16***h* for inserting bolt is used for casting, it is not necessary to form the dovetail groove **16***g* shown in FIG. **14**(*b*) on the track rail **16***a* (**16***b*), and as a result costs fall.

It is further to be noted that the present invention is not limited to the described embodiments and alternations and many other changes and modifications may be made without departing from the scopes of the appended claims.

What is claimed is:

1. A relative linear motion apparatus comprising:

a first structure having at least a pair of inner wall surfaces opposing to each other;

a second structure arranged between the a pair of inner wall surfaces, the second structure being movable in linear motion relative to the first structure;

at least two rectilinear guides arranged between the pair of inner wall surfaces of the first structure and the second structure; and

a displacement absorbing device arranged on at least one of the first structure and the second structure so as to allow at least one of the two rectilinear guides to move in an intersecting direction against the wall surfaces.

2. A relative linear motion apparatus according to claim **1**, wherein said at least one of the two rectilinear guides moves in the intersecting direction against the wall surfaces due to a processing error including an installation error caused when said at least one of the two rectilinear guides is installed or thermal expansion and contraction difference between the first structure and the second structure.

3. A relative linear motion apparatus according to claim **1** or **2**, wherein said displacement absorbing device is arranged between (i) one of said first structure and said second structure (ii) and one of said two rectilinear guides, and said displacement absorbing device having an elastic beam which can deflect toward the intersecting direction against the wall surfaces.

4. A relative linear motion apparatus according to claim **3**, wherein said elastic beam has span that is capable of deflection, and the span is longer than the width of said one of the two rectilinear guides.

5. A relative linear motion apparatus according to claim **4**, wherein a spacer is arranged between said elastic beam and one of said rectilinear guides so that said elastic beam deflects larger, and the spacer having width less than the width of said one of the two rectilinear guides.

6.A relative linear motion apparatus according to claim **4**, wherein said elastic beam has both longitudinal end portions fixed to said first structure or said second structure, and said one of the two rectilinear guides is substantially arranged in the middle of said elastic beam in a longitudinal direction thereof.

7. A relative linear motion apparatus according to claim **1**, wherein said first structure or said second structure has guide surfaces which guide said one of the two rectilinear guides to move in the intersecting direction against the wall surfaces.

8. A relative linear motion apparatus according to claim **7**, wherein said guide surfaces, being formed on fitting groove of which the width is equal to the width of said one of the two rectilinear guides, allow said one of the two rectilinear guides to move only in a perpendicular direction to the wall surfaces without occurrence of change in posture of said one of the two rectilinear guides.

9. A relative linear motion apparatus according to claim **1**, wherein each of said rectilinear guides comprises:

a track member formed with a rolling member rolling surface along a longitudinal direction;

a movable block mounted to be relatively movable to the track member formed with a rolling member circulation passage including a loaded rolling member rolling surface opposing to the rolling member rolling surface of the track member when mounted; and

a number of rolling members arranged in the rolling member circulation passage so as to circulate therein in conformity with the relative motion of the movable block with respect to the track rail.

10. A relative linear motion apparatus according to claim **9**, wherein each of movable blocks is fixed to said each of said inner wall surfaces of said first structure, and each of track members is fixed to each of edges of said second structure.

11. A relative linear motion apparatus comprising:

a first structure having at least a pair of inner wall surfaces opposing to each other;

a second structure arranged between the pair of inner wall surfaces, the second structure being movable in linear motion relative to the first structure;

at least two rectilinear guides arranged between the first structure and the second structure; and

a displacement absorbing device arranged on at least one of the first structure and the second structure so as to allow at least one of the two rectilinear guides to move in an intersecting direction against the wall surfaces;

wherein said displacement absorbing device is arranged between (i) one of said first structure and said second structure (ii) and one of said two rectilinear guides, said displacement absorbing device having an elastic beam which can deflect toward the intersecting direction against the wall surfaces,

and wherein said elastic beam has a span which is capable of deflection, and the span is longer than the width of said one of the two rectilinear guides.

12. A relative linear motion apparatus according to claim **11**, wherein a spacer is arranged between said elastic beam and said one of the two rectilinear guides so that said elastic beam deflects larger, and the spacer having width less than the width of said one of the two rectilinear guides.

13. A relative linear motion apparatus according to claim **11**, wherein said elastic beam has both longitudinal end portions fixed to said first structure or said second structure, and said one of the two rectilinear guides is substantially arranged in the middle of said elastic beam in a longitudinal direction thereof.

14. A relative linear motion apparatus comprising:

a first structure having at least a pair of inner wall surfaces opposing to each other;

a second structure arranged between the pair of inner wall surfaces, the second structure being movable in linear motion relative to the first structure;

at least two rectilinear guides arranged between the first structure and the second structure; and

a displacement absorbing device arranged on at least one of the first structure and the second structure so as to allow at least one of the two rectilinear guides to move in an intersecting direction against the wall surfaces;

wherein each of said rectilinear guides comprises:

a track member formed with a rolling member rolling surface along a longitudinal direction;

a movable block mounted to be relatively movable to the track member formed with a rolling member circulation passage including a loaded rolling member rolling surface opposing to the rolling member rolling surface of the track member when mounted; and

a number of rolling members arranged in the rolling member circulation passage so as to circulate therein in conformity with the relative motion of the movable block with respect to the track rail;

wherein each of said movable blocks is fixed to each of said inner wall surfaces of said first structure, and each track member is fixed to each of edges of said second structure, and wherein said track member is integrally formed with said second structure by an inserting mold.

15. A relative linear motion apparatus comprising:

a first structure having at least a pair of inner wall surfaces opposing to each other;

a second structure arranged between the pair of inner wall surfaces, the second structure being movable in linear motion relative to the first structure;

at least two rectilinear guides arranged between the pair of inner wall surfaces of the first structure and the second structure; and

a displacement absorbing device arranged on at least one of the first structure and the second structure, said displacement absorbing device comprising a span that is capable of deflection supported by at least two supports connected to one of said first structure and said second structure, and further wherein said span bends in response to contact from an opposing force from the other of said first structure and said second structure so as to allow at least one of the two rectilinear guides to move in an intersecting direction against the wall surface.

* * * * *

US006390678B1

(12) **United States Patent**
Shirai

(10) **Patent No.: US 6,390,678 B1**
(45) **Date of Patent: May 21, 2002**

(54) **ROLLER CONNECTED BODY AND LINEAR GUIDE DEVICE USING IT**

(75) Inventor: **Takeki Shirai**, Tokyo (JP)

(73) Assignee: **THK Co., Ltd.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/424,831**

(22) PCT Filed: **Apr. 8, 1999**

(86) PCT No.: **PCT/JP99/01867**

§ 371 Date: **Dec. 1, 1999**

§ 102(e) Date: **Dec. 1, 1999**

(87) PCT Pub. No.: **WO99/53208**

PCT Pub. Date: **Oct. 21, 1999**

(30) **Foreign Application Priority Data**

Apr. 9, 1998 (JP) 10-097816

(51) **Int. Cl.**[7] **F16C 29/06**
(52) **U.S. Cl.** **384/44**
(58) **Field of Search** 384/44, 569, 43, 384/565, 45

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,937,532 A 2/1976 Fuhrmann et al.
4,561,703 A 12/1985 Dabringhaus

OTHER PUBLICATIONS

English Abstract of Japanese Utility Model Laid–Open No. 04–66421, dated Jun. 11, 1992.
Patent Abstracts of Japan, Publication No. 10089358, Published Apr. 7, 1998.

English Abstract of Japanese Utility Model Laid–Open No. 06–40451, dated May 31, 1994.

Patent Abstracts of Japan, Publication No. 05196037, Published Aug. 6,1993.

Patent Abstracts of Japan, Publication No. 05052217, Published Mar. 2, 1993.

Primary Examiner—Lenard A. Footland
(74) *Attorney, Agent, or Firm*—Arent Fox Kintner Plotkin & Kahn, PLLC

(57) **ABSTRACT**

The present invention provides a roller connector rotatably retaining a plurality of rollers arranged in a line and capable of being incorporated into an endless roller-circulation path of an endless sliding type linear guide unit and it also provides an improved linear guide unit using such roller connector. The roller connector comprises a plurality of rollers arranged in a row with the axes of rotation of the rollers being held parallel with one another, a plurality of spacers interposed between a plurality of rollers and each provided with a pair of concave seats with which each of the rollers comes into sliding contact and an elongate flexible connecting portion adapted to connect the spacers together and characterized in that the connecting portion is connected to the spacers at a position at which the outer peripheral surface of each of the rollers is divided into two substantially equal parts in the axial direction and that the connecting portion is provided only one side of the line of rollers.

4 Claims, 12 Drawing Sheets

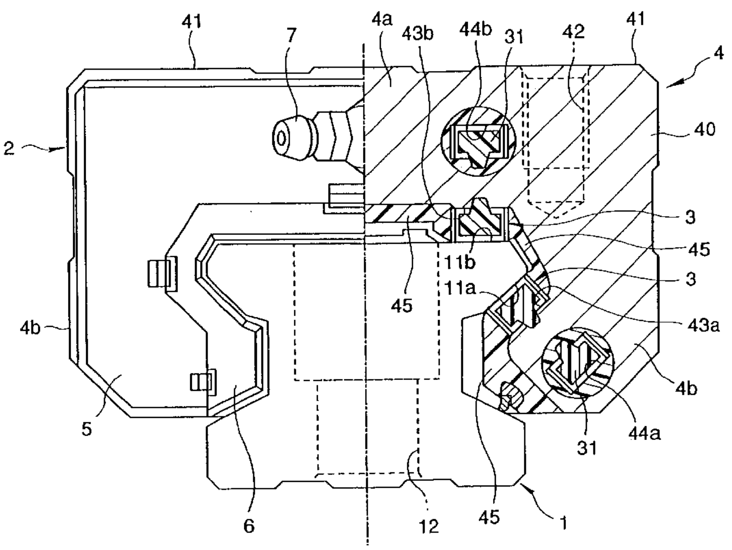


Fig. 1

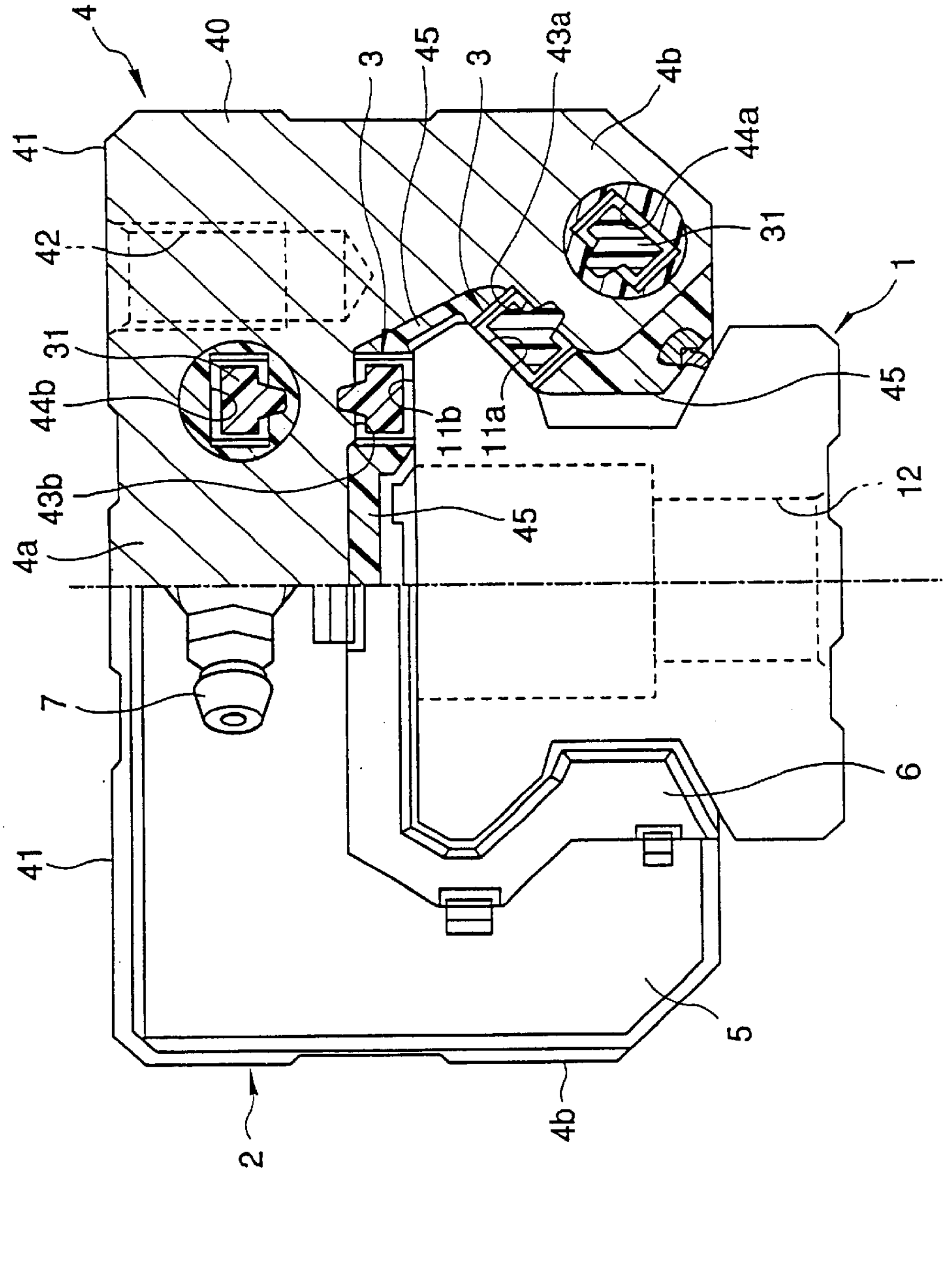

4
40
41
42
31
44b
43b
4a
3
45
3
43a
4b
44a
31
1
11b
11a
45
45
12
7
6
41
5
4b
2

Fig. 2

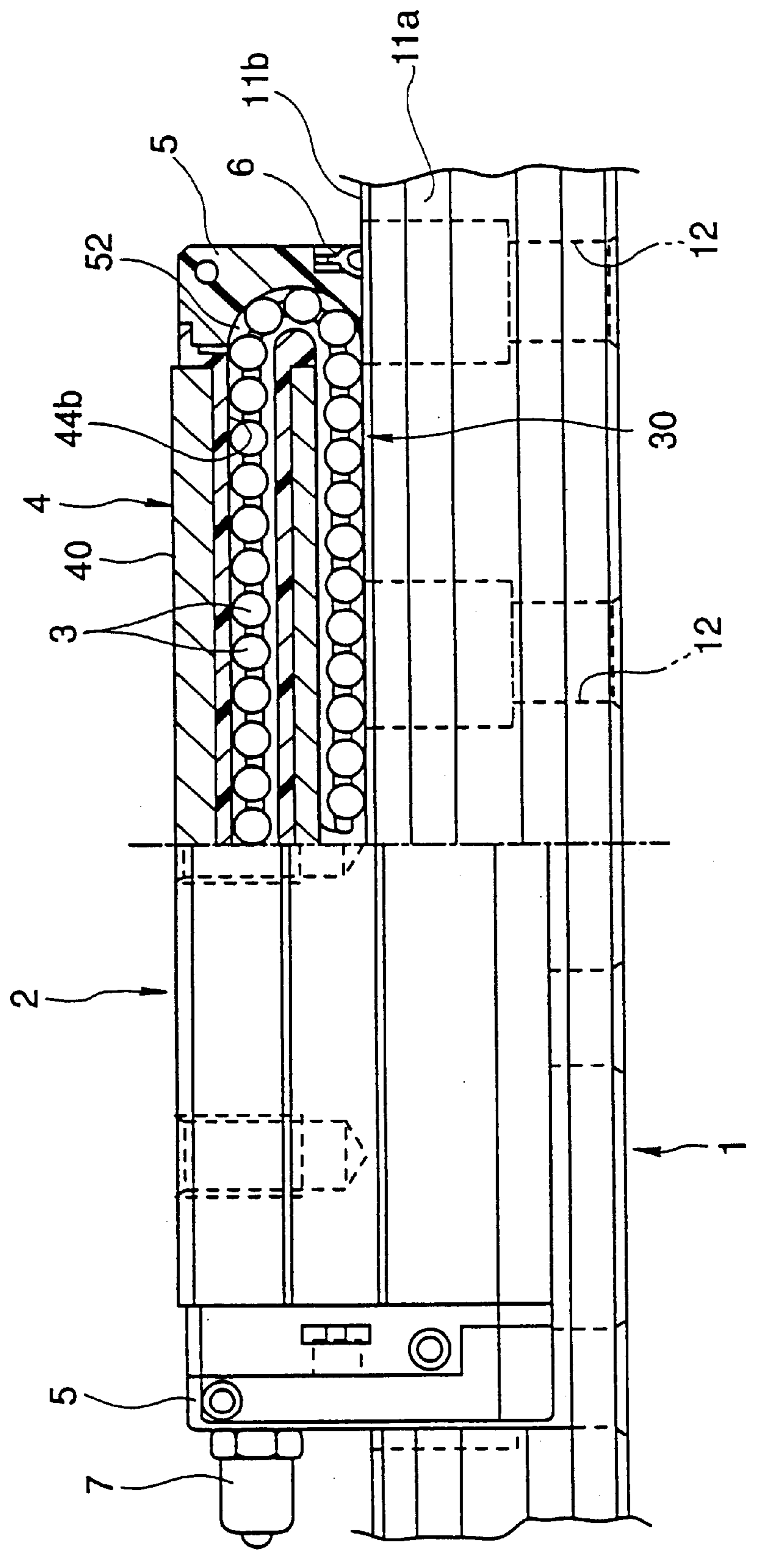


Fig.3

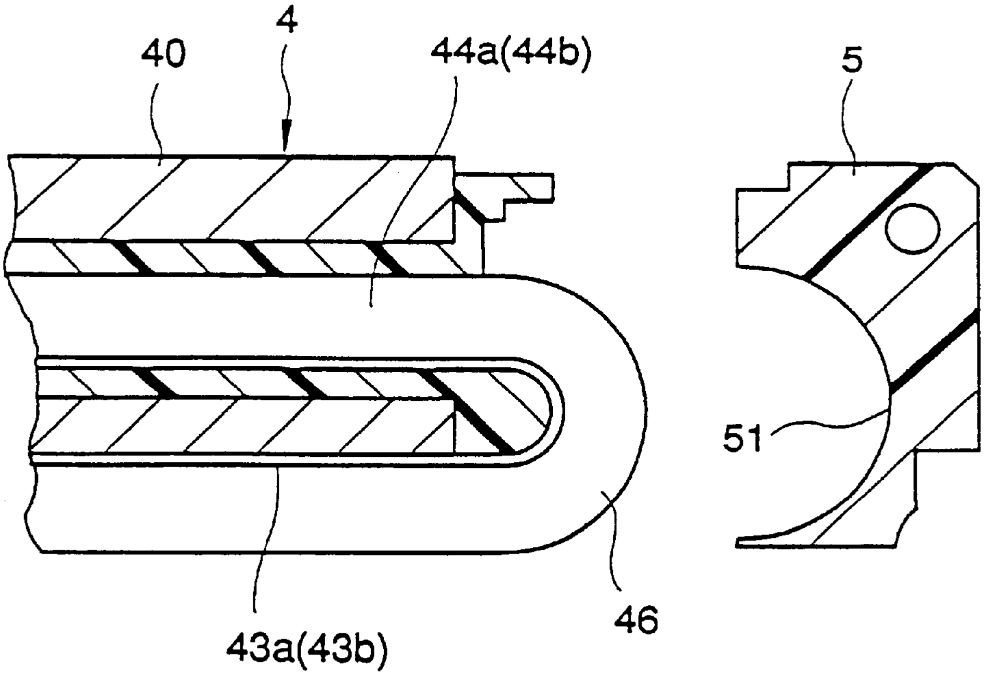


Fig.4

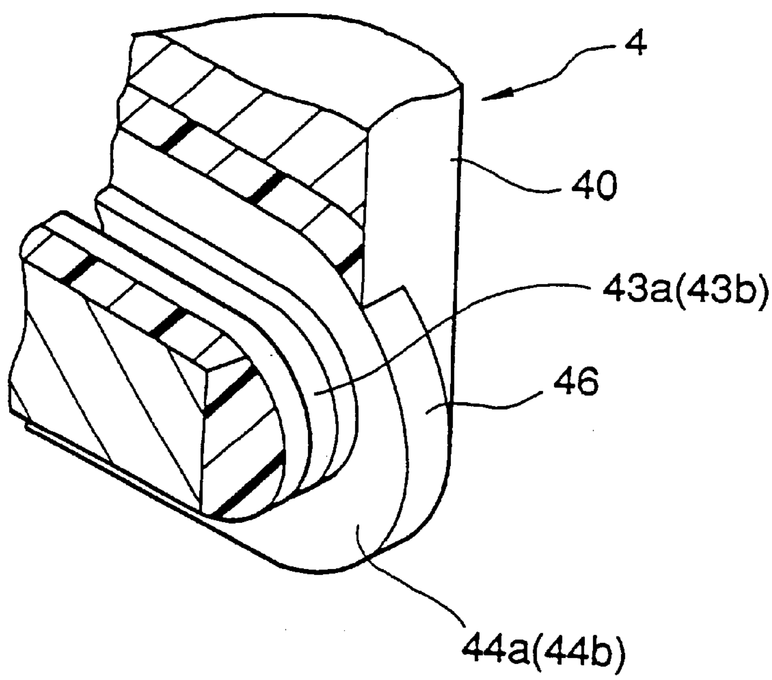


Fig. 5

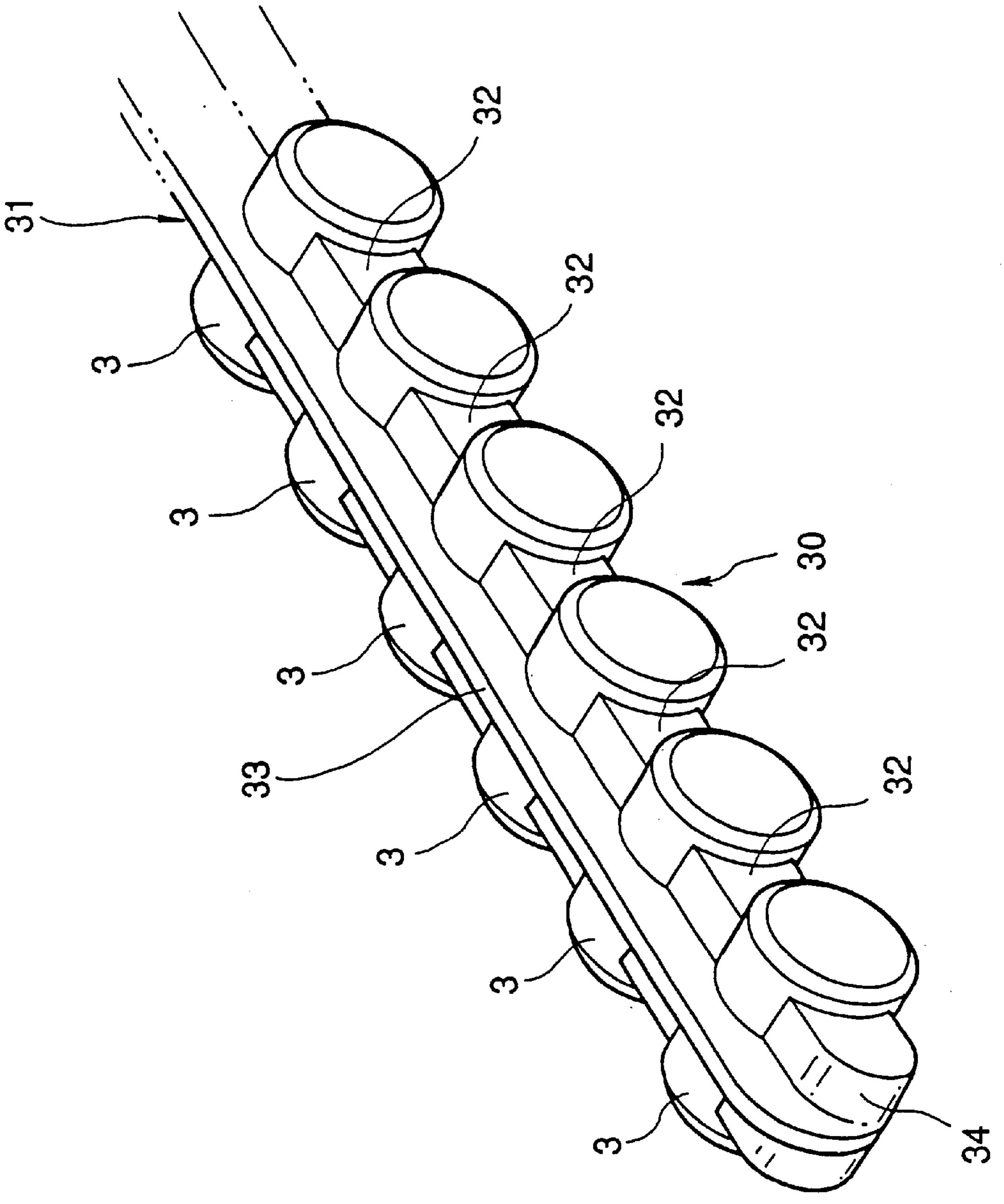


Fig. 6

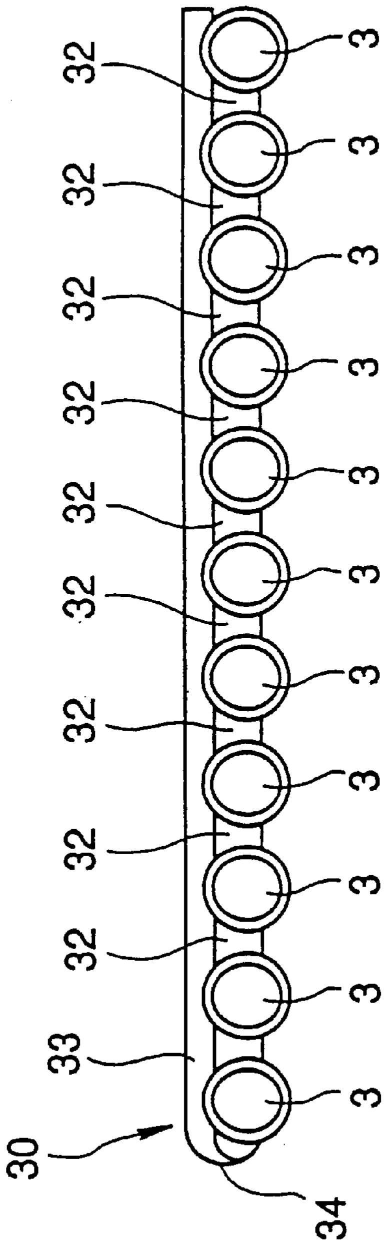


Fig. 7

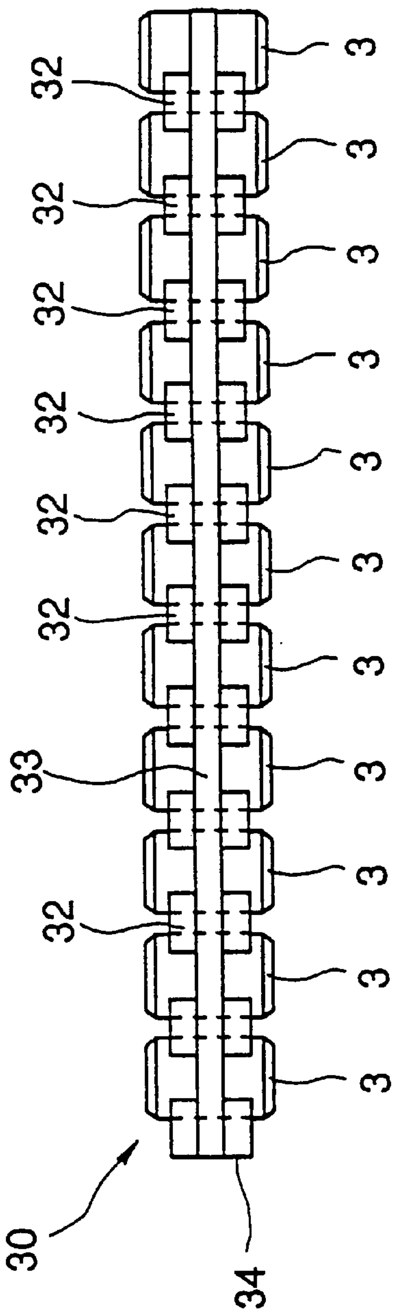
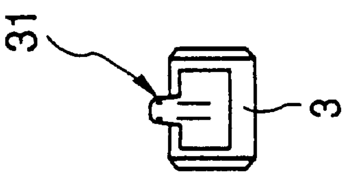
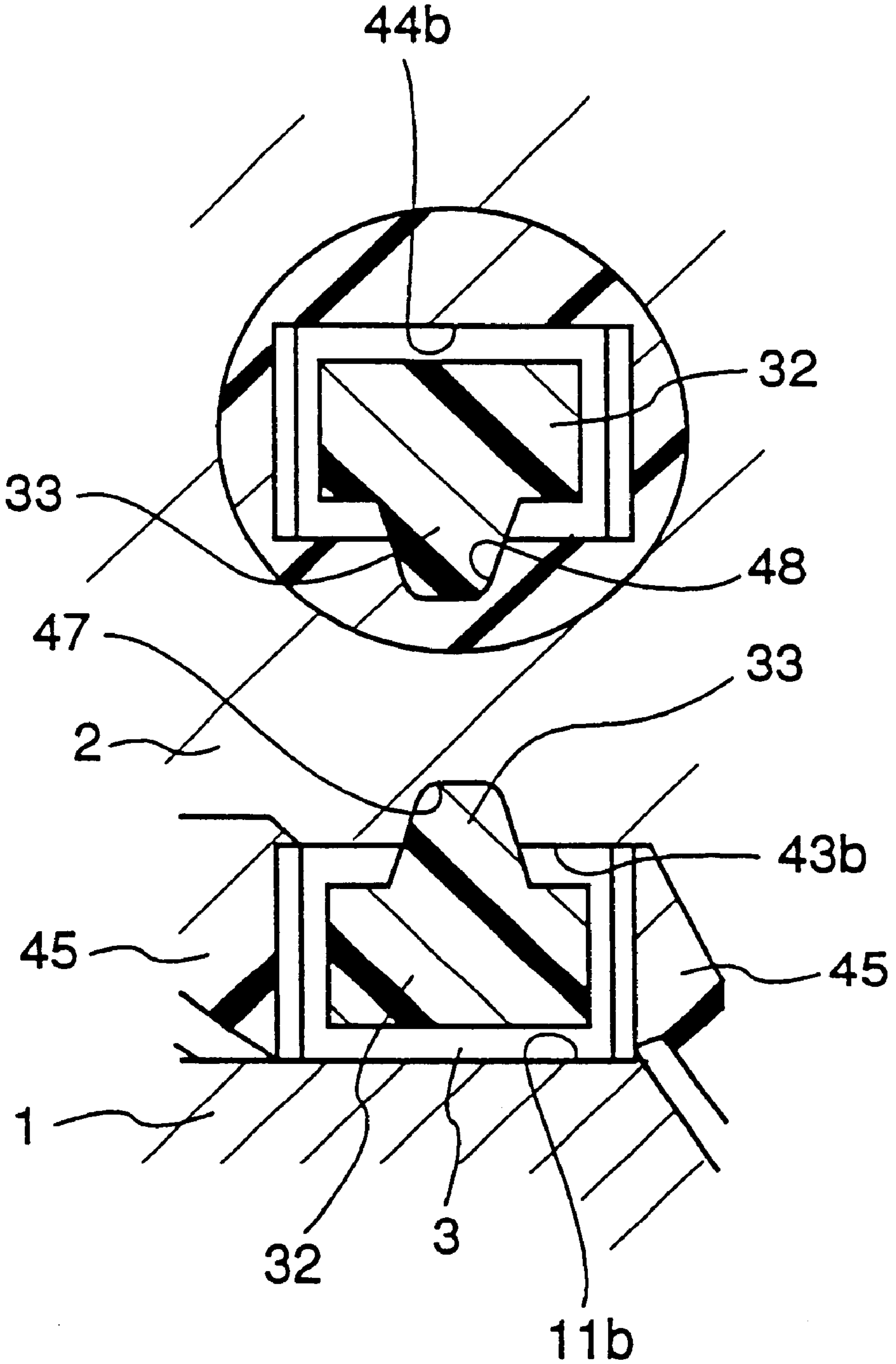


Fig. 8



F i g.9



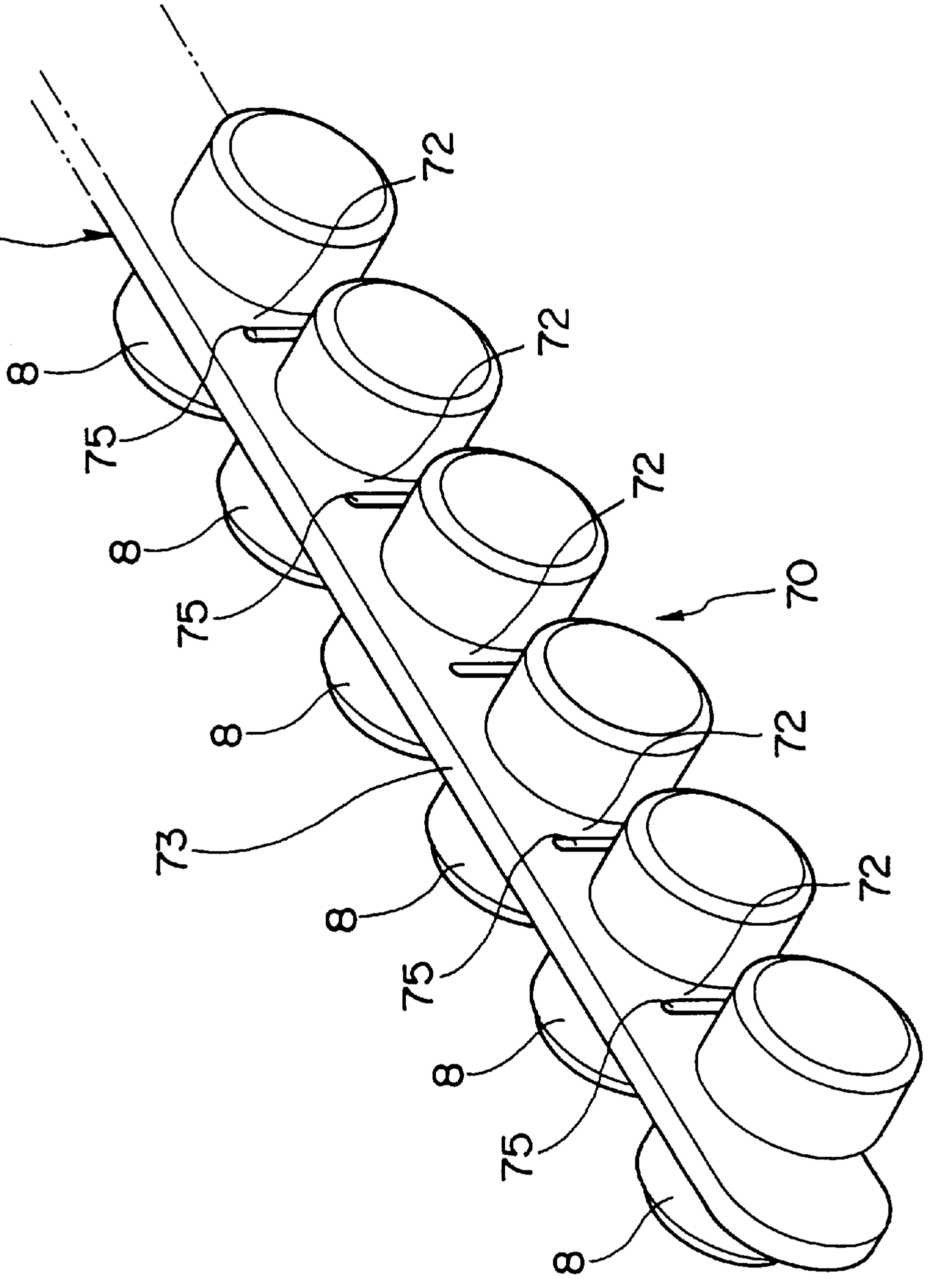


Fig. 10

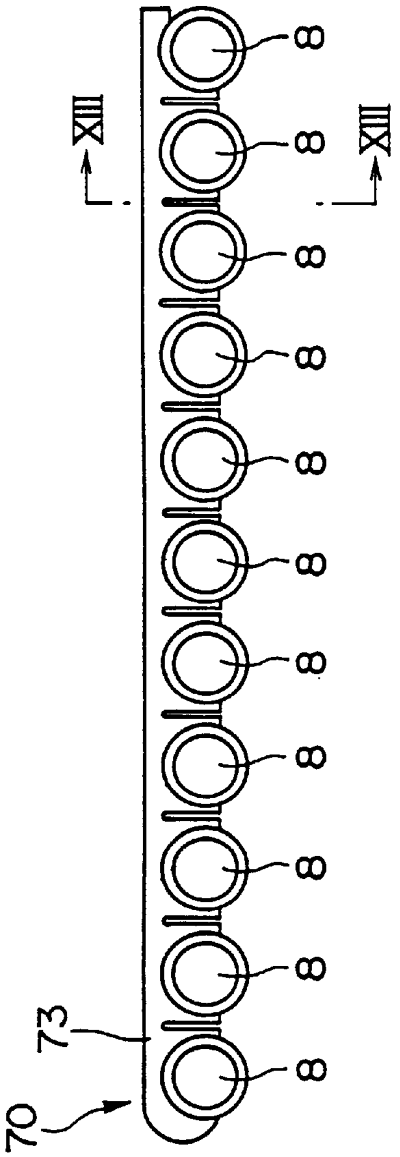


Fig. 11

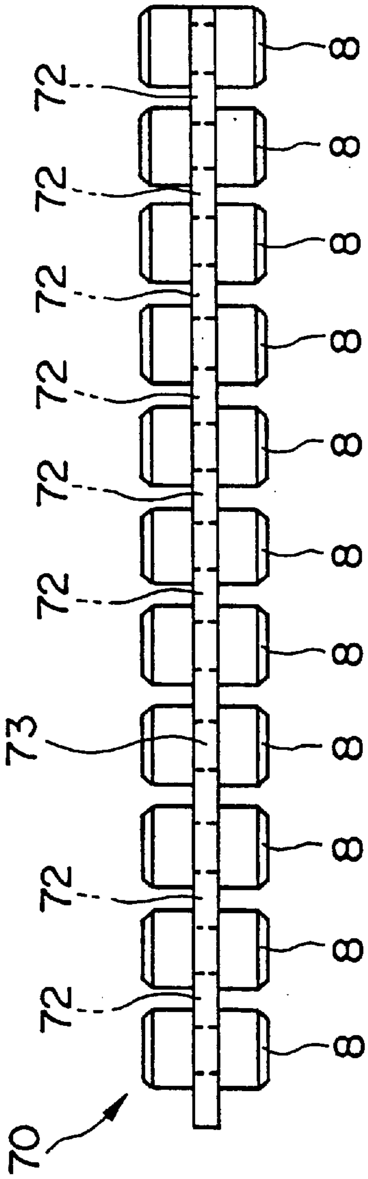


Fig. 12

Fig.13

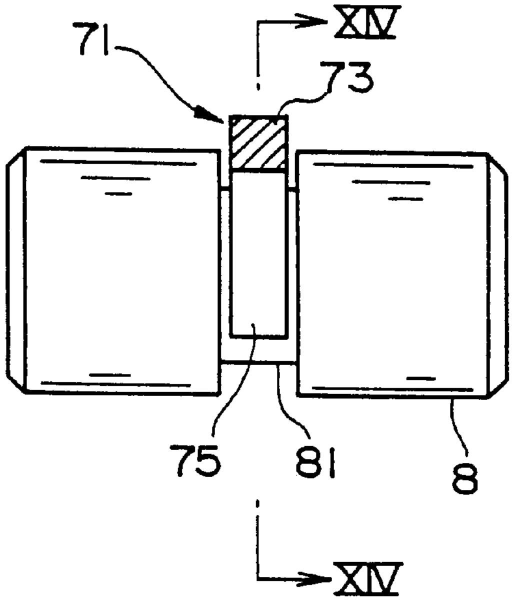


Fig.14

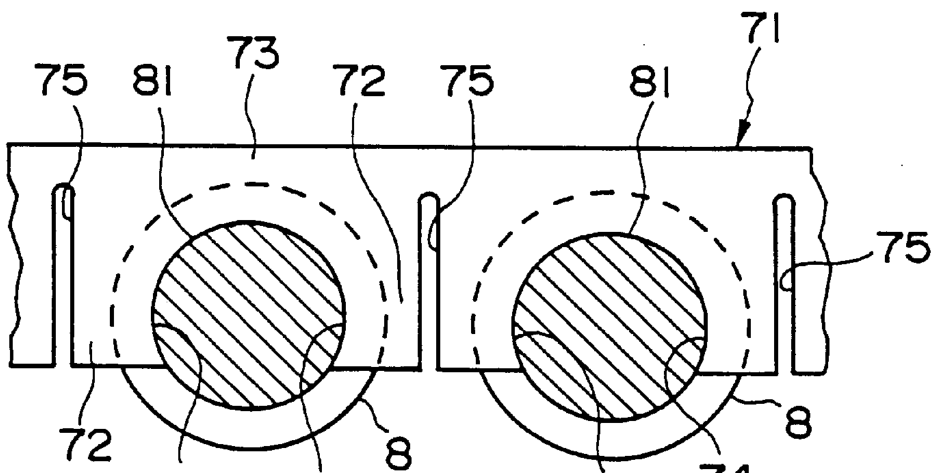


Fig.15

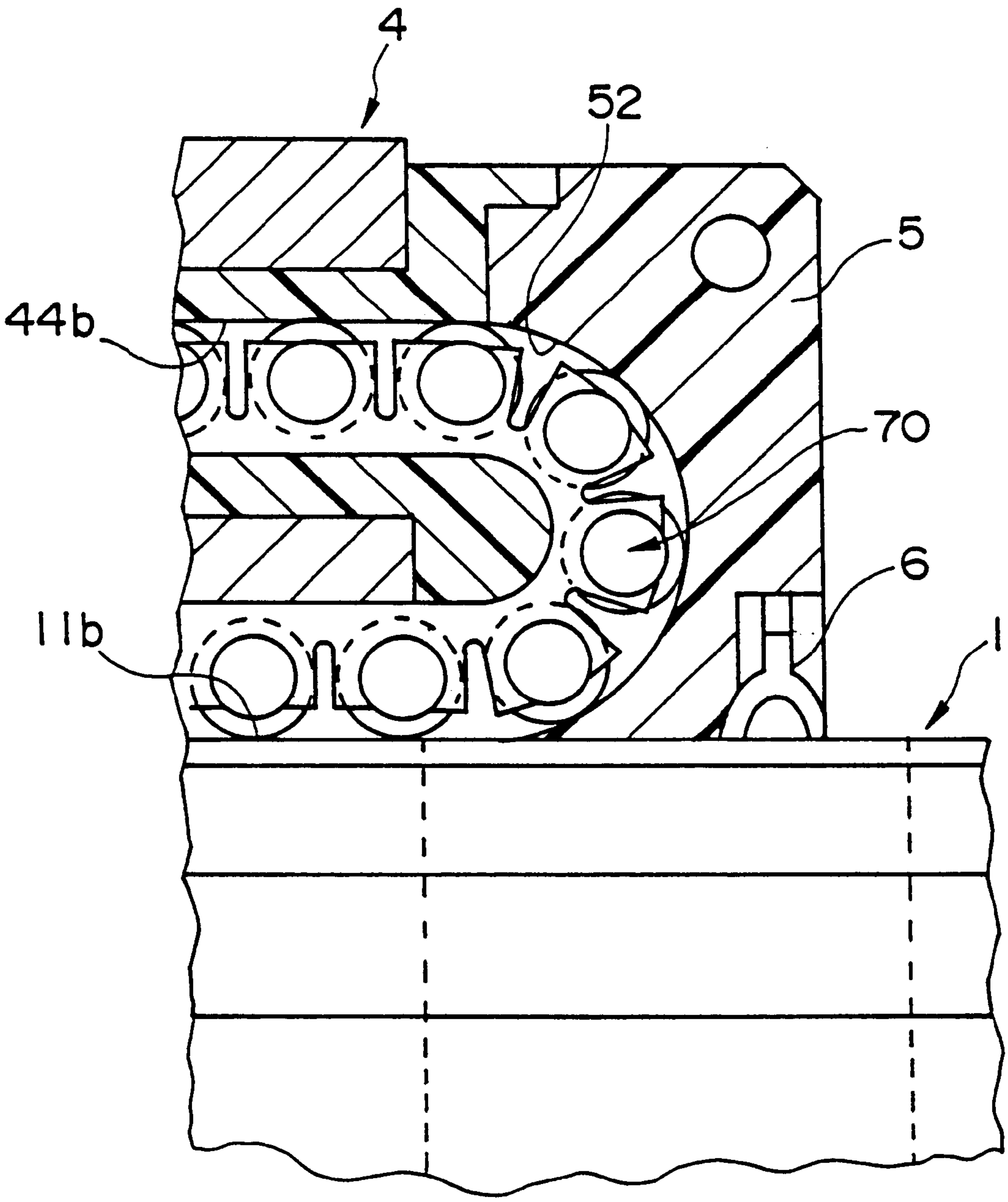


Fig.16

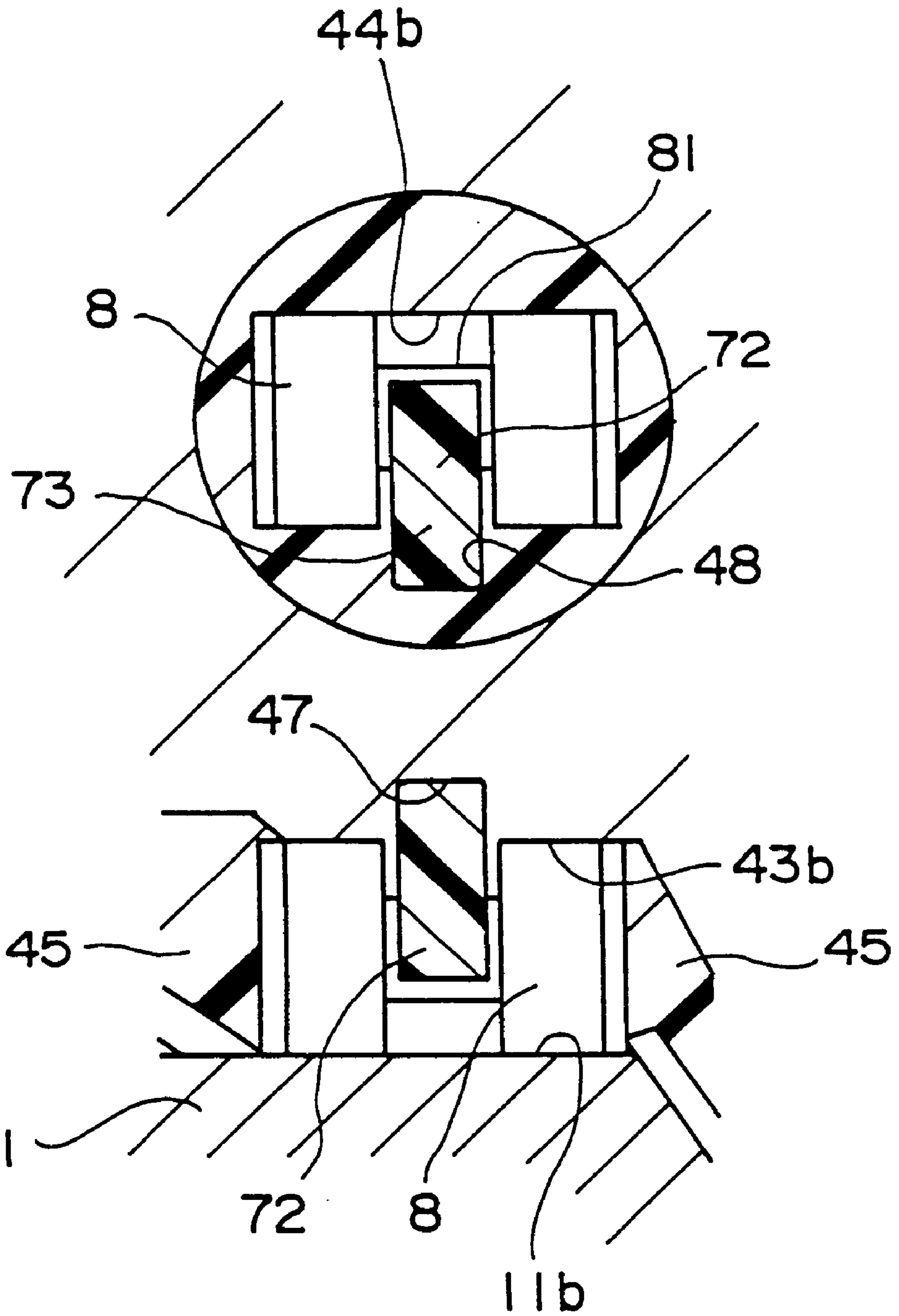


Fig.17

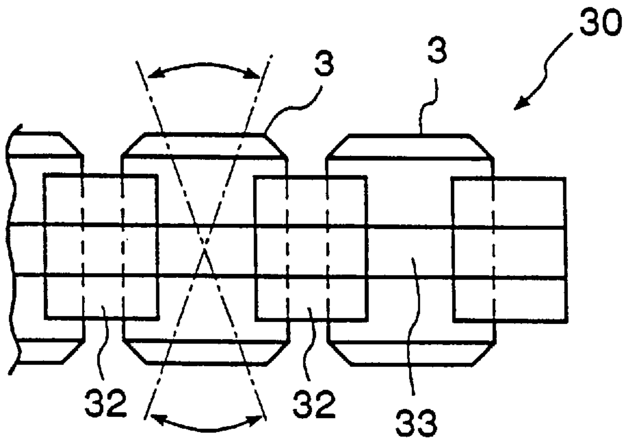


Fig.18

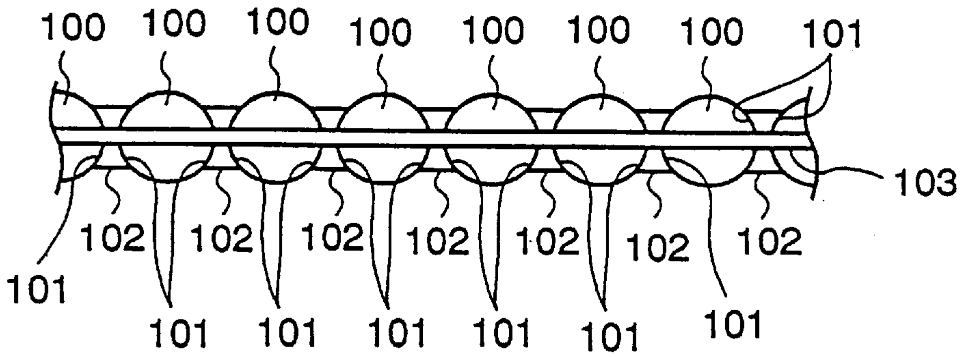
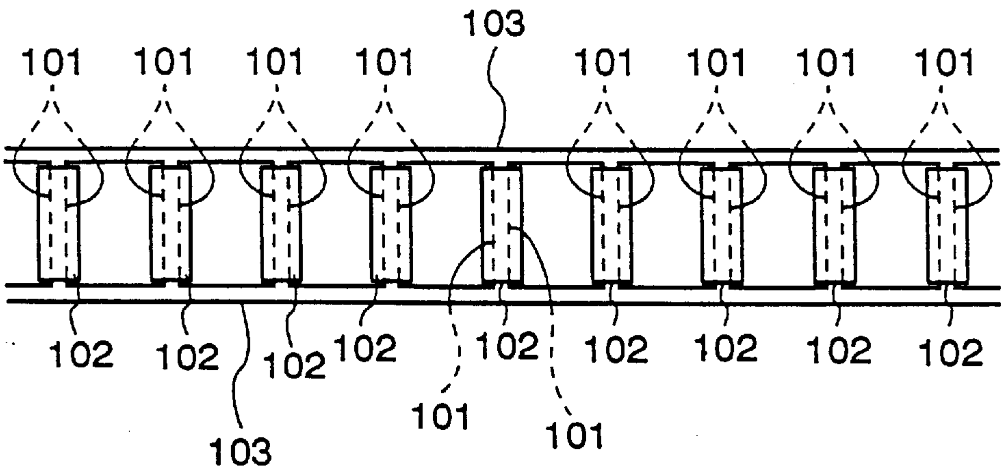


Fig.19



ROLLER CONNECTED BODY AND LINEAR GUIDE DEVICE USING IT

FIELD OF THE INVENTION

The present invention relates to a roller connector which rotatably retains a plurality of rollers in a line and which is incorporated into an endless roller-circulation path of an endless sliding type linear guide unit and also to an improvement in the linear guide unit of the above-type using such roller connector.

DESCRIPTION OF THE RELATED ART

Conventionally, there has been known a linear guide unit in which a slider is movably held in engagement with a track rail through a line of endlessly circulating rollers. More concretely, this linear guide unit comprises a plurality of rollers, a track rail which is arranged on a stationary portion such as a bed and which is provided with roller rolling surfaces and a slider provided with load rolling surfaces on which the rollers roll with respect to the roller rolling surfaces of the track rail while bearing a load thereon and an endless roller-circulation path with the inclusion of the load rolling surfaces whereby the slider having a table or a mechanical apparatus mounted thereon can move freely on the track rail following the endless circulation of the rollers.

The above-described linear guide unit having the track rail and the slider held in engagement with the track rail through the rollers has the advantage of improving the load bearing capacity of the slider as compared to such type of linear guide unit that makes use of rollers while on the other hand, it has the problem that the so called skewing of the rollers (oscillatory rotation of each roller about its axis) tends to take place. Therefore, it has been an important theme in securing the smooth rotation of the rollers and hence the smooth movement of the slider within the endless roller-circulation path how to prevent the above-described skewing of the rollers.

Therefore, as a means for solving the above-described problems, there have already been provided a roller connector comprising a plurality of rollers connected together in a predetermined posture like a string of beads and a linear guide unit having an endless roller-circulation path of the slider into which the roller connector is incorporated (Japanese Patent Laid-Open No. 52217/1993). As shown in FIGS. **18** and **19**, such roller connector comprises a plurality of rollers **100** arranged in a line with the axes of rotation thereof being held parallel to one another, a plurality of spacers **102** interposed among the rollers **100** and provided with concave seats **101** with which the rollers **100** come into sliding contact, respectively, and elongate flexible connecting portions **103** connecting the spacers **102** together and adapted to rotatably retain each of the rollers **100** by causing the spacers to sandwich the roller **100** therebetween from the front and rear sides thereof.

Accordingly, when such roller connector is incorporated into the endless roller-circulation path of the slider of the linear guide unit, each of the rollers **100** rolls within the endless roller-circulation path while it is retained in its predetermined posture by means of the spacers **102** from on both front and rear sides so that it is possible to cause the rollers **100** to smoothly circulate through the endless roller-circulation path while preventing the skewing of the rollers **100** and hence it is possible to make smooth the movement of the sliders with respect to the track rail.

However, in the case of the conventional roller connector of the above-described structure, there has hitherto been the

possibility that the connecting portions become fatigued at an early stage of operation since the connecting portions are formed along both axial end surfaces of each of the rollers as shown in FIGS. **18** and **19**, and therefore, when a force urging each of the rollers rolling through the endless roller-circulation path to skew, that is, a force oscillating the axis of rotation of each of the rollers acts on the roller, the connecting portions expand and contract in a repetitive fashion by such force.

Further, where the above-described roller connector is incorporated into the endless roller-circulation path of the slider, the sectional area of the endless roller-circulation path must be enlarged by a width corresponding to each of the connecting portions connecting the spacers together. Accordingly, if the connecting portions are present on both axial ends of each of the rollers as described above, where, for example, an endless roller-circulation path is formed by opening a roller return path in a slider, the diameter of the roller return path has to be made large so that the rigidity of the slider lowers to that degree which results in hindering the miniaturization of the slider.

SUMMARY OF THE INVENTION

The present invention has been made in view of the above-described problems.

Accordingly, an object of the invention is to provide a roller connector which can rotatably and stably retain a plurality of rollers in a predetermined posture for a prolonged period of time within an endless roller-circulation path formed in a slider of a linear guide unit.

Another object of the invention is to provide a roller connector which can improve the rigidity of the slider and contribute to the miniaturization of the slider.

A further object of the invention is to provide a linear guide unit using such roller connector.

In order to achieve the above-described objects, the roller connector of the present invention comprises a plurality of rollers arranged in a line with the axes of rotation of the rollers being held parallel to one another, a plurality of spacers interposed among the rollers and each provided with a pair of concave seats with which each of the rollers comes into sliding contact and an elongate flexible connecting portion connecting the spacers together and characterized in that the connecting portion is connected to the spacers at a position at which the connecting portion divides the outer peripheral surface of each of the rollers into two substantially equal parts in the axial direction and that the connecting portion is arranged only on one side of the line of rollers.

Further, the linear guide unit of the present invention using the above-described roller connector is required to have a structure comprising a number of rollers, a track rail having roller-rolling surfaces and a slider provided with an endless roller-circulation path having load rolling surfaces on which the rollers roll with respect to the roller-rolling surface of the track rail while bearing a load and it is characterized in that the above-described roller connector is incorporated into the endless roller-circulation path with the connecting portion of the roller connector lying inside the inner peripheral surface of the endless roller-circulation path of the slider, and that the endless roller-circulation path is provided with clearance grooves by which the connecting portion of the roller connector is received and guided.

According to such technical means, as in the case of the above-described conventional roller connector, each of the rollers is embraced in front and in rear by the adjoining spacers and rolls through the endless roller-circulation path of the slider of the linear guide unit in a state in which it is retained in a predetermined posture by the spacers. Consequently, it becomes possible to effectively prevent each of the rollers from skewing within the endless roller-circulation path.

However, in the case of the conventional roller connector, the connecting portions connecting the spacers are arranged along both end surfaces of each of the rollers in the axial direction thereof so that the connecting portions tend to become fatigued due to the application thereon of a force urging the rollers to skew during rolling while, on the contrary, the connecting portion of the roller connector according to the present invention is connected to each of the spacers at a position at which the connecting portion divides the outer peripheral surface of each of the rollers into two substantially equal parts in the axial direction so that the connecting portion does not expand and contract repeatedly due to the above kind of force thereby preventing the breakage of the connecting portion resulting from the fatigue thereof.

Further, since the connecting portion is provided only on one side of the line of rollers, where the roller connector of the present invention is incorporated into the endless roller-circulation path of the slider of the liner guide unit, the sectional area of the endless roller-circulation path can be made smaller than in the case of the conventional roller connector and also where roller return paths are formed in the slider, the lowering of the rigidity of the slider can be avoided and the miniaturization of the slider can be made with ease.

At the same time, when both axial end surfaces of each of the rollers come into contact with the inner wall of the endless roller-circulation path of the slider during the rolling operation of the roller, the posture of the roller becomes unstable due to a frictional force generating between the two so that the skewing of the roller tends to take place. Accordingly, it is preferable from the above point of view that the spacers be so provided as to prevent the movement of each of the rollers in the axial direction. For example, an annular groove may be provided in the central portion of the outer peripheral surface of each of the rollers in the axial direction so that each of the spacers fits in such annular groove so as to come into sliding contact with the roller.

With the above structure, since the axial position of each of the rollers is determined by the connecting portion of the roller connector and each of the spacers, if clearance grooves for guiding the connecting portion of the roller connector are formed in the endless roller-circulation path of the slider to be incorporated with the roller connector, it will be possible to completely prevent the displacement of each of the rollers in the axial direction during the rotation thereof and to minimize the possibility of skewing of the roller.

Further, where the roller connector circulates through the endless roller-circulation path as it expands and contracts, it is preferable to form a slit in each of the spacers from the side opposite to the connecting portion so as to separate the pair of concave seats formed on both sides thereof from the point of view of allowing each of the rollers to keep its suitable posture by the spacers. Thus, by the formation of such slit in each of the spacers, even when the roller connector bends to a great degree within the endless roller-circulation path, each of the spacers can be kept in sliding contact with the outer peripheral surface of each of the rollers by widening the slit so that the roller can always keep its suitable posture. Further, the formation of the slit has the advantage that each of the rollers can be removably mounted between the adjoining spacers with ease.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front view (partly in section) of a linear guide unit using a roller connector according to the present invention;

FIG. **2** is a side view (partly in section) of the linear guide unit shown in FIG. **1**;

FIG. **3** is an exploded sectional view of an endless roller-circulation path of a slider of the linear guide unit shown in FIG. **1** with the view showing how the endless roller-circulation path of the slider is assembled;

FIG. **4** is a perspective view of one end surface portion of a movable block according to the present invention;

FIG. **5** is a perspective view of a roller connector to be incorporated into a liner guide unit according to a first embodiment of the present invention;

FIG. **6** is a front view of a roller connector according to the first embodiment of the present invention:

FIG. **7** is a side view of the roller connector shown in FIG. **6**;

FIG. **8** is a plan view of the roller connector shown in FIG. **6**;

FIG. **9** is an enlarged sectional view of the roller connector shown in FIG. **6** especially when the roller connector is incorporated into the endless roller-circulation path of the slider of the linear guide unit according to the first embodiment of the present invention;

FIG. **10** is a perspective view of a roller connector to be incorporated into the linear guide unit according to a second embodiment of the present invention;

FIG. **11** is a front view of the roller connector shown in FIG. **10**;

FIG. **12** is a plan view of the roller connector shown in FIG. **10**;

FIG. **13** is a sectional view taken along the XIII—XIII line of FIG. **11**;

FIG. **14** is a sectional view taken along the XIV—XIV line of FIG. **13**;

FIG. **15** is a sectional view of the roller connector shown in FIG. **10** especially when the roller connector is in its curved state within an endless roller-circulation path of a slider;

FIG. **16** is an enlarged sectional view of the roller connector shown in FIG. **10** especially when the roller connector is incorporated into the endless roller-circulation path of the slider;

FIG. **17** is an enlarged sectional view illustrating how the connecting portion of the roller connector is affected by the skewing of each of the rollers;

FIG. **18** is a side view of a conventional roller connector; and

FIG. **19** is a plan view of a conventional roller connector.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A roller connector according to the present invention and a linear guide unit using the roller connector will now be described with reference to the accompanying drawings.

FIGS. **1** and **2** show a linear guide unit using a roller connector according to the present invention.

In these figures, reference numeral **1** designates a track rail arranged on a stationary portion such as a bed of a machine tool, reference numeral **2** designates a slider for guiding a movable body such as a table along the track rail **1** and reference numeral **3** designates rollers capable of rolling between the track rail **1** and the slider **2** while bearing a load and circulating endlessly within the slider **2**.

First, the track rail **1** is substantially rectangular in shape and is provided with a total of four roller rolling surfaces **11***a* and **11***b* extending along the longitudinal direction (vertically in FIG. **1**) of the slider. These roller rolling surfaces **11***a* and **11***b* are formed on both side surfaces and on both edges of the upper surface of the track rail **1**, respectively, in such a manner that the roller rolling surfaces **11***a* on both side surfaces formed inwardly and downwardly at an angle of 30° with respect to the horizontal while the roller rolling surfaces **11***b* on the upper surface are formed vertically and upwardly. Further, the track rail **1** is provided with a plurality of bolt fitting holes **12** arranged in the longitudinal direction of the track rail **1** in spaced-apart relationships with one another and is fixed to the stationary portion by means of fixing bolts (not shown) to be inserted into the bolt fitting holes **12**, respectively.

On the other hand, the slider **2** is formed of a movable block **4** having a fixing surface **41** to which a movable body such as a table is fixed and a plurality of tapped holes **42** into which fixing bolts for the movable body are respectively screw-fitted and a pair of covers **5** to be respectively fixed to the front and rear end surfaces of the movable block **4** whereby an endless roller-circulation path for the rollers **3** is formed within the slider by fixing the covers **5** to the movable block **4**. Further, to the covers **5** there are respectively fixed sealing members **6** which come into sliding contact with the track rail **1** whereby the entry of dust adhered to the track rail **1** into the slider **2** due to the movement of the slider **2** is prevented. Note that in the drawings, reference numeral **7** designates a grease nipple for supplying grease into the slider **2**.

The movable block **4** is substantially saddle-shaped in section with the inclusion of a horizontal portion **4***a* on which the mounting surface **41** is formed and a pair of skirts **4***b* and **4***b* extending downward from the horizontal portion **4***a*. Further, on the lower surface of the horizontal portion **4***a* and on the inner surface of each of the skirt portions **4***b* there are formed four load rolling surfaces **43***a* and **43***b* in opposite relationships with the roller rolling surfaces **11***a* and **11***b* of the track rail **1**, respectively. In addition, on the horizontal portions **4***a* and the skirt portions **4***b* there are formed roller return ports **44***a* and **44***b* so as to correspond to the load rolling surfaces **43***a* and **43***b*, respectively.

This movable block **4** is manufactured by injection-molding a synthetic resin material. That is, it comprises a metallic block **40** and a synthetic resin portion padded to the former by injection-molding and the above-described movable body mounting surface **41** and the load rolling surfaces **43***a* and **43***b* of the rollers **3** of which a sufficient mechanical strength is required are formed on the movable block **40** while the roller return ports **44***a* and **44***b* of which not so high mechanical strength is required are formed on the synthetic resin portion thereby reducing the weight of the movable block **4** as small as possible.

As shown in FIG. **3**, the endless circulation path for the rollers becomes complete by fixing the covers **5** to the end surfaces of the movable block **4**, respectively. That is, on the inner surface of each of the covers **5** is provided with a U-shaped groove **51** for guiding the rollers **3** which have rolled on the load rolling surfaces **43***a* and **43***b* while projecting semicircular roller guide portions **46** are formed on the both end surfaces of the movable block **4** as shown in FIG. **4** so that when the covers **5** are respectively fixed to the end surfaces of the movable block **4**, the roller guide portion **46** of the movable block **4** fits in the U-shaped groove **51** of each of the covers **5** to thereby complete a U-shaped change direction path **52** as shown in FIG.**2**. Thus, by this change direction path **52** the load rolling surfaces **43***a* and **43***b* of the movable block **4** and the roller return ports **44***a* and **44***b* are connected.

With the above arrangement, when the rollers **3** which are bearing a load between the roller rolling surfaces **11***a* and **11***b* of the track rail **1** and the load rolling surfaces **43***a* and **43***b* of the movable block **4** have rolled on the load rolling surfaces **43***a* and **43***b* with the movement of the slider **2**, the rollers **3** are released from the load to enter into the change direction path **52** of one of the covers **5**. Then the rollers **3** roll through the roller return ports **44***a* and **44***b* of the movable block **4** in a direction reverse to their rolling direction through the load rolling surfaces **43***a* and **43***b* in a no-load state. Further, the rollers **3** which have finished rolling through the roller return ports **44***a* and **44***b* again enter between the track rail **1** and the movable block **4** through the change direction path **52** of the other cover **5** and roll on the load rolling surfaces **43***a* and **43***b* while bearing the load.

Further, on both sides of each of the load rolling surfaces **43***a* and **43***b* there are formed synthetic resin roller guide portions **45** for guiding both end surfaces of the rollers **3** rolling on the load rolling surfaces **43***a* and **43***b* so that the rolling direction of the rollers **3** is regulated by these roller guide portions **45** from on both sides thereof and the skewing of the rollers **3** during their rolling operation is prevented.

FIGS. **5** through **8** show first embodiment of the roller connector of the present invention to be used in the linear guide unit. The roller connector **30** comprises a flexible synthetic resin roller connecting member **31** and a plurality of rollers **3** arranged on the roller connecting member **31** in spaced apart relationships with one another with the axes of rotation of the rollers **3** being held parallel to one another. The roller connecting member **31** comprises a plurality of spacers **32** interposed among the adjoining rollers **3**, respectively, and a band-shaped connecting portion **33** for connecting the spacers **32** and each of the spacers **32** is provided with a pair of concave seats which come into sliding contact with the adjoining rollers **3**. Accordingly, each of the rollers **3** is held by the spacers **32** from on both front and rear sides of its rolling direction so that the rollers **3** are rotatably retained by the connecting member **31**. Further, the spacer **32** and the connecting portion **33** at the front or rear end of the roller connector **30** have convex curved guide surfaces **34**, respectively, so that the movement of the roller connector **30** at the time of rolling of the rollers **3** is made smooth.

Further, the connecting portion **33** connecting the spacers **32** is connected to the spacers **32** at a position at which the outer peripheral surface of the roller **3** is divided into substantially two equal parts in the axial direction and the end surfaces of each of the rollers **3** are left open without being covered by the connecting portion **33**. Accordingly, the movement of each of the rollers **3** in the axial direction at the time of its rolling is regulated by the above-described roller guide portions **45**.

Still further, the connecting portion **33** is provided only on one side of the rollers **3** arranged in a line and with respect to the direction opposite to the other side of the rollers **3**, the roller connector **1** is made to bend freely. Consequently, where the roller connector **30** is incorporated into the endless circulation path of the slider **2**, the connecting portion **33** is made to lie inside the endless circulation path as shown in FIGS. **1** and **2**.

Such roller connector **30** is formed by injection-molding a synthetic resin material in such a manner that the rollers **3** are inserted, as cores, into a mold and by such injection molding, the connecting member **31** comprising each of the spacers **32** and the connecting member **31** which are integral with each other is formed and the roller connector **30** with the rollers **3** arranged along the connecting portion **33** can be taken out of the mold.

FIG. **9** is an enlarged sectional view showing how the rollers **3** roll within the endless roller-circulation path. In the instant embodiment, the rollers **3** are incorporated into the endless roller-circulation path of the slider in a state in which they are arranged along the synthetic resin connecting member **31** as described above and the connecting portion **33** of the member **31** which connects the spacers **32** projects outwardly of the outer periphery of each of the rollers **3** so that the load rolling surfaces **43***a* and **43***b* of the slider **2** are respectively provided with clearance grooves **47** for receiving the connecting portion **33** while at the same time, similar clearance grooves **48** are respectively formed in the roller return ports **44***a* and **44***b* along the longitudinal direction. Accordingly, when the rollers **3** circulate through the endless roller-circulation path of the slider **2** following the movement of the slider **2** relative to the track rail **1**, the roller connector **30** circulates through the endless roller circulation path together with the rollers **3** in a state in which the connecting portion **33** of the roller connector **30** is kept received within the clearance grooves **47** and **48**.

According to the linear guide unit of the instant embodiment having the above-described structure, when the slider **2** moves on the track rail **1**, the rollers **3** roll between the slider **2** and the track rail **1** and the roller connector **30** circulates through the endless track formed within the slider **2**. In this case, even if a force urging each of the rolling rollers **3** to skew, that is, a force causing the axis of rotation of each of the rollers **3** to oscillate acts on the roller, since the connecting portion **33** of the roller connector **30** of the instant embodiment is connected to the spacers **32** at the position at which the connecting portion **33** connecting the spacers **32** together divides the outer peripheral surface of each of the rollers **3** into two substantially equal parts in the axial direction as shown in FIG. **17**, the oscillatory force acts on each of the rollers **3** in the manner shown by the dashed lines about the central portion of the connecting portion **33** so that the connecting portion **33** does not expand and contract due to such oscillatory force. Consequently, the trouble that the roller connector **30** breaks within the endless roller-circulation path due to the fatigue of the connecting portion **33** at the early stage of operation can be avoided and it is possible to maintain the smooth circulation of the rollers **3** within the endless roller-circulation path for a prolonged period of time and to secure the smooth movement of the slider with respect to the track rail **1**.

Further, in the case of the roller connector of the instant embodiment, the connecting portion for connecting the spacers is provided only on one side of the line of rollers and therefore, when compared to the conventional roller connector having roller connecting portions on both end surfaces of each of the rollers in the axial direction, the size of the roller return port formed in the slider can be reduced and it is possible to improve the mechanical rigidity of the slider to that degree of size-reduction.

FIGS. **10** through **14** show a roller connector according to a second embodiment of the present invention. As in the case of the first embodiment, the roller connector **70** comprises a connecting member **71** made of a flexible synthetic resin material and a plurality of rollers **8** arranged along the connecting member **71** in spaced apart relationships with one another with the axes of rotation of the rollers **8** being held parallel to one another. The connecting member **71** comprises a plurality of spacers **72** interposed among the adjoining rollers **8** and a band-shaped connecting portion **73** for connecting the spacers **72** together wherein each of the spacers **72** is provided with a pair of concave seats **74** which come into sliding contact with the adjoining roller **8**. Further, each of the rollers **8** is provided on the peripheral surface thereof with an annular groove **81** so as to bisect the peripheral surface of the roller in the axial direction so that each of the spacers **72** fits in this annular groove **81** and the pair of concave seats **74** are in sliding contact with the roller **8** within the annular groove **81**. Accordingly, each of the rollers **8** is embraced by the spacers **72** on both front and rear sides in the rolling direction thereof and is rotatably retained by the connecting member **71** while the movement of the roller **8** in the axial direction is held stopped by the spacers **72** fitted into the annular groove **81**.

Further, as in the case of the roller connector **30** according to the first embodiment of the present invention, the connecting portion **73** is provided only on one side of the line of rollers **8** in such a manner that the roller connector **70** can be bent freely on that side. In addition, in the case of the roller connector **70** of this second embodiment, each of the spacers **72** is provided with a slit **75** which is so formed as to separate the pair of concave seats **74** formed on both sides thereof, respectively, as shown in FIGS. **13** and **14**. More concretely, this slit **75** is formed in each of the spacers **72** from on the side opposite to the connecting portion **73**.

Accordingly, when the roller connector **70** is incorporated into the endless roller-circulation path of the slider **2**, if it is incorporated in such a manner that the connecting portion **73** comes to lie at the inner side of the endless circulation path, each of the slits **75** opens wide when the roller connector **70** bends in the shape of the letter-U within the change direction path **52** as shown in FIG. **15** so that the spacer **72** bisected by the slit **75** can maintain a state in which the concave seats **74** are in sliding contact with each of the rollers **8**. Consequently, the spacers **72** lying on both sides of each of the rollers **8** within the change direction path **52** securely retain the roller **8** thereby constantly stabilizing the posture of each of the rollers **8** rolling within the endless roller-circulation path of the slider.

The connecting member **71** provided with the spacers **72** and the connecting portion **73** is formed by injection-molding of a synthetic resin material but unlike the roller connector **30** of the first embodiment, each of the rollers **8** is mounted on the connecting member **71** after the connecting member **71** has been formed by molding. Thus, in the case of the roller connector **70** of the second embodiment, the slit **75** is formed in each of the spacers **72**, so that in contrast to the connecting member of the first embodiment which is not provided with slits, the space between the pair of concave seats **74** retaining the rollers **8** can be opened wide with ease whereby each of the rollers **8** can be mounted between the spacers **72** with ease. Further, for the same reason, the replacement of the rollers **8** mounted on the connecting member **71** can be performed with ease so that the amount of pre-load on the linear guide unit can be adjusted with ease.

FIG. **16** is an enlarged sectional view showing a state in which the roller connector **70** of the second embodiment of the present invention is incorporated into the endless circulation path of the linear guide unit shown in FIGS. **1** and **2**. As in the case of the roller connector **30** of the first embodiment, also in the roller connector **70** of the second embodiment, the connecting portion **73** which connects the spacers **72** together projects outwardly of the outer peripheral surfaces of the rollers **8** so that it is received within the clearance grooves **47** formed in the load rolling surfaces **43***a* and **43***b* of the slider **2** and also in the clearance grooves **48** formed in the roller return ports **44***a* and **44***b*. Consequently, where the roller connector **70** circulates through the endless roller-circulation path of the slider **2**, the connecting portion **73** of the roller connector **70** of the second embodiment can be always guided by the clearance grooves **47** and **48** on the side of the slider **2**.

As in the case of the roller connector **30** of the first embodiment, the roller connector **70** of this second embodiment is constructed such that the connecting portion **33** which connects the spacers **32** together is connected to each of the spacers **32** at a position at which the connecting portion **33** divides the outer peripheral surface of each of the rollers **3** into two substantially equal parts in the axial direction and further, it is provided only on one side of the line of rollers so that the second embodiment of the invention produces the same operation and effect as in the case of the first embodiment.

Further, in addition to the above, since the spacers **72** formed integral with the connecting-portion **73** stop the axial movement of each of the rollers **8**, when the connecting portion **73** is guided by the clearance grooves **47** and **48**, the rollers **8** are also guided by these clearance grooves **47** and **48** whereby the axial movement of each of the rollers through the endless roller-circulation path can be prevented by the clearance grooves **47** and **48**. Therefore, where the roller connector **70** of the second embodiment is incorporated into the endless roller-circulation path of the linear guide unit for use, the endless circulation of the rollers can be guided smoothly without the necessity of providing roller guides **45** on both sides of the load rolling surfaces **43***a* and **43***b* so as to guide both end surfaces of each of the rollers **8** thereby simplifying the structure of the linear guide unit.

It should be noted in this connection that the roller connector **70** of the second embodiment can be bent smoothly within the change direction path **52** of the slider due to the provision of the slit **75** in each of the spacers **72** but the roller connector **30** of the first embodiment will be able to be done so if the same slit is formed in each of the spacers **32** of the roller connector **30**.

Further, the connecting member **31** of the first embodiment and the connecting member **71** of the second embodiment are made of a synthetic resin material but the spacers **32** and the connecting portion **33** forming the connecting member **31** or the spacers **72** and the connecting portion **73** forming the connecting member **71** may be formed integral with each other by using the same material or by using different materials. When the different materials are used, it is preferable that the material for forming the connecting portion **33** (**73**) have an anti-abrasion property higher than that for the spacer **32** (**72**).

As described above, according to the roller connector of the present invention and the linear guide unit using the same, the connecting portion which connects the spacers interposed among the adjoining rollers is connected to each of the spacers at a position at which it divides the outer peripheral surface of each of the rollers into two substantially equal parts in the axial direction so that the connecting portion does not get fatigued at the early stage of operation due to a force urging the rolling rollers to skew with the advantages that there is no fear of breakage of the roller connector within the endless roller-circulation path of the linear guide unit and it is possible to secure the smooth movement of the slider with respect to the track rail for a prolonged period of time.

Further, where the roller connector of the present invention is incorporated into the endless roller-circulation path of the slider of the liner guide unit, it is possible to make the sectional area of the endless roller-circulation path for the passage of the rollers therethrough smaller than that of the conventional roller connector. Consequently, it becomes possible to prevent the lowering of the rigidity of the slider thereby improving the moving accuracy and the load bearing capacity of the slider and also to make the slider compact with ease.

What is claimed is:

1. A roller connector assembly comprising a plurality of rollers arranged in a line while keeping the axes of rotation thereof parallel to one another, a plurality of spacers interposed among the rollers and provided with concave seats with which the rollers come into sliding contact and an elongate flexible connecting portion adapted to connect said spacers with one another, wherein said connecting portion is connected to said spacers at a position at which the outer peripheral surface of each of said rollers is divided into two substantially equal parts in the axial direction and is arranged only at one side of said line of rollers.

2. The roller connector assembly as claimed in claim **1**, wherein an annular groove is formed on the outer peripheral surface of each of the rollers at a position along which the outer peripheral surface is bisected in the axial direction and each of said spacers fits in the annular groove so as to come into sliding contact with each of said rollers.

3. The roller connector assembly as claimed in claim **1**, wherein each of said spacers is provided with a pair of concave seats on both sides thereof, respectively, and a slit formed on the side opposite said connecting portion so as to separate said pair of concave seats.

4. A linear guide unit comprising a roller connector assembly retaining a plurality of rollers, a track rail having rolling surfaces for the rollers; and a slider having an endless roller-circulation path which includes load rolling surfaces along which the rollers roll with respect to the rolling surfaces of the track rail while bearing a load thereon, wherein said roller connector assembly which is claimed in any one of claims **1** through **3** is incorporated into said endless roller-circulation path of the slider in such a manner that the connecting portion of said roller connector assembly comes to lie on the inner peripheral surface portion of said endless roller-circulation path and said endless roller-circulation path is provided with clearance grooves by which the connecting portion of said roller connector assembly is received and guided.

* * * * *

US006305846B1

(12) United States Patent
Michioka et al.

(10) Patent No.: US 6,305,846 B1
(45) Date of Patent: Oct. 23, 2001

(54) **LINEAR MOTION GUIDING APPARATUS**

(75) Inventors: **Hidekazu Michioka**; **Katsuya Iida**; **Masahiro Yoshihashi**; **Hiroaki Mochizuki**; **Tadashi Hirokawa**, all of Tokyo-to (JP)

(73) Assignee: **THK Co., Ltd.**, Tokyo-to (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/639,340**

(22) Filed: **Aug. 16, 2000**

Related U.S. Application Data

(62) Division of application No. 09/088,491, filed on Jun. 2, 1998, now Pat. No. 6,132,093.

(30) **Foreign Application Priority Data**

Jun. 16, 1997 (JP) P09-175336
Apr. 30, 1998 (JP) P10-136062

(51) **Int. Cl.**[7] **F16C 29/06**
(52) **U.S. Cl.** **384/45**
(58) **Field of Search** 384/45, 43, 44; 464/168

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

0400200 * 12/1990 (EP) .
2175054 * 11/1986 (GB) .
2180303 * 3/1987 (GB) .

* cited by examiner

Primary Examiner—Lenard A. Footland
(74) *Attorney, Agent, or Firm*—Young & Thompson

(57) **ABSTRACT**

A linear motion guiding apparatus comprises a guide rail provided with a ball running groove, and a movable block movably arranged along the guide rail through balls. The movable block is provided with a ball running counter-groove, a ball returning passage arranged away from the ball running counter-groove and direction changing passages for connecting these members. A resin-formed body for forming a ball circulation passage comprises a pair of ball passage forming portions, a returning passage forming portion and a pair of direction changing passage-inner guide forming portions. The resin-formed body is separately formed from a body of the movable block. At least two portions of (a) the ball passage forming portions, (b) the returning passage forming portion, (c) one of the direction changing passage-inner guide forming portions and (d) another of the of direction changing passage-inner guide forming portions are connected with each other through integral forming so that the resin-formed body can be built in the body of the movable block.

6 Claims, 44 Drawing Sheets

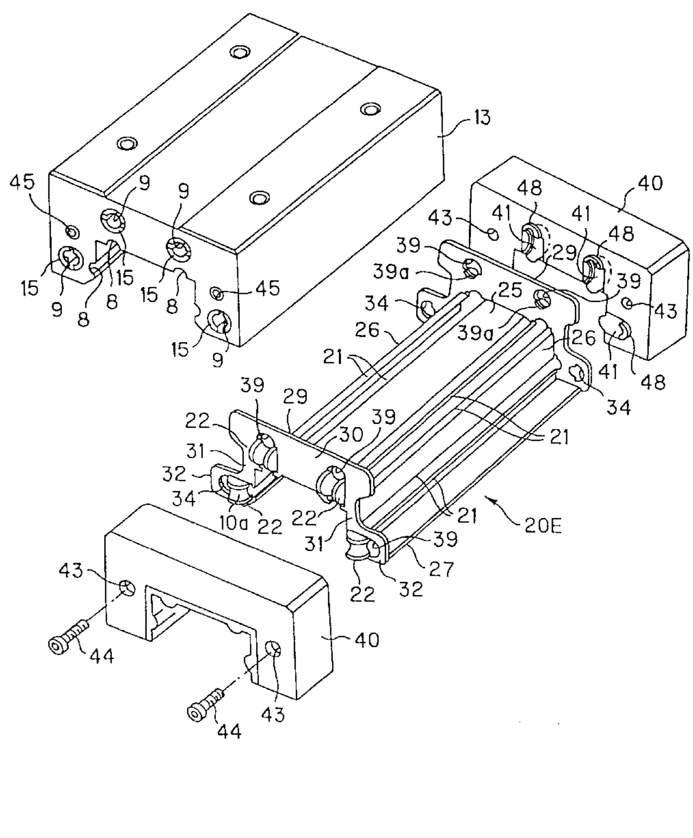


FIG. 1

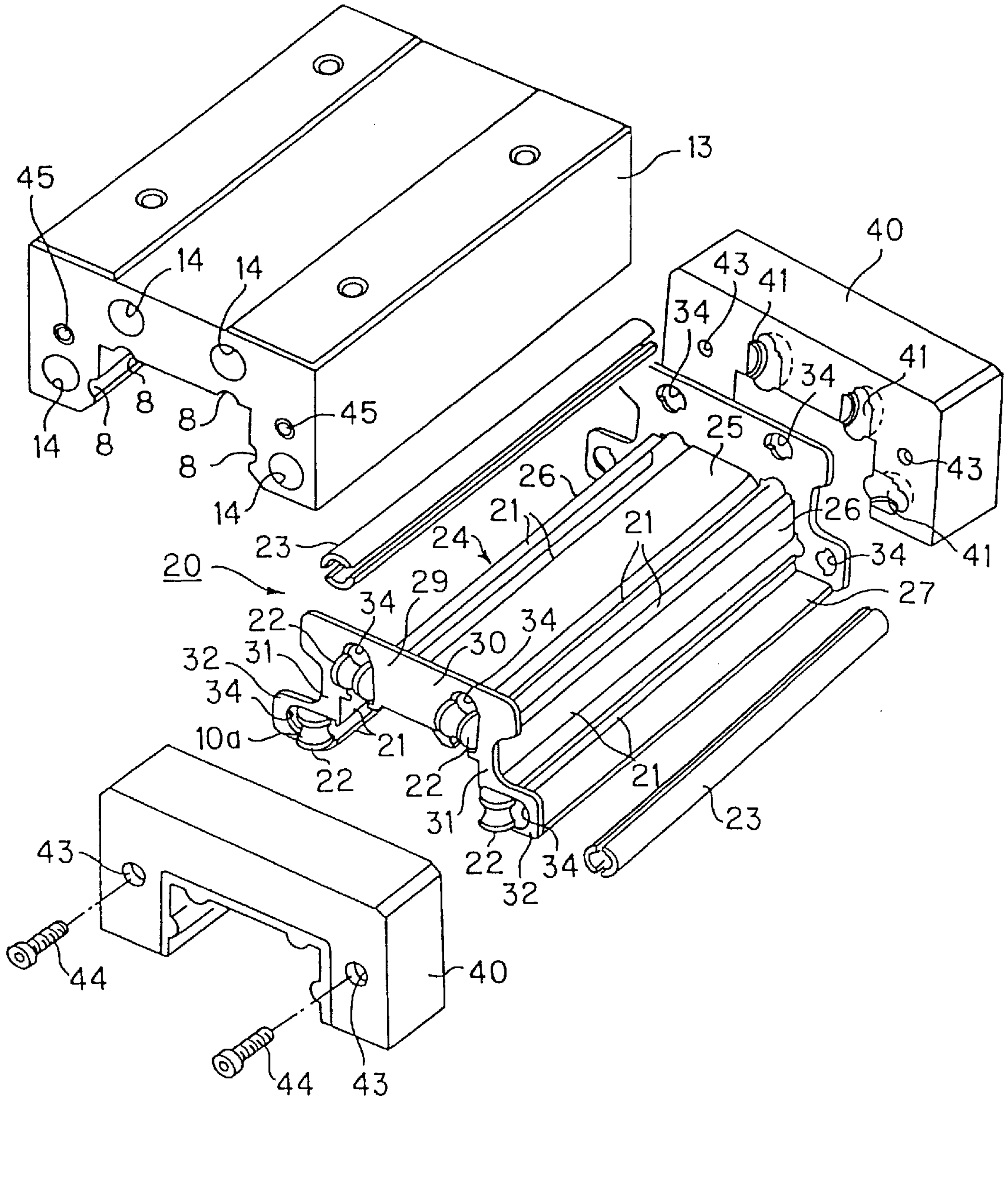

13
45
14
14
14
8
8
8
45
8
14
14
40
43
41
34
41
34
43
25
26
26
21
21
41
23
24
34
20
29
34
27
22
34
30
32
31
34
10a
21
22
22
21
23
31
43
22
34
32
44
40
44
43

FIG. 2(a)

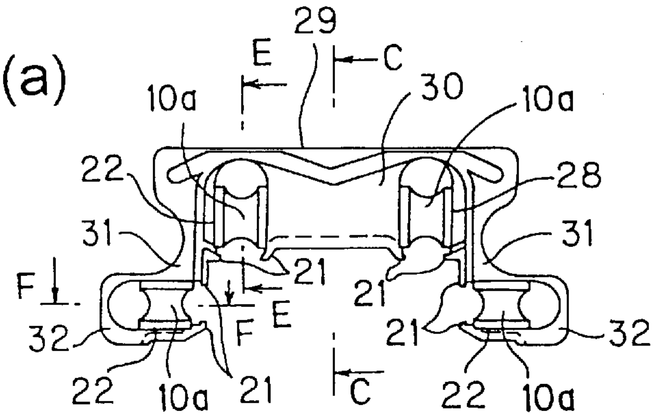


FIG. 2(b)

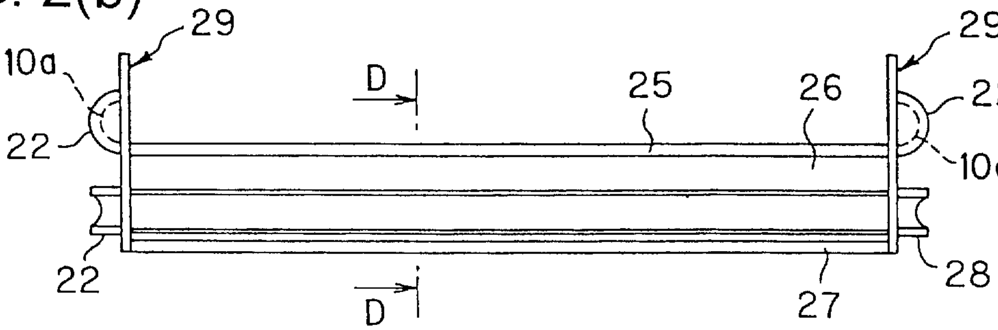


FIG. 2(c)

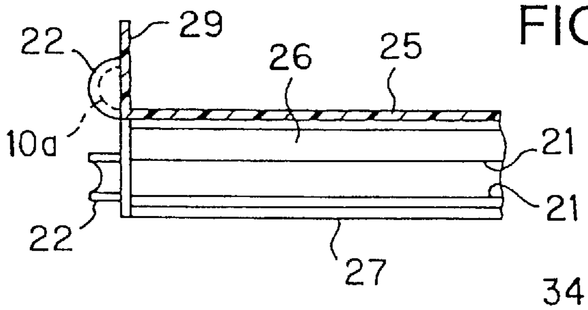


FIG. 2(d)

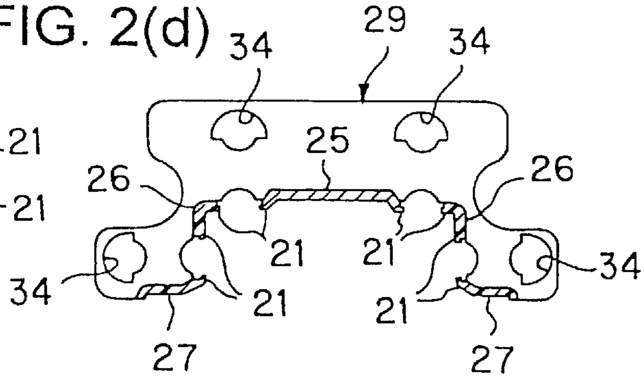


FIG. 2(e)

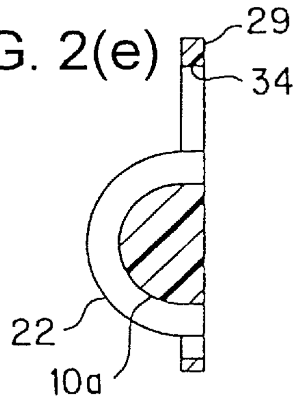


FIG. 2(f)

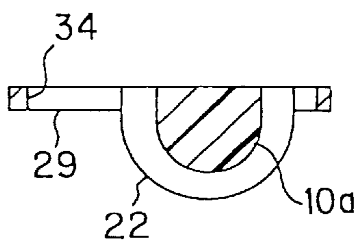


FIG. 3(a)

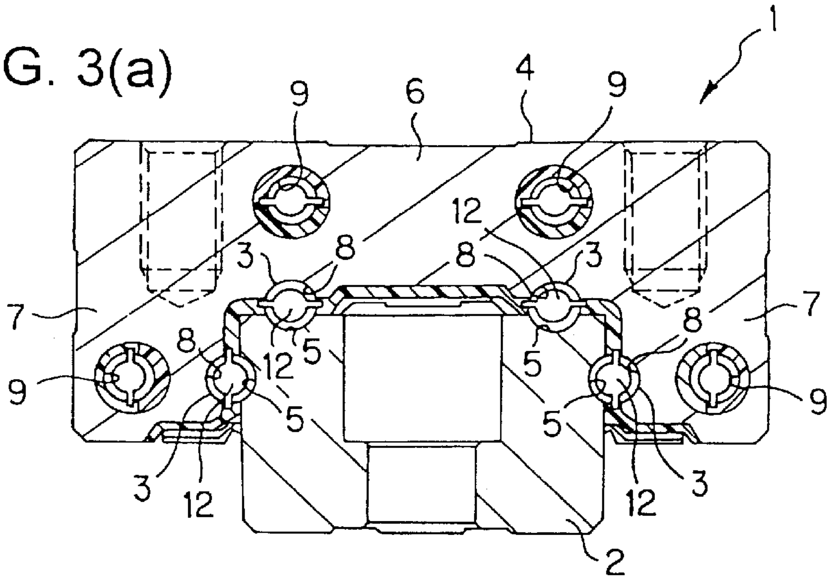


FIG. 3(b)

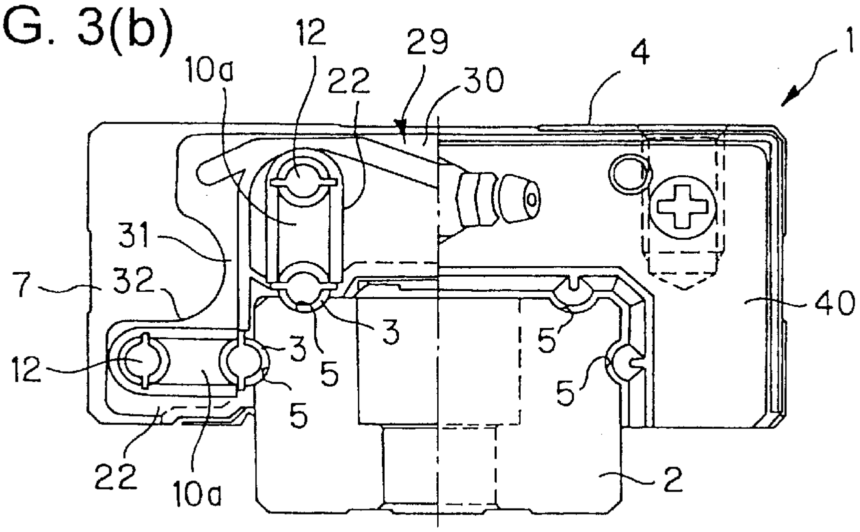


FIG. 3(c)

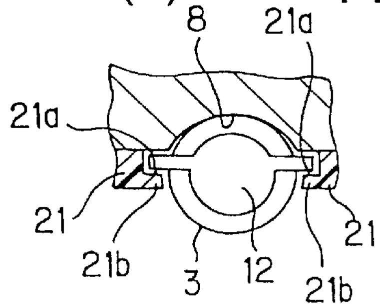


FIG. 3(d)

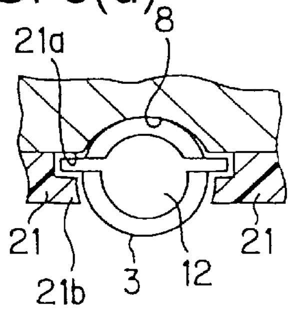


FIG. 3(e)

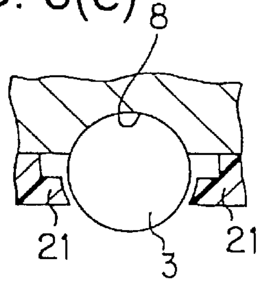


FIG. 3(f)

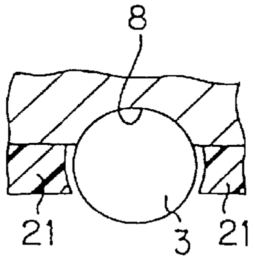


FIG. 4(a)

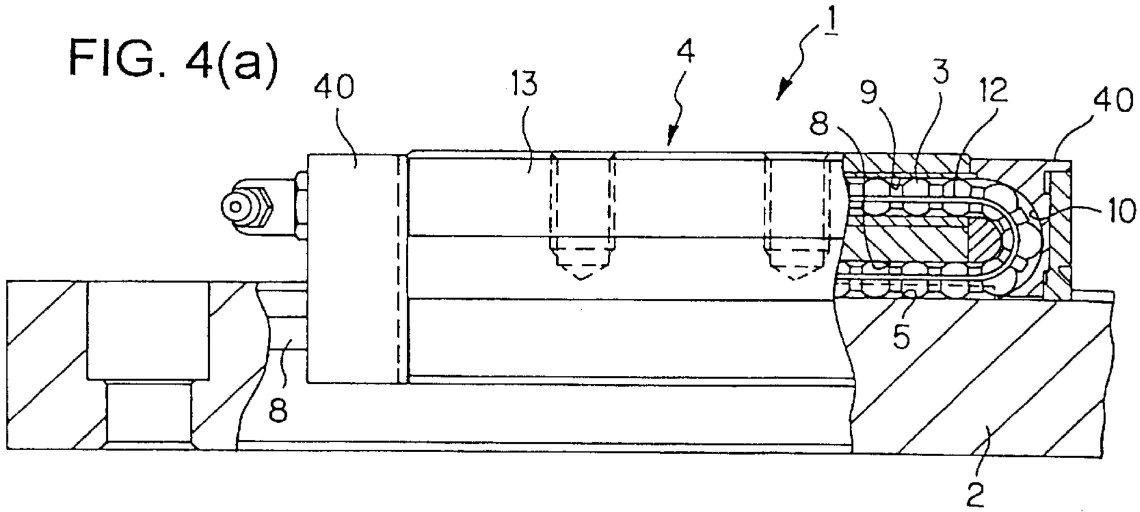


FIG. 4(b)

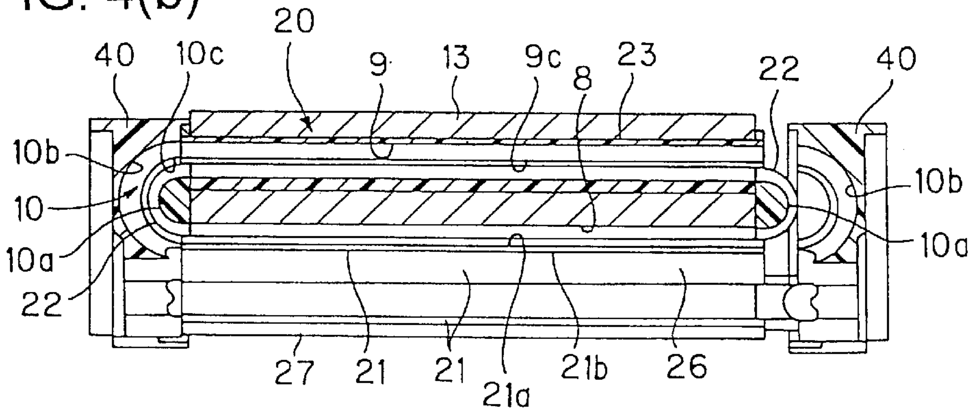


FIG. 4(c)

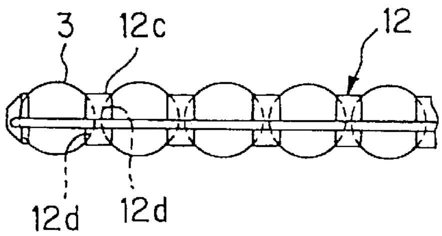


FIG. 4(d)

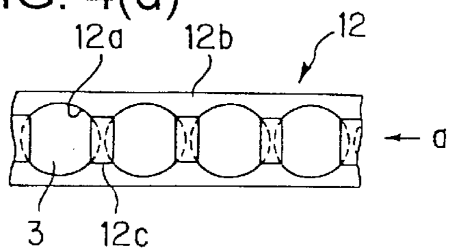


FIG. 4(e)

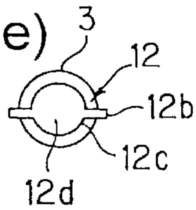


FIG. 5(a)

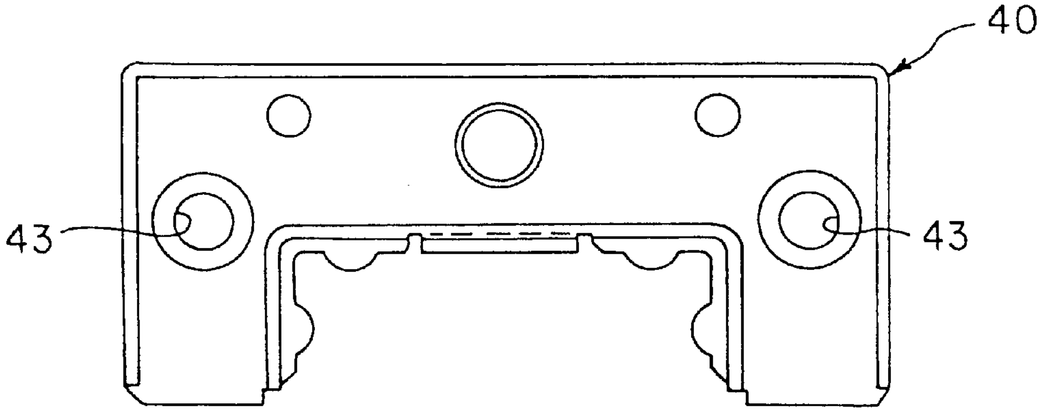


FIG. 5(b)

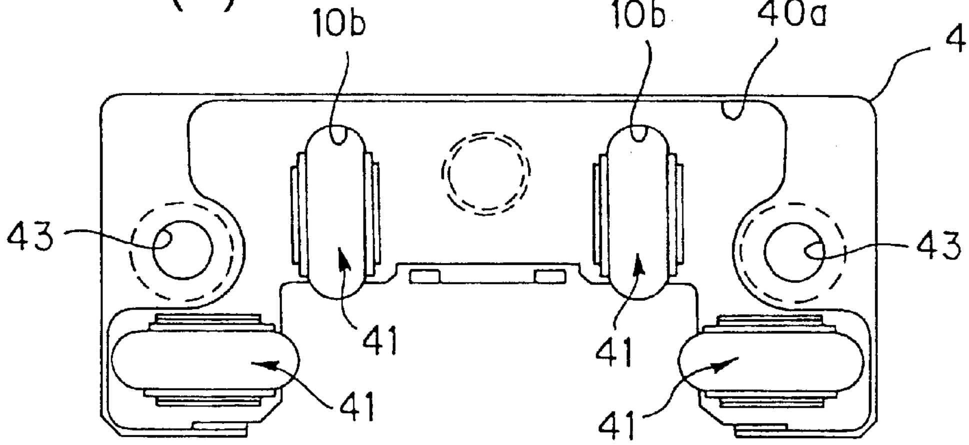


FIG. 5(c)

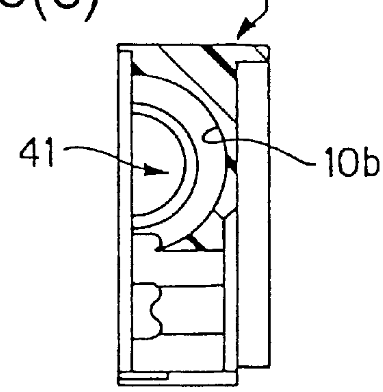


FIG. 6(a)

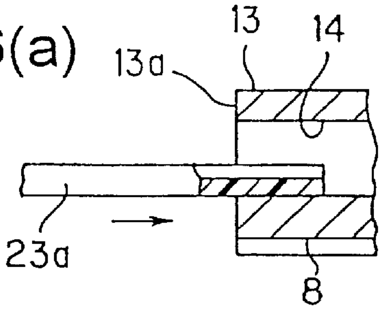


FIG. 6(b)

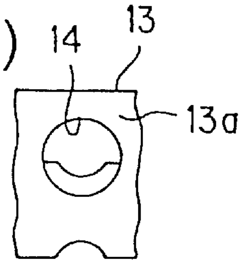


FIG. 6(c)

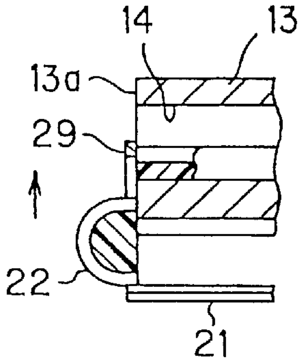


FIG. 6(d)

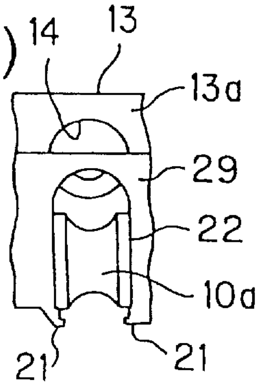


FIG. 6(e)

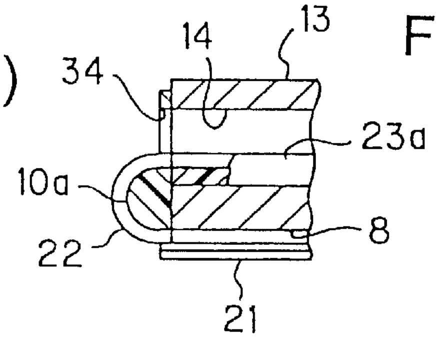


FIG. 6(f)

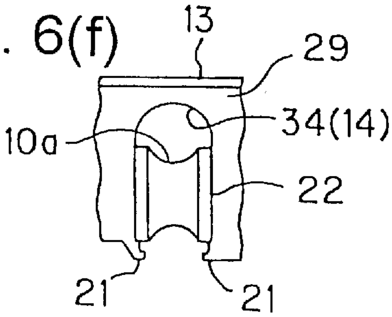


FIG. 6(g)

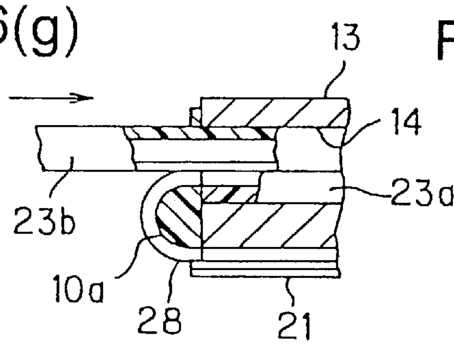


FIG. 6(h)

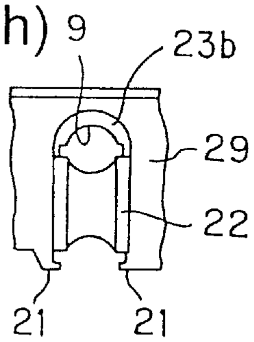


FIG. 6(i)

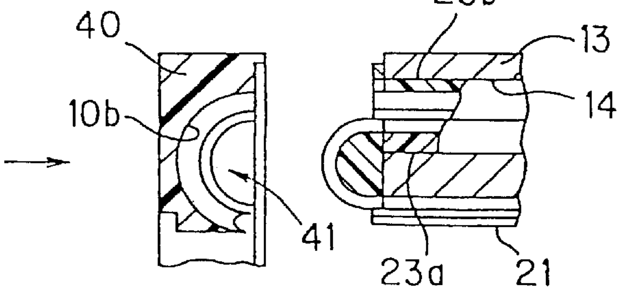


FIG. 7(a)

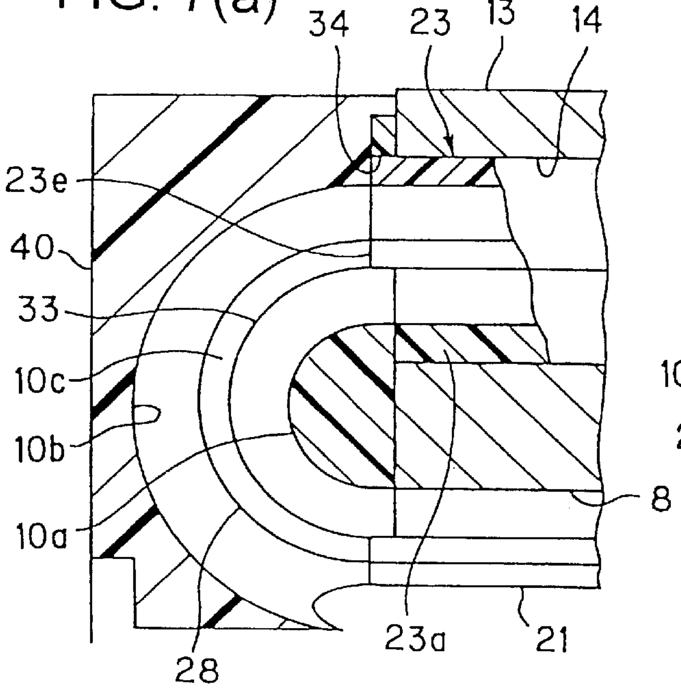


FIG. 7(b)

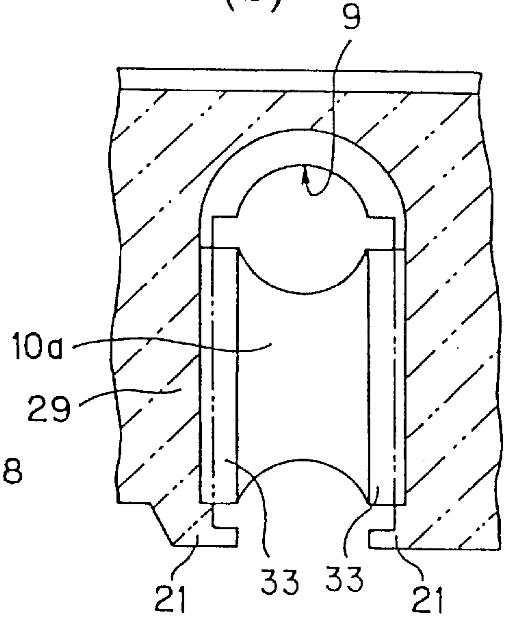


FIG. 7(c)

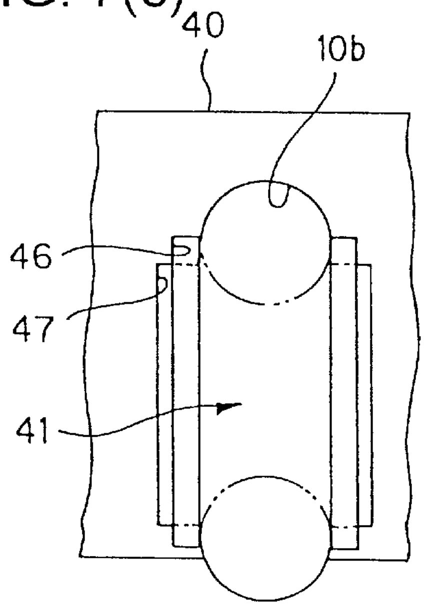


FIG. 7(e)

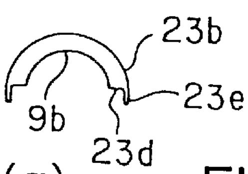


FIG. 7(d)

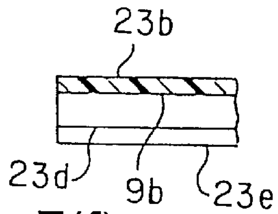


FIG. 7(g)

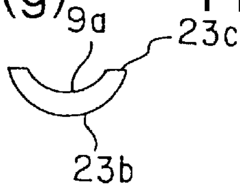
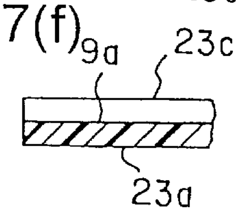


FIG. 7(f)



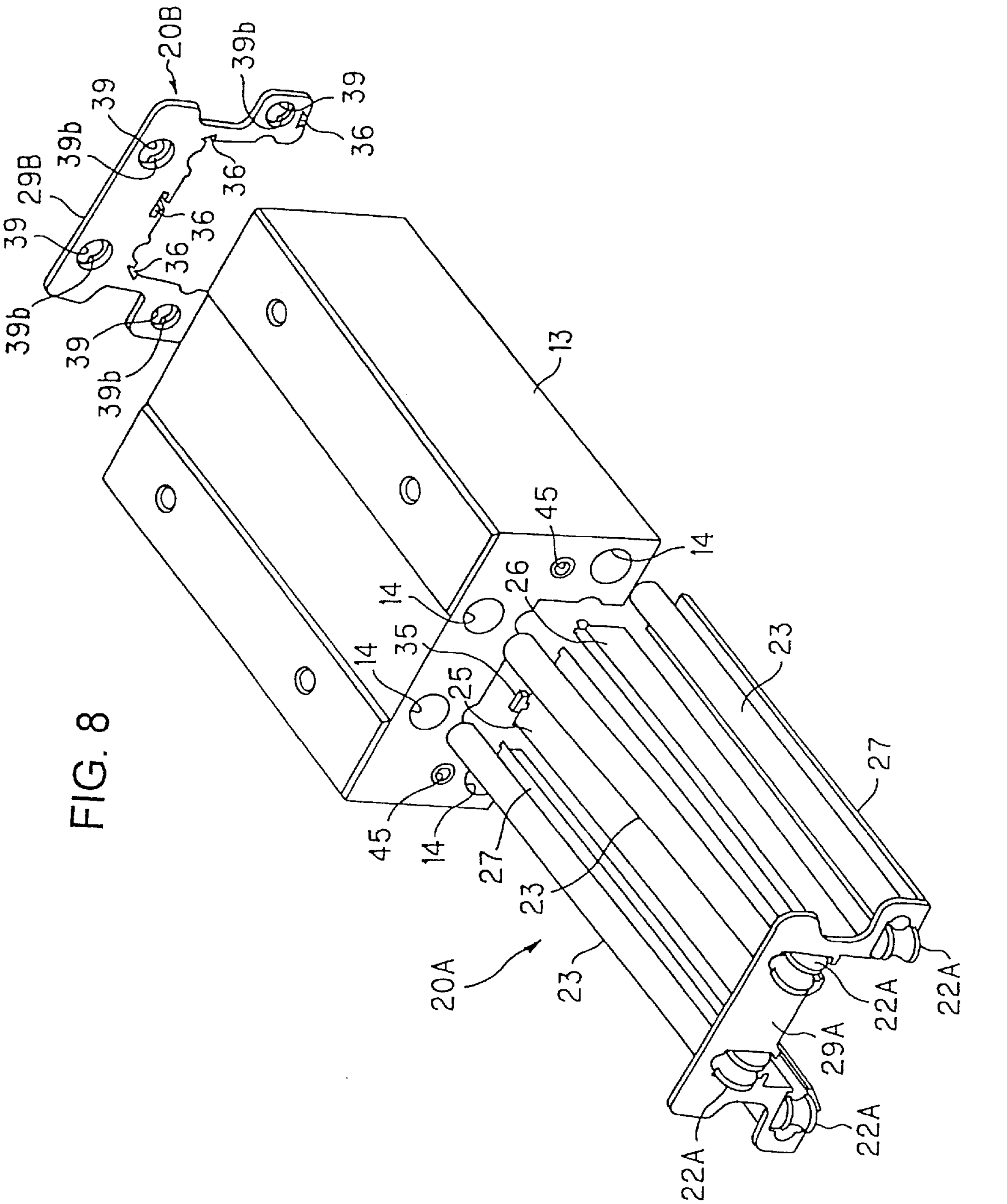

20B
39b
39
39
36
29B
39b
36
36
39
36
36
39b
39
39b
13
45
14
14
26
35
23
14
25
27
27
45
14
23
23
20A
22A
22A
29A
22A
22A

FIG. 8

FIG. 9(a)

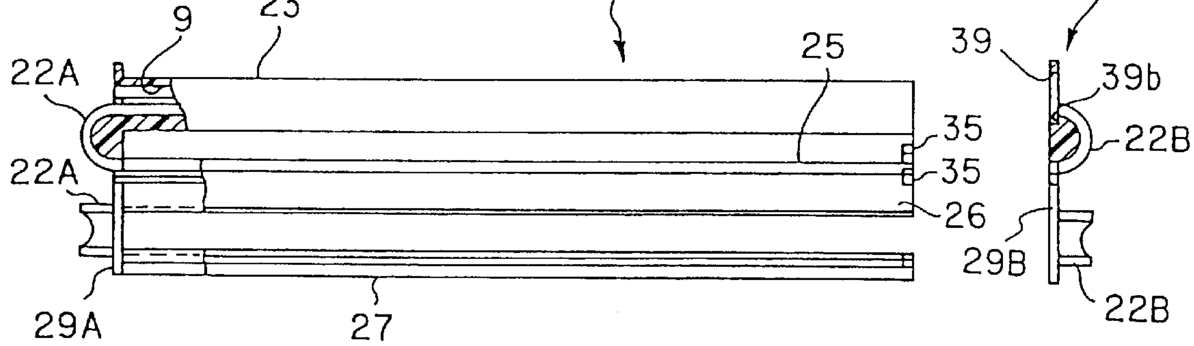


FIG. 9(b)

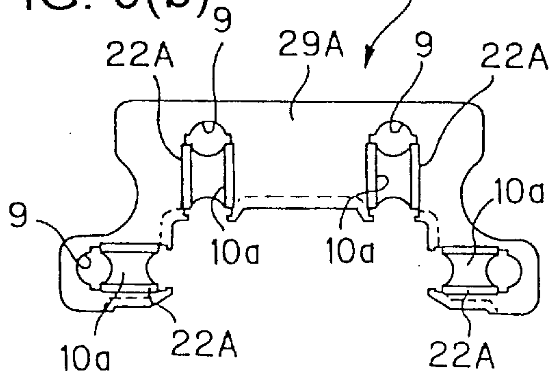


FIG. 9(c)

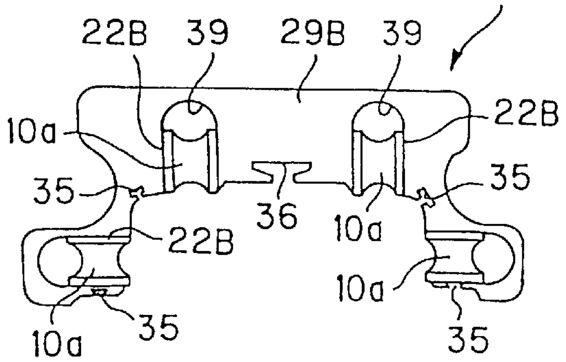


FIG. 9(d)

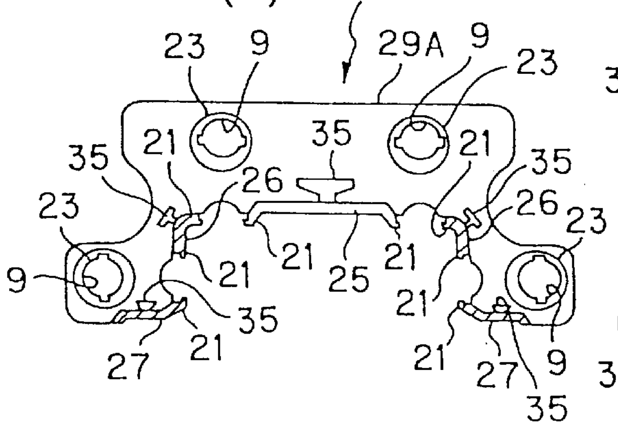
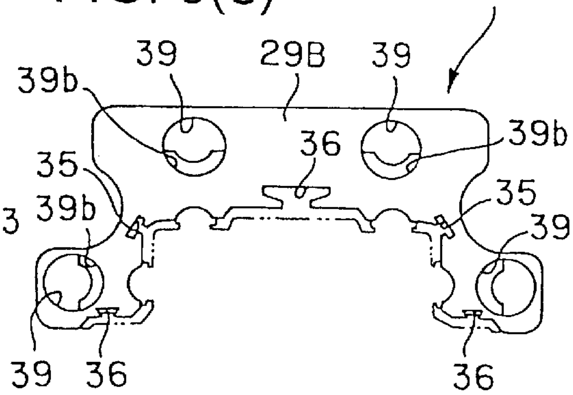


FIG. 9(e)



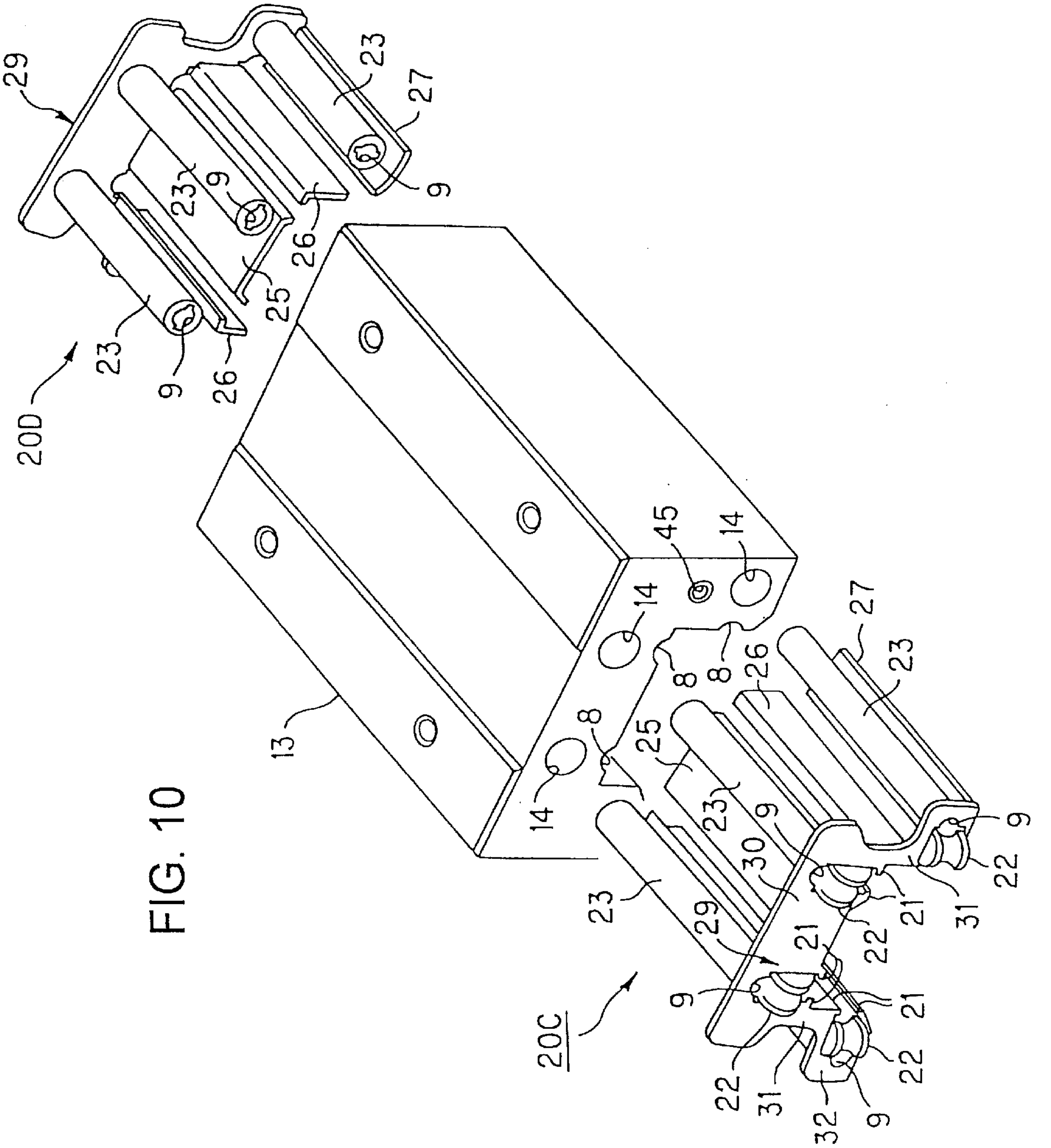


FIG. 10

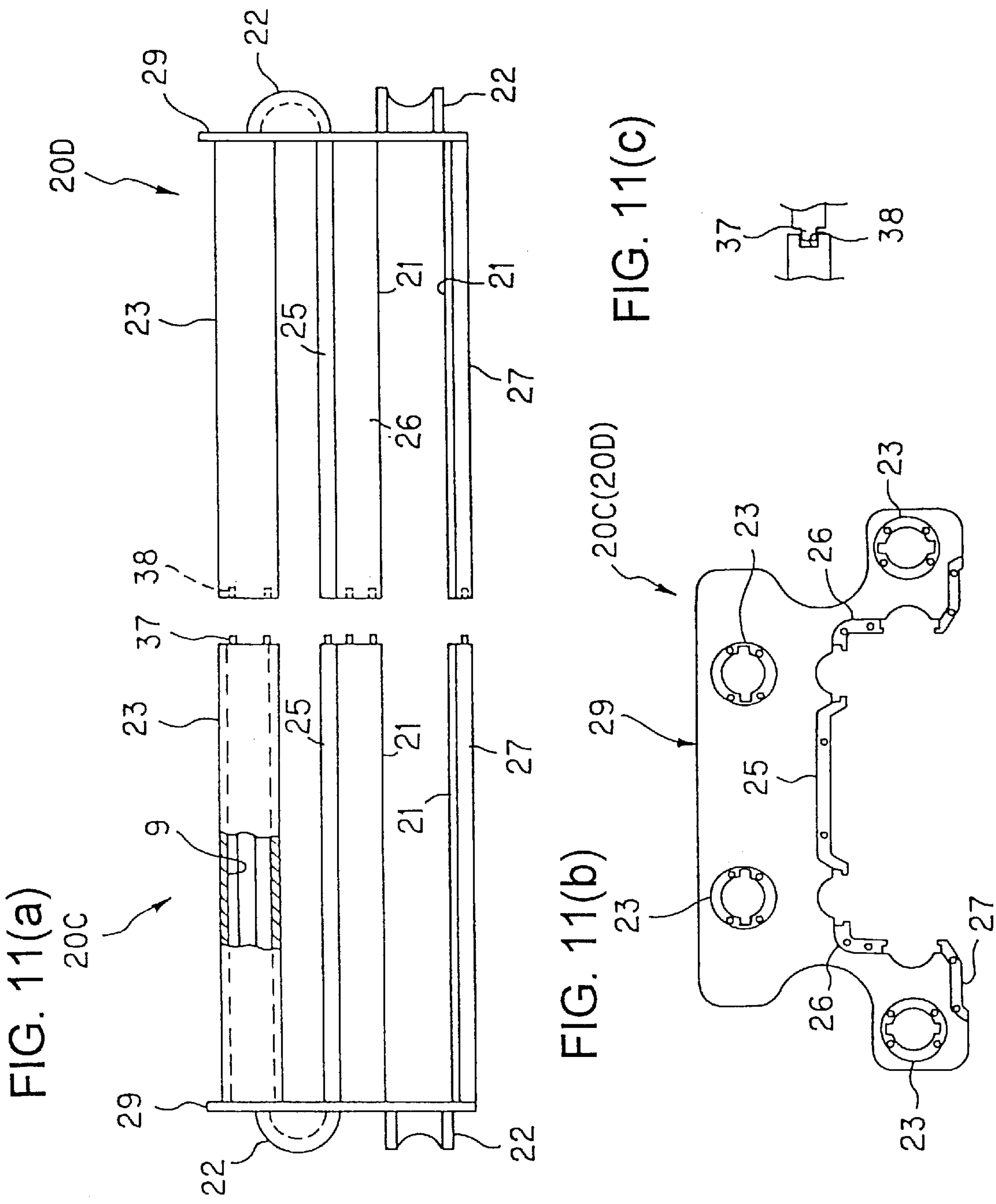


FIG. 11(a)

FIG. 11(b)

FIG. 11(c)

FIG. 12

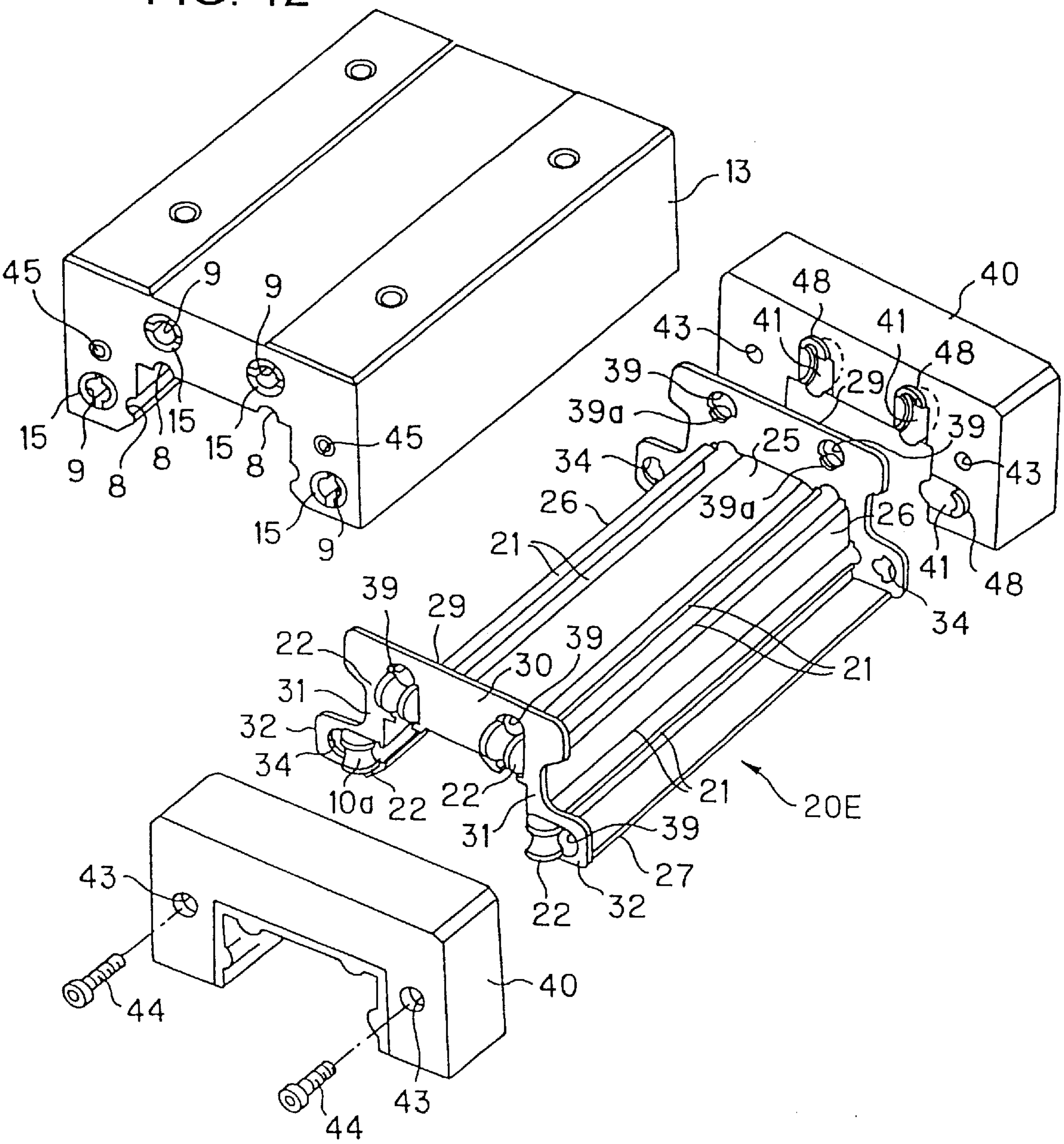

13
45
9
9
15
15
15
9
8
8
8
45
15
9
40
48
41
41
48
43
39
29
39a
39
34
25
43
26
39a
26
21
41
48
39
29
34
22
39
30
21
31
32
34
10a
22
22
21
20E
31
39
27
22
32
43
40
44
43
44

FIG. 13(a)

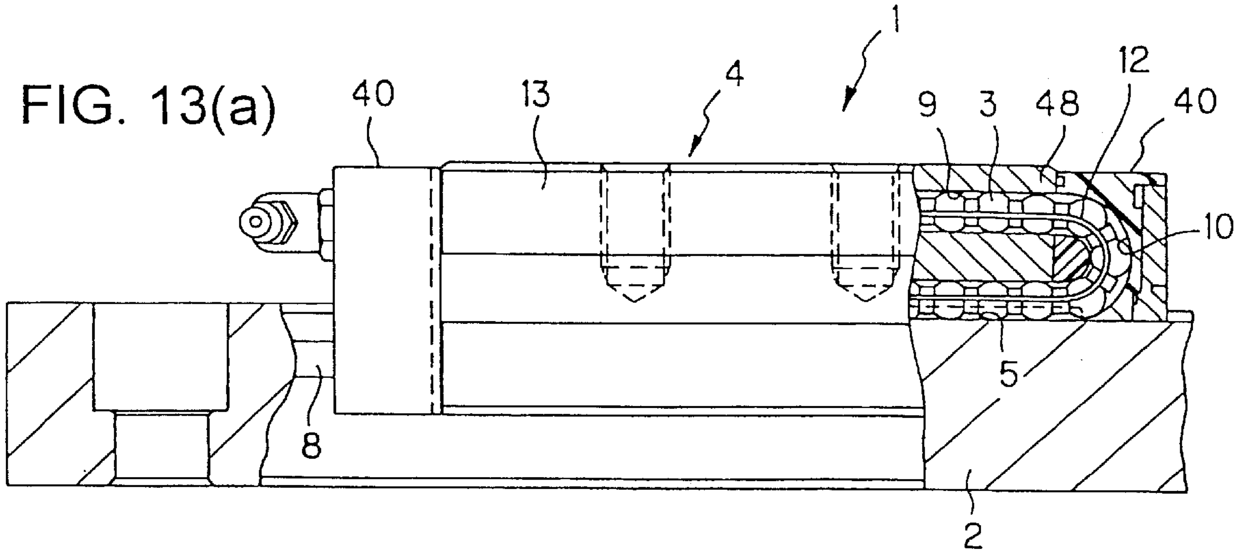


FIG. 13(b)

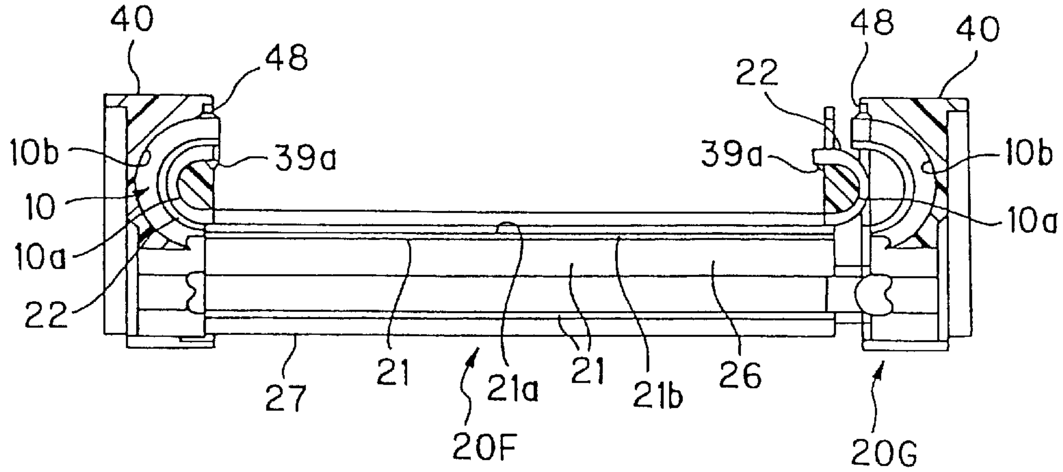


FIG. 14(a)

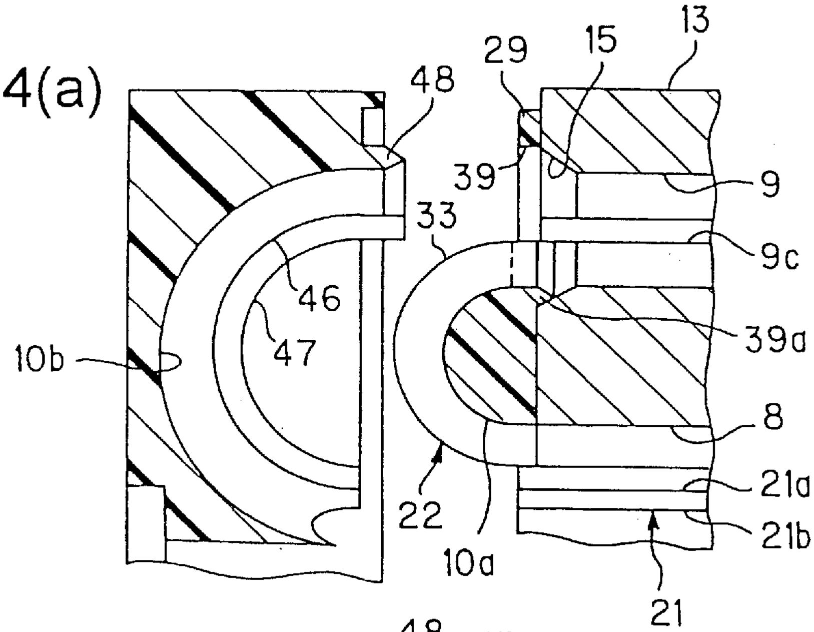


FIG. 14(b)

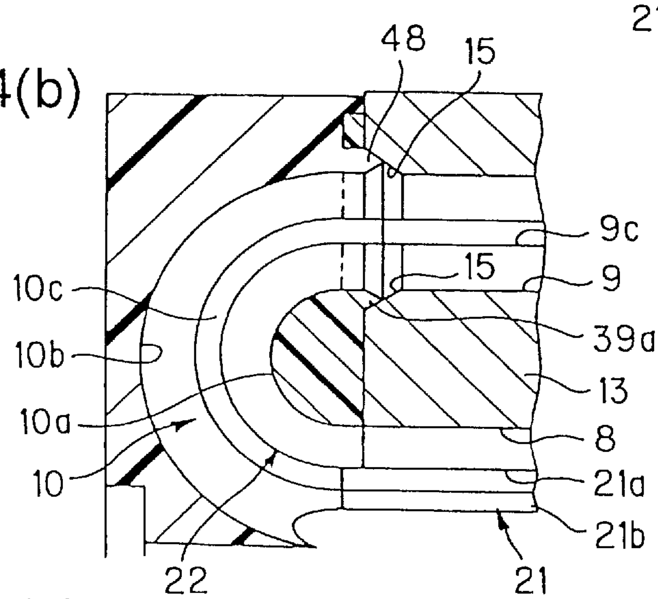


FIG. 14(c)

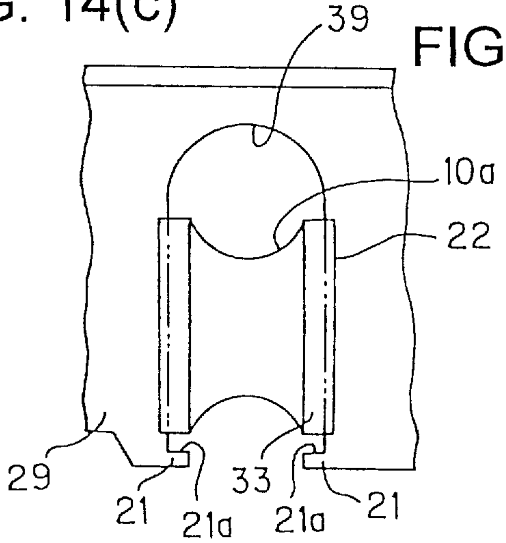


FIG. 14(d)

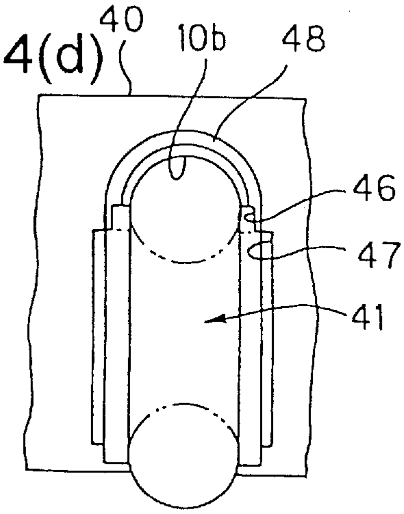


FIG. 15

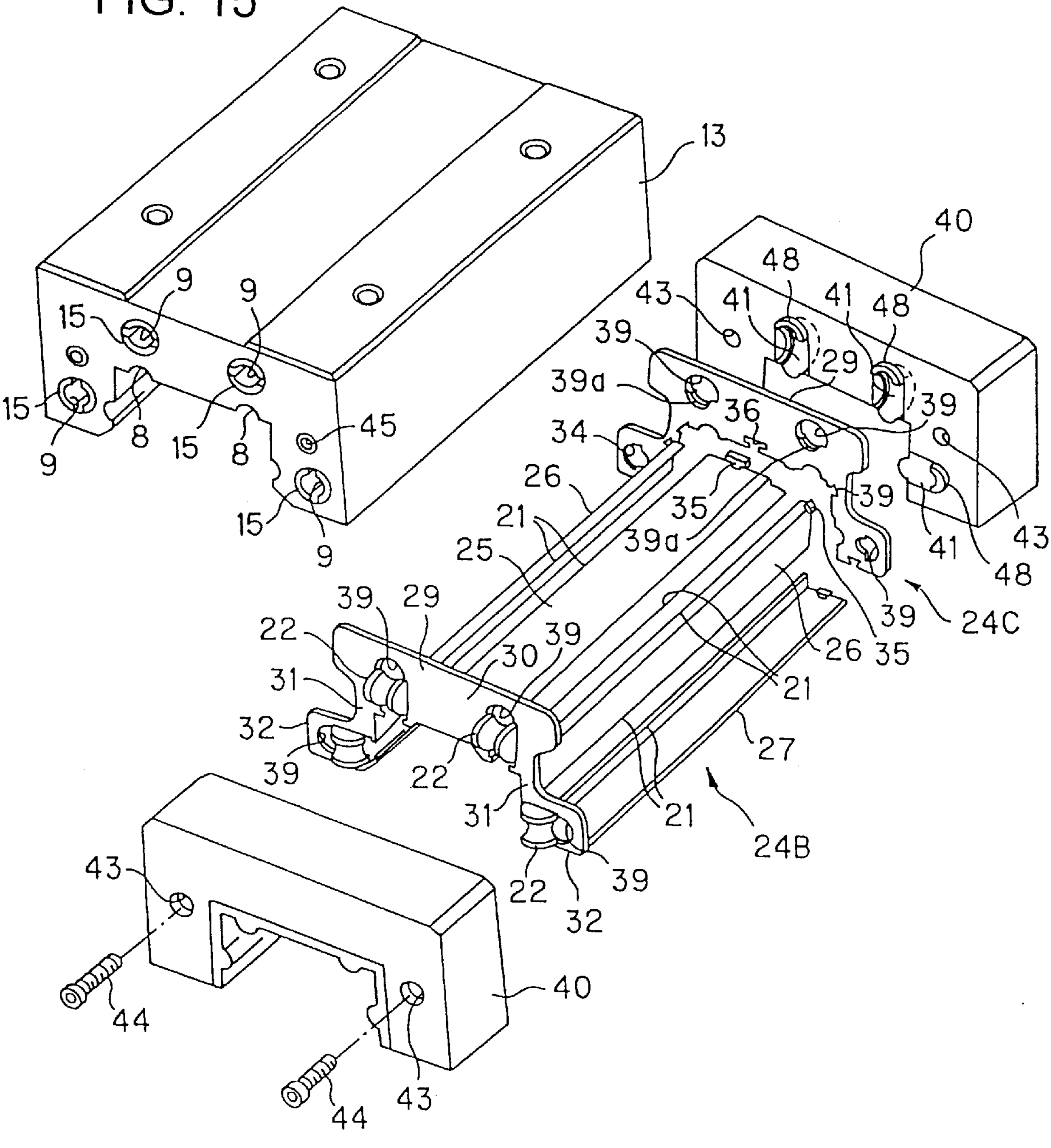

13
40
48
41
41
48
43
39
29
39d
36
39
34
26
35
39
43
21
39d
41
48
25
39
24C
39
29
26
35
22
39
30
21
31
32
27
39
22
31
21
24B
43
22
39
32
40
44
44
43
15
9
9
15
15
9
8
15
8
45
9
15
9

FIG. 16(a)

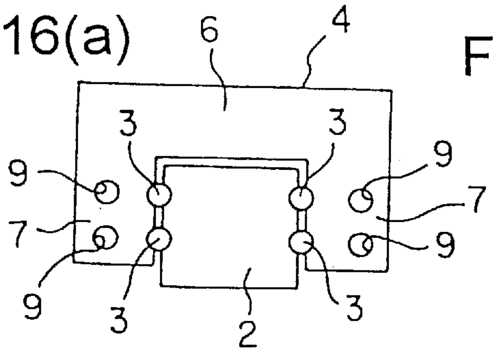


FIG. 16(b)

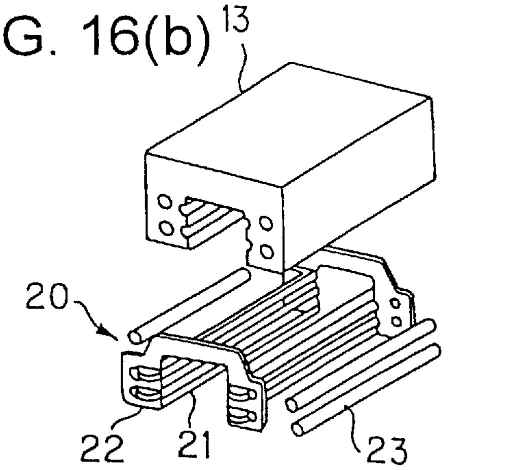


FIG. 16(c)

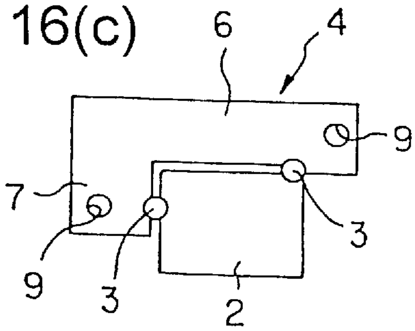


FIG. 16(d)

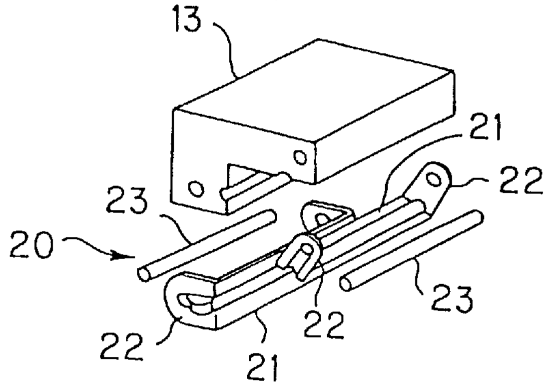


FIG. 16(e)

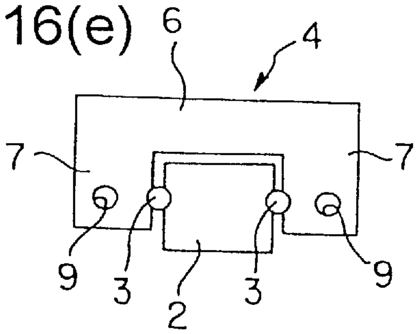


FIG. 16(f)

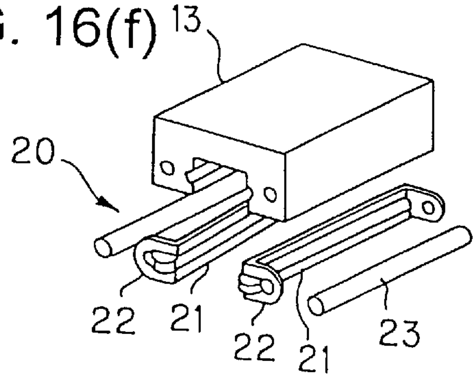


FIG. 16(g)

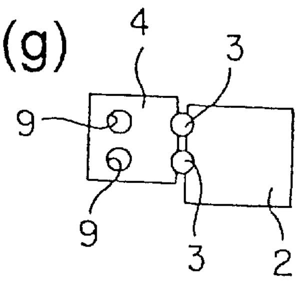


FIG. 16(h)

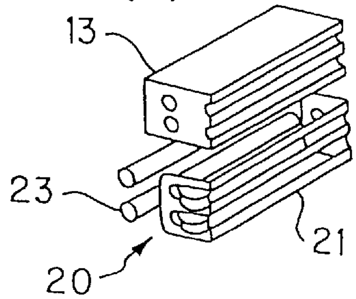


FIG. 17

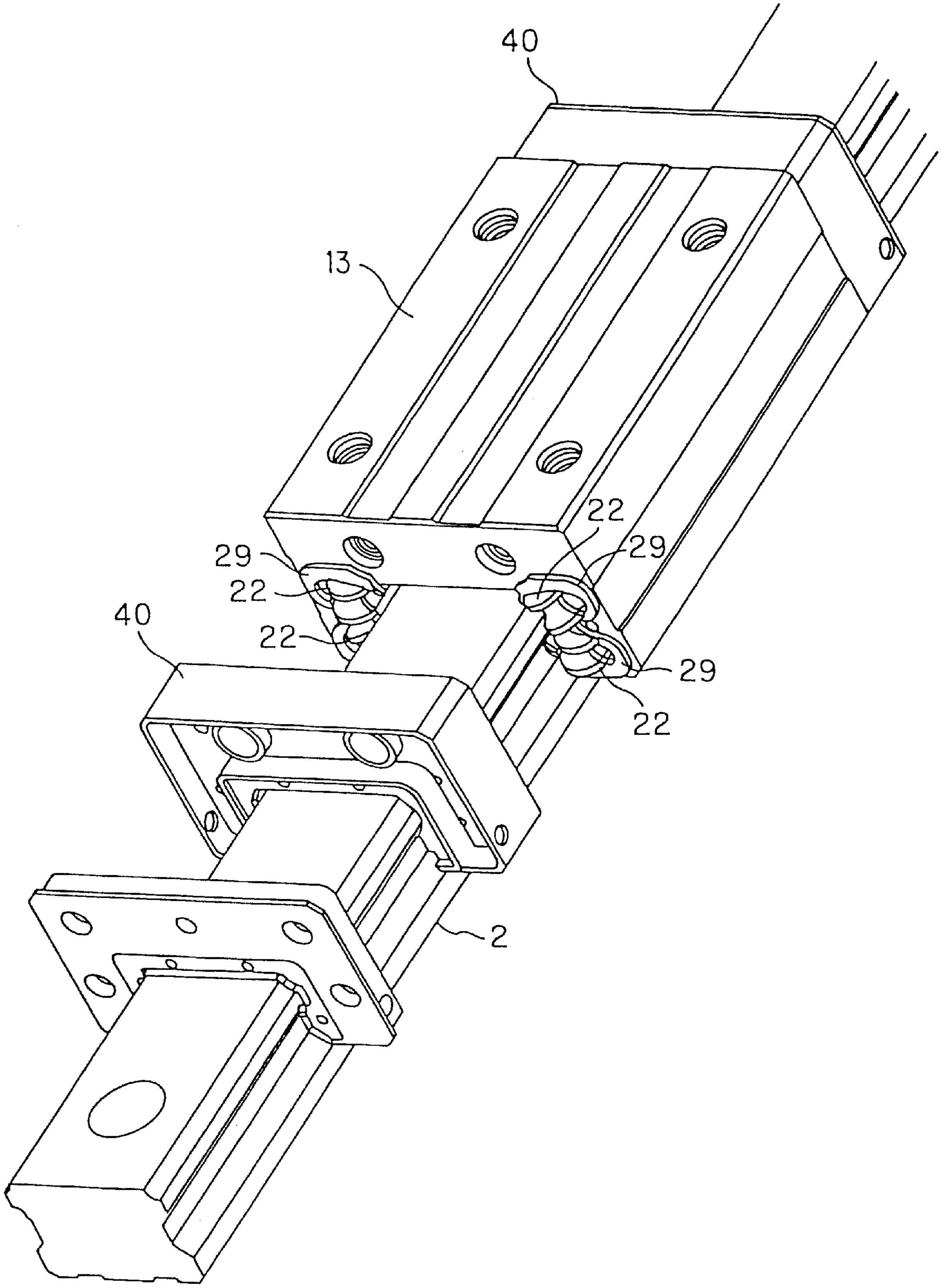


FIG. 18

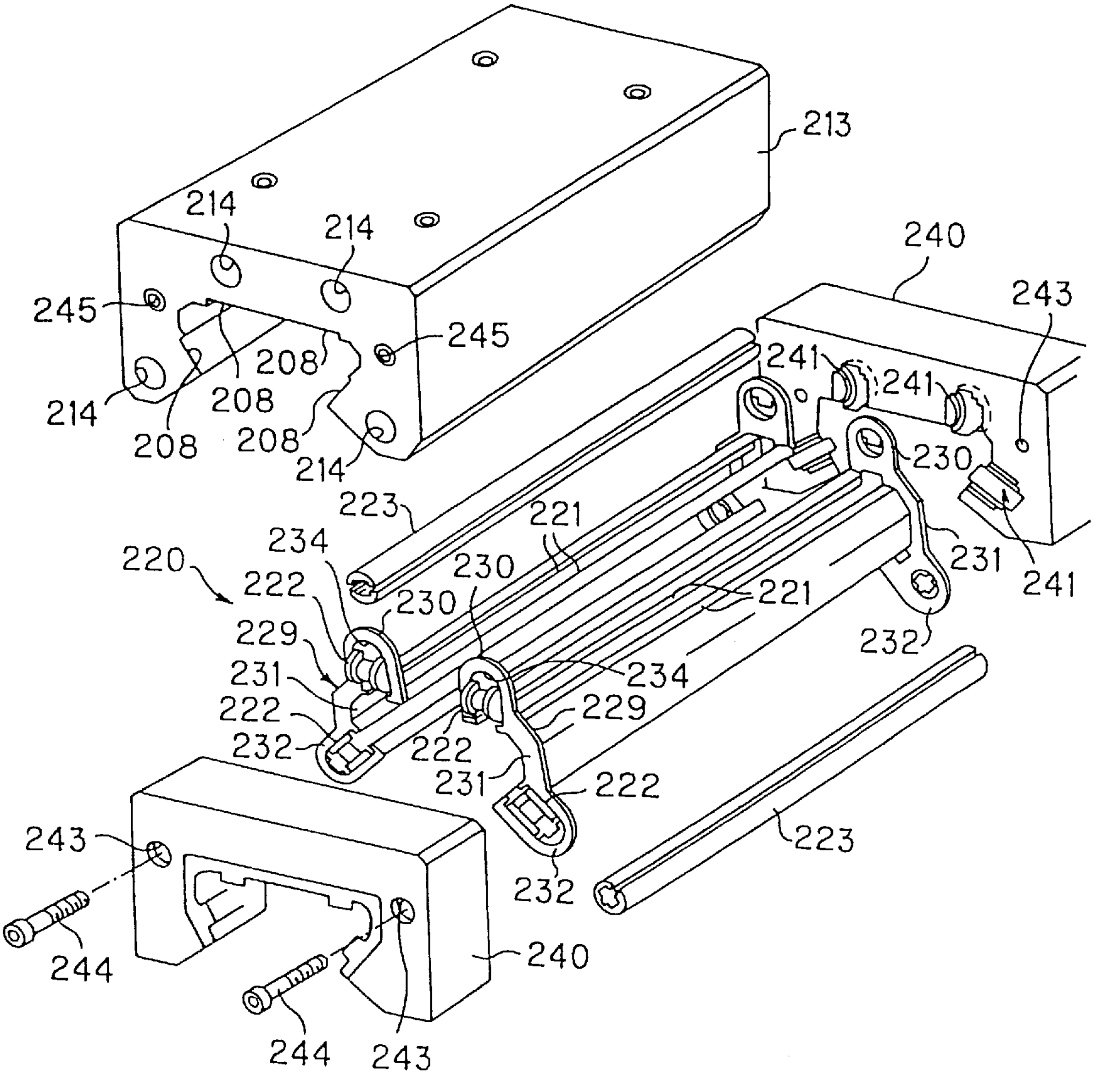

213
214
214
214
214
245
245
208
208
208
208
240
243
241
241
241
230
231
232
223
221
221
220
234
222
230
229
231
222
232
230
234
229
222
231
222
232
223
243
244
240
244
243

FIG. 19(a)

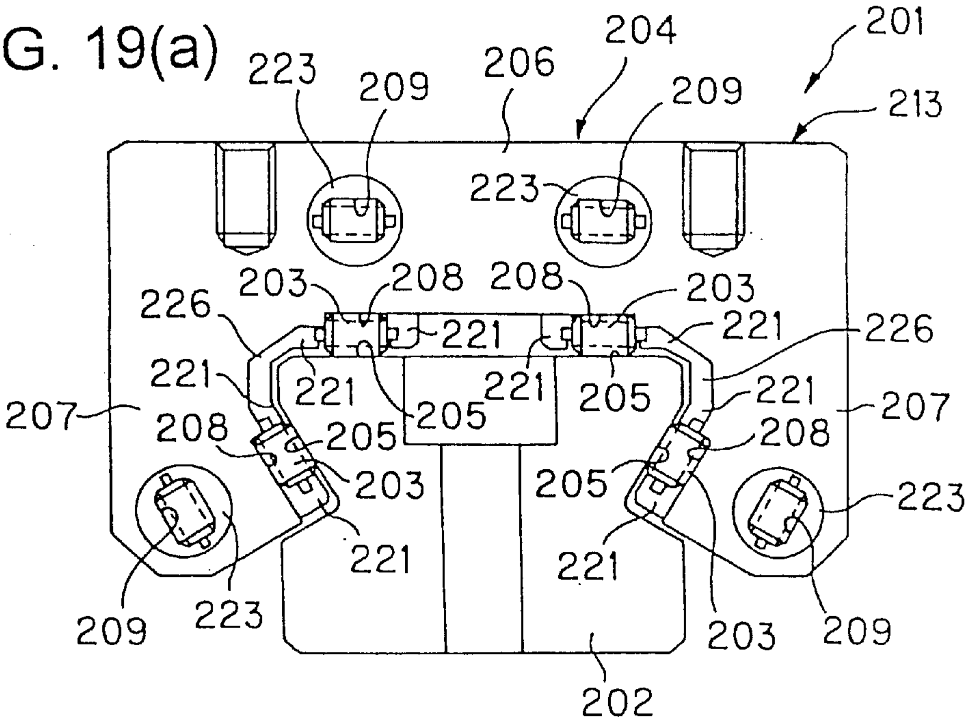


FIG. 19(b)

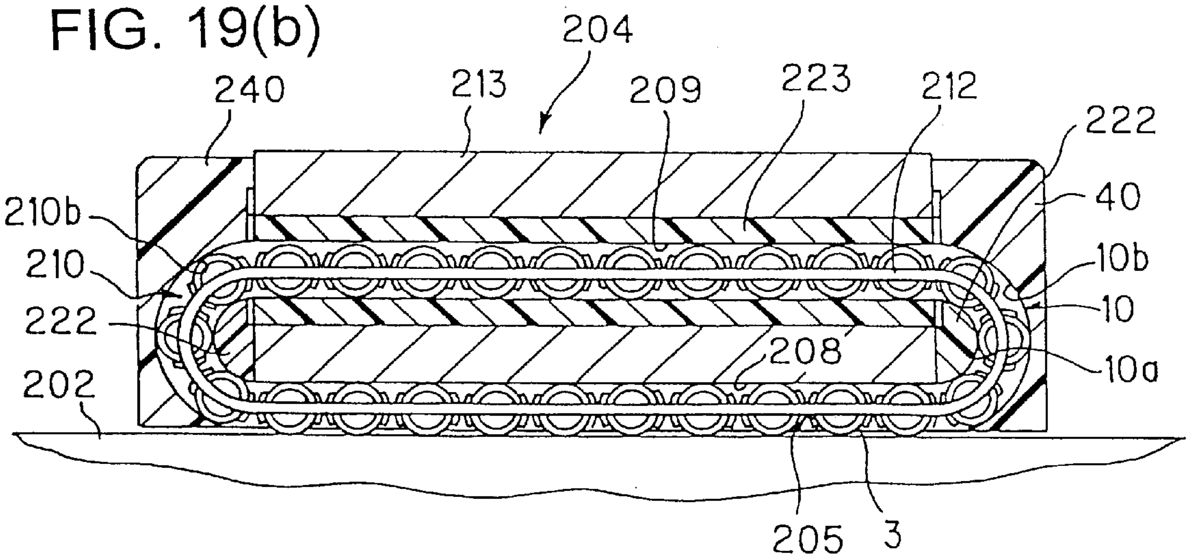


FIG. 19(c)

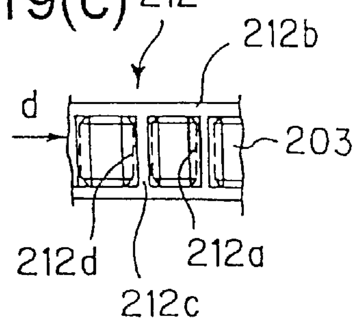
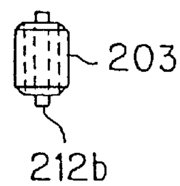


FIG. 19(d)



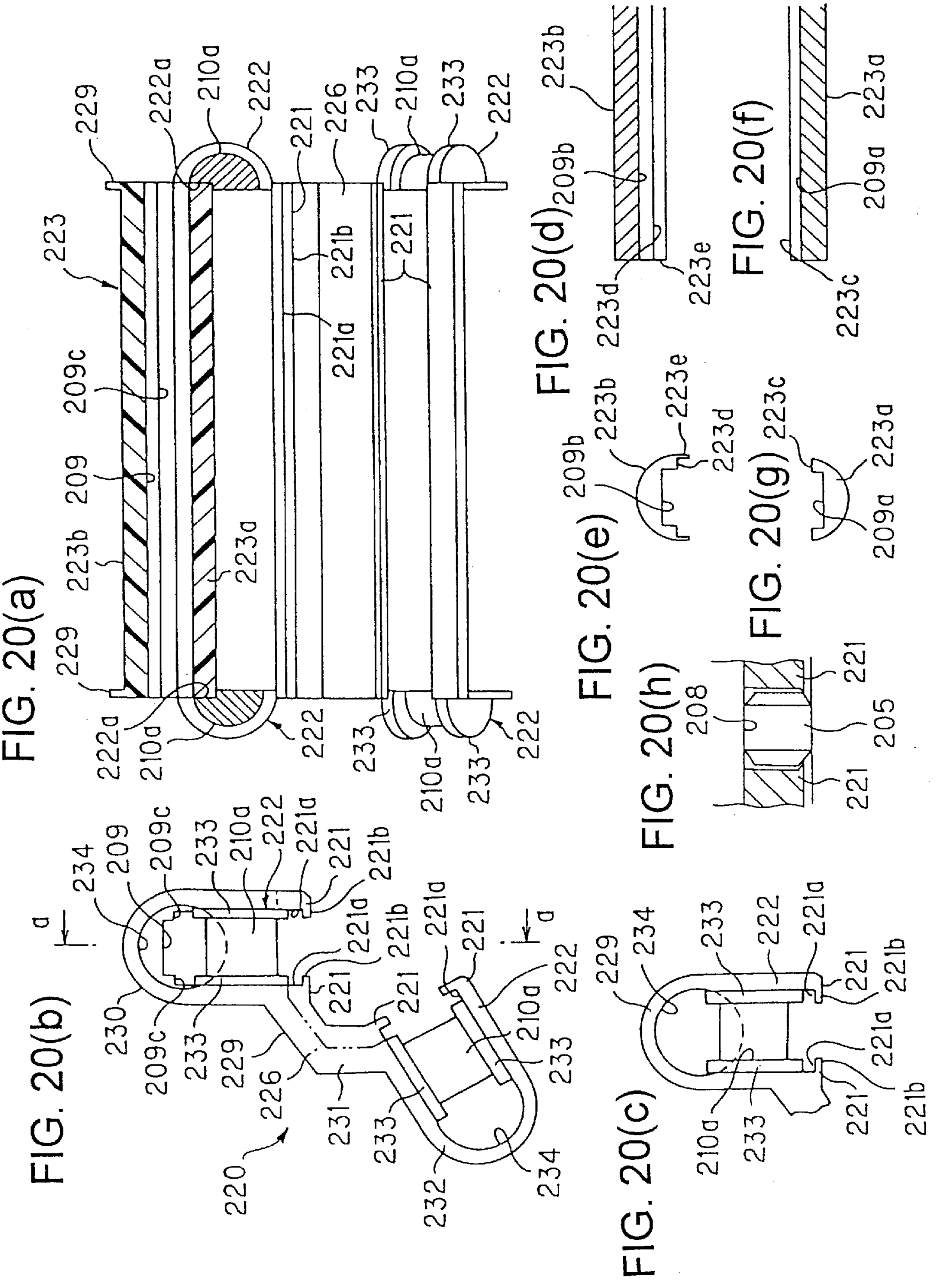


FIG. 20(a)

FIG. 20(b)

FIG. 20(c)

FIG. 20(d)

FIG. 20(e)

FIG. 20(f)

FIG. 20(g)

FIG. 20(h)

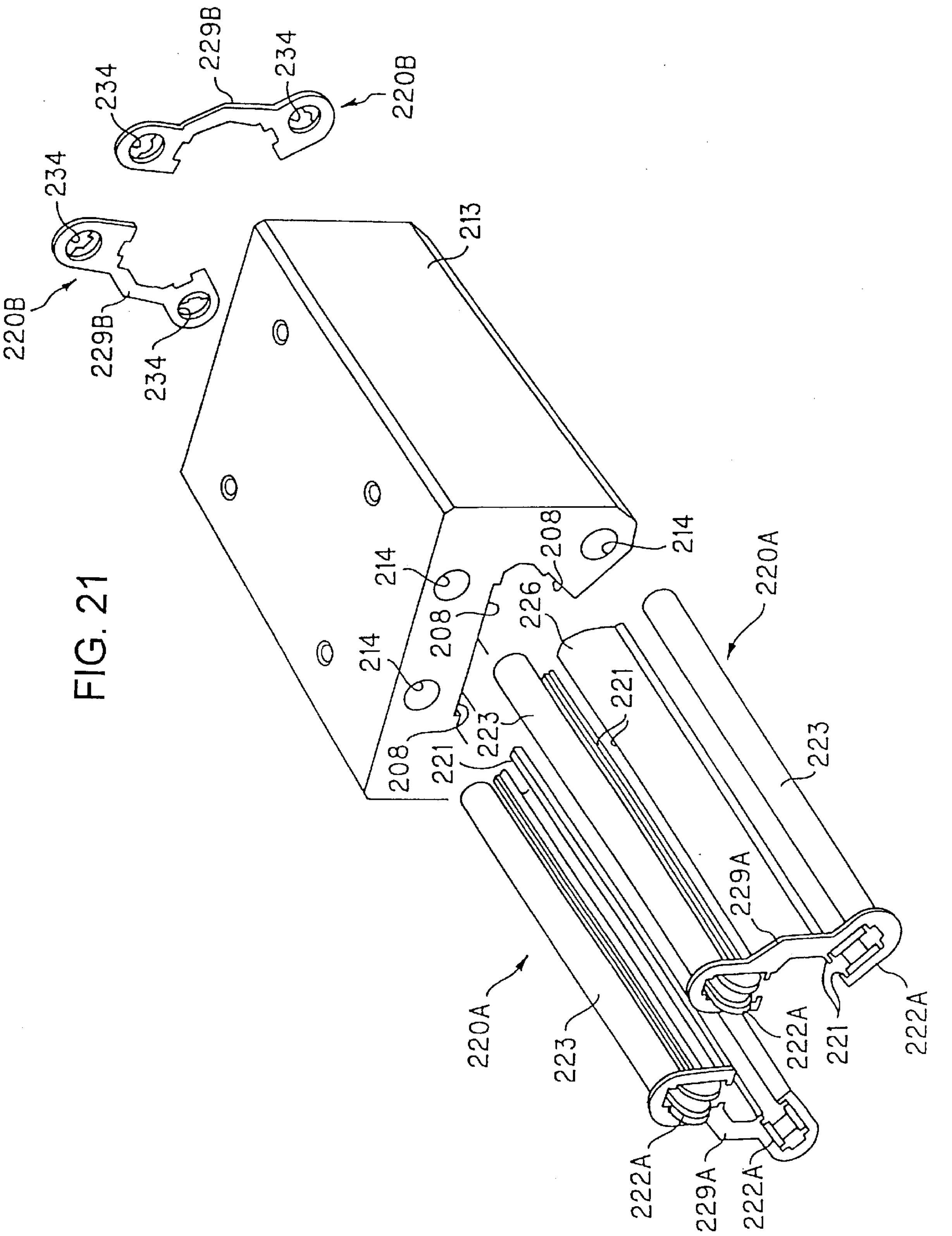

220B
229B
234
234
220B
229B
234
234
213
214
214
214
208
208
208
226
221
221
223
223
223
220A
220A
229A
222A
222A
221
222A
222A
229A
222A

FIG. 21

FIG. 22(a)

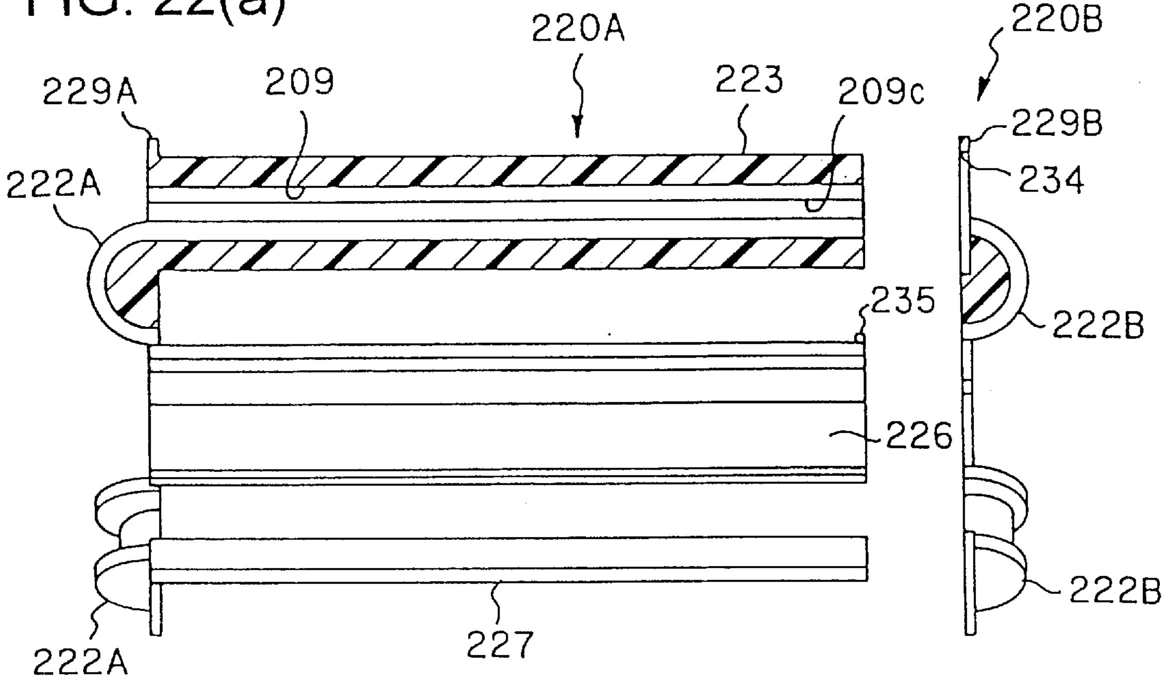


FIG. 22(b)

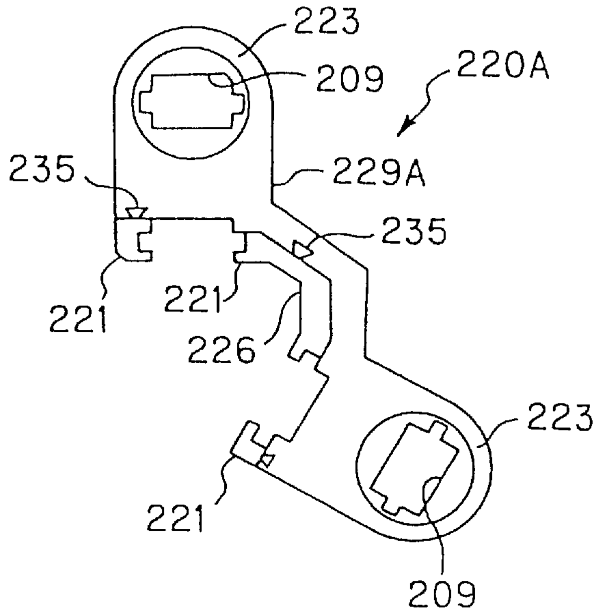
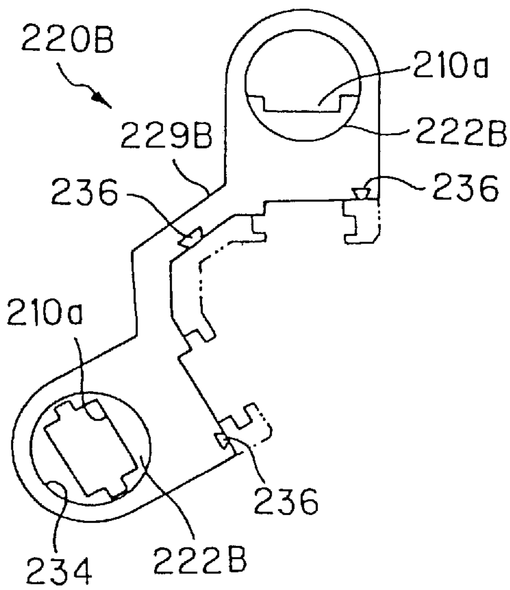


FIG. 22(c)



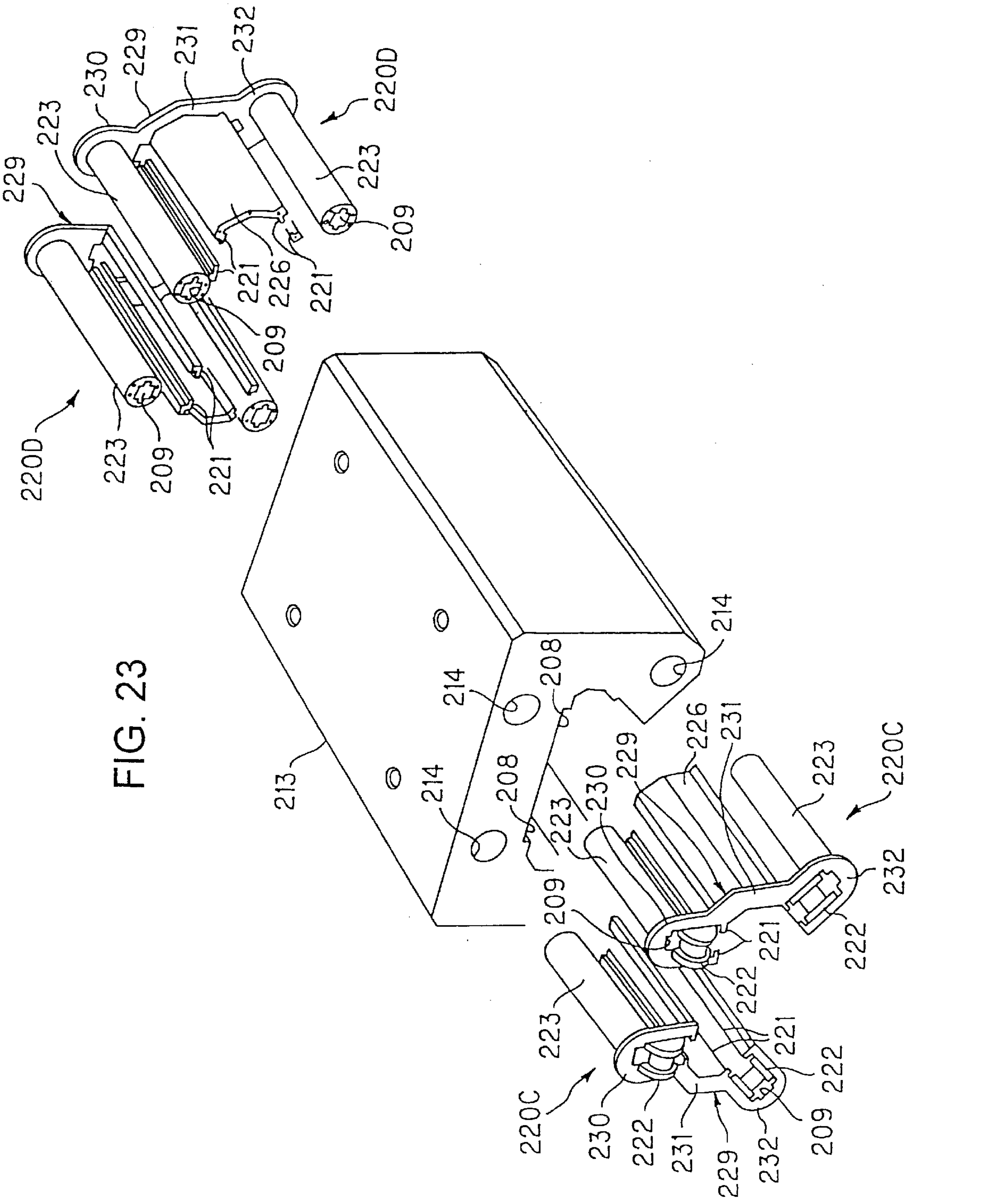

220D
223
209
221
229
223
230
229
231
232
220D
223
209
221
226
221
209
213
214
208
214
208
214
223
230
229
226
231
223
220C
232
222
221
209
222
222
221
222
223
220C
230
222
231
229
232
209
222

FIG. 23

FIG. 24(a)

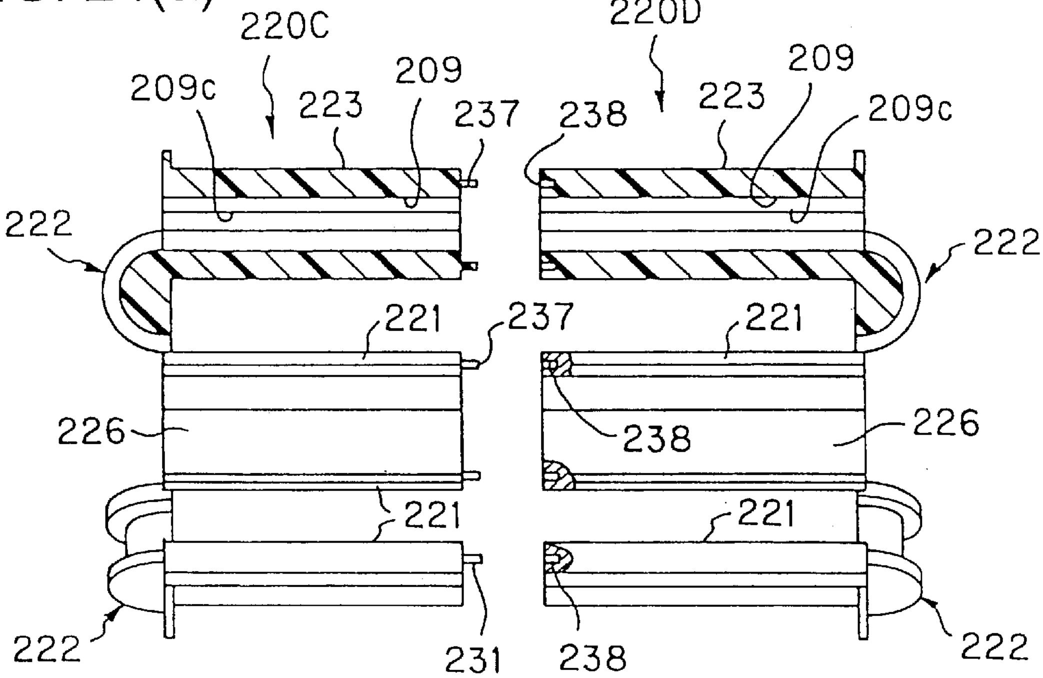


FIG. 24(b)

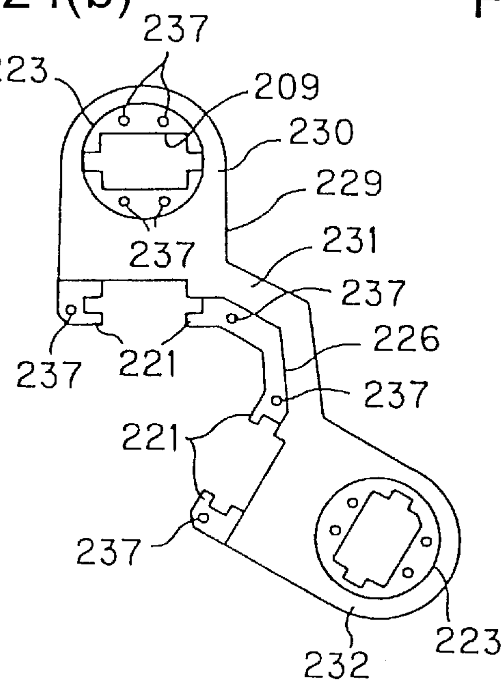


FIG. 24(c)

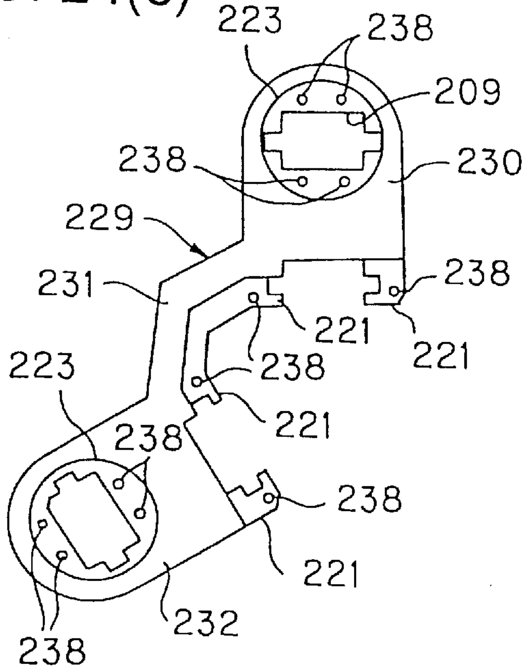
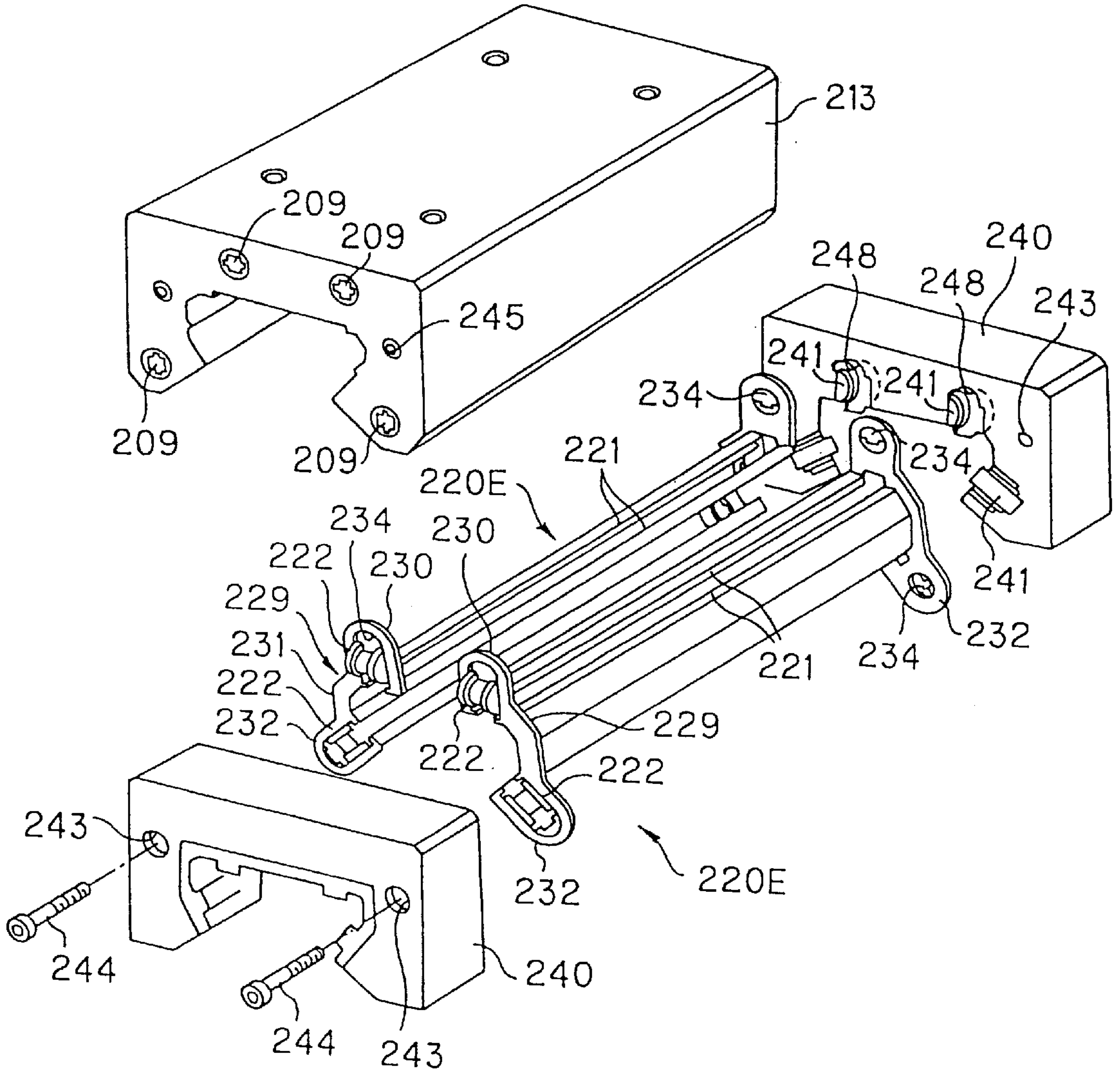


FIG. 25



213
209
209
209
209
245
240
248
248
243
241
241
241
234
234
234
234
221
221
220E
220E
230
230
222
222
222
222
229
229
231
232
232
232
243
243
244
244
240

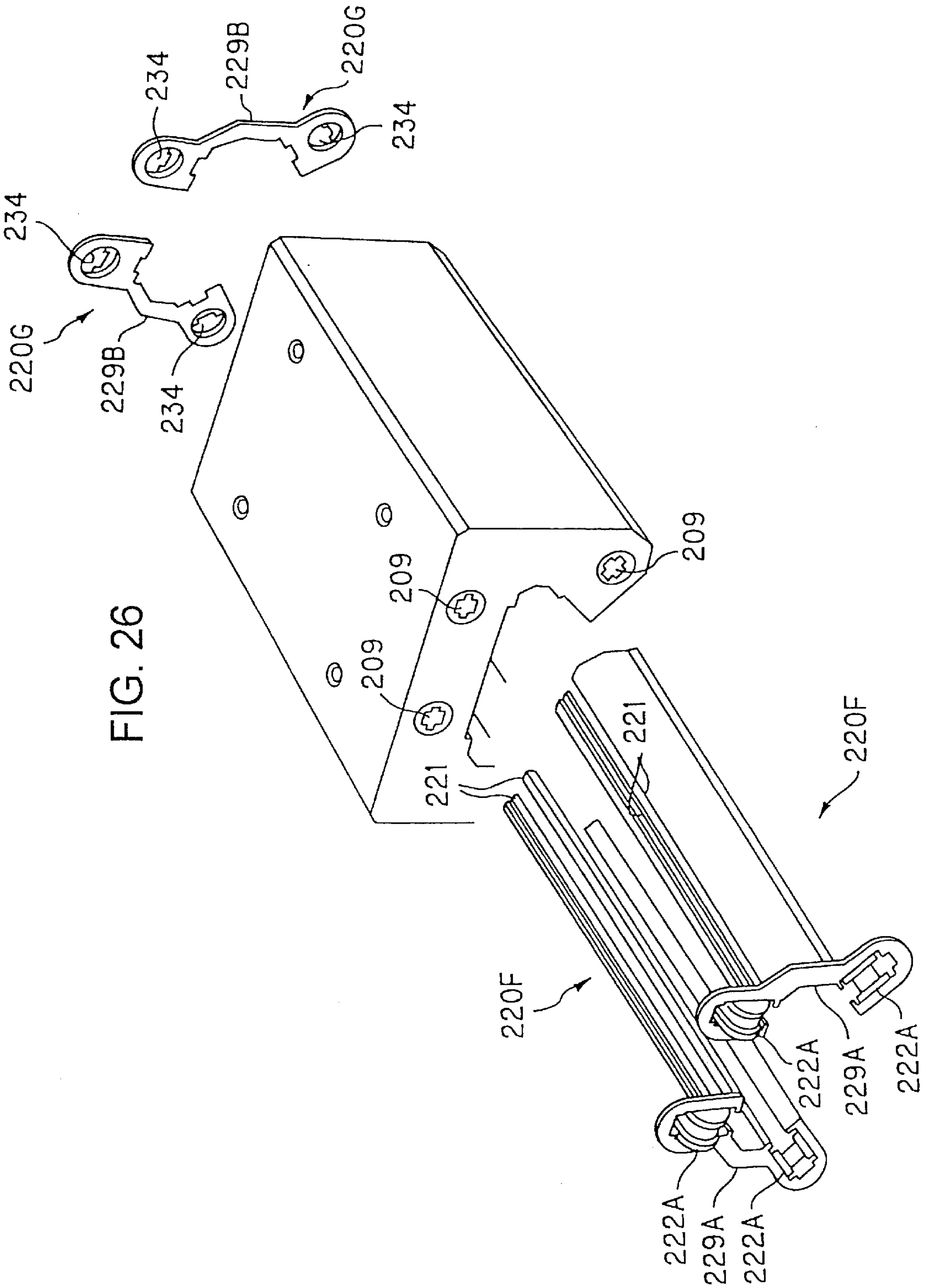


FIG. 26

FIG. 27

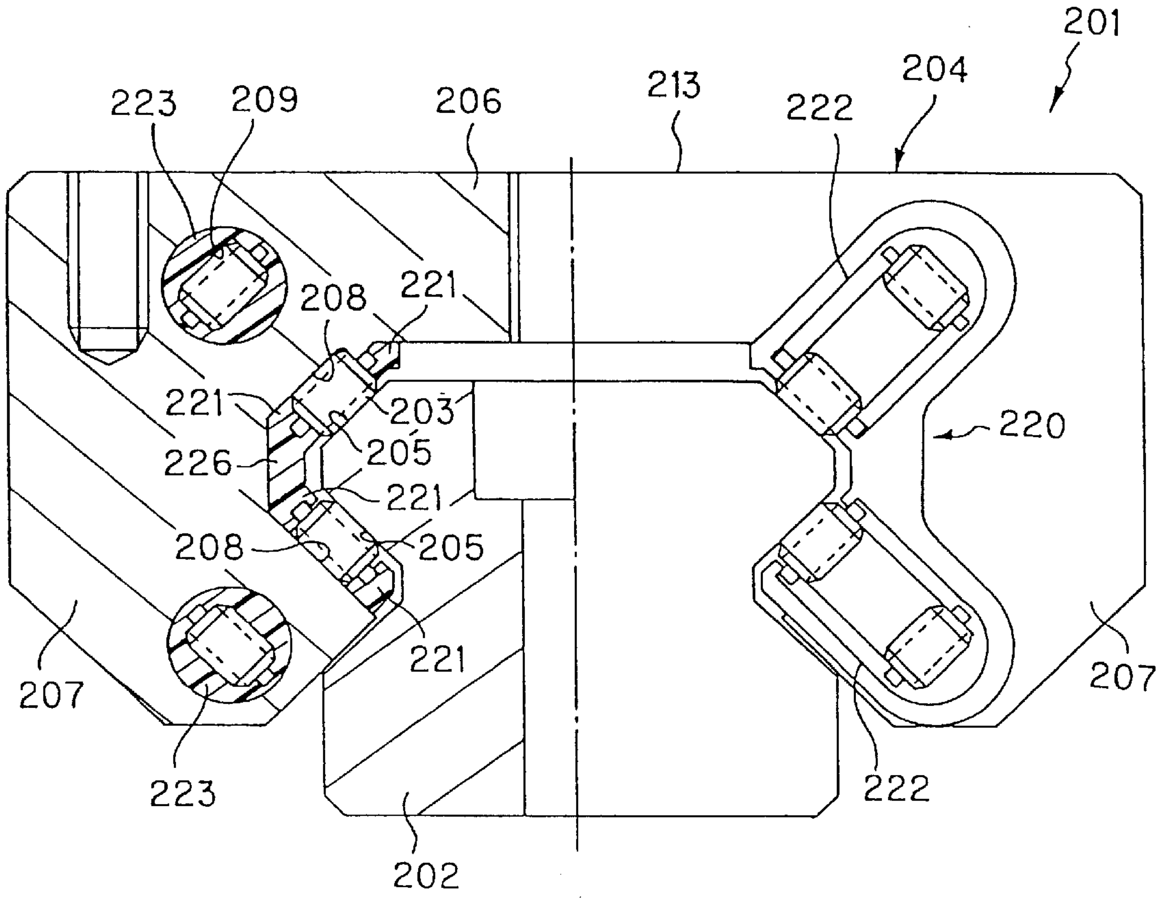

201
204
213
206
209
223
222
208
221
203
221
226
205
220
221
208
205
207
221
207
223
222
202

FIG. 28

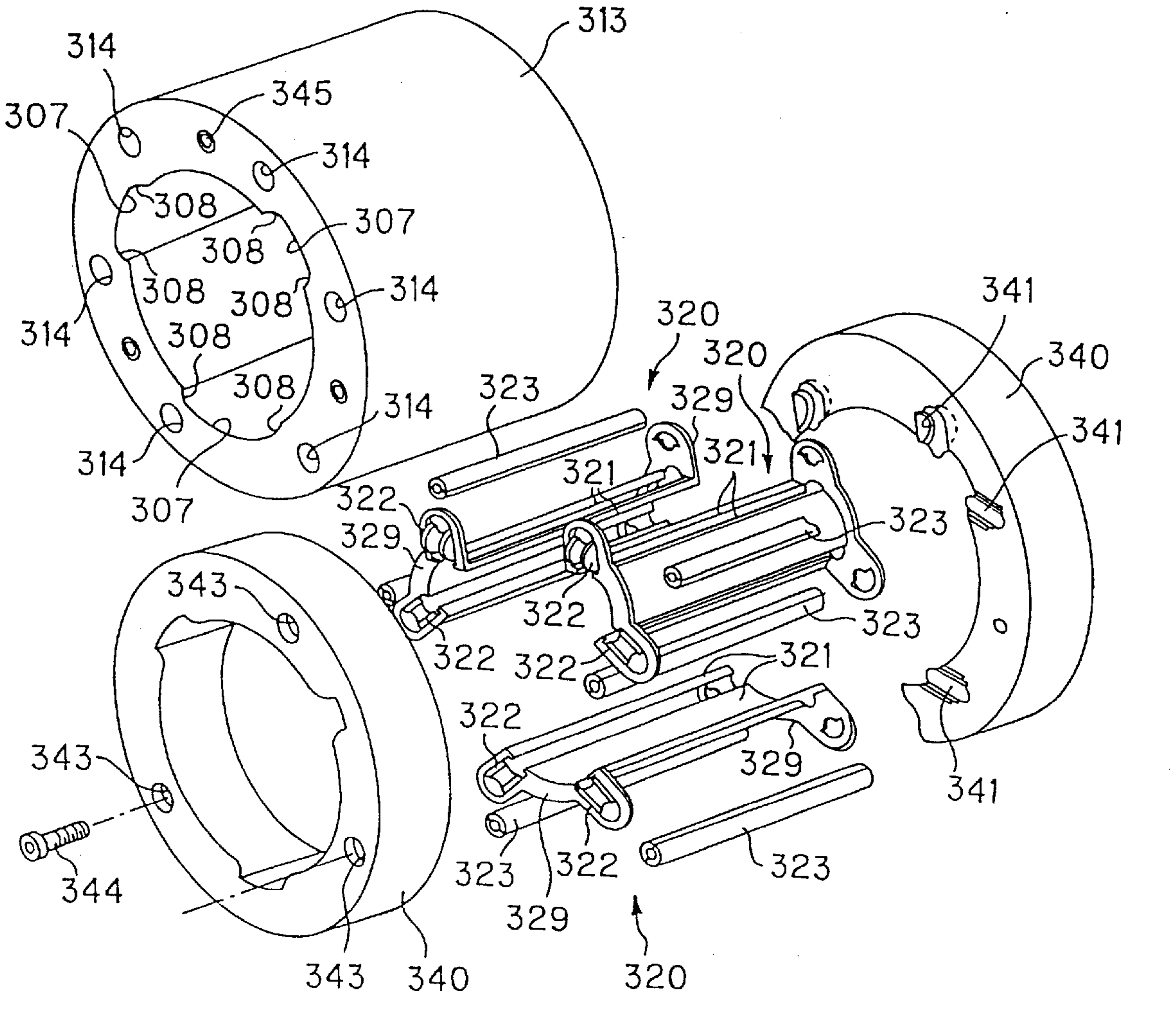

313
314
345
307
314
308
307
308
308
308
314
314
308
308
314
314
307
320
341
320
340
323
329
321
321
341
322
323
329
343
322
323
322
322
321
322
343
329
341
344
323
322
323
329
343
340
320

FIG. 29(a)

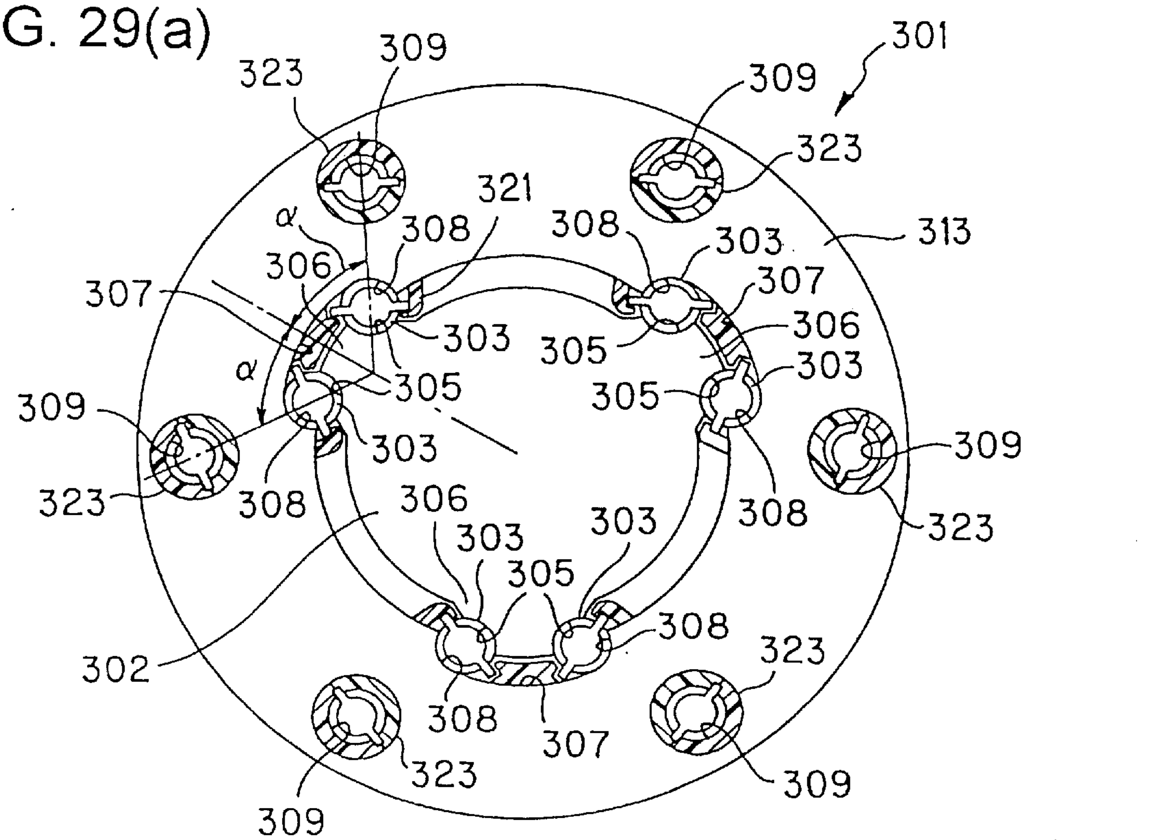


FIG. 29(b)

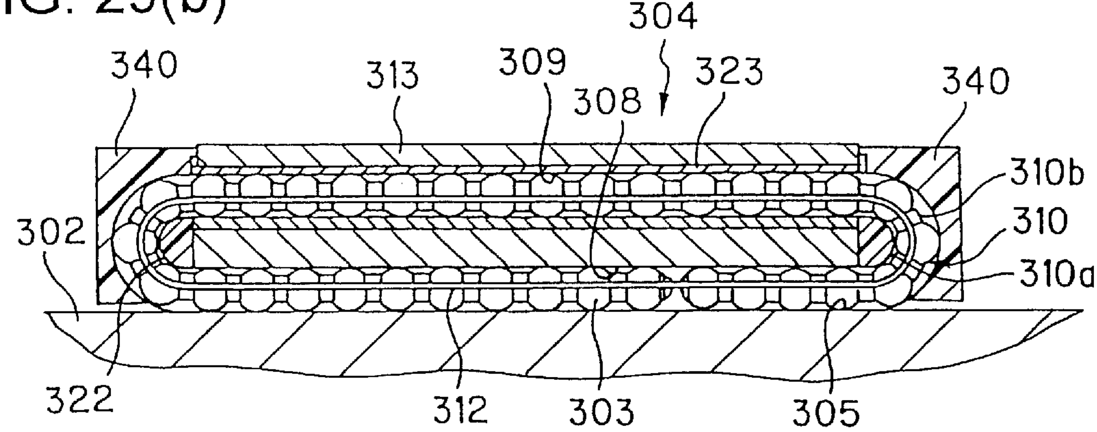
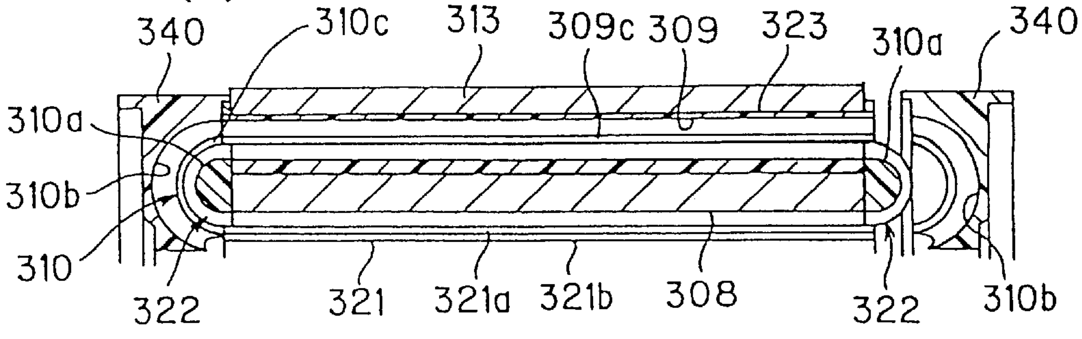


FIG. 29(c)



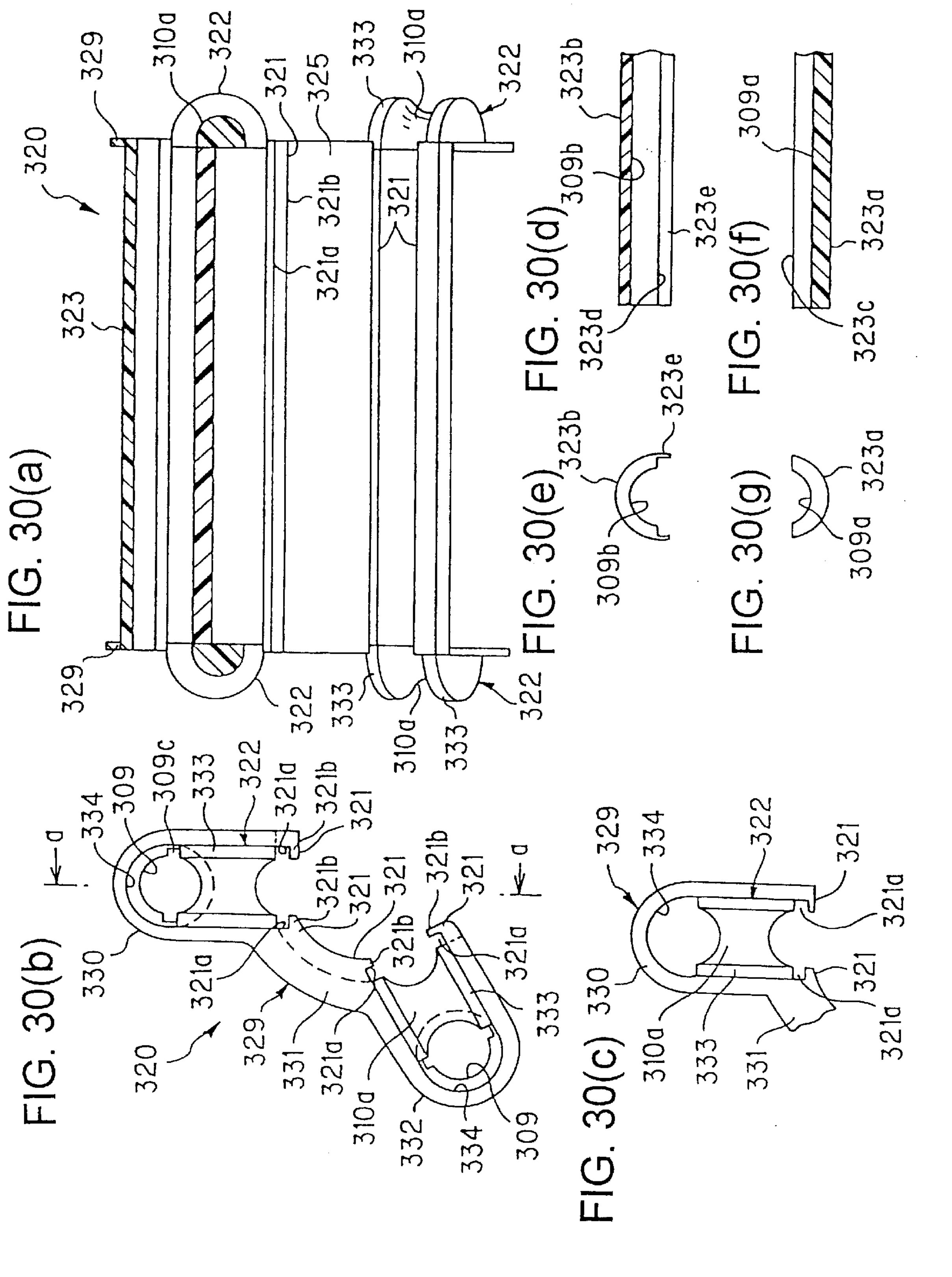


FIG. 30(a)

FIG. 30(b)

FIG. 30(c)

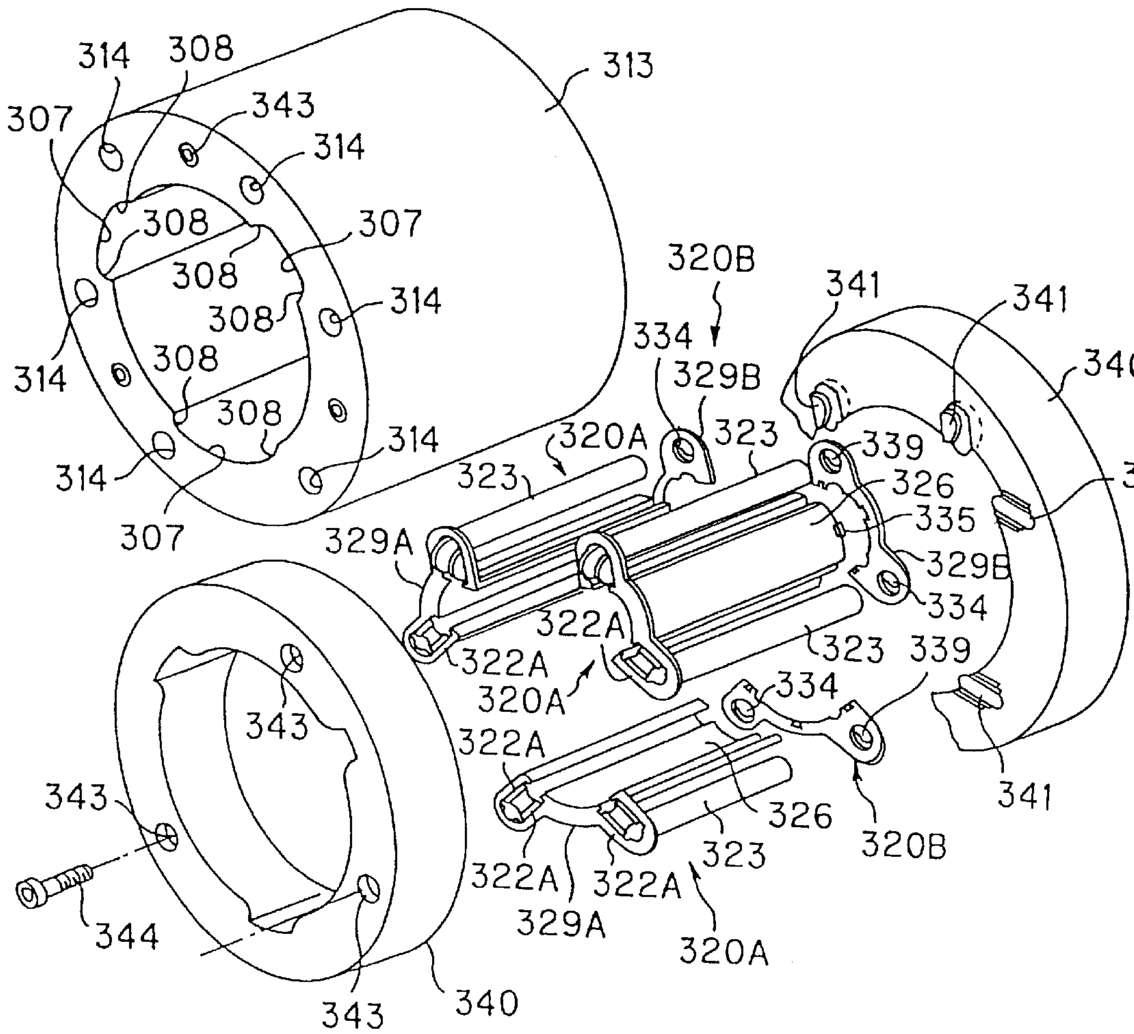
FIG. 30(d)

FIG. 30(e)

FIG. 30(f)

FIG. 30(g)

FIG. 31



314
308
307
343
314
313
308
307
308
308
314
314
308
308
314
314
307
320B
341
341
334
329B
340
320A
323
339
323
326
341
335
329A
329B
334
322A
322A
323
339
320A
334
343
322A
343
326
320B
341
323
322A
322A
344
329A
320A
343
340

FIG. 32(a)

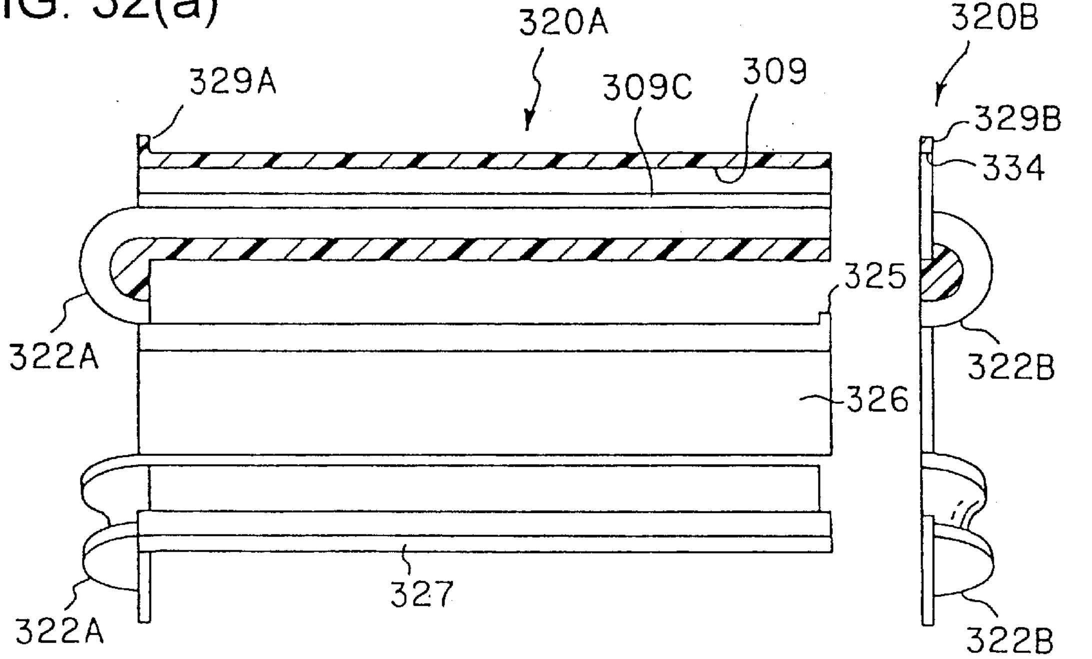


FIG. 32(b)

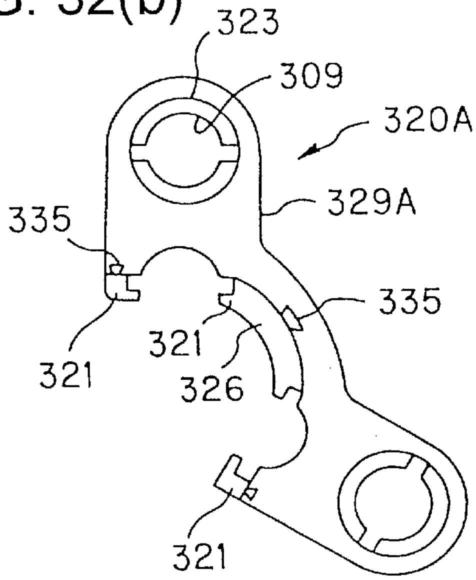


FIG. 32(c)

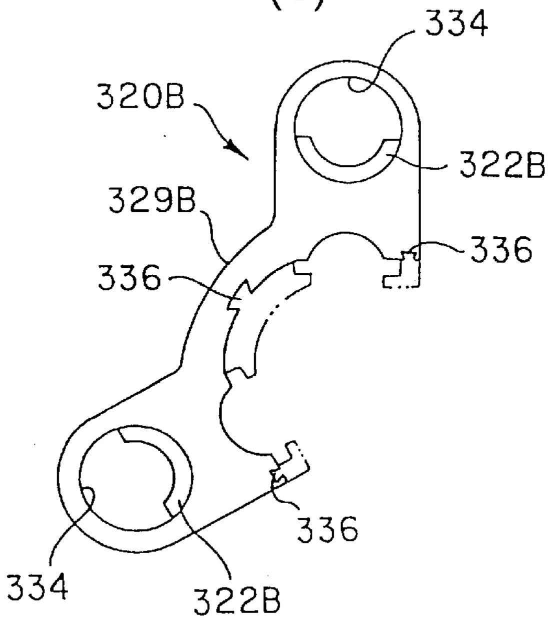


FIG. 33

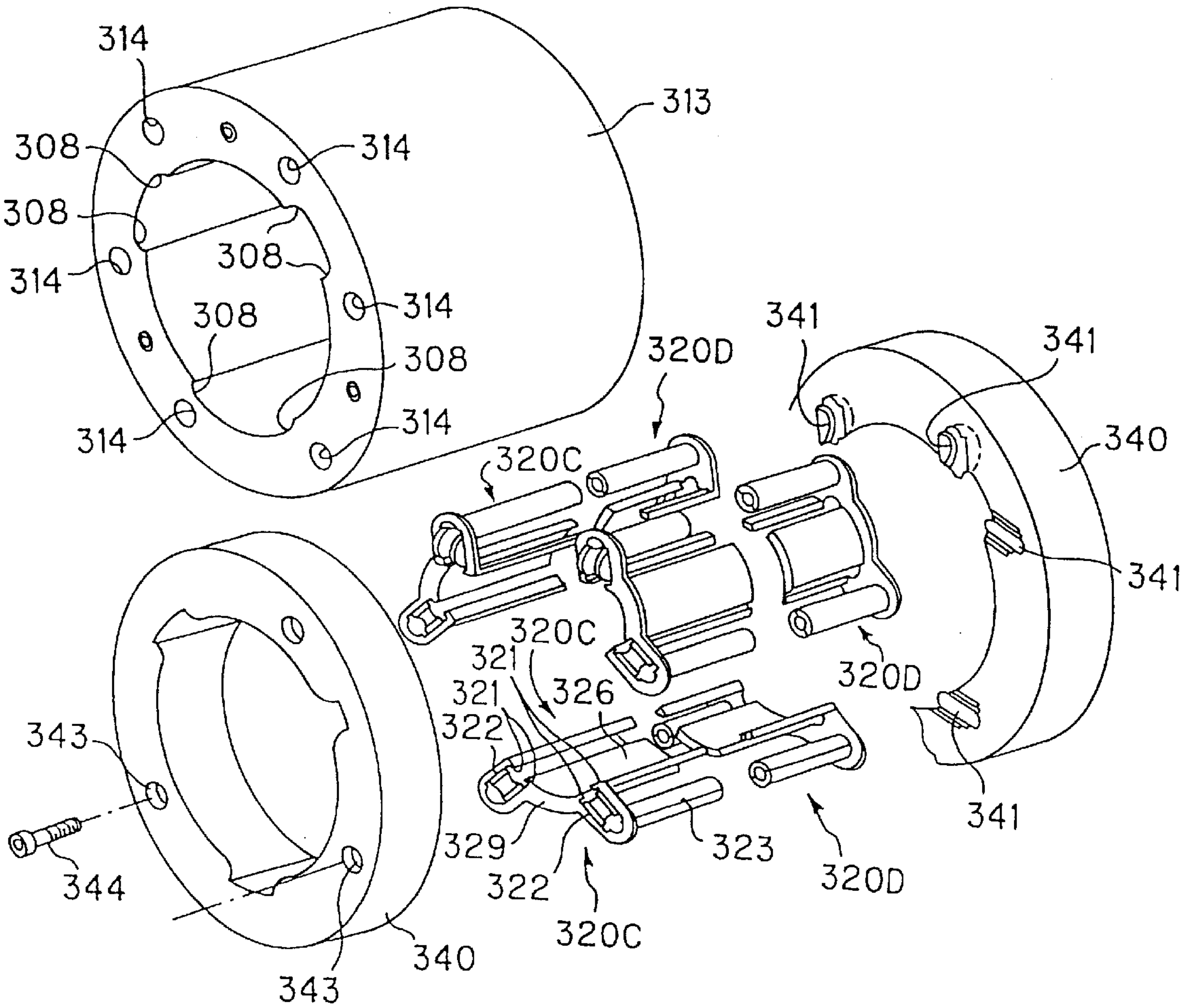

314
313
308
314
308
308
314
314
308
308
314
314
341
320D
341
340
320C
341
320C
321
321
326
320D
343
322
322
329
323
341
344
322
320D
320C
340
343

FIG. 34(a)

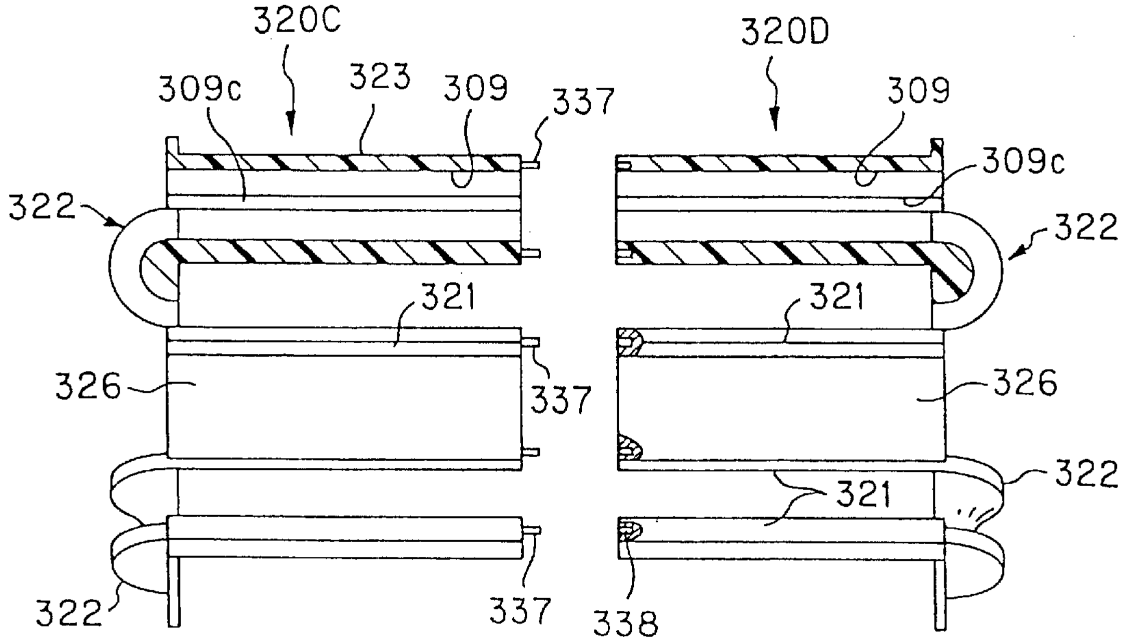


FIG. 34(b)

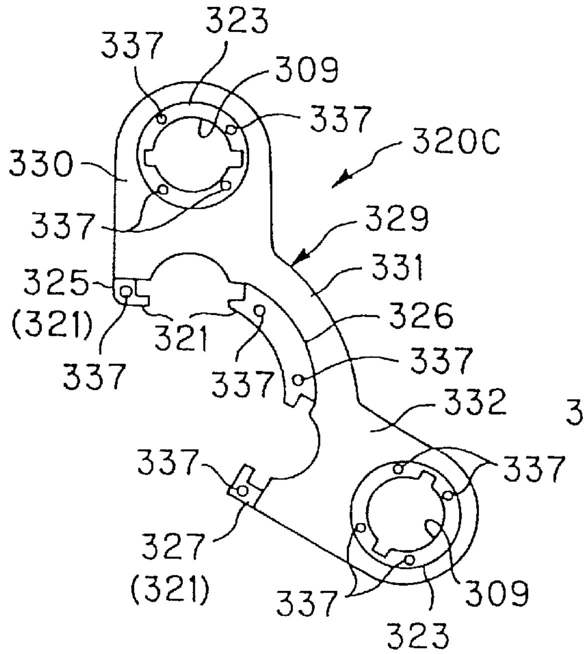


FIG. 34(c)

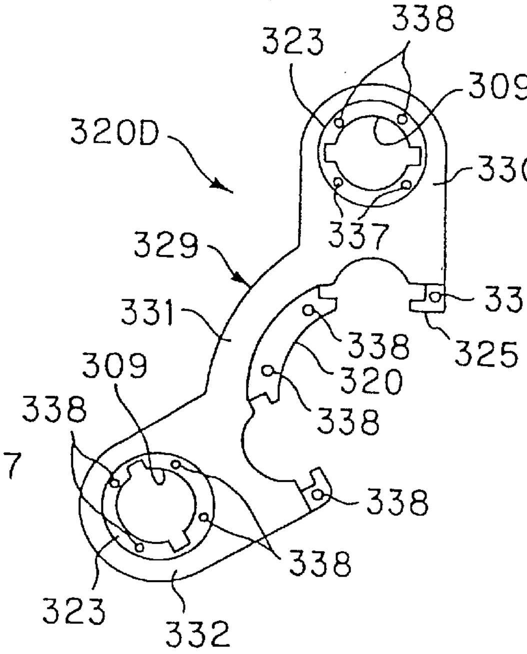


FIG. 35

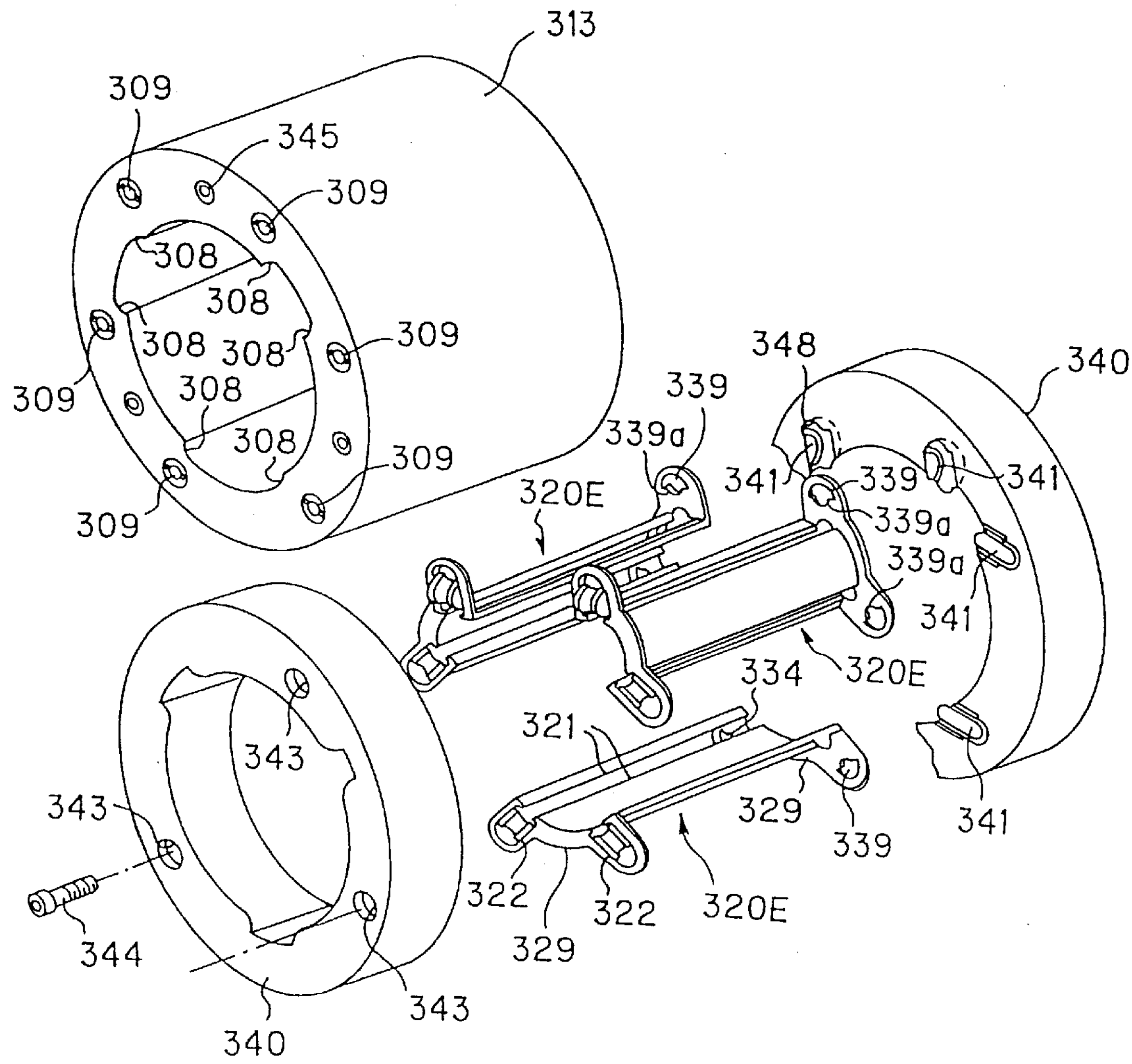
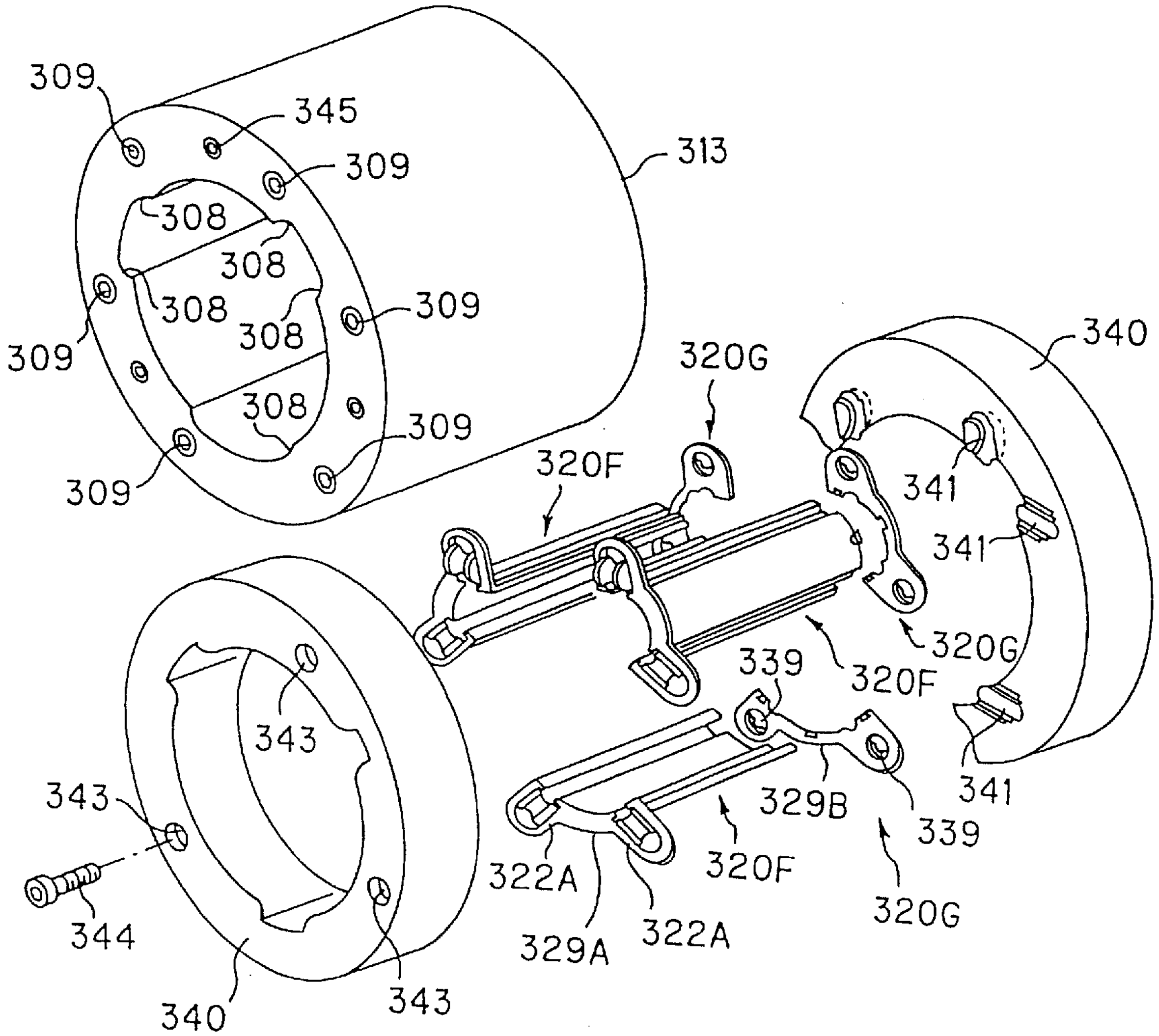

313
309
345
309
308
308
308
308
309
309
308
308
309
309
348
340
339
339a
341
339
341
339a
339a
320E
341
320E
334
321
343
343
329
339
341
322
322
320E
329
344
343
340

FIG. 36



309
345
313
309
308
308
308
308
309
309
340
320G
308
309
309
320F
341
341
343
320G
339
320F
343
341
329B
339
344
320F
322A
320G
329A
322A
340
343

FIG. 37

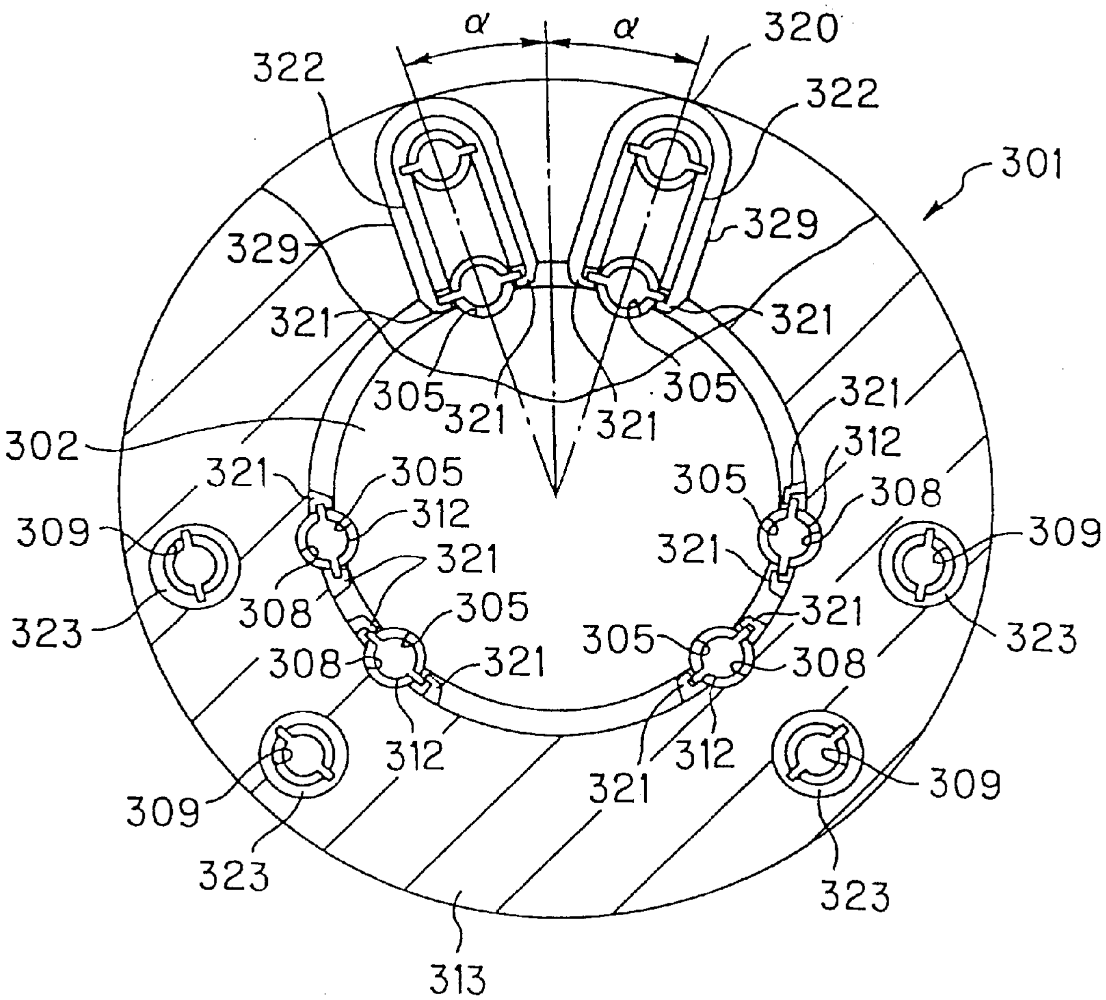

α
α
320
322
322
301
329
329
321
321
305
321
321
305
302
321
321
305
312
305
308
309
309
312
321
321
323
323
308
305
321
305
308
308
321
312
312
321
309
309
323
323
313

FIG. 38(a)

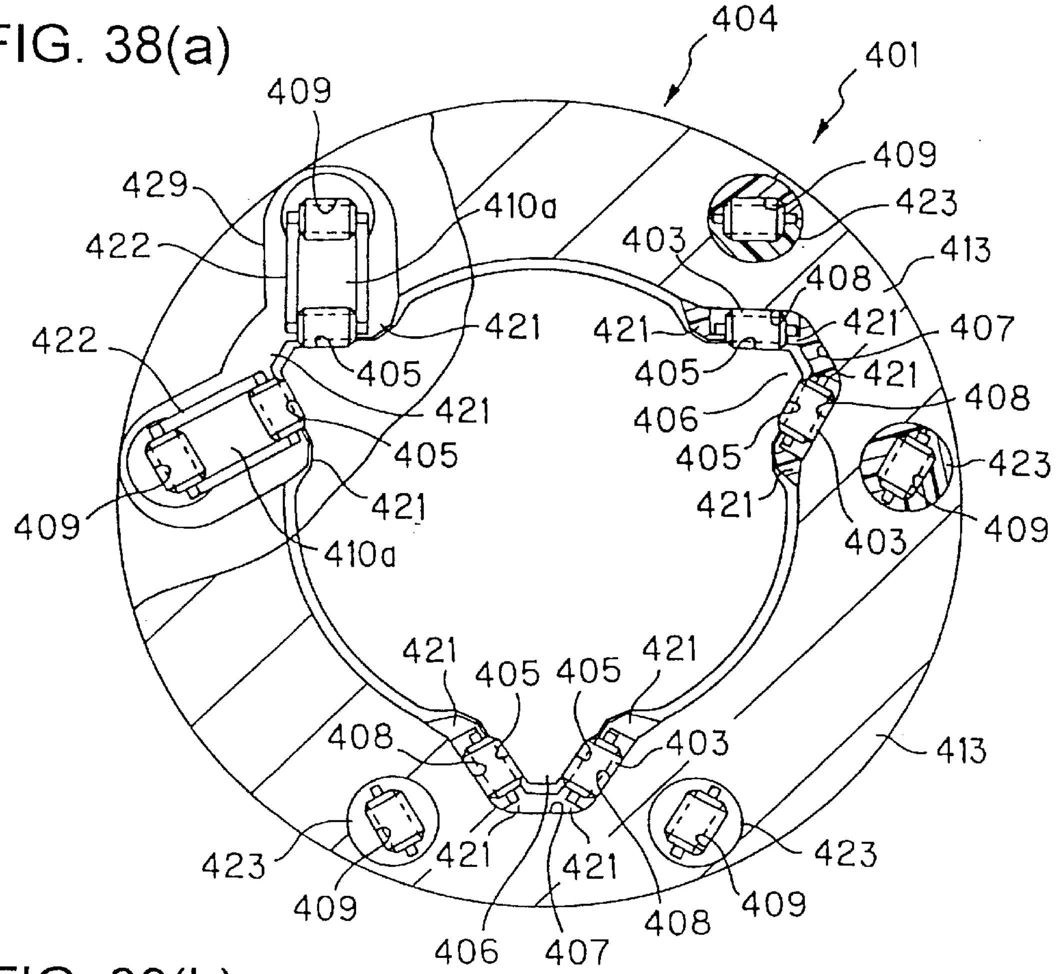


FIG. 38(b)

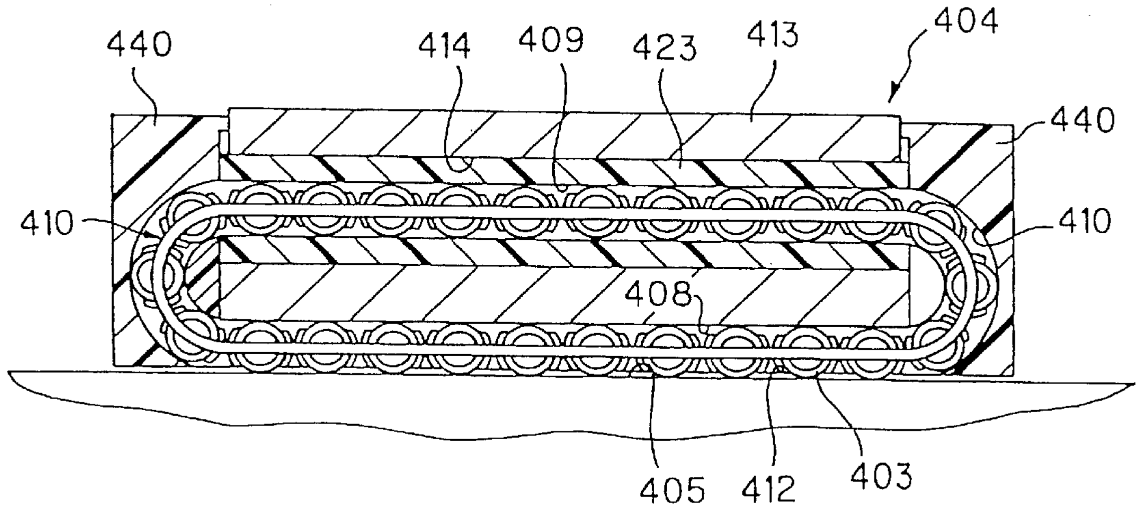


FIG. 39(a)

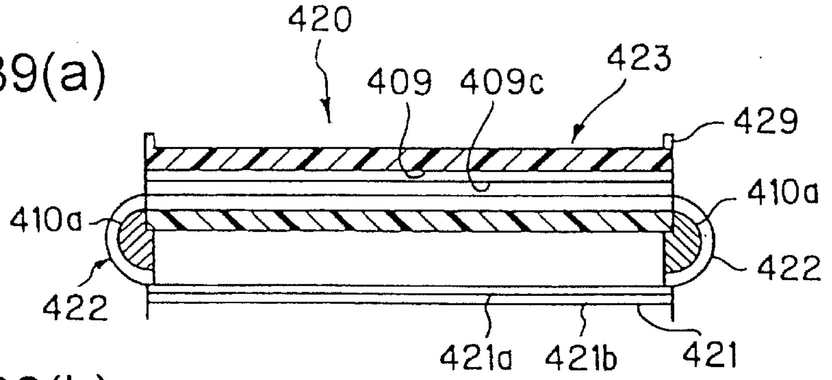


FIG. 39(b)

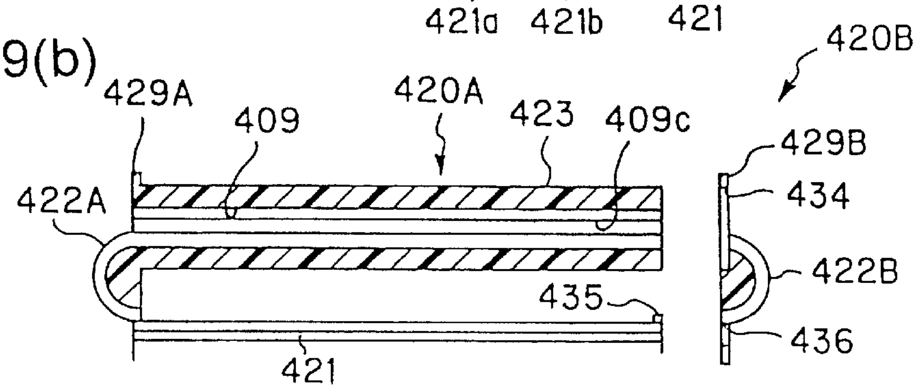


FIG. 39(c)

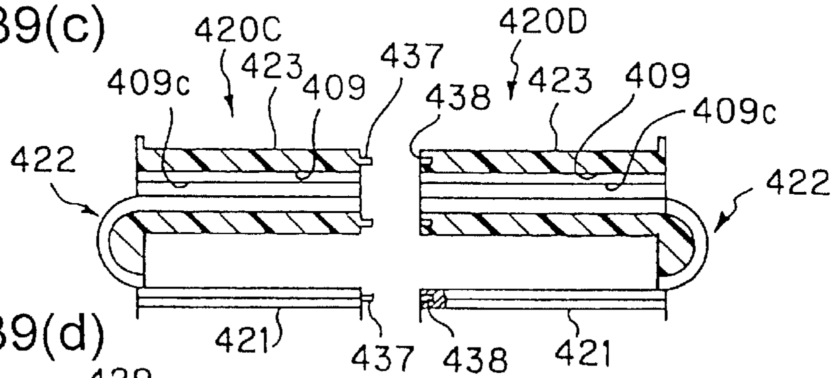


FIG. 39(d)

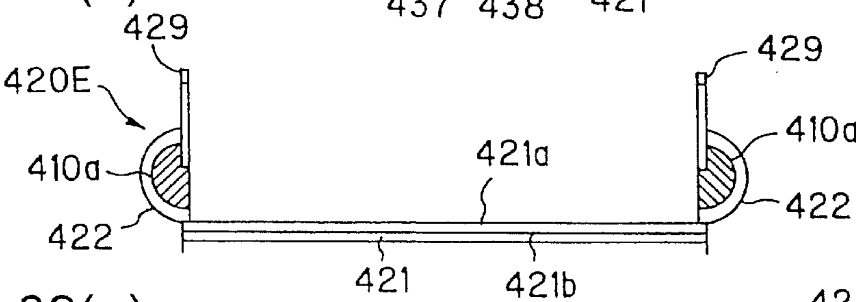


FIG. 39(e)

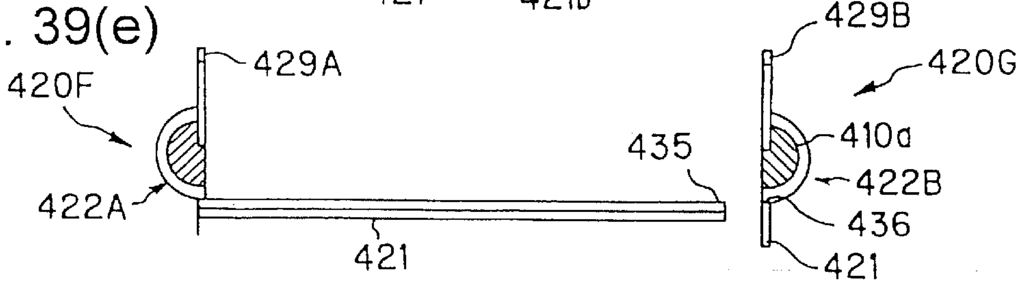


FIG.40(a)

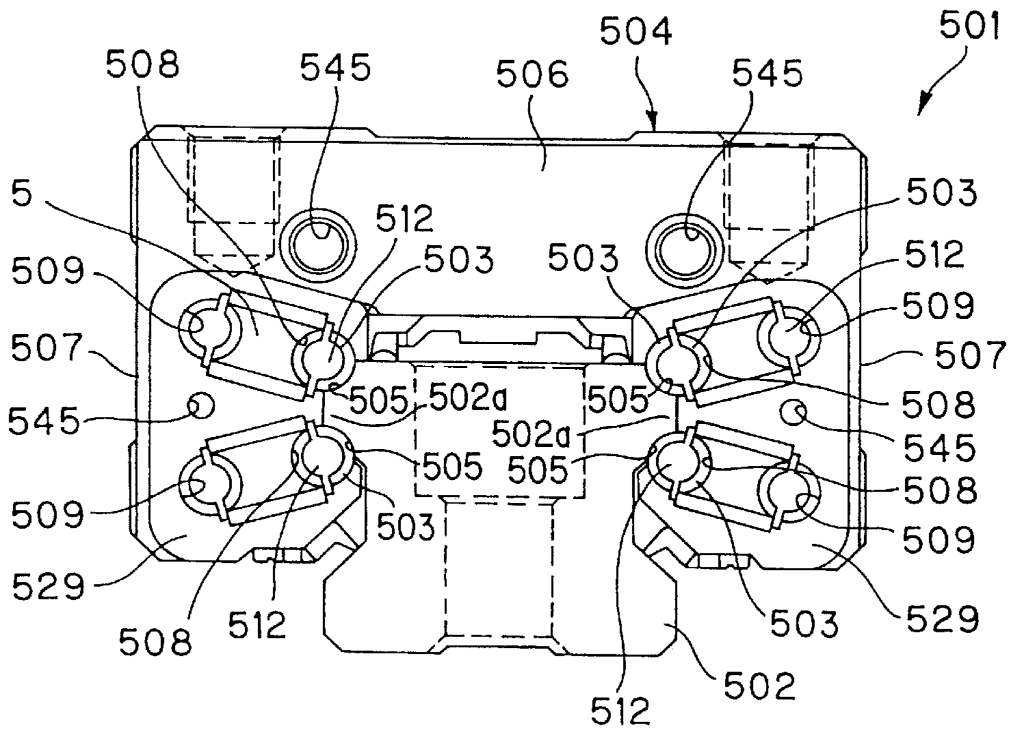


FIG.40(b)

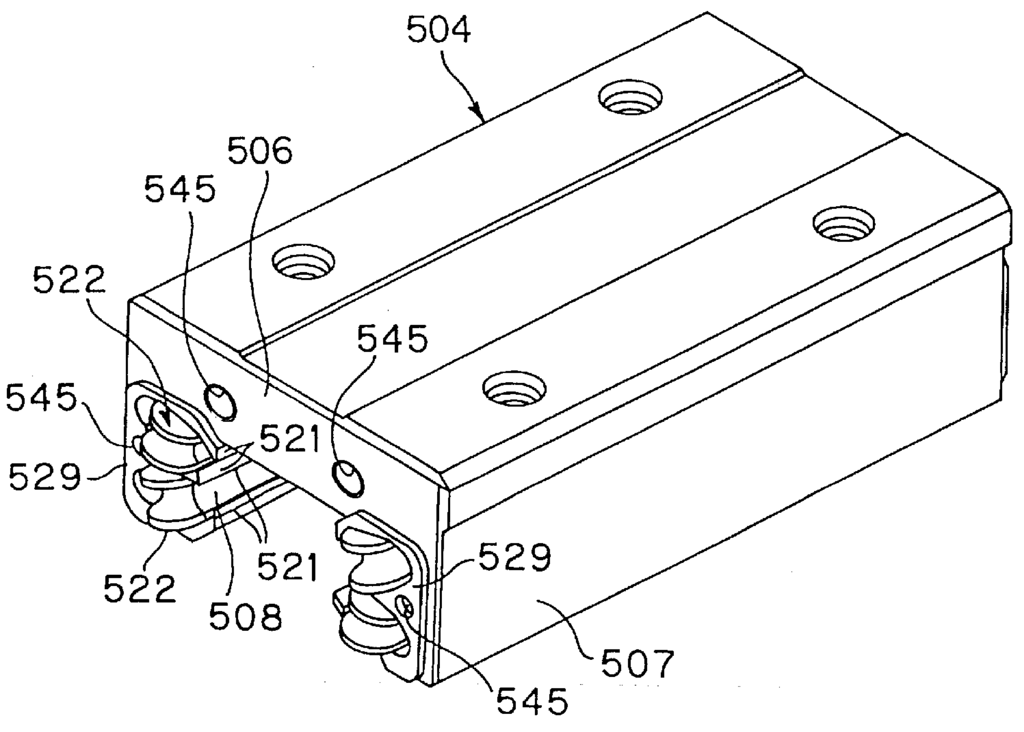


FIG.41

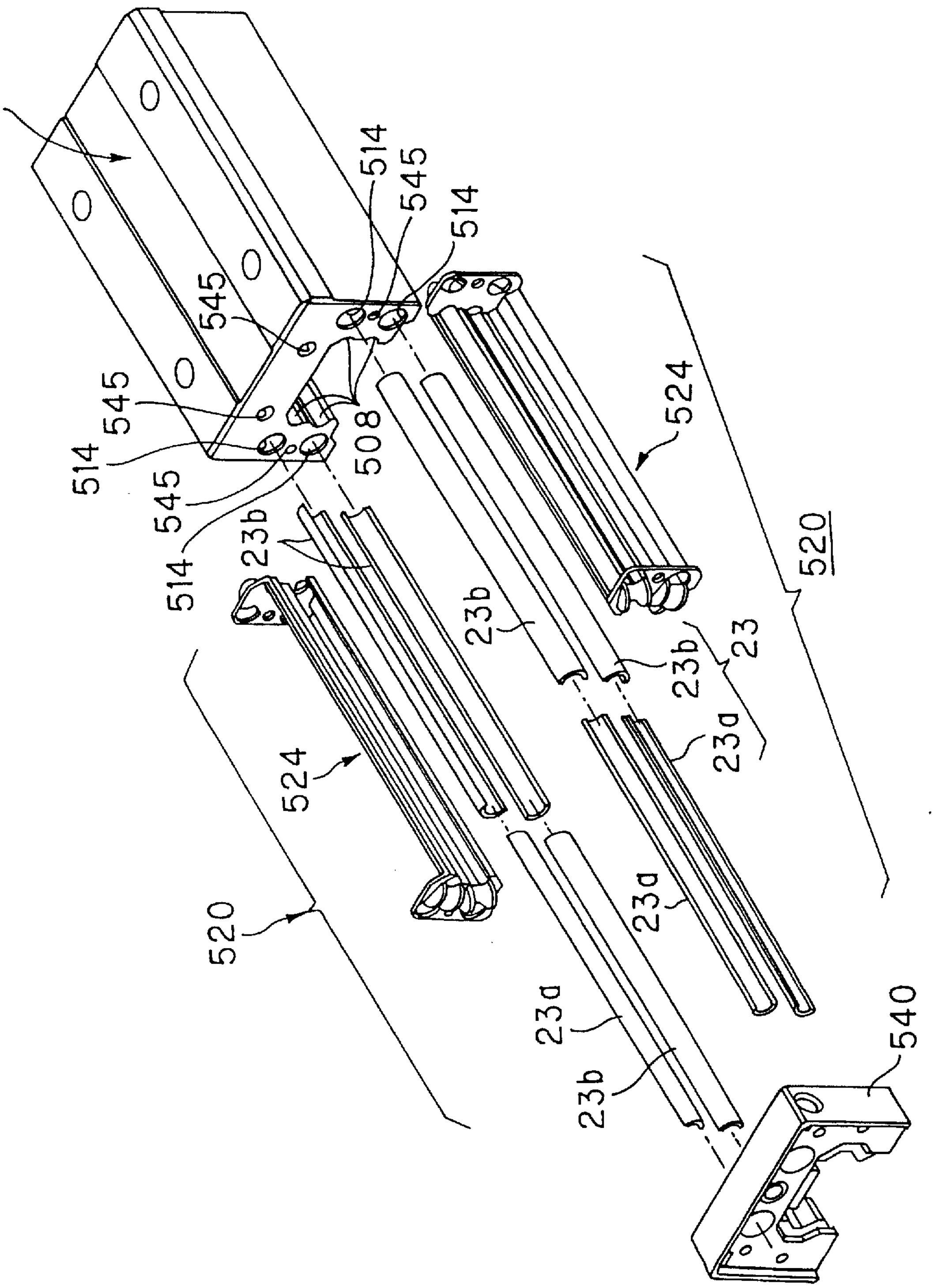

513
514
545
514
545
545
514
545
514
508
23b
524
520
23b
23b
23
23a
23a
520
23a
23b
524
540

FIG.42(a)

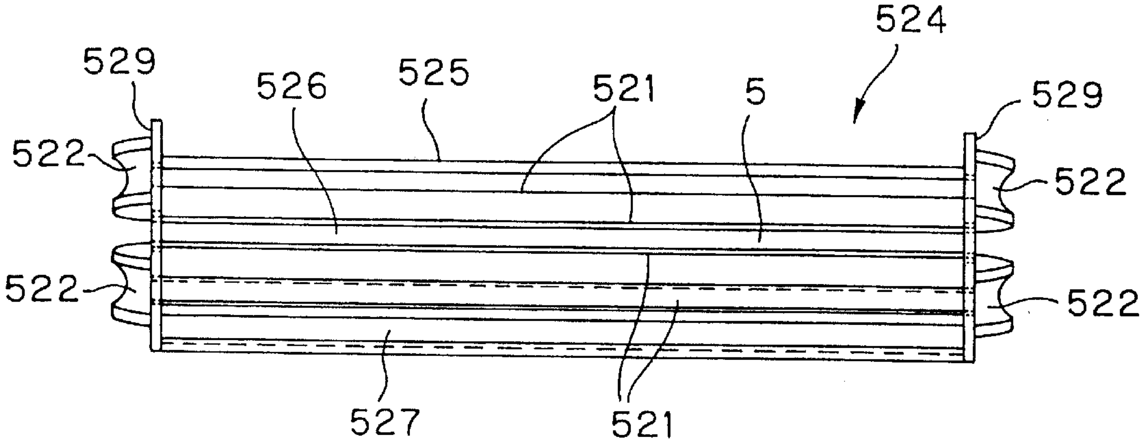


FIG.42(b)

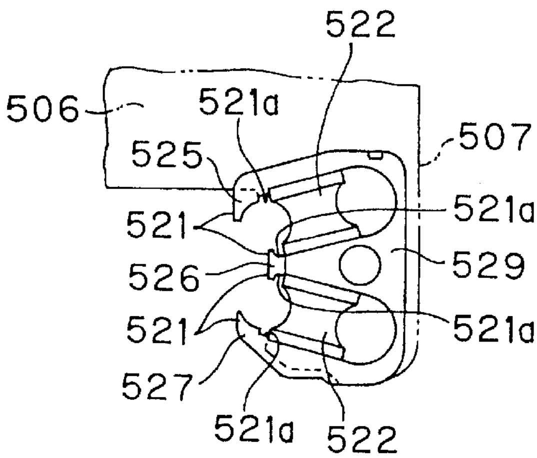


FIG.42(c)

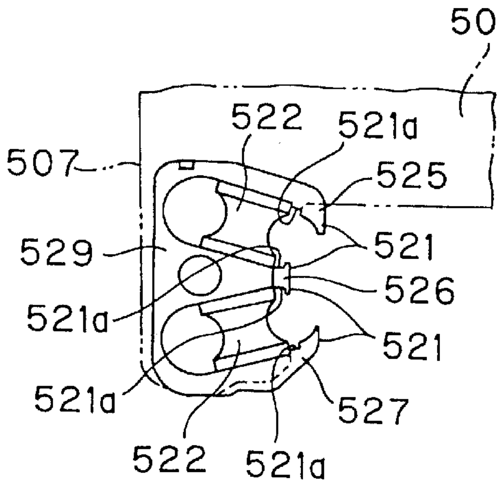


FIG.43(a)

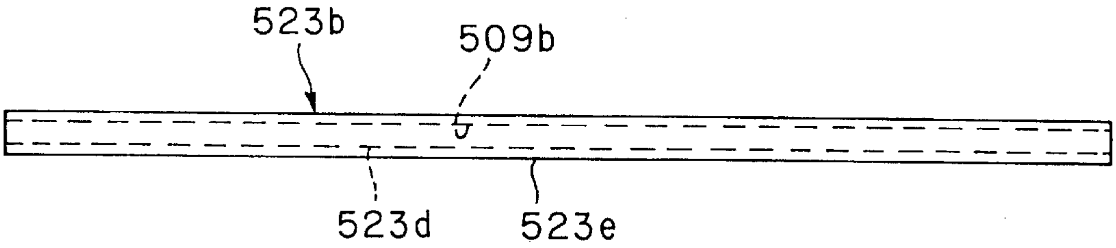


FIG.43(b)

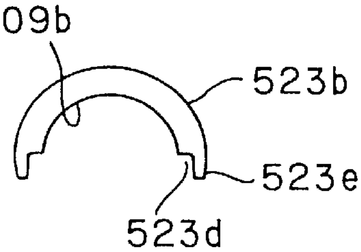


FIG.43(c)

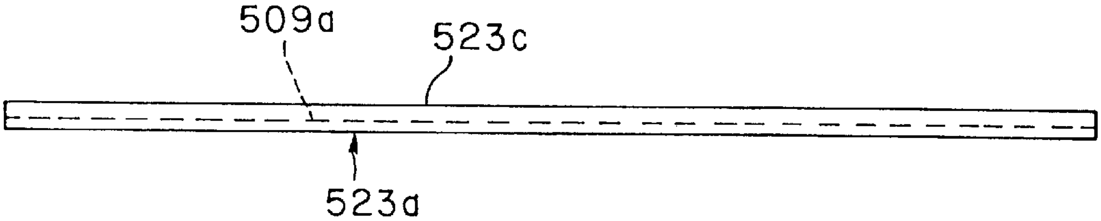


FIG.43(d)

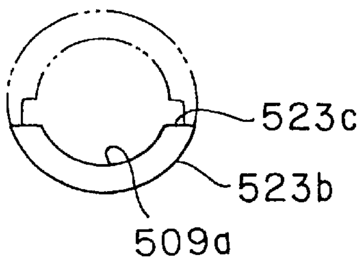


FIG.44(a)

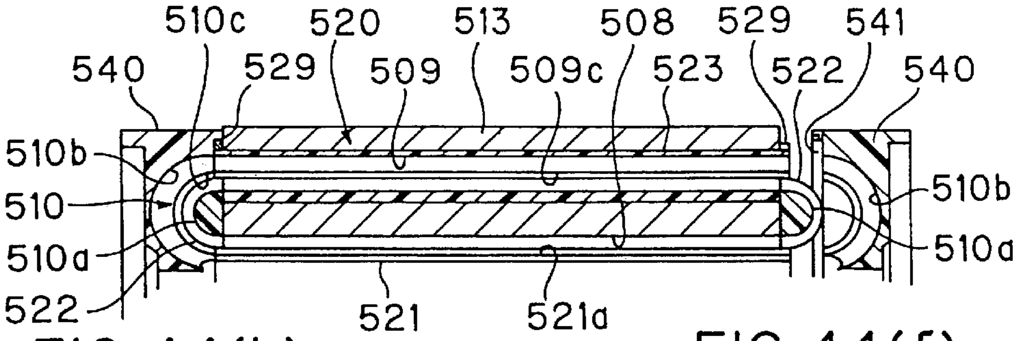


FIG.44(b)

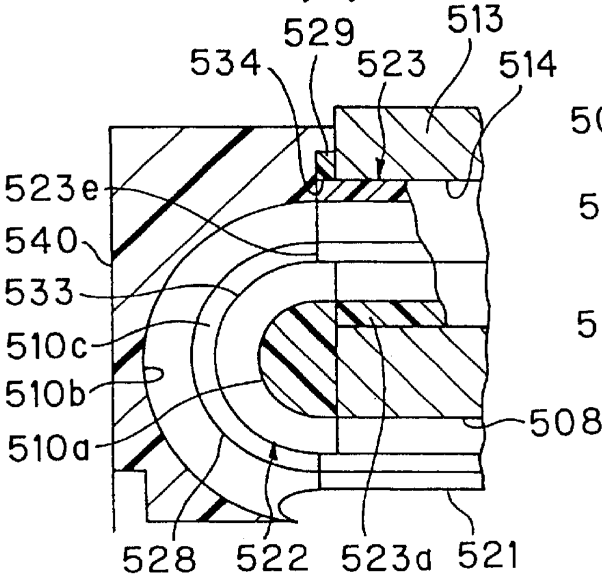


FIG.44(f)

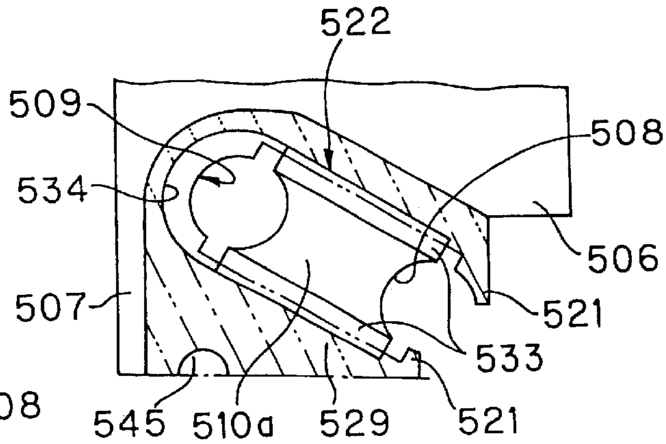


FIG.44(g)

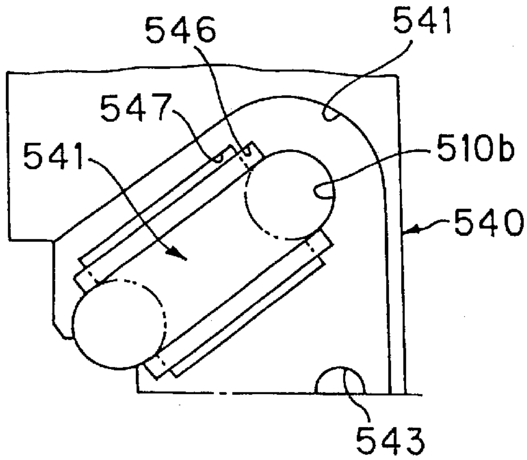


FIG.44(c)

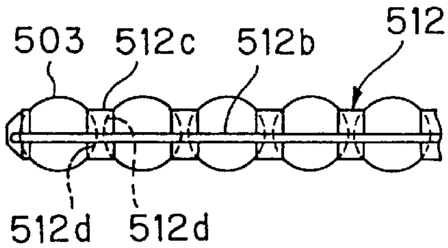


FIG.44(d)

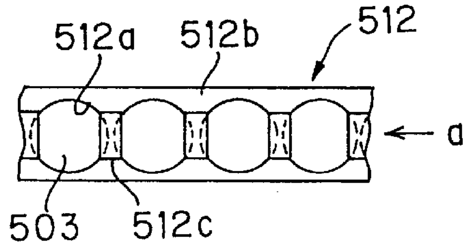
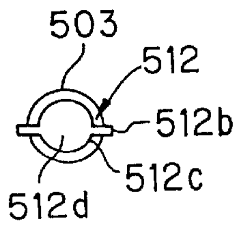


FIG.44(e)



LINEAR MOTION GUIDING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a division of application Ser. No. 09/088,491, filed Jun. 2, 1998 now U.S. Pat. No. 6,132,093.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a linear motion guiding apparatus in which a passage forming member formed of resin is built into a body of movable member.

2. Description of the Related Art

The applicant has already proposed a technical idea that, in a movable block of a linear motion guiding apparatus, a pair of ball passage forming portions extending along the opposite longitudinal sides of a loaded-ball running groove, a ball returning passage forming portion and a pair of direction changing passage-inner guide forming portions were integrally formed of resin with a body of the movable block (refer to Japanese Patent Provisional Publication No. H7-317,762).

More specifically, when a resin forming is carried out, the body of the movable block is inserted in a die, and the ball passage forming portions, the direction changing passage-inner guide forming portions or the ball returning passage forming portion is integrally formed with the block body.

In the conventional movable block obtained by the integral forming, the block body is inserted in the die, as mentioned above. When the block body has a large size, a large-scaled die is required to be used. It is not easy to prepare such a large-scaled die, and there is actual restriction in size. The ball passage forming portions located at the opposite longitudinal sides of the ball running groove extending along the longitudinal direction of the block body are thin and long, with the result that molten resin may not reach every part of the space for forming the ball passage forming portions during the resin forming treatment.

Increase in number of gates formed on the die may solve the above-mentioned problem of misrun of the molten resin. However, when the block body is inserted in the die, the block body may deteriorate the run of the molten resin.

When the movable block has a pair of wing portions, which face right and left-hand side portions of the guide rail so that the guide rail is held between the wing portions, and there are four trains of balls between the right and left-hand side portions of the guide rail and the right and left-hand wing portions of the moving block, and more specifically, the upper and lower trains of balls are arranged at each of a gap between the right-hand side portion of the guide rail and the corresponding right-hand wing portion of the moving block and another gap between the left-hand side portion of the guide rail and the corresponding left-hand wing portion of the moving block, the block body inserted in the die may deteriorate the run of the molten resin in the width direction of the moving block.

SUMMARY OF THE INVENTION

An object of the present invention is therefore to provide a linear motion guiding apparatus in which a resin-formed body for forming a rolling member circulation passage is formed separately from a body of a movable member so as to permit easy formation of the resin-formed body, and such a resin-formed body is able to be built in the body of the

movable member, ensuring integral formability of the maximum number of unit parts for defining the rolling member circulation passage.

In order to attain the aforementioned object, a linear motion guiding apparatus comprises:

a guide member provided with a rolling member running track, and

a movable member arranged so as to be movable along the guide member through a large number of rolling members, said movable member being provided with (i) a rolling member running counter-track corresponding to the rolling member running track of said guide member, (ii) a rolling member returning passage arranged away from said rolling member running counter-track by a prescribed distance and in parallel therewith and (iii) a pair of direction changing passages for connecting the rolling member running counter-track and the rolling member returning passage to permit circulation of the rolling members,

characterized in that:

a resin-formed body for forming a rolling member circulation passage comprises a pair of rolling member passage forming portions extending along both longitudinal sides of said rolling member running counter-track, a returning passage forming portion for forming the rolling member returning passage and a pair of direction changing passage-inner guide forming portions for forming inner peripheral guide portions of said direction changing passages, said resin-formed body being separately formed from a body of said movable member; and

at least two portions of (a) said pair of rolling member passage forming portions, (b) said returning passage forming portion, (c) one of said pair of direction changing passage-inner guide forming portions and (d) another of said pair of direction changing passage-inner guide forming portions are connected with each other through integral forming so that said resin-formed body can be built in the body of said movable member.

Embodiments of the combination of these portions (a) to (d) for the resin-formed body for forming the rolling member circulation passage may include the following three examples:

the first example in which the resin-formed body comprises (i) an integral body of the pair of rolling member passage forming portions and the pair of direction changing passage-inner guide forming portions, and (ii) the returning passage forming portion separately formed from the integral body the second example in which the resin-formed body comprises (i) an integral body of the pair of rolling member passage forming portions, the returning passage forming portion and one of the pair of direction changing passage-inner guide forming portions, and (ii) another of the pair of direction changing passage-inner guide forming portions separately formed from the integral body; and

the third example in which the resin-formed body is manufactured by preparing an integral body of the pair of rolling member passage forming portions, the returning passage forming portion and the pair of direction changing passage-inner guide forming portions, and then dividing the pair of rolling member passage forming portions and the returning passage forming portion in longitudinal intermediate portions thereof into respective two parts.

According to the present invention, the resin-formed body for forming the rolling member circulation passage is separately formed from the body of the movable member. Even if the movable member has a large size, the flow of molten resin is not therefore restricted by the body of the movable member unlike the conventional prior art in which the body of the movable member and the resin-formed body are integrally formed with each other, and it is possible to ensure proper run of molten resin through increase in a number of gates in the die, thus leading to an excellent formability. In general, it is hard to achieve proper run of molten resin especially at the rolling member passage forming portions extending along the longitudinal sides of the rolling member running counter-track, and it is therefore effective to separately form the resin-formed body from the body of the movable member in the same manner as the present invention.

The rolling member circulation passage is formed by the resin-formed body. Therefore, the direct positioning can be achieved in the relative positional relationship between the direction changing passage-inner guide forming portions and the rolling member passage forming portion, as well as the relative positional relationship between the direction changing passage-inner guide forming portions and the returning passage forming portion, and the continuity of the rolling member circulation passage is properly ensured, thus leading to smooth run of the rolling members.

Since the rolling member passage forming portions are located along the both longitudinal sides of the rolling member running counter-track, the direction changing passage-inner guide forming portions having a proper relative positional relationship with the rolling member passage forming portions are accurately set on the both ends of the rolling member running counter-track.

Maintenance of a proper relative positional relationship of the direction changing passage-inner guide forming portions with the rolling member returning passage causes the direction changing passage-inner guide forming portions to be accurately connected to the inner surface of the rolling member returning passage.

Especially, change in a running direction of the rolling members takes place in the connection area of the rolling member passage forming portions with the direction changing passage-inner guide forming portions as well as in the connection area of the direction changing passage-inner guide forming portions with returning passage forming portion. When two portions in such a connection area are connected with each other by integral forming, a step for assembling these two portions is not required, thus making it possible to ensure a smooth continuity of these two portions without being affected by accuracy of assembly.

The rolling member returning passage may be a through-hole formed in the body of the movable member, the resin formed-body may comprise the pair of direction changing passage-inner guide forming portions and the rolling member passage forming portions extending along the both longitudinal sides of the rolling member running counter-track, and the rolling member passage forming portions and at least one of the pair of direction changing passage-inner guide forming portions may be connected with each other through integral forming.

When the rolling member passage forming portions and the direction changing passage-inner guide forming portions are integrally formed with each other so as to provide the smooth connection area in this manner, it is possible to achieve the smooth run of the rolling members in the connection area of these portions, thus improving circulation property of the rolling member without providing any returning passage forming portion made of resin. Such a construction causes easy manufacture of the apparatus due to no existence of the returning passage forming portion.

The present invention may have additional features that a rolling member retainer is provided, the rolling member retainer being able to retain the rolling members in a train with a prescribed distance kept between adjacent two of the rolling members, and the rolling member retainer having side edge portions projecting from both sides of each of the rolling members; and guide grooves for guiding the side edge portions of the rolling member retainer are formed on an entire periphery of the rolling member circulation passage.

The present invention may have additional features that a retaining portion is provided on the rolling member passage forming portion, for preventing the rolling member retainer being out of place, when the movable member is removed from the guide member, and a guide portion is continuously formed on the entire periphery of the rolling member circulation passage, for guiding the side edge portions of the rolling member retainer.

Such provision of the rolling member retainer permits the smooth run of the rolling members by means of the rolling member retainer, due to proper maintenance of continuity of the guide portion for the rolling member retainer.

Since the guide portion for the rolling member retainer having a small thickness is not formed by inserting the body of the movable member in a die and then injecting molten resin into the die, but is separately formed from the body of the movable member, position of gates can freely be determined without being restricted by the body of the movable member, with the result that molten resin can reach, during formation of the guide portion, the entire space therefor, which is formed in the die.

The present invention may have additional features that each of the direction changing passage-inner guide forming portions has a thin sheet portion, which is to be brought into contact with the end face of the body of the movable member, and each of the direction changing passage-inner guide forming portions is connected to the rolling member passage forming portions or the returning passage forming portion by means of the thin sheet portion.

When each of the direction changing passage-inner guide forming portions is connected to the rolling member passage forming portions by means of the thin sheet portion, deformation of the thin sheet portion can absorb distortion, which occurs between the direction changing passage-inner guide forming portion and the rolling member passage forming portion, or between the direction changing passage-inner guide forming portion and the returning passage forming portion. Accordingly, it is possible to maintain an accurate positional relationship between the end of the direction changing passage-inner guide forming portion and the rolling member passage forming portion or between the direction changing passage-inner guide forming portion and the returning passage forming portion.

The thin sheet portion is urged against the flat end face of the body of the movable member by a clamping force, which is applied to the side cover plate. The position of the direction changing passage-inner guide forming portion can therefore be corrected through deformation of the thin sheet portion, even when the direction changing passage-inner guide forming portion is not correctly positioned relative to the end face of the body of the movable member. In addition, the thin sheet portion can firmly be secured between the side cover plate and the body of the movable member by the clamping force, which is applied to the side cover plate, thus preventing the direction changing passage-inner guide forming portion from being incorrectly placed.

The apparatus of the present invention may have the construction that the guide member comprises a guide rail; the movable member comprises a movable block, which is provided with a horizontal portion, which faces an upper surface of the guide rail and a pair of wing portions, between which the guide rail is held at right and left-hand side surfaces thereof; two trains of the rolling members are arranged in a gap between the upper surface of the guide rail and a lower surface of the movable block, and a single train of the rolling members is arranged in each of gaps between the right and left-hand side surfaces of the guide rail and both of the wing portions, so as to provide a total number of trains of four.

The apparatus of the present invention may have the construction that the guide member comprises a guide rail; the movable member comprises a movable block, which is provided with a pair of wing portions, between which the guide rail is held at right and left-hand side surfaces thereof; and two trains of the rolling members are arranged in each of gaps between the right and left-hand side surfaces of the guide rail and both of the wing portions, so as to provide a total number of trains of four.

In these cases, the respective four direction changing passage-inner guide forming portions may be formed into an integral body, or the respective two direction changing passage-inner guide forming portions at each of the right and left-hand sides of the movable block may be formed into an integral body.

The apparatus of the present invention may have the construction that the guide member comprises a guide rail; the movable member is provided with a horizontal portion, which faces an upper surface of the guide rail and a single wing portion, which faces one side surface of the guide rail; a single train of the rolling members is arranged in a gap between the one side surface of the guide rail and the single wing portion, and another single train of the rolling members is arranged in a gap between the upper surface of the guide rail and a lower surface of the horizontal portion in a vicinity of a corner of the guide rail.

The apparatus of the present invention may have the construction that the guide member comprises a guide rail; the movable member comprises a movable block, which is provided with a pair of wing portions, between which the guide rail is held at right and left-hand side surfaces thereof; and a single train of the rolling members is arranged in each of gaps between the right and left-hand side surfaces of the guide rail and both of the wing portions, so as to provide a total number of trains of two.

The apparatus of the present invention may have the construction that the guide member comprises a guide rail; the movable member comprises a movable block arranged along one side surface of the guide rail; and two trains of the rolling members are arranged in a gap between the one side surface of the guide rail and the movable block.

The apparatus of the present invention may have the construction that the guide member comprises a spline shaft; and the movable member comprises an outer tube, which is movably supported on the spline shaft through a plurality of trains of the rolling members.

In addition, according to the present invention, there is also provided a linear motion guiding apparatus comprising:

a guide rail provided with two rolling member running tracks on each of right and left-hand side surfaces of the guide rail, so as to provide a total number of the rolling member running tracks of four; and

a movable block provided with a pair of wing portions, between which the guide rail is held at the right and left-hand side surfaces thereof, each of said wing portions having on an inner surface thereof two rolling member running counter-tracks corresponding to said two rolling member running tracks of the guide rail, so as to provide a total number of the rolling member running counter-tracks of four, said movable block having four endless circulation passages, which are formed by four rolling member returning passages arranged in parallel with said four rolling member running counter-tracks, respectively, and rolling member returning, passages for connecting. both ends of each of said four rolling member running counter-tracks with both ends of each of said four rolling member returning passages, respectively

characterized in that:

a resin-formed body comprises, for each of said endless circulation passages, a pair of rolling member passage forming portions extending along both longitudinal sides of said rolling member running counter-track, a returning passage forming portion for forming the rolling member returning passage and a pair of direction changing passage-inner guide forming portions for forming inner peripheral guide portions of said direction changing passages, said resin-formed body being separately formed from a body of said movable block;

said resin-formed body is divided into two body-parts, which are arranged on the wing portions of the movable block, respectively, so as to form the two endless circulation passages at an inner side of each of the wing portions; and

in each of the two body-parts, the rolling member running counter-track and the pair of direction changing passage-inner guide forming portions are formed into an integral body, and the returning passage forming portion is separately formed from said integral body.

According to the present invention, the resin-formed body for forming the rolling member circulation passage is separately formed from the body of the movable block. Even if the movable block has a large size, the flow of molten resin is not therefore restricted by the body of the movable block unlike the conventional prior art in which the body of the movable block and the resin-formed body are integrally formed with each other, and it is possible to ensure proper run of molten resin through increase in a number of gates in the die, thus leading to an excellent formability. In general, it is hard to achieve proper run of molten resin especially at the rolling member passage forming portions extending along the longitudinal sides of the rolling member running counter-track, and it is therefore effective to separately form the resin-formed body from the body of the movable block in the same manner as the present invention.

Especially, since the resin-formed body is divided into the two body-parts, each of which forms two endless circulation passages, a proper run of molten resin can be ensured, even when the block of the movable block has a larger width.

The rolling member circulation passage is formed by the resin-formed body. Therefore, the direct positioning can be achieved in the relative positional relationship between the direction changing passage-inner guide forming portions and the rolling member passage forming portion, as well as the relative positional relationship between the direction changing passage-inner guide forming portions and the returning passage forming portion, and the continuity of the rolling member circulation passage is properly ensured, thus leading to smooth run of the rolling members.

Since the rolling member passage forming portions are located along the both longitudinal sides of the rolling member running counter-track, the direction changing passage-inner guide forming portions having a proper relative positional relationship with the rolling member passage forming portions are accurately set on the both ends of the rolling member running counter-track.

Maintenance of a proper relative positional relationship of the direction changing passage-inner guide forming portions with the rolling member returning passage causes the direction changing passage-inner guide forming portions to be accurately connected to the inner surface of the rolling member returning passage.

Especially, change in a running direction of the rolling members takes place in the connection area of the rolling member passage forming portions with the direction changing passage-inner guide forming portions. When these two portions in such a connection area are connected with each other by integral forming, a step for assembling these two portions is not required, thus making it possible to ensure a smooth continuity of these two portions without being affected by accuracy of assembly.

The present invention may have additional features that a rolling member retainer is provided, the rolling member retainer being able to retain the rolling members in a train with a prescribed distance kept between adjacent two of the rolling members, and the rolling member retainer having side edge portions projecting from both sides of each of the rolling members; and guide grooves for guiding the side edge portions of the rolling member retainer are formed on an entire periphery of the rolling member circulation passage.

Such provision of the rolling member retainer permits the smooth run of the rolling members by means of the rolling member retainer, due to proper maintenance of continuity of the guide portion for the rolling member retainer.

Since the guide portion for the rolling member retainer having a small thickness is not formed by inserting the body of the movable block in a die and then injecting molten resin into the die, but is separately formed from the body of the movable block, position of gates can freely be determined without being restricted by the body of the movable block, with the result that molten resin can reach, during formation of the guide portion, the entire space therefor, which is formed in the die.

The present invention may have additional features that each of the direction changing passage-inner guide forming portions has a thin sheet portion, which is to be brought into contact with the end face of the body of the movable block, and each of the direction changing passage-inner guide forming portions is connected to the rolling member passage forming portions or the returning passage forming portion by means of the thin sheet portion.

When each of the direction changing passage-inner guide forming portions is connected to the rolling member passage forming portions by means of the thin sheet portion, deformation of the thin sheet portion can absorb distortion, which occurs between the direction changing passage-inner guide forming portion and the rolling member passage forming portion, or between the direction changing passage-inner guide forming portion and the returning passage forming portion. Accordingly, it is possible to maintain an accurate positional relationship between the end of the direction changing passage-inner guide forming portion and the rolling member passage forming portion or between the direction changing passage-inner guide forming portion and the returning passage forming portion.

The thin sheet portion is urged against the flat end face of the body of the movable member by a clamping force, which is applied to the side cover plate. The position of the direction changing passage-inner guide forming portion can therefore be corrected through deformation of the thin sheet portion, even when the direction changing passage-inner guide forming portion is not correctly positioned relative to the end face of the body of the movable block. In addition, the thin sheet portion can firmly be secured between the side cover plate and the body of the movable block by the clamping force, which is applied to the side cover plate, thus preventing the direction changing passage-inner guide forming portion from being incorrectly placed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic disassembling perspective view illustrating a movable block of a linear motion guiding apparatus of the first embodiment of the present invention;

FIG. **2** shows a resin frame member as shown in FIG. **1**, as one of resin-formed bodies for forming a ball circulation passage, and more specifically, FIG. **2**(*a*) is a front view of the resin frame member, FIG. **2**(*b*) is a side view thereof, FIG. **2**(*c*) is a cross-sectional view cut along the line C—C as indicated in FIG. **2**(*a*), FIG. **2**(*d*) is a cross-sectional view cut along the line D—D as indicated in FIG. **2**(*b*), FIG. **2**(*e*) is an enlarged cross-sectional view cut along the line E—E as indicated in FIG. **2**(*a*) and FIG. **2**(*f*) is an enlarged cross-sectional view cut along the line F—F as indicated in FIG. **2**(*a*);

FIG. **3**(*a*) is a front view having a cross-section, illustrating the linear motion guiding apparatus of the first embodiment of the present invention as shown in FIG. **1**, FIG. **3**(*b*) is a front view of the apparatus as shown in FIG. **3**(*a*), in which a half portion of a side cover plate is omitted, and FIGS. **3**(*c*) to (*f*) are partially cross-sectional views illustrating embodiments of the structure of a ball passage forming portion and the vicinity thereof, as shown in FIG. **3**(*a*);

FIG. **4**(*a*) is a side view having a partial cross section, of the linear motion guiding apparatus of the first embodiment of the present invention, FIG. **4**(*b*) is a cross-sectional view of a ball circulation passage of the movable block as shown in FIG. 4(A), from which a ball retainer is removed, FIG. **4**(*c*) is a partial side view of the ball retainer, FIG. **4**(*d*) is a plan view of the ball retainer as shown in FIG. **4**(*c*) and FIG. **4**(*e*) is a view of the ball retainer, with sight being placed in a direction of an arrow of "a" as indicated in FIG. **4**(*d*);

FIG. **5** shows a side cover plate of the movable block, and more specifically, FIG. **5**(*a*) is a front view of the side cover plate, FIG. **5**(*b*) is a back view thereof and FIG. **5**(*c*) is a transverse sectional view thereof at its central portion;

FIGS. **6**(*a*) to **6**(*i*) are descriptive views illustrating steps for assembling the movable block as shown in FIG. **1**;

FIG. **7**(*a*) is an enlarged partial view of the direction changing passage as shown in FIG. **4***b*), FIG. **7**(*b*) is a partial side view of the direction changing passage as shown in FIG. **4**(*b*), in which the side cover plate is removed, FIG. **7**(*c*) is a partial side view illustrating a recess portion, which forms the direction changing passage in the side cover plate as shown in FIG. **7**(*a*), FIG. **7**(*d*) is a partial cross-sectional view of an outer peripheral side-half pipe member for forming a part of a resin pipe as shown in FIG. **7**(*a*), FIG. **7**(*e*) is a side view of the outer peripheral side-half pipe member as shown in FIG. **7**(*d*), FIG. **7**(*f*) is a partial cross-sectional view of an inner peripheral side-half pipe member for forming another part of the resin pipe as shown in FIG. 7(*a*), FIG. 7(*g*) is a side view of the inner peripheral side-half pipe member as shown in FIG. 7(*f*);

FIG. **8** is a schematic disassembling perspective view illustrating the first modification of the resin-formed body for forming the ball circulation passage in the first embodiment of the present invention;

FIG. **9**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in

FIG. **8**, FIG. **9**(*b*) is a view illustrating the first resin frame of the resin-formed body, FIG. **9**(*c*) is a view illustrating the second resin frame thereof, FIG. **9**(*d*) is a back view of the first resin frame and FIG. **9**(*e*) is a back view of the second resin frame;

FIG. **10** is a schematic disassembling perspective view illustrating the second modification of the resin-formed body for forming the ball circulation passage in the first embodiment of the present invention;

FIG. **11**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in FIG. **10**, FIG. **11**(*b*) is a side view illustrating the connecting end of one of divided resin frames, as shown in FIG. **11**(*a*) and FIG. **11**(*c*) is an enlarged cross-sectional view illustrating the connecting portion of the resin frames;

FIG. **12** is a schematic disassembling perspective view illustrating the third modification of the resin-formed body for forming the ball circulation passage in the first embodiment of the present invention;

FIG. **13**(*a*) is a side view having a partial cross section, illustrating the linear motion guiding apparatus, in which the movable block as shown in FIG. **12** is used, and FIG. **13**(*b*) is a cross-sectional view of the resin-formed body for forming the ball circulation passage as shown in FIG. **13**(*a*);

FIG. **14**(*a*) is an enlarged partial cross-sectional view of the direction changing passage as shown in FIG. **13**(*b*), which is formed in the side cover plate removed from the ball passage forming portion, FIG. **14**(*b*) is a partial cross-sectional view illustrating the side cover as shown in FIG. **14**(*a*), which is secured to the ball passage forming portion, FIG. **14**(*c*) is a partial side view illustrating the ball passage forming portion, in which the side cover plate as shown in FIG. **14**(*a*) is removed, and FIG. **14**(*d*) is a partial side view illustrating a recess portion, which forms the direction changing passage in the side cover plate as shown in FIG. **14**(*a*);

FIG. **15** is a schematic disassembling perspective view illustrating the fourth modification of the resin-formed body for forming the ball circulation passage in the first embodiment of the present invention;

FIGS. **16**(*a*) to **16**(*h*) are descriptive views illustrating the other embodiments of arrangement of the trains of balls in the linear motion guiding apparatus of the first embodiment of the present invention;

FIG. **17** is a perspective view illustrating the constructional elements other than the resin-formed body for forming the ball circulation passage of the linear motion guiding apparatus as shown in FIG. **16**(*a*), which is provided with two trains of balls at each of the both sides;

FIG. **18** is a schematic disassembling perspective view illustrating a movable block of a linear motion guiding apparatus of the second embodiment of the present invention;

FIG. **19**(*a*) is a front view illustrating the linear motion guiding apparatus of the second embodiment of the present invention as shown in FIG. **18**, FIG. **19**(*b*) is a partial cross-sectional view illustrating one ball circulation passage of the apparatus as shown in FIG. **19**(*a*), FIG. **19**(*c*) is a partial plan view of a roller retainer as shown in FIG. **19**(*b*) and FIG. **19**(*d*) is a view of the roller retainer, with sight being placed in a direction of an arrow of "d" as indicated in FIG. **19**(*c*);

FIG. **20** shows the resin-formed body for forming the ball circulation passage as shown in FIG. **18**, and more specifically, FIG. **20**(*a*) is a cross-sectional view cut along the line a—a as indicated in FIG. **20**(*b*), FIG. **20**(*b*) is a front view of the resin-formed body for forming the ball circulation passage as shown in FIG. **20**(*a*), FIG. **20**(*c*) is a partial side view of the resin-formed body for forming the ball circulation passage, in which the resin pipe as shown in FIG. **20**(*a*) is removed, FIG. **20**(*d*) is a cross-sectional view of an outer peripheral side-half pipe member for forming a part of a resin pipe as shown in FIG. **20**(*a*), FIG. **20**(*e*) is a side view of the outer peripheral side-half pipe member as shown in FIG. **20**(*d*), FIG. **20**(*f*) is a cross-sectional view of an inner peripheral side-half pipe member for forming another part of the resin pipe as shown in FIG. **20**(*a*), FIG. **20**(*g*) is a side view of the inner peripheral side-half pipe member as shown in FIG. **20**(*g*) and FIG. **20**(*h*) is a partial cross-sectional view illustrating the constructional example of the roller passage forming portion, in which the roller retainer is not used;

FIG. **21** is a schematic disassembling perspective view illustrating the first modification of the resin-formed body for forming the ball circulation passage in the second embodiment of the present invention;

FIG. **22**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in

FIG. **21**, FIG. **22**(*b*) is a view illustrating the first resin frame as shown in FIG. **22**(*a*), with sight being placed on the divided end side thereof and FIG. **22**(*c*) is a view illustrating the second resin frame as shown in FIG. **22**(*a*), with sight being placed on the divided end side thereof;

FIG. **23** is a schematic disassembling perspective view illustrating the second modification of the resin-formed body for forming the ball circulation passage in the second embodiment of the present invention;

FIG. **24**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in FIG. **23**, FIG. **24**(*b*) is a view illustrating one resin frame as shown in FIG. **24**(*a*), with sight being placed on the divided end side thereof and FIG. **24**(*c*) is a view illustrating the other resin frame as shown in FIG. **24**(*a*), with sight being placed on the divided end side thereof;

FIG. **25** is a schematic disassembling perspective view illustrating the third modification of the resin-formed body for forming the ball circulation passage in the second embodiment of the present invention;

FIG. **26** is a schematic disassembling perspective view illustrating the fourth modification of the resin-formed body for forming the ball circulation passage in the second embodiment of the present invention;

FIG. **27** is a front view having a cross-sectional half portion, illustrating the other embodiment of arrangement of the trains of balls in the linear motion guiding apparatus of the second embodiment of the present invention;

FIG. **28** is a schematic disassembling perspective view of an outer tube of a ball-spline as a linear motion guiding apparatus of the third embodiment of the present invention;

FIG. 29(*a*) is a front view having a cross-section, illustrating the ball spline of the third embodiment of the present invention, in which the outer tube as shown in FIG. 28 is used, FIG. 29(*b*) is a partial cross-sectional view illustrating one ball circulation passage of the apparatus as shown in FIG. 29(*a*) and FIG. 29(*c*) is a disassembling cross-sectional view illustrating the construction of the ball circulation passage, in which the roller retainer as shown in FIG. 29(*b*) is removed;

FIG. 30 shows the resin-formed body for forming the ball circulation passage as shown in FIG. 29, and more specifically, FIG. 30(*a*) is a cross-sectional view cut along the line a—a as indicated in FIG. 30(*b*), FIG. 30(*b*) is a front view of the resin-formed body for forming the ball circulation passage as shown in FIG. 30(*a*), FIG. 30(*c*) is a partial side view of the resin-formed body for forming the ball circulation passage, in which the resin pipe as shown in FIG. 30(*a*) is removed, FIG. 30(*d*) is a cross-sectional view of an outer peripheral side-half pipe member for forming a part of a resin pipe as shown in FIG. 30(*a*), FIG. 30(*e*) is a side view of the outer peripheral side-half pipe member as shown in FIG. 30(*d*), FIG. 30(*f*) is a cross-sectional view of an inner peripheral side-half pipe member for forming another part of the resin pipe as shown in FIG. 30(*a*) and FIG. 30(*g*) is a side view of the inner peripheral side-half pipe member as shown in FIG. 30(*f*);

FIG. 31 is a schematic disassembling perspective view illustrating the first modification of the resin-formed body for forming the ball circulation passage in the third embodiment of the present invention;

FIG. 32(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in FIG. 31, FIG. 32(*b*) is a view illustrating the first resin frame as shown in FIG. 32(*a*), with sight being placed on the divided end side thereof and FIG. 32(*c*) is a view illustrating the second resin frame as shown in FIG. 32(*a*), with sight being placed on the divided end side thereof;

FIG. 33 is a schematic disassembling perspective view illustrating the second modification of the resin-formed body for forming the ball circulation passage in the third embodiment of the present invention;

FIG. 34(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in FIG. 33, FIG. 34(*b*) is a view illustrating one resin frame as shown in FIG. 34(*a*), with sight being placed on the divided end side thereof and FIG. 34(*c*) is a view illustrating the other resin frame as shown in FIG. 34(*a*), with sight being placed on the divided end side thereof;

FIG. 35 is a schematic disassembling perspective view illustrating the third modification of the resin-formed body for forming the ball circulation passage in the third embodiment of the present invention;

FIG. 36 is a schematic disassembling perspective view illustrating the fourth modification of the resin-formed body for forming the ball circulation passage in the third embodiment of the present invention;

FIG. 37 is a front view having a partial cross-section, illustrating the another embodiment of arrangement of the trains of balls in the ball spline as the linear motion guiding apparatus of the third embodiment of the present invention;

FIG. 38(*a*) is a front view having a partial cross-section, illustrating a roller-spline as the linear motion guiding apparatus of the fourth embodiment of the present invention, in which a side cover plate is removed, and FIG. 38(*b*) is a longitudinal partial cross-sectional view of one roller circulation passage as shown in FIG. 38(*b*);

FIG. 39(*a*) is a partial cross-sectional view illustrating the constructional example of the resin-formed body for forming the roller circulation passage of the roller spline as shown in FIG. 38, and FIGS. 39(*b*) to 39(*e*) are views illustrating the first to fourth modifications of the resin-formed body for forming the roller circulation passage;

FIG. 40(*a*) is a front view of the movable block of the linear motion guiding apparatus of the fourth embodiment of the present invention, in which the side cover plate is removed, and FIG. 40(*b*) is a perspective view of the movable block as shown in FIG. 40(*a*);

FIG. 41 is a schematic disassembling perspective view of the resinformed bodies for forming the ball circulation passage as shown in FIG. 40;

FIG. 42 is a front view of the resin frame composing the resin-formed body for forming the ball circulation passage, as shown in FIG. 41, FIG. 42(*b*) is a left-hand side view of the resin-formed body as shown in FIG. 42(*a*) and FIG. 42(*c*) is a right-hand side view of the resin-formed body as shown in FIG. 42(*a*);

FIG. 43 shows a resin pipe for forming a part of the resin-formed body for forming the ball circulation passage, as shown in FIG. 41, and more specifically, FIG. 43(*a*) is a front view of an outer peripheral side-half pipe member, FIG. 43(*b*) is a side view of the outer peripheral side-half pipe member as shown in FIG. 43(*a*), FIG. 43(*c*) is a front view of an inner peripheral side-half pipe member, FIG. 43(*d*) is a side view of the inner peripheral side-half pipe member as shown in FIG. 43(*c*); and

FIG. 44(*a*) is a cross-sectional view of one ball circulation passage, in which the ball retainer is removed from the movable block as shown in FIG. 40(*a*), FIG. 44(*b*) is an enlarged partial view of the direction changing passage as shown in FIG. 44(*a*), FIG. 44(*c*) is a partial side view of the ball retainer, FIG. 44(*d*) is a plan view of the ball retainer as shown in FIG. 44(*c*), FIG. 44(*e*) is a view of the ball retainer, with sight being placed in a direction of an arrow of "a" as indicated in FIG. 44(*d*), FIG. 44(*f*) is a partial side view of the direction changing passage as shown in FIG. 44(*b*), in which the side cover plate is removed, and FIG. 44(*g*) is a partial side view illustrating a recess portion, which forms the direction changing passage in the side cover plate as shown in FIG. 44(*b*).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now, embodiments of a linear motion guiding apparatus the present invention will be described in detail below with reference to the accompanying drawings.

[FIRST EMBODIMENT]

FIGS. 1 to 7 show a linear motion guiding apparatus of the first embodiment of the present invention.

The linear motion guiding apparatus **1** is provided with a guide rail **2** as a guide member, which extends linearly, and a movable block **4** as a movable member, which is arranged so as to be movable along the guide rail **2** through a large number of balls **3** as rolling members.

The guide rail **2** is formed into a long bar shape having a rectangular cross-section. Two ball running grooves **5, 5** as a rolling member running track are formed on the horizontal upper surface of the guide rail **2**, and a single ball running groove **5** as the rolling member running track is formed on each of the right and left-hand vertical surfaces of the guide rail **2**, so as to provide a total number of grooves **5** of four.

The movable block **4** is formed as a block body having an inverse U-shaped cross-section, with its opening end being directed downwardly. The block body is provided with a horizontal portion **6**, which faces the upper surface of the guide rail **2** and with a pair of wing portions **7, 7**, which extend downwardly from the right and left ends of the horizontal portion **6** and face the right and left-hand side surfaces of the guide rail **2**, respectively. The horizontal portion **6** has on its lower surface two ball running counter-grooves **8, 8** as a rolling member running counter-track, which correspond to the ball running grooves **5, 5** formed on the upper surface of the guide rail **2**. Each of the wing portions **7, 7** has on its inner surface a single ball running counter-groove **8** as the rolling member running counter-track, which corresponds to the respective ball running grooves **5, 5** formed on the right and left-hand side surfaces of the guide rail **2**.

In addition, in the movable block **4**, there are formed four ball returning passages **9, 9, 9, 9** as a rolling member returning passage, which are provided in parallel with the four ball running counter-grooves **8, 8, 8, 8**, respectively, as well as four pairs of direction changing passages **10, 10, 10, 10** each having a U-shape, for connecting the respective both ends of the ball running counter-grooves **8, 8, 8, 8** with the respective both ends of the ball returning passages **9, 9, 9, 9**, so as to form four endless circulation passages. The ball returning passages **9, 9** respectively corresponding to the ball running grooves **5, 5** formed on the upper side of the guide rail **2** are formed in the horizontal portion **6**. The other ball returning passages **9, 9** respectively corresponding to the ball running grooves **5, 5** formed on the right and lefthand vertical surfaces of the guide rail **2** are formed in the wing portions **7, 7** of the movable block **4**, respectively.

In each of the four endless circulation passages in this embodiment, the balls **3** are retained in the form of train by means a ball retainer **12** as a rolling member retainer, as shown in FIG. **4** so that the balls **3** can be circulated while being guided by the ball retainer **12**.

The ball retainer **12** comprises a flexible belt portion **12*b***, which is provided with ball holes **12*a*** for respectively receiving the balls **3**, and spacing portions **12*c*** provided between the adjacent two balls **3, 3**. The belt portion **12*b*** has a width longer than the diameter of the ball **3** so that the both side edges of the belt portion **12*b*** extend outwardly from the ball **3**.

The spacing portion **12*c*** is provided with a ball supporting spherical recess **12*d*** corresponding to the spherical surface of the ball **3**. The ball **3** is supported on its both sides by a pair of supporting spherical recesses **12*d*** so as to prevent the ball **3** from coming off the belt portion **12*b***. In this embodiment, the one end of the belt portion **12*b*** is not connected to the other end thereof, thus forming a strip-shaped belt having the both ends. The one end of the belt portion **12*b*** may be connected to the other end thereof so as to form an endless belt.

The movable block **4** is composed of a block body **13** having ball running counter-grooves **8, 8, 8, 8**, a resin-formed body **20** for forming ball circulation passages, which is inserted in the block body **13**, and a pair of side cover plates **40, 40** secured to the both end surfaces of the block body **13**, in which the resin-formed body **20** is inserted.

Each of the ball circulation passages of the resin-formed body **20** comprises a pair of ball passage forming portions **21, 21** extending along both longitudinal sides of the ball running counter-groove **8**, a pair of direction changing passage inner guide forming portion **22, 22** provided on the both side surfaces of the block body **13**, and a resin pipe **23** as a returning passage forming portion, which is inserted into a through-hole formed in the block body **13**. In this embodiment, the ball passage forming portions **21, 21** and the pair of direction changing passage-inner guide forming portions **22, 22** are integrally formed with each other into an integral body, and the resin pipe **23** is separately formed from the above-mentioned integral body. More specifically, there is used a construction that the ball passage forming portions **21, 21** and the pair of direction changing passage-inner guide forming portions **22, 22** are integrally connected with each other through integral forming to form an integral resin frame **24**, and the four resin pipes **23** can respectively be inserted into the block body **13**.

The ball passage forming portions **21, 21** are provided with guide grooves for guiding the both side edges of the belt portion **12*b*** of the ball retainer **12** in a loaded area. The guide grooves can prevent the ball retainer **12** not only from being swung during run of the ball, but also from being sagged by engaging the side edges of the belt portion **12*b*** with the guide groove **21*a***, when the movable block **4** is removed from the guide rail **2**. The balls **3** are supported by the ball retainer **12**. More specifically, the ball retainer **12** is supported by a jaw portion of the guide groove **21*a***, with the result that the balls **3** are kept in its proper position so as not to come off the movable block **4**.

In this embodiment, a distance between the pair of ball passage forming portions **21, 21** arranged in parallel with each other on the both longitudinal sides of the ball running counter-groove **8** is slightly larger than the diameter of the ball **3**. The balls **3** come off the ball running counter-groove **8**, if the ball retainer **12** is not used. When an amount of projection of the jaw portion **21*b*** is predetermined so that a distance between the pair of ball passage forming portions **21, 21** is slightly smaller than the diameter of the ball **3** as shown in FIG. **3(*d*)**, it is however possible to prevent the balls **3** from coming off the ball running counter-groove **8** even without the ball retainer **12**. Such a construction can apply not only to the case where the balls **3** are inserted into the ball circulation passage with the use of the ball retainer **12**, but also to the case where the balls are inserted therein without the ball retainer **12**. The distance between the pair of ball passage forming portions **21, 21** may be slightly smaller than the diameter of the ball **3** so that the ball passage forming portions **21, 21** directly hold the ball **3** without the use of the ball retainer **12** as shown in FIG. **3(*e*)**.

Guide grooves **9*c*, 10*c*** are also formed in the ball returning passage **9** and the direction changing passage **10** as non-loaded areas, in order to guide the side edges of the belt portion **12*b***. The guide grooves **9*c*, 10*c*** are connected to the above-mentioned guide groove **21*a*** in the loaded area so as to form an endless groove on the entire periphery.

When the ball retainer **12** is not used as shown in FIG. **3(*f*)**, the distance between the pair of ball passage forming portions **21, 21** arranged on the both longitudinal sides of the ball running counter-groove **8**, which portions do not have any jaw portions **21**, may be slightly smaller than the diameter of the ball **3**, thus preventing the balls **3** from coming off the ball running counter-groove **8**.

The four sets of ball passage forming portions **21, 21** are composed of the first thin connecting plate portion **25** extending longitudinally along the under surface of the horizontal portion **6** of the block body **13**, a pair of second connecting plate portions **26, 26**, which have an L-shaped cross section and extend in the longitudinal direction of the block body **13** along the corner portions between the horizontal portion **6** and the wing portions **7, 7** of the block body **13**, and a pair of third connecting plate portions **27, 27**, which extend in the longitudinal direction of the block body **13** along the lower surfaces of the wing portions **7**, **7** of the block body **13**.

More specifically, the right and left-hand side edges of the first connecting plate portion **25** and the upper edges of the pair of right and left-hand second connecting plate portions **26**, **26** are located at the both sides of the respective ball running counter-grooves **8**, **8** provided on the under surface of the horizontal portion **6**, so as to form the ball passage forming portions **21**, **21**; **21**, **21**. The lower edges of the second connecting plate portions **26**, **26** and the inner edges of the third connecting plate portions **27**, **27** are located at the both sides of the respective ball running counter-grooves **8**, **8** provided on the respective inner surface of the wing portions **7**, **7**, so as to form the other ball passage forming portions **21**, **21**; **21**, **21**.

The direction changing passage-inner guide forming portion **22** has a thin sheet portion **29**, which is to be connected to the end surface of the block body **13**. The ball passage forming portions **21**, **21** and the resin pipe **23** are connected through the above-mentioned thin sheet portion **29**. In this embodiment, the direction changing passage-inner guide forming portions **22**, **22** and the ball passage forming portions **21**, **21** are connected by means of the thin sheet portion **29** through integral forming. The resin pipe **23** is inserted in a hole **34** formed on the thin sheet portion **29** so as to make a faucet joint, and fixed to the thin sheet portion **29**.

The thin sheet portion **29** has the first end plate portion **30** corresponding to the end surface of the horizontal portion **6** of the block body **13**, a pair of third end plate portions **32**, **32** corresponding to the end surfaces of the wing portions **7**, **7** and the second end plate portions **31**, **31** for connecting the first end plate portion **30** and the respective third end plate portions **32**, **32**. The first end plate portion **30** has the direction changing passage-inner guide forming portions **22**, **22**, which are formed so as to project corresponding to the two trains of balls **3**, **3** on the upper surface side of the guide rail **2**. Each of the third end plate portions **32**, **32** has the direction changing passage-inner guide forming portion **22**, which is formed so as to project corresponding to the single train of balls **3** on the side surface of the guide rail **2**

The first end plate portions **30**, **30**, which are to be placed respectively on the both ends of the block body **13** are connected at its lower portion with the both ends of the first connecting plate portion **25** extending longitudinally between the first end plate portions **30**, **30**. The second end plate portions **31**, **31**, which are to be placed respectively on the both ends of the block body **13** are connected at its inner edge portion with the both ends of the second connecting plate portion **26** extending longitudinally between the second end plate portions **31**, **31**. The other second end plate portions **31**, **31** have the same connecting structure. The third end plate portions **32**, **32**, which are to be placed respectively on the both ends of the block body **13** are connected at its inner edge portion with the both ends of the third connecting plate portion **27** extending longitudinally between the third end plate portions **32**, **32**. The other third end plate portions **32**, **32** have the same connecting structure. A single resin frame **24** is formed in this way.

Each of the direction changing passage-inner guide forming portions **22** has a semi-cylindrical shape. On the outer periphery of the direction changing passage-inner guide forming portion **22**, there is formed an inner guide-groove **10***a* -having a semi-circular cross-section so as to form the inner guide portion for the direction changing passage **10**. The one end of the inner guide groove **10***a* is connected to the end of the ball running counter-groove **8**. Accordingly, the one end of the inner guide groove **10***a* has the same cross-sectional shape as the ball running counter-groove **8** so as to make an alignment of the one end of the inner guide groove **10***a* with the end of the ball running counter-groove **8**. The other end of the inner guide groove **10***a* of the direction changing passage **10** is connected to the end of the ball returning passage **9**. Accordingly, the other end of the inner guide groove **10***a* has the same cross-sectional shape as the ball returning passage **9** so as to make an alignment of the other end of the inner guide groove **10***a* with the end of the ball returning passage **9**.

Cylindrical flange portions **33**, **33** are formed on the both ends of the inner guide groove **10***a*. The distance between the respective outer surfaces of the cylindrical flange portions **33**, **33** is larger than the width of the belt portion **12***b*. The cylindrical flange portions **33**, **33** form a retainer-guide groove **10***c* for the ball retainer **12** in cooperation with a semi-circular recess portion having cutouts, which is formed on the inner periphery of the recess of the side cover plate **40**, described later.

The both ends of the inner guide groove **10***a* for the direction changing passage **10** extend to the contacting surface of the first and third end plate portions **30**, **32** with the end surface of the block body **13** so as to be connected to the respective ends of the ball running counter-groove **8** and the ball returning passage **9**. Pipe inserting holes **34**, **34**, **34**, **34** having a semi-circular shape, in which the ends of the resin pipes **23** are to be inserted are formed on the first and third end plate portions **30**, **32**.

As shown in FIG. **7**, the resin pipe **23** is composed of an inner peripheral side-half pipe member **23***a* located in the inner peripheral side of the ball circulation passage, which is continuously connected to the inner guide groove **10***a* for the direction changing passage, and an outer peripheral side-half pipe member **23***b* located in the outer peripheral side of the ball circulation passage, which is continuously connected to an outer guide groove **10***b* for the direction changing passage **10**, which is formed on the side cover plate **40**. The inner peripheral side-half pipe member **23***a* has a groove portion **9***a* having a semi-circular cross section, and side edge portions **23***c* extending longitudinally along the groove portion **9***a*.

The outer peripheral side-half pipe member **23***b* is formed into a linear member having the same circular cross section as the outer guide groove **10***b* for the direction changing passage, which is formed on the side cover plate **40**. The outer peripheral side-half pipe member **23***b* has a groove portion **9***b*, which is continuously connected to the outer guide groove **10***b*, and side edge portions **23***d* extending longitudinally along the groove portion **9***b*. The side edge portions **23***d* is provided on its outer edges with projections **23***e*, which are to be brought into contact with the outer edges of the side edge portions **23***c* of the inner peripheral side-half pipe member **23***a* to form the retainer-guide groove **9***c* for the ball retainer **12**.

The inner peripheral side-half pipe member **23***a* of the resin pipe **23** has the same length of the block body **13**. The inner peripheral side-half pipe member **23***a* is positioned so as to be brought into contact with the back surface of the direction changing passage-inner guide forming portion **22**.

The outer peripheral side-half pipe member **23***b* of the resin pipe **23** has on the other hand a longer length than the block body **13** by a length corresponding to the thickness of the thin sheet portion **29**. The outer peripheral side-half pipe members **23***b* are inserted in the inserting holes **34** of the first and third end plate portions **30**, **32**. Longitudinal positional determination of the outer peripheral side-half pipe member **23***b* is made by bringing the both ends of the outer peripheral side-half pipe member **23***b* inserted in the inserting holes **34** into contact with the peripheral edge of the end portion of the outer guide grooves **10***b* for the direction changing passage, which are formed on the side cover plate **40**. The projections **23***e* formed on the both side edges of the outer peripheral side-half pipe member **23***b* come into contact with the outer edges of the cylindrical flange portions **33** formed on the direction changing passage-inner guide forming portion **22** to form a part of the guide groove **10***c*, and the outer peripheral side-half pipe member **23***b* and the inner peripheral side-half pipe member **23***a* are restricted to be turned in the inserting hole **14**.

The resin pipes **23** and the direction changing passage-inner guide forming portions **22** are accurately positioned through the inserting holes **34** formed on the first and third end plate portions **30**, **32** of the thin sheet portion **29** and a proper assembling is carried out in this manner.

As shown in FIG. **5**, the side cover plate **40** is provided with an inserting recess portion **40***a*, in which the thin sheet portion **29** is inserted, four recess portions **41** having the outer guide grooves **10***b* for the direction changing passage, into which portions the direction changing passage-inner guide forming portions **22** are fitted, and screw-fixing portions for securing the side cover plate **40** to the block body **13**. In the screw-fixing portions, the side cover plate **40** is fixed to the block body **13** by inserting bolts **44** into holes **43** formed on the side cover plate **40** and engaging the bolts with screwed holes **45** formed on the end surface of the block body **13**. The holes **43** are located between the first and third end plate portions **30**, **32** of the thin sheet portion

As shown in FIG. **7**, the outer guide groove **10***b* for the direction changing passage in the recess portion **41** has on its side edges larger-diameter arcuate recesses **46**, which form the retainer-guide groove **10***c* in cooperation with the cylindrical flange portions **33** of the direction changing passage-inner guide forming portions **22**, and a smaller-diameter arcuate recesses **47**, in which the cylindrical flange portions **33** are inserted. The direction changing passage-inner guide forming portion **22** provided with the inner guide groove **10***a* for the direction changing passage is fitted into the recess portion **41** of the side cover plate **40**, and the thin sheet portion **29** is received in the inserting recess portion **40***a* of the side cover plate **40**. The thin sheet portion **29** is held between the side cover plate **40** and the end surface of the block body **13** through a clamping force so as to be firmly fixed therebetween.

The direction changing passage-inner guide forming portions **22** and the ball passage forming portion **21** are connected through the thin sheet portion **29**, thus making it possible to maintain an accurate positional relationship of the end of the inner guide groove **10***a* for the direction changing passage formed in the direction changing passage-inner guide forming portion **22** relative to the ball passage forming portions **21**, **21**, as well as an accurate positional relationship of the inner guide groove **10***a* for the direction changing passage relative to the ball returning passage **9**.

The thin sheet portion **29** located in the vicinity of the direction changing passage-inner guide forming portion **22** is uniformly urged against the flat end surface of the block body **13** through a clamping force applied to the side cover plate **40** (see FIG. **7**). Even when the direction changing passage-inner guide forming portion **22** is not located in a correct position, the thin sheet portion **29** changes its shape on the end surface of the block body **13**, thus permitting the correct positioning of the direction changing passage-inner guide forming portion **22**. The thin sheet portion **29** is firmly clamped and fixed through a clamping force, which is applied to the side cover plate **40**, and frictional force caused by such a clamping step may prevent an unfavorable movement of the inner guide groove **10***a* for the direction changing passage.

The side cover plate **40** is secured to the block body **13** so that the direction changing passage-inner guide forming portion **22** assembled to the block body **13** is fitted into the recess portion **41** of the side cover plate **40**. Such a fitting step permits to make an accurate positioning of the side cover plate **40** relative to the block body **13**.

FIG. **6** shows assembling steps for the above-described resin-formed body for forming the ball circulation passage.

First, the inner peripheral side-half pipe member **23***a* of the resin pipe **23** is inserted in the through-hole **14** of the block body **13** (see FIGS. **6**(*a*) and **6**(*b*)).

Then, the resin frame **24** obtained by integral forming is inserted in the recess of the block body **13**, while causing the thin sheet portions **29** at the both ends of the resin frame **24** to slide on the respective end surfaces of the block body **13** (see FIGS. **6**(*c*) and **6**(*d*)). The first connecting plate portion **25** of the resin frame **24** comes into contact with the under surface of the horizontal portion **6**, thus making positional determination in the vertical direction of the resin frame **24**. The second connecting plate portion **26** and the third connecting plate portion **27** of the resin frame **24** come into contact with the respective inner surfaces of the wing portions **7**, **7** of the block body **13**, thus making positional determination of the ball passage forming portions **21**, **21** and the direction changing passage-inner guide forming portion **22** (see FIGS. **6**(*e*) and **6**(*f*). At this time, the inserting hole **34** of the thin sheet portion **29** is aligned with the through-hole **14** of the block body **13**.

Then, the outer peripheral side-half pipe member **23***b* is inserted in the through-hole **14** from the inserting hole **34**, thus completing the assembling step of the resin-formed body **20** for forming the ball circulation passage (see FIGS. **6**(*g*) and **6**(*h*)).

Then, the one side cover plate **40** is secured to the one end surface of the block body **13** by a clamping step, the ball retainer **12** holding the balls is inserted, and the other side cover plate **40** is secured to the other end surface of the block body **13** by the same clamping step, thus completing the assembling step of the movable block **4**.

According to the present invention, the resin-formed body **20** for forming the ball circulation passage is separately formed from the block body **13**. Even when the movable block **4** has a larger size, there is no restriction of flow of molten resin by the block body **13**, unlike the case where the block body **13** is integrally formed with the resin-formed body **20**. Increase in number of gates formed on a die may ensure proper run of the molten resin, thus improving the formability. Especially, the ball passage forming portions **21**, **21** located at the opposite longitudinal sides of the ball running groove **8** are thin, with the result that molten resin may not reach every part of the space for forming the ball passage forming portions **21**, **21**. It is therefore effective to form the resin-formed body **20** separately from the block body **13** in accordance with the embodiment of the present invention.

The continuous circulation passage is formed by the resin-formed body **20**, and it is therefore possible to make positional determination of the inner guide groove **10***a* for the direction changing passage relative to the ball passage forming portions **21**, **21**, as well as positional determination of the inner guide groove **10***a* for the direction changing passage relative to the ball returning passage **9**, thus ensuring continuity of the circulation passage so as to make smooth circulation of the balls **3**.

When the proper positional relationship of the inner guide groove **10***a* for the direction changing passage relative to the ball passage forming portions **21, 21**, is maintained, the ball passage forming portions **21, 21** are located at the longitudinal both sides of the ball running groove **8** so as to be aligned with the ends of the inner guide groove **10***a* for the direction changing passage.

When the proper positional relationship of the inner guide groove **10***a* for the direction changing passage relative to the ball returning passage **9** is maintained, the inner guide groove **10***a* for the direction changing passage can be aligned with the inner groove **23***a* of the ball returning passage **9**.

The connecting portion of the ball passage forming portions **21, 21** and the direction changing passage-inner guide forming portion **22** is obtained by integral forming, thus permitting omission of an assembling step of the connecting portion. Although the running direction of the balls **3** is changed in such a connecting portion, the above-mentioned integral structure may ensure continuity of the circulation passage, without being affected by assembling accuracy. It is therefore possible to make smooth run of the balls **3** from the ball running passage between the ball running groove **5** and the ball running counter-groove **8** to the direction changing passage **10**, as well as from the direction changing passage **10** to the ball returning passage **9**.

Description will be given of modifications of the resin-formed body **20** for forming the ball circulation passage, which is divided into parts In the description of the modifications, modified features will only be explained in comparison with the first embodiment of the present invention. The same reference numerals will be given to the same components as those in the first embodiment of the present invention, and description thereof will be omitted.

[First Modification]

FIGS. **8** and **9** show the first modification of the resin-formed body **20** for forming the ball circulation passage, which is described in the first embodiment.

In the first modification, the resin-formed body **20** for forming the ball circulation passage is composed of the first resin-formed frame **20**A, which is obtained by integrally connecting both of the ball passage forming portions **21, 21** and the resin pipes **23** at their ends with the direction changing passage-inner guide forming portions **22**A for one side, and the second resin-formed frame **20**B, which is provided with the direction changing passage-inner guide forming portions **22**B for the other side and separately formed from the first resin-formed frame **20**A.

In this case, the ball passage forming portions **21, 21** are integrally connected with the direction changing passage-inner guide forming portions **22**A through the thin sheet portion **29**A as in the first embodiment.

The direction changing passage-inner guide forming portions **22**A are also integrally connected with the resin pipes **23** through the thin sheet portion **29**A. In this case, the resin pipe **23** is formed into a tubular integral body, although the half pipe members are used in the first embodiment. Accordingly, there exists no inserting hole **34** in the thin sheet portion **29**A, and the ball returning passage **9** is exposed on the thin sheet portion **29**A.

The first resin-formed frame **20**A and the second resin-formed frame **20**B are connected, as shown in FIG. **9**, by means of a joint method using the combination of a recess and a projection to be inserted therein, such as a faucet joint method. In the illustrated example, a recess portion **36** of a dove-tail groove is formed in the second resin-formed frame **20**B, and an engaging projection **35** to be engaged with the recess portion **36** is formed, on the other hand, in the ball passage forming portions **21, 21**.

In this case, the resin pipe **23** of the first resin-formed frame **20**A is inserted in the through-hole **14** of the block body **13**, and the first, second and third connecting plate portions **25, 26, 27** are inserted along the under surface of the horizontal portion **6** of the block body **13** and the inner surfaces of the wing portions **7, 7**.

Then, the engaging projections **35** formed at the respective free end portions of the first, second and third connecting plate portions **25, 26, 27** are engaged with the recess portions **36** formed on the thin sheet portion **29**B of the second resin-formed frame **24**B, which is arranged on the other end surface of the block body **13**.

The recess portions **36** may be formed on the first resin-formed frame **20**A and the engaging projections **35** may be formed on the second resin-formed frame **20**B. The connecting method is not limited to the method described above, and there may be used any conventional connecting method, in which the ends of the divided parts can be maintained in a proper connecting position and connected.

[Second Modification]

FIGS. **10** and **11** show the second modification of the resin-formed body **20** for forming the ball circulation passage, which is described in the first embodiment.

In the second modification, the resin-formed body **20** for forming the ball circulation passage, which has been obtained by integrally forming both of the ball passage forming portions **21, 21** and the resin pipes **23** as a returning passage forming portion with a pair of direction changing passage-inner guide forming portions **22, 22**, is divided at the middle portion of each of the ball passage forming portions **21, 21** and the resin pipes **23** into two parts. More specifically, the ball passage forming portions **21, 21** and the resin pipes **23** are divided at their middle portion into the respective two half parts, and each of the thus divided two half parts is integrally formed with the direction changing passage-inner guide forming portions **22, 22**, thus forming two resin-formed frames **20**C, **20**D having substantially the same shape.

Four sets of the ball passage forming portions **21, 21** are formed on the first, second and third connecting plate portions **25, 26, 27**. Recess portions **38** and engaging projections **37** to be inserted therein are formed on the divided ends of the first, second and third connecting plate portions **25, 26, 27** and the divided ends of the resin pipes **23**.

[Third Modification]

FIGS. **12** to **14** show the third modification of the resin-formed body for forming the ball circulation passage, which is described in the first embodiment.

In the third modification, there is not used the resin pipe **23** as a returning passage forming portion described in the first embodiment, and a resin-formed frame **20**E is obtained by integrally forming the first, second and third connecting plate portions **25, 26, 27** having the ball passage forming portions **21, 21** with the thin sheet portions **29, 29** each having the pair of direction changing passage-inner guide forming portions **22, 22**. The ball returning passage **9** is composed as a through-hole formed in the block body **13**.

In this case, an engaging projection **39***a*, which is engageable with a tapered portion **15** formed in the opening end of the ball returning passage **9** may be formed in the opening end of the ball hole **39** of the thin sheet portion **29**. Such a construction permits to make a proper connection of the end of the ball returning passage **9** and the direction changing passage-inner guide forming portion **22**.

In the illustrated example, an arcuate engaging projection **48** is additionally formed on the connection portion of the outer guide groove **10***b* for the direction changing passage with the ball returning passage **9**. The engaging projection **48** can be fitted into the ball hole **39** of the thin sheet portion **29** and engaged with the tapered portion **15** of the opening end of the ball returning passage **9**.

[Fourth Modification]

FIG. **15** shows the fourth modification of the resin-formed body **20** for forming the ball circulation passage, which is described in the first embodiment.

In the fourth modification, there is not used the resin pipe **23** described in the third modification, a resin-formed frame **24**B is obtained by integrally forming, the ball passage forming portions **21** with the direction changing passage-inner guide forming portions **22** for the one side, the other resin-formed frame **24**C provided with the direction changing passage-inner guide forming portions **22** for the other side is separately formed from the above-mentioned resin-formed frame **24**B, and the resin-formed frames **24**B, **24**C are connected with each other by engagement of the engaging projection **35** with the recess **36**. The structure other than the above-mentioned construction is the same as that of the third modification.

[Modifications of the ball train]

In the first embodiment and the first to fourth modifications, there is described that two trains of the balls are provided on the upper surface of the guide rail **2** and the single train of the balls is provided on each of the side surfaces of the guide rail **2**, so as to provide the total number of trains of four. In the present invention, the other type of ball trains can however be applied as shown in FIG. **16**. With respect to the division of the resin-formed body **20** for forming the ball circulation passage, all the modifications as shown in FIG. **16** are based on the divisional pattern of the first embodiment. All the divisional patterns of the first to fourth modifications may however be applied to the modifications of the ball train as shown in FIG. **16**.

In the example as shown in FIGS. **16**(*a*) and **16**(*b*), two lower and upper trains of the balls as rolling members are provided on each of the gaps between the right and left-hand side surfaces of the guide rail **2** and the inner surfaces of the right and left-hand wing portions **7**, **7** of the movable block **13**, so as to provide the total number of trains of four.

FIG. **16**(*b*) shows the resin-formed body **20** in which all the ball passage forming portions for the four trains of the balls are integrally formed with each other. The resin-formed body **20** may however be divided into two resin-formed bodies **20**, **20**, which correspond to two trains of the balls for each of the right and left-hand sides of the guide rail **2**, as shown in FIG. **18**.

In the example as shown in FIGS. **16**(*c*) and **16**(*d*), the movable block **4** is provided with the horizontal portion **6** facing the upper surface of the guide rail **2** and a single wing portion **7** facing the one side surface of the guide rail **2**. The single train of the balls **3** as rolling members is provided between the one side surface of the guide rail **2** and the single wing portion **7** of the movable block **4**, and the other single train of the balls **3** is provided between the upper surface of the guide rail **2** and the lower surface of the horizontal portion in the vicinity of the corner of the guide rail **2**, so as to provide the total number of trains of two.

In the example as shown in FIGS. **16**(*e*) and **16**(*f*), the movable block **4** is provided with a pair of wing portions **7**, **7** between which the guide rail **2** is held at its right and left-hand surfaces. The single train of the balls **3** is provided in each of the gaps between the right and left-hand surfaces of the guide rail **2** and the inner surfaces of the right and left-hand wing portions **7**, **7** of the movable block **4**, so as to provide the total number of trains of two.

In the example as shown in FIGS. **16**(*g*) and **16**(*h*), the movable block **4** is arranged along the one side surface of the guide rail **2**. Two upper and lower trains of the balls **3** are provided between the one side surface of the guide rail **2** and the movable block **4**.

[SECOND EMBODIMENT]

FIGS. **18** to **20** show a linear motion guiding apparatus of the second embodiment of the present invention.

In the second embodiment, rollers are used as rolling members. More specifically, the linear motion guiding apparatus comprises a guide rail **202** as a guide member, extending linearly, and a movable block **204** arranged so as to be movable along the guide rail **202** through a large number of rollers **203** as rolling members.

The guide rail **202** is formed into a long bar shape having a rectangular cross-section. Two roller running surfaces **205**, **205** as a rolling member running track are formed on the horizontal upper surface of the guide rail **2**, and a single roller running surface **205** as the rolling member running track is formed on each of the right and left-hand vertical surfaces of the guide rail **2**, so as to provide a total number of surfaces **5** of four.

The movable block **204** is formed as a block body having an inverse U-shaped cross-section, with its opening end being directed downwardly. The block body is provided with a horizontal portion **206**, which faces the upper surface of the guide rail **202** and with a pair of wing portions **207**, **207**, which extend downwardly from the right and left ends of the horizontal portion **206** and face the right and left-hand side surfaces of the guide rail **202**, respectively. The horizontal portion **206** has on its lower surface two roller running counter-surfaces **208**, **208** as a rolling member running counter-track, which correspond to the roller running surfaces **205**, **205** formed on the upper surface of the guide rail **202**. Each of the wing portions **207**, **207** has on its inner surface a single roller running counter-surface **208** as the rolling member running counter-track, which corresponds to the respective roller running surfaces **205**, **205** formed on the right and left-hand side surfaces of the guide rail **202**.

In addition, in the movable block **204**, there are formed four roller returning passages **209**, **209**, **209**, **209** as a rolling member returning passage, which are provided in parallel with the four roller running counter-surfaces **208**, **208**, **208**, **208**, respectively, as well as four pairs of direction changing passages **210**, **210**, **210**, **210** each having a U-shape, for connecting the respective both ends of the roller running counter-surfaces **208**, **208**, **208**, **208** with the respective both ends of the roller returning passages **209**, **209**, **209**, **209**, so as to form four endless circulation passages.

The roller returning passages **209**, **209** respectively corresponding to the roller running surfaces **205**, **205** formed on the upper side of the guide rail **202** are formed in the horizontal portion **206**. The other roller returning passages **209**, **209** respectively corresponding to the roller running surfaces **205**, **205** formed on the right and left-hand vertical surfaces of the guide rail **202** are formed in the wing portions **207**, **207** of the movable block **204**, respectively.

In each of the endless circulation passages in this embodiment, the rollers **3** are retained in the form of train by means a roller retainer **212** as a rolling member retainer so that the rollers **203** can be circulated while being guided by the roller retainer **212**.

As shown in FIGS. **19**(*b*) to **19**(*d*), the roller retainer **212** comprises a flexible belt portion **212***b*, which is provided with roller holes **212***a* for respectively receiving the rollers **203**, and spacing portions **212***c* provided between the adjacent two rollers **203, 203**. The belt portion **212***b* has a width longer than the diameter of the roller **203** so that the both side edges of the belt portion **212***b* extend outwardly from the roller **203**.

The spacing portion **212***c* is provided with a roller supporting recess **212***d* corresponding to the cylindrical surface of the roller **203**. The roller **203** is supported on its both sides by a pair of supporting recesses **212***d* so as to prevent the roller **203** from coming off the belt portion **212***b*. In this embodiment, the one end of the belt portion **212***b* is not connected to the other end thereof, thus forming a strip-shaped belt having the both ends. The one end of the belt portion **212***b* may be connected to the other end thereof so as to form an endless belt.

As shown in FIGS. **18** and **20**, the movable block **204** is composed of a metallic block body **213** having roller running counter-surfaces **208, 208, 208, 208**, a resin-formed body **220** for forming roller circulation passages, which is inserted in the block body **213**, and a pair of side cover plates **214, 214** secured to the both end surfaces of the block body **213**, in which the resin-formed body **220** is inserted.

In the second embodiment, four circulation passages are formed by two resin-formed bodies **220, 220** for forming the roller circulation passage, which are arranged at the right and left-hand sides.

Each of the roller circulation passages of the resin-formed bodies **220** comprises a pair of roller passage forming portions **221, 221** extending along both longitudinal sides of the roller running counter-surface **208**, a pair of direction changing passage-inner guide forming portions **222, 222** provided on the both side surfaces of the block body **213**, and a resin pipe **223** as a returning passage forming portion, which is inserted into a through-hole formed in the block body **213**.

The roller passage forming portions **221, 221** are provided with guide surfaces for guiding the both side edges of the belt portion **212***b* of the roller retainer **212** in a loaded area as illustrated in detain in FIG. **20**. The guide grooves can prevent the roller retainer **212** not only from being swung during run of the roller, but also from being sagged by engaging the side edges of the belt portion **212***b* with the guide groove **221***a*. The rollers **203** are supported by the roller retainer **212**. More specifically, the roller retainer **212** is supported by a jaw portion of the guide groove **221***a*, with the result that the rollers **203** are kept-in its proper position so as not to come off the movable block **204**.

In this embodiment, the one end of the belt portion **212***b* is not connected to the other end thereof, thus forming a strip-shaped belt having the both ends. The one end of the belt portion **212***b* may be connected to the other end thereof so as to form an endless belt.

Guide grooves **209***c*, **210***c* are also formed in the roller returning passage **209** and the direction changing passage **210** as non-loaded areas, in order to guide the side edges of the belt portion **212***b*. The guide grooves **209***c*, **210***c* are connected to the above-mentioned guide groove **221***a* in the loaded area so as to form an endless groove on the entire periphery.

In each of the resin-formed bodies **220, 220** for forming the roller circulation passage, the roller passage forming portions **221, 221** and the pair of the direction changing passage-inner guide forming portions **222, 222** are integrally formed with each other. The resin pipe **223** for forming the roller returning passage **209** is separately formed from the resin-formed bodies **220, 220**. More specifically, the one ends of the two pairs of the roller passage forming portions **221, 221** are integrally connected with the ends of the pair of direction changing passage-inner guide forming portions **222, 222** to form a single resin frame **220**A so that the thus formed resin frame **220**A can be inserted into the block body **213**. The other resin frame **220**A has the same construction.

The roller passage forming portions **221, 221** to be arranged on the upper surface of the guide rail **202** are integrally connected with the other roller passage forming portions **221, 221** to be arranged on the side surface of the guide rail **202** by means of a thin connecting plate portion **226**.

The direction changing passage-inner guide forming portion **222** is integrally formed with a thin sheet portion **229**, which is to be brought into contact with the end surface of the block body **213**.

The thin sheet portion **229** has the first end plate portion **230**, which is to be brought into contact with the end surface of the horizontal portion **206** of the block body **213**, the third end plate portion **232**, which is to be brought into contact with the end surface of the wing portion **207**, and the second end plate portion **231**, which is arranged at the corner between the horizontal portion **206** and the wing portion **207** on the end surface of the block body **213**, and connects the first end plate portion **230** with the third end plate portion **232**.

The pair of roller passage forming portions **221, 221**, which are arranged on the both longitudinal sides of the roller running surface **208** are integrally formed on the inside edge of the first end plate portion **230** and the inside edge of the third end plate portion **232**, respectively. The both ends of the connecting plate portion **226** are integrally connected with the inside edges of the second plate portions **231, 231**.

Each of the direction changing passage-inner guide forming portions **222** has a semi-cylindrical shape. On the outer periphery of the direction changing passage-inner guide forming portion **222**, there is formed an inner guide groove **210***a* having a rectangular cross section so as to form the inner guide portion for the direction changing passage **210**. The one end of the bottom of the inner guide groove **210***a* is connected to the end of the roller running counter-surface **208**. Accordingly, the one end of the inner guide groove **210***a* has the same cross-sectional shape as the roller running counter-surface **208** so as to make an alignment of the one end of the inner guide groove **210***a* with the end of the roller running counter-surface **208**. The other end of the inner guide groove **210***a* of the direction changing passage **210** is connected to the end of the roller returning passage **229**. Accordingly, the other end of the inner guide groove **210***a* has the same cross-sectional shape as the roller returning passage **209** so as to make an alignment of the other end of the inner guide groove **210***a* with the end of the roller returning passage **209**.

Cylindrical flange portions **233, 233** are formed on the both ends of the inner guide groove **210***a*. The distance between the respective outer surfaces of the cylindrical flange portions **233, 233** is larger than the width of the belt portion **212***b*. The cylindrical flange portions **233, 233** form a guide groove **210***c* for the roller retainer **212** in cooperation with the side cover plate **240** described later.

The one end of the inner guide groove **210***a* for the direction changing passage **210** extends to the contacting surface of the first and third end plate portions **230, 232** with the end surface of the block body **213** so as to be connected to the end of the roller running counter-surface **208**. The other end of the inner guide groove **210***a* for the direction changing passage **210** extends to the end surface of the thin sheet portion **229**, which is apart from the block body **213**. A step portion **222***a* having a depth identical to the thickness of the thin sheet portion **229** is formed at the other end of the inner guide groove **210***a*. The inner peripheral side-half pipe member for the resin pipe **223** projects from the end surface of the block body **13** by a length identical to the thickness of the thin sheet portion **229**. The projected end of the half pipe member **223***a* is fitted into the step portion **222***a* of the thin sheet portion **229**.

Pipe inserting holes **234**, **234** having a semi-circular shape, in which the ends of for the outer peripheral side-half pipe member **223***a* for the resin pipes **223** for forming the roller returning passage **209** are to be inserted are formed on the first and third end plate portions **230**, **232** of the thin sheet portion **229**. The resin pipe **223** is inserted into the circular through-hole **214** formed in the block body **213** so that the inner peripheral surface of the resin pipe **223** form the roller returning passage **209**.

As shown in FIG. **20**, the resin pipe **223** is composed of the inner peripheral side-half pipe member **223***a*, which is continuously connected to the inner guide groove **210***a* for the direction changing passage, and the outer peripheral side-half pipe member **223***b*, which is continuously connected to the outer guide groove **210***b* for the direction changing passage **210**, which is formed on the side cover plate **240**. The inner peripheral side-half pipe member **223***a* has an inner groove portion **209***a* having a rectangular cross section, and side edge portions **223***b* extending longitudinally along the inner groove portion **209***a*. The longitudinal edge portions **223***c* of the inner peripheral side-half pipe member **223***a* has the same width as the flange portion **233** of the portion **228**.

The outer peripheral side-half pipe member **223***b* is formed into a linear member having the same rectangular cross section as the outer guide groove **210***b* for the direction changing passage, which is formed on the side cover plate **240**. The outer peripheral side-half pipe member **223***b* has a outer groove portion **209***b*, which is continuously connected to the outer guide groove **210***b*, and side edge portions **223***d* extending longitudinally along the outer groove portion **209***b*. The side edge portions **223***d* is provided on its outer edges with projections **223***e*, which are to be brought into contact with the side edge portions **223***c* of the inner peripheral side-half pipe member **223***a* to form the guide groove for the belt portion **212** of the roller retainer **212**.

The inner peripheral side-half pipe member **223***a* of the resin pipe **223** has the same length of the block body **213**. The inner peripheral side-half pipe member **223***a* is positioned so as to be brought into contact with the end surface of the direction changing passage-inner guide forming portion **222**, which is arranged on the side of the block body **213**.

The outer peripheral side-half pipe member **223***b* of the resin pipe **223** has on the other hand a longer length than the block body **213** by a length corresponding to the thickness of the first and third end plate portions of the thin sheet portion **229**, which are arranged on the both ends of the block body **213**. The outer peripheral side-half pipe members **223***b* are inserted in the inserting holes **234** of the first and third end plate portions **230**, **232**. Longitudinal positional determination of the outer peripheral side-half pipe member **223***b* is made by bringing the both ends of the outer peripheral side-half pipe member **223***b* inserted in the inserting holes **234** into contact with the peripheral edge of the end portion of the outer guide grooves **210***b* for the direction changing passage, which are formed on the side cover plate **240**. The projections **223***e* formed on the both longitudinal side edges **223** of the outer peripheral side-half pipe member **223***b* come into contact with the cylindrical flange portions **233** at the side edges of the inner guide groove **210***a* of the direction changing passage-inner guide forming portion **222**, and the outer peripheral side-half pipe member **223***b* and the inner peripheral side-half pipe member **223***a* are restricted to be turned in the inserting hole **214**.

The resin pipes **223** and the direction changing passage-inner guide forming portions **222** are accurately positioned through the inserting holes **234** formed on the first and third end plate portions **230**, **232** of the thin sheet portion **229** and a proper assembling is carried out in this manner.

The side cover plate **240** is provided with four recess portions **241** having the outer guide grooves **210***b* for the direction changing passage, into which the portions **228** of the direction changing passage-inner guide forming portions **222** are fitted, and screw-fixing portions for securing the side cover plate **240** to the block body **213**. In the screw-fixing portions, the side cover plate **240** is fixed to the block body **213** by inserting bolts **244** into holes **243** formed on the side cover plate **240** and engaging the bolts **244** with screwed holes **245** formed on the end surface of the block body **213**. The holes **243** are located between the first and third end plate portions **230**, **232** of the thin sheet portion **229**.

The direction changing passage-inner guide forming portion **222** provided with the inner guide groove **210***a* for the direction changing passage is fitted into the recess portion **241** of the side cover plate **240**. The thin sheet portion **229** is held between the side cover plate **240** and the end surface of the block body **213** through a clamping force so as to be firmly fixed therebetween.

The direction changing passage-inner guide forming portions **222** and the roller passage forming portion **221** are connected through the thin sheet portion **229**, thus making it possible to maintain an accurate positional relationship of the end of the inner guide groove **210***a* for the direction changing passage relative to the roller passage forming portions **221**, as well as an accurate positional relationship of the inner guide groove **210***a* for the direction changing passage relative to the roller returning passage **209**.

The thin sheet portion **229** is uniformly urged against the flat end surface of the block body **213** through a clamping force applied to the side cover plate **240**. Even when the direction changing passage-inner guide forming portion **222** is not located in a correct position, the thin sheet portion **229** changes its shape, thus permitting the correct positioning of the direction changing passage-inner guide forming portion **222**. The thin sheet portion **229** is firmly clamped and fixed through a clamping force, which is applied to the side cover plate **240**, and frictional force caused by such a clamping step may prevent an unfavorable movement of the inner guide groove **210***a* for the direction changing passage;

Description will be given of modifications of the resin-formed body **220** for forming the roller circulation passage, which is divided into parts In the description of the modifications, modified features will only be explained in comparison with the second embodiment of the present invention. The same reference numerals will be given to the same components as those in the second embodiment of the present invention, and description thereof will be omitted.

[First Modification]

FIGS. **21** and **22** show the first modification of the resin-formed body **20** for forming the ball circulation passage, which is described in the second embodiment.

In the first modification, the resin-formed body **220** for forming the ball circulation passage is composed of the first resin-formed frame **220**A, which is obtained by integrally connecting both of the roller passage forming portions **221**, **221** and the resin pipes **223** at their ends with the direction changing passage-inner guide forming portions **222**A for one side, and the second resin-formed frame **220**B, which is provided with the direction changing passage-inner guide forming portions **222**B for the other side and separately formed from the first resin-formed frame **220**A.

In this case, the roller passage forming portions **221**, **221** are integrally connected with the direction changing passage-inner guide forming portions **222**A through the thin sheet portion **229**A as in the second embodiment.

The direction changing passage-inner guide forming portions **222** are also integrally connected with the resin pipes **223** through the thin sheet portion **229**A. In this case, the resin pipe **223** is formed into a tubular integral body, although the half pipe members are used in the second embodiment. Accordingly, there exists no inserting hole **234** in the thin sheet portion **229**A, and the roller returning passage **209** is exposed on the thin sheet portion **229**A.

The first resin-formed frame **220**A and the second resin-formed frame **220**B are connected, as shown in FIG. **22**, by means of a joint method using the combination of a recess and a projection to be inserted therein, such as a faucet joint method. In the illustrated example, a recess portion **236** of a dove-tail groove is formed in the second resin-formed frame **220**B, and an engaging projection **235** to be engaged with the recess portion **236** is formed, on the other hand, in the roller passage forming portions **221**, **221**.

In this case, the resin pipe **223** of the first resin-formed frame **220**A is inserted in the through-hole **214** of the block body **213**, and the roller passage forming portions **221**, **221** and the connecting plate portion **226** are inserted along the under surface of the horizontal portion **206** of the block body **213** and the inner surfaces of the wing portions **207**, **207**.

Then, the engaging projections **235** formed at the roller passage forming portions **221**, **221** and the connecting plate portion **226** are engaged with the recess portions **236** formed on the thin sheet portion **229**B of the second resin-formed frame **224**B, which is arranged on the other end surface of the block body **213**.

The recess portions **236** may be formed on the first resin-formed frame **220**A and the engaging projections **235** may be formed on the second resin-formed frame **220**B. The connecting method is not limited to the method described above, and there may be used any conventional connecting method in which the ends of the divided parts can be maintained in a proper connecting position and connected.

[Second Modification]

FIGS. **23** and **24** show the second modification of the resin-formed body **220** for forming the ball circulation passage, which is described in the second embodiment.

In the second modification, the resin-formed body **220** for forming the roller circulation passage, which has been obtained by integrally forming both of the roller passage forming portions **221**, **221** and the resin pipes **223** as a returning passage forming portion with a pair of direction changing passage-inner guide forming portions **222**, **222**, is divided at the middle portion of each of the roller passage forming portions **221**, **221** and the resin pipes **223** into two parts. More specifically, the roller passage forming portions **221**, **221** and the resin pipes **223** are divided at their middle portion into the respective two half parts, and each of the thus divided two half parts is integrally formed with the direction changing passage-inner guide forming portions **222**, **222**, thus forming two resin-formed frames **220**C, **220**D having substantially the same shape.

Recess portions **238** and engaging projections **237** to be inserted therein are formed on the divided ends of the roller passage forming portions **221**, **221** and the divided ends of the connecting plate portion **226** and the divided ends of the resin pipes **223**.

[Third Modification]

FIGS. **25** to **26** show the third modification of the resin-formed body **220** for forming the roller circulation passage, which is described in the second embodiment.

In the third modification, there is not used the resin pipe **223** as a returning passage forming portion described in the second embodiment, and a resin-formed frame **220**E is obtained by integrally forming the both of the roller passage forming portions and the connecting plate portion **226** with the thin sheet portions **229**, **229** each having the pair of direction changing passage-inner guide forming portions **222**, **222**. The roller returning passage **209** is composed as a through-hole formed in the block body **213**.

In this case, an engaging projection **239***a*, which is engageable with a tapered portion **215** formed in the opening end of the roller returning passage **209** may be formed in the opening end of the roller hole **239** of the thin sheet portion **229**. Such a construction permits to make a proper connection of the end of the roller returning passage **209** and the direction changing passage-inner guide forming portion **222**.

In the illustrated example, an arcuate engaging projection **248** is additionally formed on the connection portion of the outer guide groove **210***b* for the direction changing passage with the roller returning passage **209**. The engaging projection **248** can be fitted into the roller hole **239** of the thin sheet portion **229** and engaged with the tapered portion **215** of the opening end of the roller returning passage **209**.

[Fourth Modification]

FIG. **26** shows the fourth modification of the resin-formed body **220** for forming the roller circulation passage, which is described in the second embodiment.

In the fourth modification, there is not used the resin pipe **223** described in the third modification, a resin-formed frame **220**F is obtained by integrally forming the roller passage forming portions **221** with the direction changing passage-inner guide forming portions **222** for the one side, the other resin-formed frame **220**F provided with the direction changing passage-inner guide forming portions **222** for the other side is separately formed from the above-mentioned resin-formed frame **220**F, and the resin-formed frames **220**F, **220**F are connected with each other by engagement of the engaging projection **235** with the recess **236**. The structure other than the above-mentioned construction is the same as that of the third modification.

[Modifications of the roller train]

In the second embodiment and the first to fourth modifications, there is described that two trains of the rollers are provided on the upper surface of the guide rail **2** and the single train of the rollers is provided on each of the side surfaces of the guide rail **2**, so as to provide the total number of trains of four. In the present invention, the other type of roller trains can however be applied as shown in the figures. With respect to the division of the resin-formed body **220** for forming the roller circulation passage, all the modifications are based on the divisional pattern of the first embodiment. All the divisional patterns of the first to fourth modifications may however be applied to the modifications of the roller train.

In the example as shown in FIG. **27**, two lower and upper trains of the rollers as rolling members are provided on each of the gaps between the right and left-hand side surfaces of the guide rail **202** and the inner surfaces of the right and left-hand wing portions **207**, **207** of the movable block **204**, so as to provide the total number of trains of four.

In this case, four inner guide portions **210***a* corresponding to the four trains of the rollers **203** are integrally formed with each other in the direction changing passage-inner guide forming portions **222**.

In the above description, the present invention is applied to the linear motion guiding apparatus, in which the movable block is arranged on the guide rail as a track shaft through the rolling members. The present invention may however be applied to a so-called ball-spline, in which an outer tube as a movable member is fitted on a spline shaft as a track shaft, as described below.

[THIRD EMBODIMENT]

A ball spline **301** as shown in FIGS. **28** to **30** is of a so-called "angular contact" ball spline, and has a spline shaft **302** as a guide member extending linearly and an outer tube **304** arranged so as to be movable along the spline shaft **302** through balls **303** as a large number of rolling members.

The spline shaft **304** is formed into a long bar shape having a circular cross-section. The spline shaft **304** has on its outer periphery three projections **306**. Two ball running grooves **305, 305** are formed on the both sides of each of the projections **306**, so as to provide the total number of groove of six.

The outer tube **304** has on its inner periphery three recesses **307** corresponding to the projections **306** of the spline shaft **302**, respectively. Ball running counter-grooves **308**, **308** are formed at the both corners of each of the recesses **307**, so as to correspond to the above-mentioned ball running grooves **305**, **305**.

In addition, the outer tube **304** has six ball returning passage **309**, **09**; **309**, **309**; **309**, **309**, which are in parallel with the six ball running counter-grooves **308**, **308**; **308**, **308**; **308**, **308**, and six direction changing massages **310**, **.310**; **310**, **310**; **310**, **310** formed into a U-shaped tube, which connect the ends of the above-mentioned ball running counter-grooves **308**, **308**; **308**, **308**; **308**, **308** with the ends of the above-mentioned ball returning passage **309**, **309**; **309**, **309**; **309**, **309**. The outer tube **304** has six circulation passages in this manner.

The ball arranged at each of the both side surfaces of the projection **306** of the spline shaft **302** comes in contact, at its opposite points, with the ball running groove **305** and the ball running counter-groove **308**, respectively. A line connecting the above-mentioned contact points is referred to as the "contact angle line". A contact angle α, i.e., an angle between the contact angle line and the radius line, which connects the center of the spline shaft **302** and the central portion of the projection **306** is relatively large. The ball returning passage **309** is located on the contact angle line.

In this third embodiment, the balls **303** inserted in each of the circulation passages are connected with each other by means of a ball retainer **312** so as to form the train of the balls **303**. The balls **303** are guided by means of the ball retainer **312** and circulated in each of the circulation passages. The ball retainer **312** has the same structure as shown in FIG. **14** and the description thereof is therefore omitted.

The outer tube **304** is composed of a tubular main body **313** having the ball running counter-grooves **308**, **308**; **308**, **308**; **308**, **308**, three resin-formed bodies **320**, **320**, **320** for forming the ball circulation passage, which are to be inserted in the main body **313**, and a pair of side cover plates **314**, **314** secured on the both ends of the main body **313** after the insertion of the resin-formed bodies **320**, **320**, **320** in the main body **313**.

In the third embodiment, the six circulation passages are formed by the three resin-formed bodies **320**, **320**, **320**.

Each of the circulation passages **311** of the resin-formed bodies **320** for forming the ball circulation passage has a pair of the ball passage forming portions **321**, **321** extending along the longitudinal side edges of the ball running counter-groove **308**, a pair of direction changing passage-inner guide forming portions **322**, **322** provided on the both ends of the main body **313**, and resin pipes **323** as a returning passage forming portion, which are inserted in through-holes formed in the main body **313**.

The ball passage forming portions **321**, **321** are provided with guide grooves for guiding the both side edges of the belt portion **312***b* of the ball retainer **312** in a loaded area. The guide grooves can prevent the ball retainer **312** not only from being swung during run of the ball, but also from being sagged by engaging the side edges of the belt portion **312***b* with the guide groove **321***a*, when the outer tube **304** is removed from the spline shaft **302**. The balls **303** are supported by the ball retainer **312**. More specifically, the ball retainer **312** is supported by a jaw portion of the guide groove **321***a*, with the result that the balls **303** are kept in its proper position so as not to come off the outer tube **304**.

Guide grooves **309***c*, **310***c* are also formed in the ball returning passage **309** and the direction changing passage **310** as non-loaded areas, in order to guide the side edges of the belt portion **312***b*. The guide grooves **309***c*, **310***c* are connected to the above-mentioned guide groove **321***a* in the loaded area so as to form an endless groove on the entire periphery.

In each of the resin-formed bodies **320** for forming the ball circulation passage, the ball passage forming portions **321**, **321** and the pair of the direction changing passage-inner guide forming portions **322**, **322** are integrally connected with each other. The resin-formed body **320** is divided at the other portions into separate parts so as to be able to be inserted in the main body **313**. In the third embodiment, a single resin frame **324** is obtained by integrally connecting the ends of the four sets of ball passage forming portions **321**, **321** with the end of the pair of direction changing passage-inner guide forming portions **322**, **322**, and the thus obtained resin frame **324** is divided at the connecting portion of the returning passage forming portion **323** with the direction changing passage-inner guide forming portions **322**, **322** into the separate parts so as to be able to be inserted in the main body **313**.

The adjacent two of the roller passage forming portions **321**, **321**, **321**, **321** are integrally connected with each other by means of a thin connecting sheet portion **326**. The direction changing passage-inner guide forming portion **322** is integrally formed with the thin sheet portion **329**, which is to be brought into contact with the end surface of the main body **313**.

The thin sheet portion **329** is provided with the first end plate portions **330**, **330** and the second end plate portion **231** for connecting the first end plate portions **330**, **330** with each other. Each of the pair of ball passage forming portions **321**, **321** is integrally connected with the inner edge of the first end plate portion **230**. The both ends of the connecting plate portion **326** are integrally connected with the inner edge of the second end plate portion **331**.

Each of the direction changing passage-inner guide forming portions **22** has a semi-cylindrical shape. On the outer periphery of the direction hanging passage-inner guide forming portion **322**, there is formed an inner guide groove **310***a* having a semi-circular cross section so as to form the inner guide portion for the direction changing passage **310**.

The one end of the inner guide groove **310***a* is connected to the end of the ball running counter-groove **308**. Accordingly, the one end of the inner guide groove **310***a* has the same cross-sectional shape as the ball running counter-groove **308** so as to make an alignment of the one end of the inner guide groove **310***a* with the end of the ball running counter-groove **308**. The other end of the inner guide groove **310***a* of the direction changing passage **310** is connected to the end of the ball returning passage **309**. Accordingly, the other end of the inner guide groove **310***a* has the same cross-sectional shape as the ball returning passage **309** so as to make an alignment of the other end of the inner guide groove **310***a* with the end of the ball returning passage **309**.

Cylindrical flange portions **333, 333** are formed on the both ends of the inner guide groove **310***a*. The distance between the respective outer surfaces of the cylindrical flange portions **333, 333** is larger than the width of the belt portion **312***b*. The cylindrical flange portions **333, 333** form a retainer-guide groove **310***c* for the ball retainer **312** in cooperation with the side cover plate **340** described later.

The both ends of the inner guide groove **310***a* for the direction changing passage **310** extend to the contacting surface of the first end plate portion **330** with the end surface of the main body **313** so as to be connected to the respective ends of the ball running counter-groove **308** and the ball returning passage **309**.

Pipe inserting holes **334, 334** having a semi-circular shape, in which he ends of for the outer peripheral side-half pipe member **323***a* for the resin pipes **323** for forming the roller returning passage **309** are to be inserted are formed on the first and third end plate portions **330, 332** of the thin sheet portion **329**. The resin pipe **323** is inserted into the circular through-hole **314** formed in the main body **313** so that the inner peripheral surface of the resin pipe **323** form the ball returning passage **309**.

The resin pipe **323** is composed of the inner peripheral side-half pipe member **323***a*, which is continuously connected to the inner guide groove **310***a* for the direction changing passage, and the outer peripheral side-half pipe member **323***b*, which is continuously connected to the outer guide groove **310***b* for the direction changing passage **310**, which is formed on the side cover plate **340**. The inner peripheral side-half pipe member **323***a* has an inner groove portion **309***a* having a rectangular cross section, and side edge portions **323***b* extending longitudinally along the inner groove portion **309***a*. The longitudinal edge portions **323***c* of the inner peripheral side-half pipe member **323***a* has the same width as the flange portion **333** of the direction changing passage-inner guide forming portion **322**.

The outer peripheral side-half pipe member **323***b* is formed into a linear member having the same rectangular cross section as the outer guide groove **310***b* for the direction changing passage, which is formed on the side cover plate **340**. The outer peripheral side-half pipe member **323***b* has a outer groove portion **309***b*, which is continuously connected to the outer guide groove **310***b*, and side edge portions **323***d* extending longitudinally along the outer groove portion **309***b*. The side edge portions **323***d* is provided on its outer edges with projections **323***e*, which are to be brought into contact with the side edge portions **323***c* of the inner peripheral side-half pipe member **323***a* to form the guide groove for the belt portion **312** of the ball retainer **312**.

The inner peripheral side-half pipe member **323***a* of the resin pipe **23** has the same length of the main body **313**. The inner peripheral side-half pipe member **323***a* is positioned so as to be brought into contact with the end surface of the direction changing passage-inner guide forming portion **322**, which is arranged on the side of the main body **313**.

The outer peripheral side-half pipe member **323***b* of the resin pipe **323** has on the other hand a longer length than the main body **313** by a length corresponding to the thickness of the first end plate portions **330, 330** of the thin sheet portion **329**, which are arranged on the both ends of the main body **313**. The outer peripheral side-half pipe members **323***b* are inserted in the inserting holes **334** of the first end plate portions **330, 332**. Longitudinal positional determination of the outer peripheral side-halfpipe member **323***b* is made by bringing the both ends of the outer peripheral side-half pipe member **323***b* inserted in the inserting holes **334** into contact with the peripheral edge of the end portion of the outer guide grooves **310***b* for the direction changing passage, which are formed on the side cover plate **340**. The projections **323***e* formed on the both longitudinal side edges **323** of the outer peripheral side-half pipe member **323***b* come into contact with the outer edges of the cylindrical flange portions of the direction changing passage-inner guide forming portion **322** to form a guide groove, and the outer peripheral side-half pipe member **323***b* and the inner peripheral side-half pipe member **323***a* are restricted to be turned in the inserting hole **314**.

The resin pipes **323** and the direction changing passage-inner guide forming portions **322** as the ball returning passage forming portions are accurately positioned through the inserting holes **334** formed on the first end plate portion **330, 330** of the thin sheet portion **329** and a proper assembling is carried out in this manner.

The side cover plate **340** is provided with four recess portions **341** having the outer guide grooves **310***b* for the direction changing passage, into which the direction changing passage-inner guide forming portions **322** are fitted, and screw-fixing portions for securing the side cover plate **340** to the main body **313**. In the screw-fixing portions, the side cover plate **340** is fixed to the main body **313** by inserting bolts **344** into holes **343** formed on the side cover plate **340** and engaging the bolts **344** with screwed holes **345** formed on the end surface of the main body **313**. The holes **343** are located between the first end plate portions **330, 330** of the thin sheet portion **329**.

The direction changing passage-inner guide forming portion **322** is fitted into the recess portion **341** of the side cover plate **340**. The thin sheet portion **329** is held between the side cover plate **340** and the end surface of the main body **313** through a clamping force so as to be firmly fixed therebetween.

The direction changing passage-inner guide forming portions **322** and the ball passage forming portion **321** are connected through the thin sheet portion **329**, thus making it possible to maintain an accurate positional relationship of the end of the inner guide grooves **310***a* for the direction changing passage relative to the ball passage forming portions **321**, as well as an accurate positional relationship of the inner guide groove **310***a* for the direction changing passage relative to the ball returning passage **309**.

The thin sheet portion **329** is uniformly urged against the flat end surface of the main body **313** through a clamping force applied to the side cover plate **340**. Even when the direction changing passage-inner guide forming portion **322** is not located in a correct position, the thin sheet portion **329** changes its shape, thus permitting the correct positioning of the direction changing passage-inner guide forming portion **322**. The thin sheet portion **329** is firmly clamped and fixed through a clamping force, which is applied to the side cover plate **340**, and frictional force caused by such a clamping step may prevent an unfavorable movement of the inner guide groove **310***a* for the direction changing passage.

According to the present invention, only the ball running counter-groove **308** for the circulation passage **311** is formed of the main body **313** having high rigidity, and the other portions are formed of the resin-formed bodies **320** for forming the ball circulation passage. Precision working of the ball running counter-groove **308** of the main body **313** suffices, thus permitting reduction in steps for working and decrease in the production cost.

The resin-formed body **320** for forming the ball circulation passage is separately formed from the main body **313**. Even when the outer tube **304** has a larger size, there is no restriction of flow of molten resin by the main body **313**, unlike the case where the main body **313** is integrally formed with the resin-formed body **320**. Increase in number of gates formed on a die may ensure proper run of the molten resin, thus improving the formability. Especially, the ball passage forming portions **321, 321** located at the opposite longitudinal sides of the ball running groove **308** are thin, with the result that molten resin may not reach every part of the space for forming the ball passage forming portions **321, 321**. It is therefore effective to form the resin-formed body **320** separately from the main body **313** in accordance with the embodiment of the present invention.

The ball passage forming portions **321, 321** are continuously and integrally connected with the direction changing passage-inner guide forming portions **322**, and the divided parts are jointed so as to make alignment of them to make a faucet joint. It is therefore possible to ensure a proper continuity of the connecting portion of the circulation passage and to make smooth run of the balls **303** from the ball running passage between the ball running groove **305** and the ball running counter-groove **308** to the direction changing passage **310**, as well as from the direction changing passage **310** to the ball returning passage **309**.

Description will be given of modifications of the resin-formed body **320** for forming the ball circulation passage, which is divided into parts. In the description of the modifications, modified features will only be explained in comparison with the third embodiment of the present invention. The same reference numerals will be given to the same components as those in the third embodiment of the present invention, and description thereof will be omitted.

[First Modification]

FIGS. **31** and **32** show the first modification of the resin-formed body **320** for forming the ball circulation passage, which is described in the third embodiment.

In the first modification, the resin-formed body **320** for forming the ball circulation passage is composed of the first resin-formed frame **320**A, which is obtained by integrally connecting both of the ball passage forming portions **321, 321** and the resin pipes **323** at their ends with the direction changing passage-inner guide forming portions **322**A for one side, and the second resin formed frame **320**B, which is provided with the direction changing passage-inner guide forming portions **322**B for the other side and separately formed from the first resin-formed frame **320**A.

In this case, the ball passage forming portions **321, 321** are integrally connected with the direction changing passage-inner guide forming portions **322**A through the thin sheet portion **329**A as in the first embodiment.

The direction changing passage-inner guide forming portions **322**A are also integrally connected with the resin pipes **323** through the thin sheet portion **329**A. In this case, the resin pipe **323** is formed into a tubular integral body, although the half pipe members are used in the third embodiment. Accordingly, there exists no inserting hole s**34** in the thin sheet portion **329**A, and the ball returning passage **309** is exposed on the thin sheet portion **329**A.

The first resin-formed frame **320**A and the second resin-formed frame **320**B are connected, as shown in FIG. **32**, by means of a joint method using the combination of a recess and a projection to be inserted therein, such as a faucet joint method. In the illustrated example, a recess portion **336** of a dove-tail groove is formed in the second resin-formed frame **320**B, and an engaging projection **335** to be engaged with the recess portion **336** is formed, on the other hand, in the ball passage forming portions **321, 321**.

In this case, the resin pipe **323** of the first resin-formed frame **320**A is inserted in the through-hole **314** of the main body **313**, and the ball passage forming portions **321, 321** and the connecting plate portion **236** are inserted along the inner surface of the recess **307** of the main body **313**.

Then, the engaging projections **335** formed at the respective free end portions of the ball passage forming portions **321, 321** and the connecting plate portion **326** are engaged with the recess portions **336** formed on the thin sheet portion **329**B of the second resin-formed frame **324**B, which is arranged on the other end surface of the main body **313**.

The recess portions **336** may be formed on the first resin-formed frame **320**A and the engaging projections **335** may be formed on the second resin-formed frame **320**B. The connecting method is not limited to the method described above, and there may be used any conventional connecting method, in which the ends of the divided parts can be maintained in a proper connecting position and connected.

[Second Modification]

FIGS. **33** and **34** show the second modification of the resin-formed body **320** for forming the ball circulation passage, which is described in the third embodiment.

In the second modification, the resin-formed body **320** for forming the ball circulation passage, which has been obtained by integrally forming both of the ball passage forming portions **321, 321** and the resin pipes **323** as a returning passage forming portion with a pair of direction changing passage-inner guide forming portions **322, 322**, is divided at the middle portion of each of the ball passage forming portions **321, 321** and the ball returning passage forming portions **323** into two parts. More specifically, the ball passage forming portions **321, 321** and the ball returning passage forming portions **323** are divided at their middle portion into the respective two half parts, and each of the thus divided two half parts is integrally formed with the direction changing passage-inner guide forming portions **322, 322**, thus forming two resin-formed frames **320**C, **320**D having substantially the same shape.

Recess portions **338** and engaging projections **337** to be inserted therein are formed on the divided ends of the ball passage forming portions **321, 321**, the divided ends of the central connecting plate portion **326** and the divided ends of the resin pipes **323**.

[Third Modification]

FIG. **35** shows the third modification of the resin-formed body **320** for forming the ball circulation passage, which is described in the third embodiment.

In the third modification, there is not used the resin pipe **323** as a returning passage forming portion described in the first embodiment, and a resin-formed frame **320**E is obtained by integrally forming the ball passage forming portions, the connecting plate portions **326** with the thin sheet portions **329, 329** each having the pair of direction changing passage-inner guide forming portions **322, 322**. The ball returning passage **309** is composed as a through-hole formed in the main body **313**.

In this case, an engaging projection **339***a*, which is engageable with a tapered portion **315** formed in the opening end of the ball returning passage **309** may be formed in the opening end of the ball hole **339** of the thin sheet portion **329**. Such a construction permits to make a proper connection of the end of the ball returning passage **309** and the direction changing passage-inner guide forming portion **322**.

In the illustrated example, an arcuate engaging projection **348** is additionally formed on the connection portion of the outer guide groove **310***b* formed on the side cover plate **340** with the ball returning passage **309**. The engaging projection **48** can be engaged with the thin sheet portion **329**.

[Fourth Modification]

FIG. **36** shows the fourth modification of the resin-formed body **320** for forming the ball circulation passage, which is described in the third embodiment.

In the fourth modification, there is not used the resin pipe **323** described in the third modification, a resin-formed frame **320**F is obtained by integrally forming the ball passage forming portions **321** with the direction changing passage-inner guide forming portions **322** for the one side, the other resin-formed frame **320**G provided with the direction changing passage-inner guide forming portions **322** for the other side is separately formed from the above-mentioned resin-formed frame **320**F, and the resin-formed frames **320**F, **320**G are connected with each other by engagement of the engaging projection **335** with the recess **336**. The structure other than the above-mentioned construction is the same as that of the third modification.

In the third embodiment described above, there are used three sets of resin-formed bodies for forming the ball circulation passage, each of which is divided into two parts. Six sets of resin-formed bodies may however be used for the respective circulation passages. The single set of resin-formed body may also be used. In this case, the divisional method of the resin-formed body should be based on the first, second and fourth modifications described above, taking into consideration the difficulty of insertion of the resin-formed body into the main body of the outer tube.

[Modifications of the ball train]

In the third embodiment and the first to fourth modifications thereof, the ball spline has the angular contact type ball train. The present invention may also be applied to the ball spline having the radial contact type ball train as shown in FIG. **37**. In such a radial contact type ball train, the spline shaft has no projections on the outer periphery so as to reveal the circular cross-section, and the outer tube has no recesses on the inner periphery so as to reveal the hollow cylindrical shape. The radial contact type ball train has the smaller contact angle α than that of the angular contact type ball train. With respect to the divisional method of the resin-formed body **320** for forming the ball circulation passage, all the patterns described in the third embodiment and the first to fourth modifications thereof may be used.

In the example illustrated in FIG. **37**, six resin-formed bodies **320** for forming the ball circulation passage are separately provided from each other for the respective six ball trains. The two sets of resin-formed bodies **320** mentioned above may be integrally formed with each other so as to prepare three sets of resin-formed bodies **320** having the six ball circulation passages. The single resin-formed body having the six ball circulation passages may also be used.

[FOURTH EMBODIMENT]

FIGS. **38** and **39** illustrate the forth embodiment of the present invention. In the fourth embodiment, the present invention is applied to a roller spline, in which rollers are used as the rolling members.

The roller spline **401** as shown in FIG. **38** is composed of a spline shaft **402** as a guide member extending linearly, and

an outer tube **404** arranged so as to be movable along the spline shaft **402** through the rollers **403** as the rolling members.

The spline shaft **402** is formed into a long bar shape having a modified cross-section. The spline shaft **402** has on its outer periphery three projections **406**. Two roller running surfaces **405**, **405** are formed on the both sides of each of the projections **406**, so as to provide the total number of running surfaces of six.

The outer tube **404** has on its inner periphery three recesses **407** corresponding to the projections **406** of the spline shaft **402**, respectively. Roller running counter-surfaces **408**, **408** are formed at the both corners of each of the recesses **407**, so as to correspond to the above-mentioned roller running surfaces **405**, **405**.

In addition, the outer tube **404** has six roller returning passage **409**, **409**; **409**, **409**; **409**, **409**, which are in parallel with the six roller running counter-surfaces **408**, **408**; **408**, **408**; **408**, **408**, and six direction changing passages **410**, **410**; **410**, **410**; **410**, **410** formed into a U-shaped tube, which connect the ends of the above-mentioned roller running counter-surfaces **408**, **408**; **408**, **408**; **408**, **408** with the ends of the above-mentioned roller returning passage **409**, **409**; **409**, **409**; **409**, **409**. The outer tube **404** has six circulation passages in this manner.

The rollers **403** inserted in each of the circulation passages are connected with each other by means of the same roller retainer **412** as the roller retainer **212** shown in FIG. **19**, so as to form the train of the rollers **403**. The rollers **403** are guided by means of the roller retainer **412** and circulated in each of the circulation passages.

The outer tube **404** is composed of a tubular main body **413** having he roller running counter-grooves **408**, **408**; **408**, **408**; **408**, **408**, three resin-formed bodies **420**, **420**, **420** for forming the ball circulation passage, which are to be inserted in the main body **413**, and a pair of side cover plates **440**, **440** secured on the both ends of the main body **413** after the insertion of the resin-formed bodies **420**, **420**, **420** in the main body **413**.

In the fourth embodiment, the six circulation passages are formed by the three resin-formed bodies **420**, **420**, **420** as in the third embodiment.

Each of the resin-formed bodies **420** for forming the ball circulation passage has a pair of the roller passage forming portions **421**, **421** extending along the longitudinal side edges of the roller running counter-groove **408**, a pair of direction changing passage-inner guide forming portions **422**, **422** provided on the both ends of the main body **413**, and resin pipes **423** as a returning passage forming portion, which are inserted in through-holes formed in the main body **413**.

The roller passage forming portions **421**, **421** are provided with guide grooves for guiding the both side edges of the belt portion **412***b* of the roller retainer **412** in a loaded area. The guide grooves can prevent the roller retainer **412** not only from being swung during run of the roller, but also from being sagged by engaging the side edges of the belt portion **412***b* with the guide groove **421***a*, when the outer tube **404** is removed from the spline shaft **402**. The rollers **403** are supported by the roller retainer **412**. More specifically, the roller retainer **412** is supported by a jaw portion of the guide groove **421***a*, with the result that the rollers **403** are kept in its proper position so as not to come off the outer tube **404**.

Guide grooves **409***c*, **410***c* are also formed in the roller returning passage **409** and the direction changing passage **410** as non-loaded areas, in order to guide the side edges of the belt portion **412***b*. The guide grooves **409***c*, **410***c* are connected to the above-mentioned guide groove **421***a* in the loaded area so as to form an endless groove on the entire periphery.

When the roller retainer **412** is not used, the guide grooves **421***a*, **410***a*, **409***a* are not needed, and the jaw portions as shown in FIG. **20**(*h*) for supporting the ends of the roller are formed on the roller passage forming portions **421**.

In each of the resin-formed bodies **420** for forming the roller circulation passage, at least one of four connecting portions of the roller passage forming portions **421, 421** with the pair of the direction changing passage-inner guide forming portions **422, 422** are integrally connected with each other. The resin-formed body **420** is divided at the other portions into separate parts so as to be able to be inserted in the main body **413**.

The fundamental embodiment of the resin-formed body for forming the roller circulation passage, which is to be used for the spline unit is described in detail in the third embodiment. The structure of the resin-formed body for forming the roller circulation passage is described in detail in the second embodiment. Here, only the fundamental divisional pattern of the resin-formed body **420** for forming the roller circulation passage will be briefly described below with reference to FIG. **39**.

In FIG. **39**(*a*), the both ends of the four sets of roller passage forming portions **421, 421** are integrally connected with the respective one end of the pair of direction changing passage-inner guide forming portions **422, 422** to form a single resin frame **424**, and the both ends of each of the returning passage forming portions **423** are not connected with the other end of the direction changing passage-inner guide forming portion **422** so that these parts can be assembled into the main body **413**.

In FIG. **39**(*b*), the resin-formed body **420** for forming the roller circulation passage is composed of the first resin-formed frame **420**A, which is obtained by integrally connecting both of the roller passage forming portions **421, 421** and the resin pipes **423** as a returning passage forming portion at their ends with the direction changing passage-inner guide forming portions **422**A for one side, and the second resin-formed frame **420**B, which is provided with the direction changing passage-inner guide forming portions **422**B for the other side and separately formed from the first resin-formed frame **420**A.

In FIG. **39**(*c*), the resin-formed body **420** for forming the roller circulation passage, which has been obtained by integrally forming both of the roller passage forming portions **421, 421** and the resin pipes **423** as a returning passage forming portion with a pair of direction changing passage-inner guide forming portions **422, 422**, is divided at the middle portion of each of the roller passage forming portions **421, 421** and the returning passage forming portions **423** into two parts. More specifically, the roller passage forming portions **421, 421** and the resin pipes **423** are divided at their middle portion into the respective two half parts, and each of the thus divided two half parts is integrally formed with the direction changing passage-inner guide forming portions **422, 422**, thus forming two resin-formed frames **420**C, **420**D having substantially the same shape.

In FIG. **39**(*d*), there is not used the resin pipe **423** as shown in FIG. **39**(*a*), and a resin-formed frame **420**E is obtained by integrally forming both of the roller passage forming portions and the connecting plate portion **326** with the thin sheet portions **429, 429** each having the pair of direction changing passage-inner guide forming portions **422, 422**. The roller returning passage **409** is composed as a through-hole formed in the main body **413**.

In FIG. **39**(*e*), there is not used the resin pipe **423** as shown in FIG. **39**(*b*), and a resin-formed frame **420**F is obtained by integrally forming the roller passage forming portions **421** with the direction changing passage-inner guide forming portions **422** for the one side, the other resin-formed frame **420**G provided with the direction changing passage-inner guide forming portions **422** for the other side is separately formed from the above-mentioned resin-formed frame **420**F.

In FIGS. **39**(*a*) to **29**(*e*), the resin-formed frames are connected with each other by means of the conventional joint method such as a faucet joint, which uses engagement of the engaging projection with the recess.

[FIFTH EMBODIMENT]

FIGS. **40** to **44** show a linear motion guiding apparatus of the fifth embodiment of the present invention.

The linear motion guiding apparatus **501** is provided with a guide rail **502** as a guide member, which extends linearly, and a movable block **504** as a movable member, which is arranged so as to be movable along the guide rail **502** through a large number of balls **503** as rolling members.

The guide rail **502** is formed into a long bar shape having a rectangular cross-section. Two ball running grooves **505, 505** as a rolling member running track are formed on each of the right and left-hand side surfaces of the guide rail **502**, so as to provide a total number of grooves **505** of four. The guide rail **502** has on each of its side surfaces a projection **502***a*, on the upper and lower positions of which the ball running grooves **505, 505** are arranged.

The movable block **504** is formed as a block body having an inverse U-shaped cross-section, with its opening end being directed downwardly. The block body is provided with a horizontal portion **506**, which faces the upper surface of the guide rail **502** and with a pair of wing portions **507, 507**, which extend downwardly from the right and left ends of the horizontal portion **506** and face the right and left-hand side surfaces of the guide rail **502**, respectively. Each of the wing portions **507, 507** has on its inner surface two ball running counter-grooves **508, 508** as a rolling member running counter-track, which correspond to the ball running grooves **505, 505** formed on the right and left-hand side surfaces of the guide rail **502**.

Each of the right and left-hand wing portions **507, 507** of the movable block **504** has two ball returning passage forming portions **509, 509** formed therein, which extend in parallel with the ball running counter-grooves **508, 508**. At both the longitudinal ends of each of the wing portions **507, 507**, there are arranged direction changing passages **510, 510; 510, 510** for connecting the ends of the ball running counter-grooves **508, 508; 508, 508** with the ends of the ball returning passage **509, 509; 509, 509**. In summary, each of the wing portions **507, 507** of the movable block **504** has two endless circulation passages, in which the balls **503** are circulated, so as to provide the total number of passage of four.

In each of the four endless circulation passages in this embodiment, the balls **503** are retained in the form of train by means a ball retainer **512** as a rolling member retainer so that the balls **503** can be circulated while being guided by the ball retainer **512**.

As shown in FIGS. **44**(*c*) to **44**(*e*), the ball retainer **512** comprises a flexible belt portion **512***b*, which is provided with ball holes **512***a* for respectively receiving the balls **503**, and spacing portions **512***c* provided between the adjacent two balls **503, 503**. The belt portion **512***b* has a width longer than the diameter of the ball **503** so that the both side edges of the belt portion **512***b* extend outwardly from the ball **503**.

The spacing portion **512***c* is provided with a ball supporting spherical recess **512***d* corresponding to the spherical surface of the ball **503**. The ball **503** is supported on its both sides by a pair of supporting spherical recesses **512***d* so as to prevent the ball **503** from coming off the belt portion **512***b*. In this embodiment, the one end of the belt portion **512***b* is not connected to the other end thereof, thus forming a strip-shaped belt having the both ends. The one end of the belt portion **512***b* may be connected to the other end thereof so as to form an endless belt.

As shown in FIG. **41**, the movable block **504** is composed of a block body **513** having ball running counter-grooves **508, 508, 508, 508,** a pair of right and left-hand resin-formed bodies **520, 520** for forming ball circulation passages, which is inserted in the block body **513**, and a pair of side cover plates **540** (only one cover plate **540** is illustrated) secured to the both end surfaces of the block body **13**, in which the resin-formed bodied **520, 520** are inserted.

Each of the right and left-hand resin-formed bodies **520, 520** for forming the ball circulation passage forms two endless circulation passages. The right and left-hand resin-formed bodies **520, 520** have the symmetrical shape. One of them will be described below and the description of other thereof will be omitted.

More specifically, the resin-formed body **520** for forming the ball circulation passage is composed of a resin frame **524** obtained by integrally forming the ball passage forming portions **521, 521** extending along both longitudinal sides of the ball running counter-groove **508** with the pair of direction changing passage-inner guide forming portions **522, 522** (see FIG. **42**); and a pair of resin pipes **523, 523** as a returning passage forming portion, which are to be inserted in through-holes **514, 514** formed in the block body **513** (see FIG. **43**). The ball passage forming portions **521, 521** are integrally formed with the pair of direction changing passage-inner guide forming portions **522, 522** to form the resin frame **524** as an integral body, and the pair of resin pipes **523, 523** are separately formed from such an integral body, so that these parts can be assembled into the block body **513**.

As shown in FIG. **42**, the ball passage forming portions **521, 521** are provided with guide grooves for guiding the both side edges of the belt portion **512***b* of the ball retainer **512** in a loaded area. The guide grooves can prevent the ball retainer **512** not only from being swung during run of the ball, but also from being sagged by engaging the side edges of the belt portion **512***b* with the guide groove **521***a*, when the movable block **504** is removed from the guide rail **502**. The balls **503** are supported by the ball retainer **512**. More specifically, the ball retainer **512** is supported by a jaw portion of the guide groove **521***a*, with the result that the balls **503** are kept in its proper position so as not to come off the movable block **504**.

The distance between the pair of ball passage forming portions **521, 521** arranged in parallel with each other on the both longitudinal sides of the ball running counter-groove **508** is slightly smaller than the diameter of the ball **503**. In such a construction, it is possible to prevent the balls **503** from coming off the ball passage forming portions **521, 521** even when the ball retainer **512** is not used.

Guide grooves **509***c*, **510***c* are also formed, as shown in FIGS. **44**(*a*) and **44**(*b*), in the ball returning passage **509, 509** and the direction changing passage **510, 510** as non-loaded areas, in order to guide the side edges of the belt portion **512***b*. The guide grooves **509***c*, **10***c* are connected to the above-mentioned guide groove **521***a* in the loaded area so as to form an endless groove on the entire periphery.

The ball passage forming portions **521, 521; 521, 521** are composed, as shown in FIG. **42**(*a*), of the first connecting plate portion **525** extending longitudinally along the corner between the horizontal portion **506** and the wing portion **507** of the block body **513** in the longitudinal direction of the block body **513**; the second connecting plate portion **526** extending longitudinally between the ball running counter-grooves **508, 508** on the inner surface of each of the wing portions **507** of the block body **513**; and a pair of third connecting plate portions **527** extending along the under surface of the wing portion **507** of the block body **513** in the longitudinal direction thereof The upper edge of the first connecting plate portion **525** and the lower edge of the second connecting plate portion **526**, which face to each other, are placed on the opposite longitudinal sides of the upper ball running counter-groove **508** provided in the wing portion **507**, so as to form the ball passage forming portions **521, 521**. The lower edge of the second connecting plate portion **526** and the upper edge of the third connecting plate portion **527**, which face to each other, are placed on the opposite longitudinal sides of the lower ball running counter-groove **508** provided in the wing portion **507**, so as to form the ball passage forming portions **521, 521**.

As shown in FIGS. **44**(*a*), **44**(*b*) and **44**(*c*), the direction changing passage-inner guide forming portions **522** and the ball passage forming portions **521, 521** are connected by means of the thin sheet portion **529** through integral forming. The resin pipe **523** is inserted in a hole **534** formed on the thin sheet portion **529** so as to make a faucet joint, and fixed to the thin sheet portion **529**.

The thin sheet portion **529** has the direction changing passage-inner guide forming portions **522, 522**, which are formed so as to project corresponding to the two trains of balls **503, 503** on the side surface of the guide rail **502**. The both ends of the first, second and third connecting plate portions **525–527** are connected to the thin sheet portion **529** to be arranged on the end of the block body **513** so as to form the single resin frame **524**.

Each of the direction changing passage-inner guide forming portions **522** has a semi-cylindrical shape. On the outer periphery of the direction changing passage-inner guide forming portion **522**, there is formed an inner guide groove **510***a* having a semi-circular cross section so as to form the inner guide portion for the direction changing passage **510**. The one end of the inner guide groove **510***a* is connected to the end of the ball running counter-groove **508**. Accordingly, the one end of the inner guide groove **510***a* has the same cross-sectional shape as the ball running counter-groove **508** so as to make an alignment of the one end of the inner guide groove **510***a* with the end of the ball running counter-groove **508**. The other end of the inner guide groove **510***a* of the direction changing passage **510** is connected to the end of the ball returning passage **509**. Accordingly, the other end of the inner guide groove **510***a* has the same cross-sectional shape as the ball returning passage **509** so as to make an alignment of the other end of the inner guide groove **510***a* with the end of the ball returning passage **509**.

Cylindrical flange portions **533, 533** are formed on the both ends of the inner guide groove **510***a*. The distance between the respective outer surfaces of the cylindrical flange portions **533, 533** is larger than the width of the belt portion **512***b*. The cylindrical flange portions **533, 533** form a retainer-guide groove **510***c* for the ball retainer **512** in cooperation with a semi-circular recess portion having cutouts, which is formed on the inner periphery of the recess of the side cover plate **5040** described later.

The both ends of the inner guide groove **510***a* for the direction changing passage **510** extend to the contacting surface of the thin sheet portion **529** with the end surface of the block body **513** so as to be connected to the respective ends of the ball running counter-groove **508** and the ball returning passage **509**. Pipe inserting holes **534**, **534** having a semi-circular shape, in which the ends of the resin pipes **523** are to be inserted are formed on the thin sheet portion **529**.

As shown in FIG. **43**, the resin pipe **523** is composed of an outer peripheral side-half pipe member **523**b located in the outer peripheral side of the ball circulation passage, which is continuously connected to the outer guide groove **510**b for the direction changing passage **510** of the side cover plate **540**, and an inner peripheral side-half pipe member **523**a located in the inner peripheral side of the ball circulation passage, which is continuously connected to an inner guide groove **510**a for the direction changing passage **510** of the side cover plate **540**.

The inner peripheral side-half pipe member **523**a has a groove portion **509**a having a semi-circular cross section, and side edge portions **523**c extending longitudinally along the groove portion **509**a, as shown in FIGS. **43**(c) and **43**(d). The outer peripheral side-half pipe member **523**b is formed into a linear member having the same circular cross section as the outer guide groove **510**b for the direction changing passage, which is formed on the side cover plate **540**. The outer peripheral side-half pipe member **523**b has a groove portion **509**b, which is continuously connected to the outer guide groove **510**b, and side edge portions **523**d extending longitudinally along the groove portion **509**b. The side edge portions **523**d is provided on its outer edges with projections **523**e, which are to be brought into contact with the outer edges of the side edge portions **523**c of the inner peripheral side-half pipe member **523**a to form the retainer-guide groove **509**c for the ball retainer **512**.

The inner peripheral side-half pipe member **523**a of the resin pipe **523** has the same length of the block body **513**. The inner peripheral side-half pipe member **523**a is positioned so as to be brought into contact with the back surface of the direction changing passage-inner guide forming portion **522**.

The outer peripheral side-half pipe member **523**b of the resin pipe **523** has on the other hand a longer length than the block body **513** by a length corresponding to the thickness of the thin sheet portion **529**. The outer peripheral side-half pipe members **523**b are inserted in the inserting holes **534**. Longitudinal positional determination of the outer peripheral side-half pipe member **523**b is made by bringing the both ends of the outer peripheral side-half pipe member **523**b inserted in the inserting holes **534** into contact with the peripheral edge of the end portion of the outer guide grooves **510**b for the direction changing passage, which are formed on the side cover plate **540**. The projections **523**e formed on the both side edges of the outer peripheral side-half pipe member **523**b come into contact with the outer edges of the cylindrical flange portions **533** formed on the direction changing passage-inner guide forming portion **522** to form a part of the guide groove **510**c, and the outer peripheral side-half pipe member **523**b and the inner peripheral side-half pipe member **523**a are restricted to be turned in the inserting hole **514**.

The resin pipes **523** and the direction changing passage-inner guide forming portions **522** are accurately positioned through the inserting holes **534** formed on the thin sheet portion **529** and a proper assembling is carried out in this manner.

As shown in FIGS. **44**(f) and **44**(g), the side cover plate **540** is provided with an inserting recess portion **540**a, in which the thin sheet portion **529** is inserted, recess portions **541** having the outer guide grooves **510**b for the direction changing passage, into which portions the direction changing passage-inner guide forming portions **522** are fitted, and screw-fixing portions for securing the side cover plate **540** to the block body **513**. In the screw-fixing portions, the side cover plate **540** is fixed to the block body **513** by inserting bolts (not shown) into holes **543** formed on the side cover plate **540** and engaging the bolts with screwed holes **545** formed on the end surface of the block body **513**. The holes **543** are located at four positions, i.e., the position corresponding to the thin sheet portion **529** between the direction changing passage-inner guide forming portions **522**, **522** of each of the resin-formed bodies **520**, **520**, and the positions in the vicinity of the thin sheet portions **529**, **529** on the horizontal portion **506**.

As shown in FIG. **44**(g), the outer guide groove **510**b for the direction changing passage in the recess portion **541** has on its side edges larger-diameter arcuate recesses **546**, which form the retainer-guide groove **510**c in cooperation with the cylindrical flange portions **533** of the direction changing passage-inner guide forming portions **522** as shown in FIG. **44**(f), and a smaller-diameter arcuate recesses **547**, in which the cylindrical flange portions **533** are inserted. The direction changing passage-inner guide forming portion **522** provided with the inner guide groove **510**a for the direction changing passage is fitted into the recess portion **541** of the side cover plate **540**, and the thin sheet portion **529** is received in the inserting recess portion **540**a of the side cover plate **540**. The thin sheet portion **529** is held between the side cover plate **540** and the end surface of the block body **513** through a clamping force so as to be firmly fixed therebetween.

The direction changing passage-inner guide forming portions **522** and the ball passage forming portion **521** are connected through the thin sheet portion **529**, thus making it possible to maintain an accurate positional relationship of the end of the inner guide groove **510**a for the direction changing passage formed in the direction changing passage-inner guide forming portion **522** relative to the ball passage forming portions **521**, **521**, as well as an accurate positional relationship of the inner guide groove **510**a for the direction changing passage relative to the ball returning passage **509**.

The thin sheet portion **529** located in the vicinity of the direction changing passage-inner guide forming portion **522** is uniformly urged against the flat end surface of the block body **513** through a clamping force applied to the side cover plate **540** (see FIG. **44**). Even when the direction changing passage-inner guide forming portion **522** is not located in a correct position, the thin sheet portion **529** changes its shape on the end surface of the block body **513**, thus permitting the correct positioning of the direction changing passage-inner guide forming portion **522**. The thin sheet portion **529** is firmly clamped and fixed through a clamping force, which is applied to the side cover plate **540**, and frictional force caused by such a clamping step may prevent an unfavorable movement of the inner guide groove **510**a for the direction changing passage.

The side cover plate **540** is secured to the block body **513** so that the direction changing passage-inner guide forming portion **522** assembled to the block body **513** is fitted into the recess portion **541** of the side cover plate **40**. Such a fitting step permits to make an accurate positioning of the side cover plate **540** relative to the block body **513**.

Now, description will be given of assembling steps for the above-mentioned resin-formed bodies **520** for forming the ball circulation passage.

First, the inner peripheral side-half pipe member **523***a* of the resin pipe **523** is inserted in the through-hole **514** of the wing portion **507** of the block body **513**.

Then, the resin frame **524** obtained by integral forming is inserted in the recess of the block body **513**, while causing the thin sheet portions **529** at the both ends of the resin frame **524** to slide on the respective end surfaces of the wing portion **507** of the block body **513**. The first connecting plate portion **525** of the resin frame **524** comes into contact with the corner portion between the horizontal portion **506** and the wing portion **507**, thus making positional determination in the vertical direction of the resin frame **524**. The second connecting plate portion **526** and the third connecting plate portion **527** of the resin frame **524** come into contact with the respective inner surfaces of the wing portions **507** of the block body **513**, thus making positional determination of the ball passage forming portions **521, 521** and the direction changing passage-inner guide forming portions **522, 522**. At this time, the inserting holes **534, 534** of the thin sheet portion **529** are aligned with the through-holes **514, 514** of the block body **513**.

Then, the outer peripheral side-half pipe members **523***b*, **523***b* are inserted in the through-holes **514, 514** from the inserting holes **534, 534**, thus completing the assembling step of one of the resin-formed bodies **520, 520** for forming the ball circulation passage.

The assembling step of the other of the resin-formed bodies **520, 520** is carried out in the same manner.

Then, the one side cover plate **540** is secured to the one end surface of the block body **513** by a clamping step, the ball retainer **512** holding the balls is inserted, and the other side cover plate **540** is secured to the other end surface of the block body **513** by the same clamping step, thus completing the assembling step of the movable block **504**.

According to the present invention, the resin-formed bodies **520, 520** for forming the ball circulation passage are separately formed from the block body **513**. Even when the movable block **504** has a larger size, there is no restriction of flow of molten resin by the block body **513**, unlike the case where the block body **513** is integrally formed with the resin-formed bodies **520, 520**. Increase in number of gates formed on a die may ensure proper run of the molten-resin, thus improving the formability. Especially, the ball passage forming portions **521, 521** located at the opposite longitudinal sides of the ball running groove **508** are thin, with the result that molten resin may not reach every part of the space for forming the ball passage forming portions **521, 521**. It is therefore effective to form the resin-formed bodies **520, 520** separately from the block body **513** in accordance with the embodiment of the present invention.

In addition, since there are formed the right and left-hand resin-formed bodies **520, 520** for forming the ball circulation passage, each of which has two endless circulation passages, a proper run of molten resin is ensured even when the movable block **513** has a larger width.

The continuous circulation passage is formed by the resin-formed body **520**, and it is therefore possible to make positional determination of the inner guide groove **510***a* for the direction changing passage relative to the ball passage forming portions **521, 521**, as well as positional determination of the inner guide groove **510***a* for the direction changing passage relative to the ball returning passage **509**, thus ensuring continuity of the circulation passage so as to make smooth circulation of the balls **503**.

When the proper positional relationship of the inner guide groove **510***a* for the direction changing passage relative to the ball passage forming portions **521, 521**, is maintained, the ball passage forming portions **521, 521** are located at the longitudinal both sides of the ball running groove **508** so as to be aligned with the ends of the inner guide groove **510***a* for the direction changing passage.

When the proper positional relationship of the inner guide groove **510***a* for the direction changing passage relative to the ball returning passage **509** is maintained, the inner guide groove **510***a* for the direction changing passage can be aligned with the inner groove **523***a* of the ball returning passage **509**.

The connecting portion of the ball passage forming portions **521, 521** and the direction changing passage-inner guide forming portion **522** is obtained by integral forming, thus permitting omission of an assembling step of the connecting portion. Although the running direction of the balls **503** is changed in such a connecting portion, the above-mentioned integral structure may ensure continuity of the circulation passage, without being affected by assembling accuracy. It is therefore possible to make smooth run of the balls **503** from the ball running passage between the ball running groove **505** and the ball running counter-groove **508** to the direction changing passage **510**, as well as from the direction changing passage **510** to the ball returning passage **509**.

According to the present invention as described in detail, since the resin-formed body for forming the rolling member circulation passage is separately formed from the block body, even when the movable block has a larger size, increase in number of gates formed on a die may ensure proper run of the molten resin, thus improving the formability. It is therefore effective to form the resin-formed body separately from the block body in accordance with the present invention, taking into consideration the fact that the rolling member passage forming portions located at the opposite longitudinal sides of the rolling member running track are thin, with the result that molten resin may not reach every part of the space for forming the rolling member passage forming portions.

The continuous circulation passage is formed by the resin-formed body, and it is therefore possible to make positional determination of the inner guide groove for the direction changing passage relative to the rolling member passage forming portions, as well as positional determination of the inner guide groove for the direction changing passage relative to the rolling member returning passage, thus ensuring continuity of the circulation passage so as to make smooth circulation of the rolling members.

When the connecting portion of the rolling member passage forming portions and the direction changing passage-inner guide forming portion or the connecting portion of the direction changing passage-inner guide forming portion and the returning passage forming portion, in which portion the running direction of the rolling members is changed is obtained by integral forming, it is possible to omit an assembling step of the connecting portion and to ensure continuity of the circulation passage, without being affected by assembling accuracy.

The integral formation of the connecting portion of the rolling member passage forming portion with the direction changing passage-inner guide forming portion may cause the smooth running of the rolling members between the rolling member running track in the loaded area and the direction changing passage-inner guide forming portion, even when the returning passage forming portion formed of resin is not used.

When the rolling member retainer is used, it is possible to maintain a proper continuity on the entire periphery of the circulation passage in the retainer guide portion for guiding the rolling member retainer.

The thin retainer guide portion is formed without insertion of the body of the movable member in a die, and position of gates in the die can freely be determined without being restricted by the body of the movable member, with the result that molten resin can reach, during formation of the guide portion, the entire space therefor, which is formed in the die.

In addition, the formation of the right and left-hand resin-formed bodies for forming the rolling member circulation passage, each of which has two endless circulation passages may ensure a proper run of molten resin even when the body of the movable member has a larger width.

The connection of the direction changing passage-inner guide forming portion with the rolling member passage forming portion through the thin sheet portion makes it possible to maintain, through deformation of the thin sheet portion, a proper positional relationship between the direction changing passage-inner guide forming portion and the rolling member passage forming portion or a proper positional relationship between the direction changing passage-inner guide forming portion and the rolling member returning passage forming portion, thus making an accurate positional determination of the end of the direction changing passage-inner guide forming portion relative to the rolling member returning passage forming portion as well as an accurate positional determination of the direction changing passage-inner guide forming portion relative to the rolling member returning passage forming portion.

The thin sheet portion is urged against the flat end face of the body of the movable member by a clamping force, which is applied to the side cover plate. It is therefore possible to correct the position of the direction changing passage-inner guide forming portion through deformation of the thin sheet portion, even when the direction changing passage-inner guide forming portion is not correctly positioned relative to the end face of the body of the movable member.

In addition, the thin sheet portion can firmly be secured between the side cover plate and the body of the movable member by the clamping force, which is applied to the side cover plate, and it is therefore possible to prevent the direction changing passage-inner guide forming portion from being incorrectly placed.

What is claimed is:

1. A linear motion guiding apparatus comprising:

a guide member provided with a rolling member running track, and

a movable member arranged so as to be movable along the guide member through a large number of rolling members, said movable member being provided with (i) a rolling member running counter-track corresponding to the rolling member running track of said guide member, (ii) a rolling member returning passage arranged away from said rolling member running counter-track by a prescribed distance and in parallel therewith and (iii) a pair of direction changing passages for connecting the rolling member running counter-track and the rolling member returning passage to permit circulation of the rolling members

characterized in that:

a resin-formed body for forming a rolling member circulation passage comprises a pair of rolling member passage forming portions extending along both longitudinal sides of said rolling member running counter-track and a pair of direction changing passage-inner guide forming portions for forming inner peripheral guide portions of said direction changing passages, said resin-formed body being separately formed from a body of said movable member;

said rolling member returning passage is made by forming a through-hole in the body of said movable member; and

said pair of rolling member passage forming portions and at least one of said air of direction changing passage-inner guide forming portions are connected with each other through integral forming.

2. The apparatus as claimed in claim **1**, wherein:

a rolling member retainer is provided, said rolling member retainer being able to retain the rolling members in a train with a prescribed distance kept between adjacent two of the rolling members, and said rolling member retainer having side edge portions projecting from both sides of each of the rolling members; and

guide portions for guiding the side edge portions of the rolling member retainer are formed on an entire periphery of the rolling member circulation passage.

3. The apparatus as claimed in claim **1**, wherein:

each of said direction changing passage-inner guide forming portions has a thin sheet portion, which is to be brought into contact with an end face of the body of said movable member, and said each of said direction changing passage-inner guide forming portions is connected to the rolling member passage forming portions or the returning passage forming portion by means of said thin sheet portion.

4. The apparatus as claimed in claim **1**, wherein:

said guide member comprises a guide rail;

said movable member comprises a movable block, which is provided with a horizontal portion, which faces an upper surface of said guide rail and a pair of wing portions, between which the guide rail is held at right and left-hand side surfaces thereof; and

two trains of the rolling members are arranged in a gap between the upper surface of the guide rail and a lower surface of the movable block, and a single train of the rolling members is arranged in each of gaps between the right and left-hand side surfaces of the guide rail and both of the wing portions, so as to provide a total number of trains of four.

5. The apparatus as claimed in claim **1**, wherein:

four direction changing passage-inner guide forming portions are formed corresponding to the four trains of the rolling members, respectively, and said four direction changing passage-inner guide forming portions are integrally connected with each other.

6. The apparatus as claimed in claim **1**, wherein:

each of said pair of rolling member passage forming portions are divided at a prescribed position in a longitudinal direction thereof into two parts.

* * * * *

US006231238B1

(12) **United States Patent**
Teramachi

(10) **Patent No.: US 6,231,238 B1**
(45) **Date of Patent: *May 15, 2001**

(54) **LINEAR MOVEMENT GUIDE APPARATUS AND METHOD FOR ASSEMBLING THE APPARATUS**

(75) Inventor: **Hiroshi Teramachi**, Tokyo (JP)

(73) Assignee: **THK Co., Ltd.**, Tokyo (JP)

(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **08/338,523**

(22) PCT Filed: **Mar. 30, 1994**

(86) PCT No.: **PCT/JP94/00526**

§ 371 Date: **Nov. 29, 1994**

§ 102(e) Date: **Nov. 29, 1994**

(87) PCT Pub. No.: **WO94/23219**

PCT Pub. Date: **Oct. 13, 1994**

(30) **Foreign Application Priority Data**

Mar. 30, 1993 (JP) 5-095349
Jul. 6, 1993 (JP) 5-192075

(51) **Int. Cl.**[7] **F16C 29/06**
(52) **U.S. Cl.** **384/45**; 29/898.03
(58) **Field of Search** 384/45, 43, 44; 464/168; 29/898.03

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,582,369	4/1986	Itoh .	
4,692,038	9/1987	Kasai	384/45
5,273,365 *	12/1993	Kondoh	385/45
5,492,412 *	2/1996	Tsukada	384/45

FOREIGN PATENT DOCUMENTS

40 41 421 A1	7/1991	(DE) .
0 577 963 A1	1/1994	(EP) .
57-33217	2/1982	(JP) .
59-54814	3/1984	(JP) .
60-155012	8/1985	(JP) .
62-141308	6/1987	(JP) .
63-24258	7/1988	(JP) .
64-53621	4/1989	(JP) .
64-53622	4/1989	(JP) .
3-199710	8/1991	(JP) .
4-102714 *	4/1992	(JP) .
WO 84/01194	3/1984	(WO) .

OTHER PUBLICATIONS

Blurb translation above ref. 4–102714 (1992).*
"THK LM System" catalog, Published Jan. 1997, p. 1.

* cited by examiner

Primary Examiner—Lenard A. Footland
Assistant Examiner—C Williams
(74) *Attorney, Agent, or Firm*—Armstrong, Westerman, Hattori, McLeland & Naughton

(57) **ABSTRACT**

The linear movement guide apparatus according to the invention has features that two rows of ball rolling grooves are formed on an upper surface of a tracking base and one or two rows of ball rolling grooves are formed on both side surfaces thereof, respectively, on a concave portion of a sliding base are provided corresponding ball rolling grooves so as to face to the ball rolling grooves formed on the tracking base; the depth of each ball rolling groove about ½ of the diameter of balls to be held therein; and the distance between the ball rolling grooves formed on the upper surface of the tracking base and the distance between said ball rolling grooves and the ball rolling grooves formed on side surfaces are varied with respect to the distances between the corresponding ball rolling grooves formed on the sliding base. Thereby, the pitches between the ball rolling grooves on the tracking and sliding bases can be selected so as to obtain an optimum contact angles of balls for the load condition applied to the linear movement guide apparatus.

3 Claims, 14 Drawing Sheets

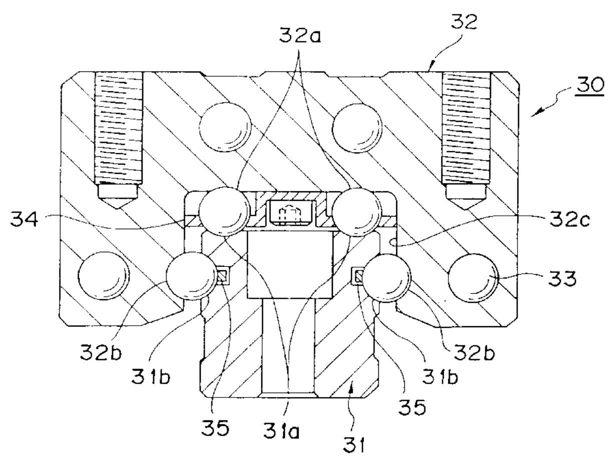


FIG. 1

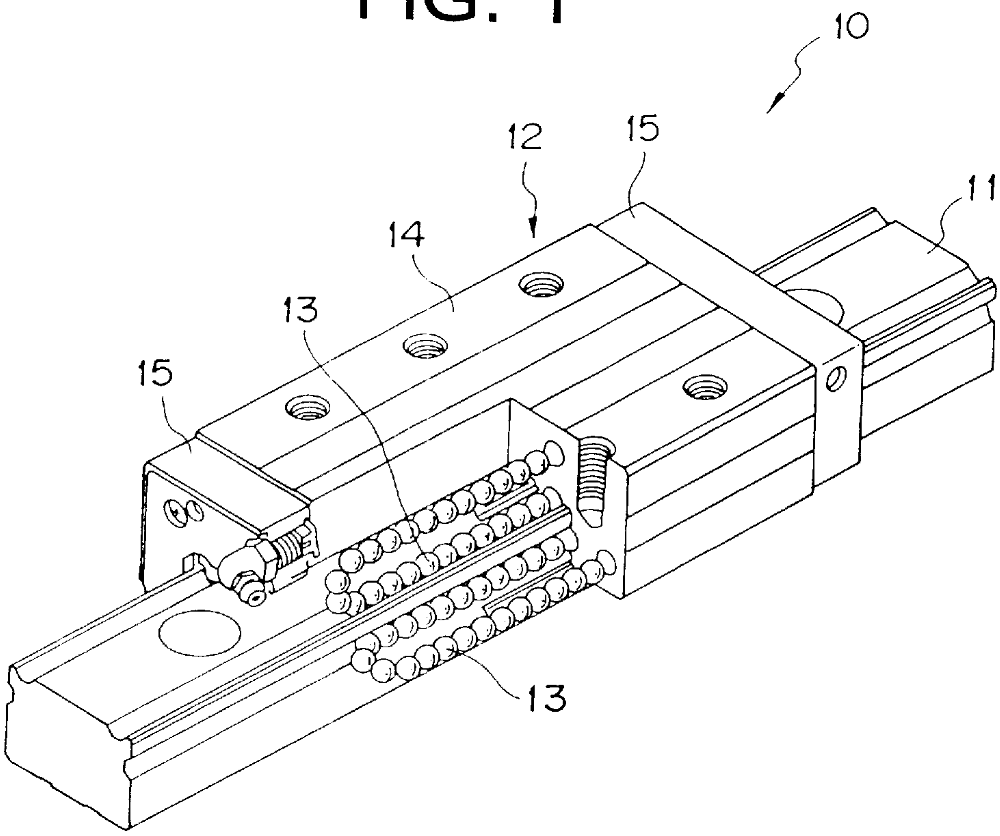

10
12
15
11
14
13
15
13

FIG.2

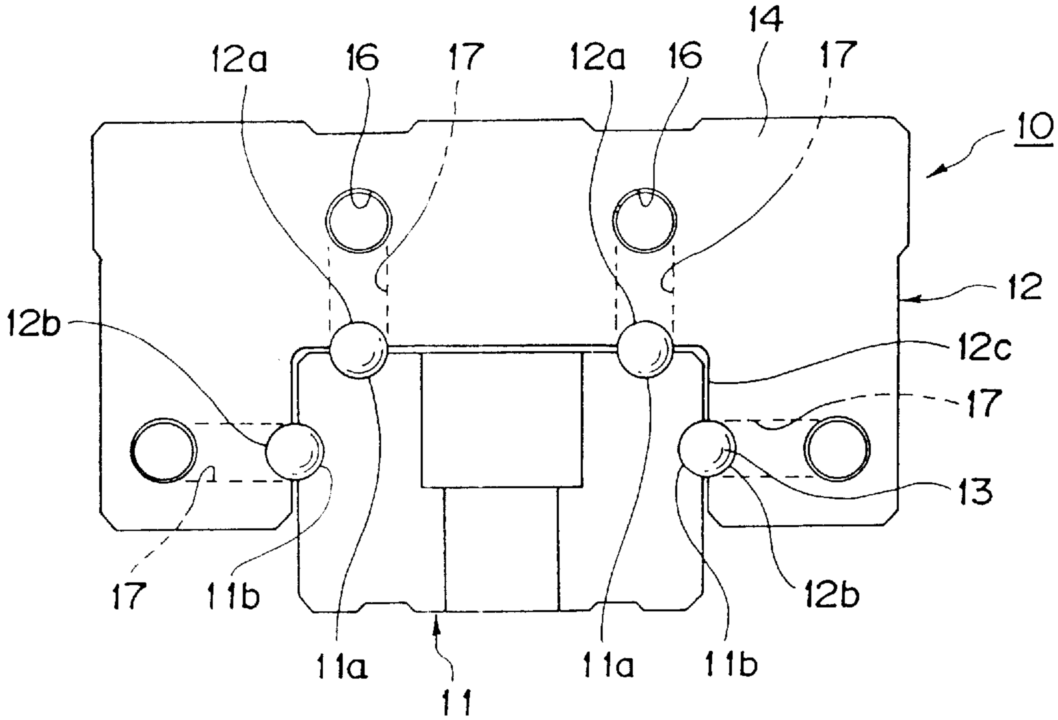

14
12a
16
17
12a
16
17
10
12
12b
12c
17
13
17
11b
12b
11a
11a
11b
11

FIG. 3

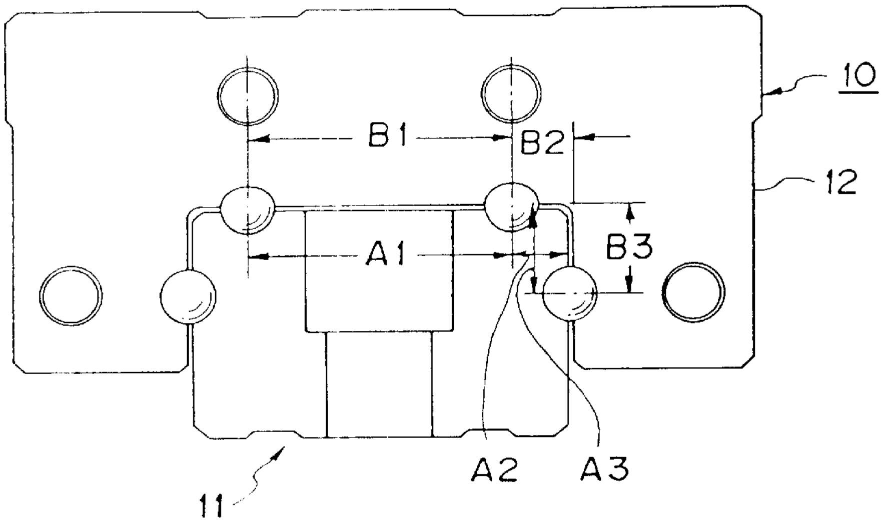


FIG. 4

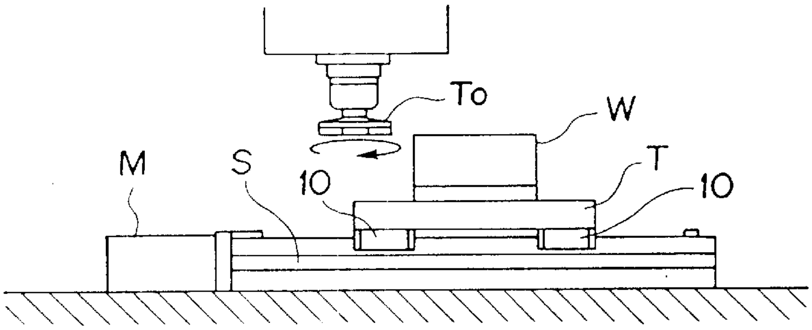


FIG. 5

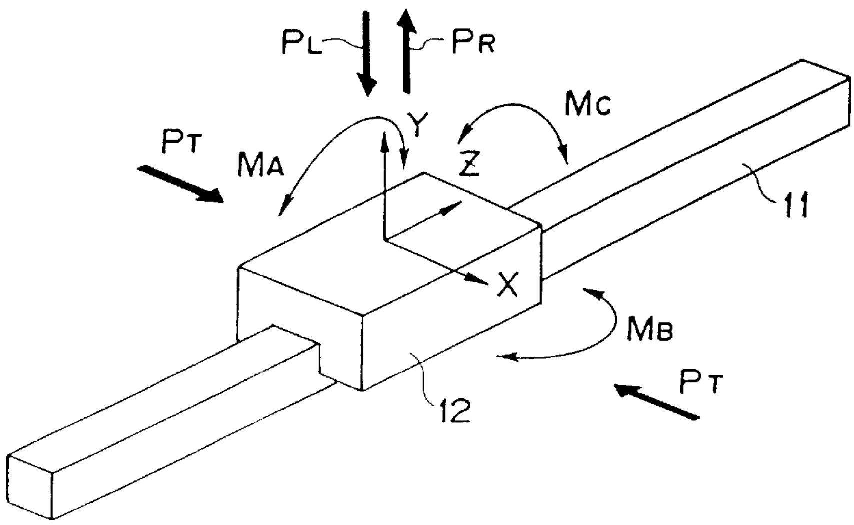


FIG. 6

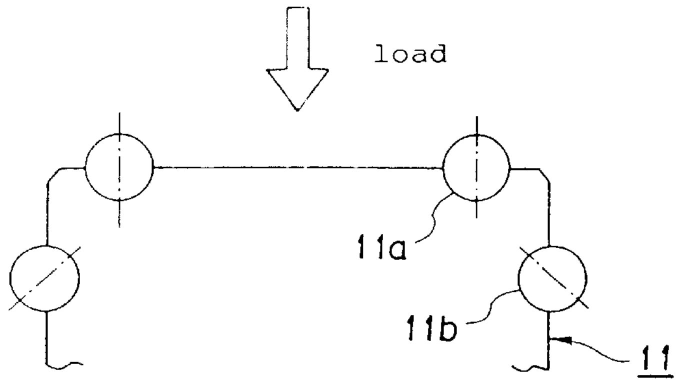


FIG.7(a)

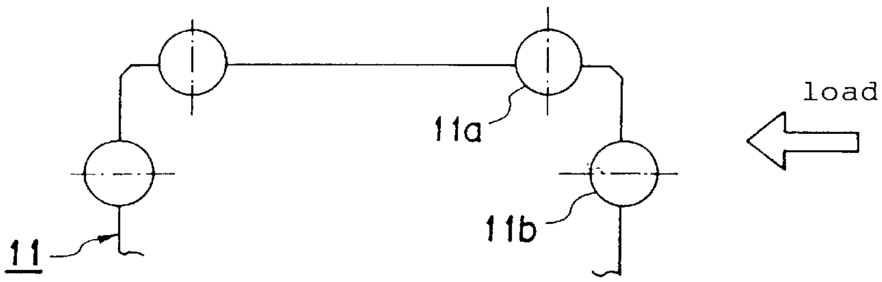


FIG.7(b)

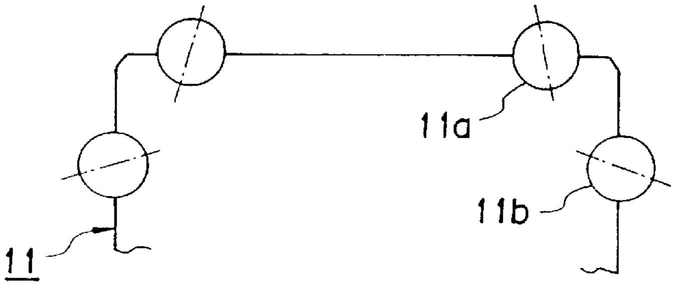


FIG.8(a)

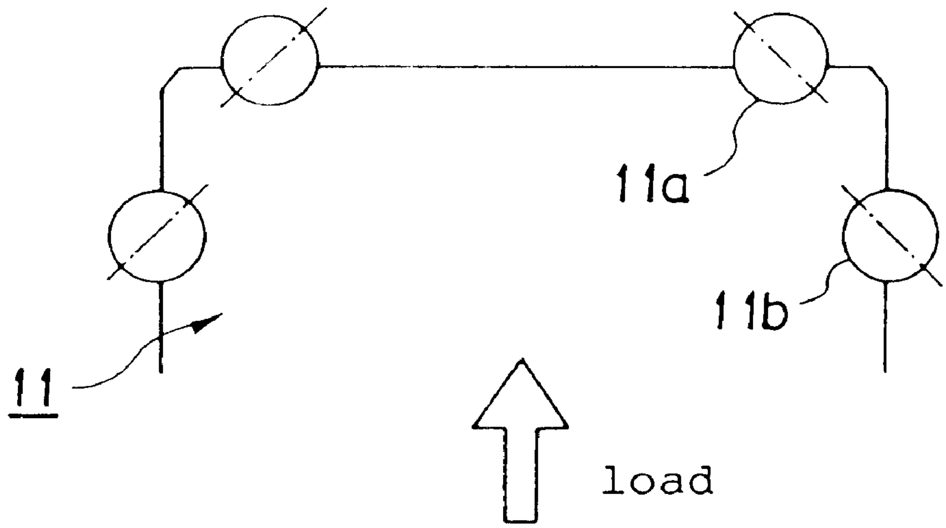


FIG.8(b)

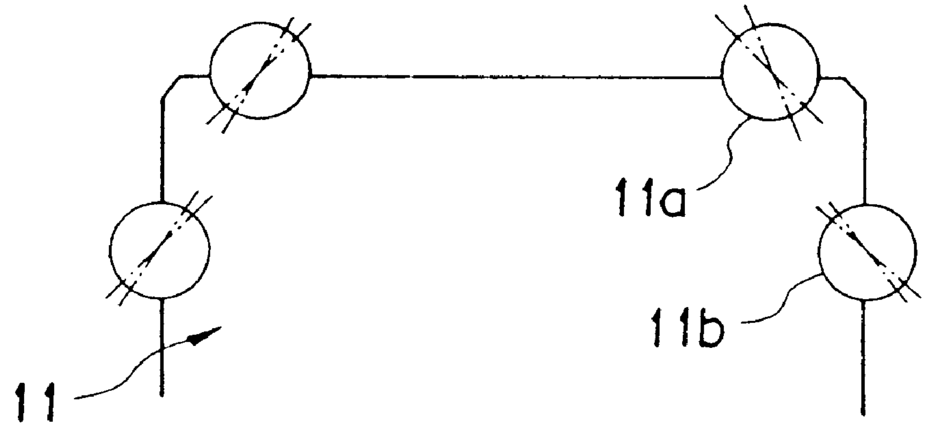


FIG. 9

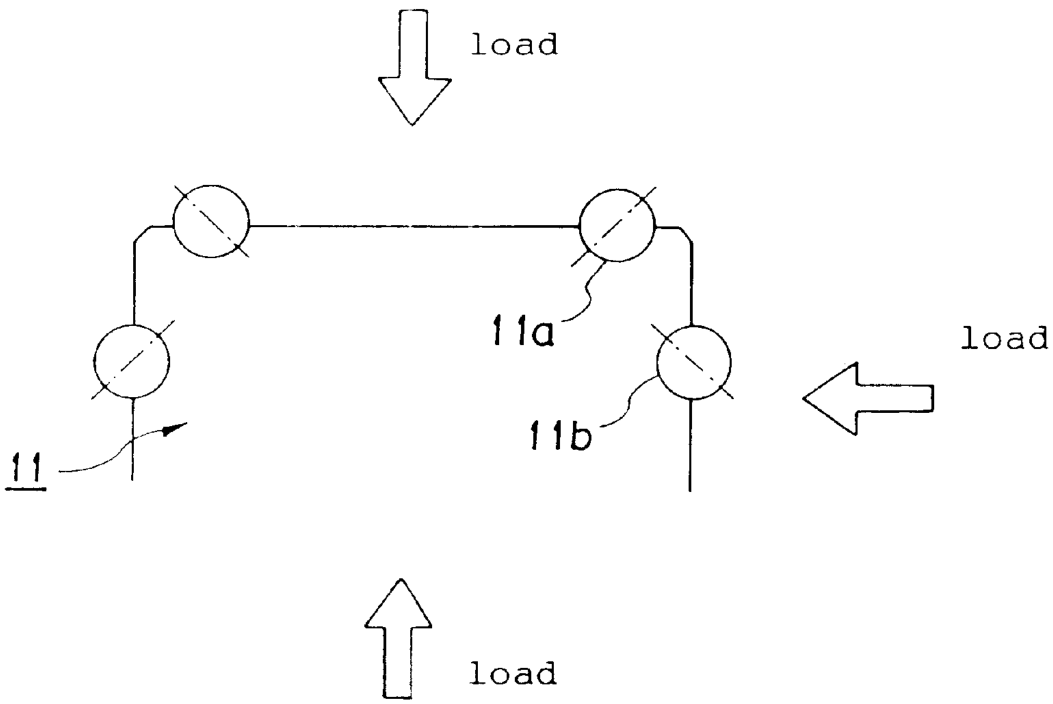


FIG. 10

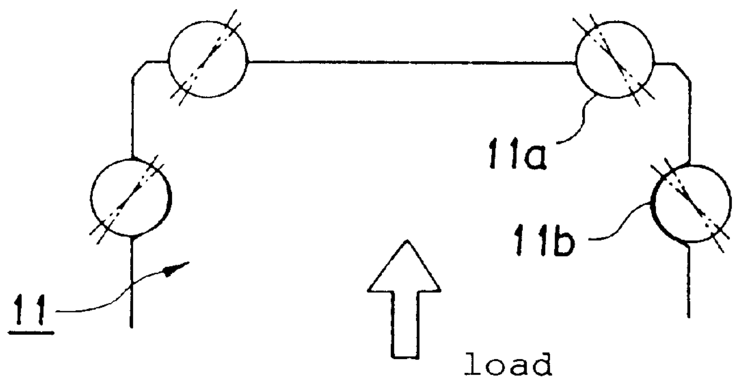


FIG. 11(a)

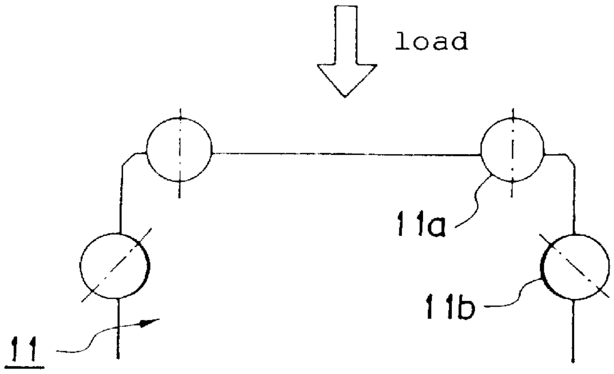


FIG. 11(b)

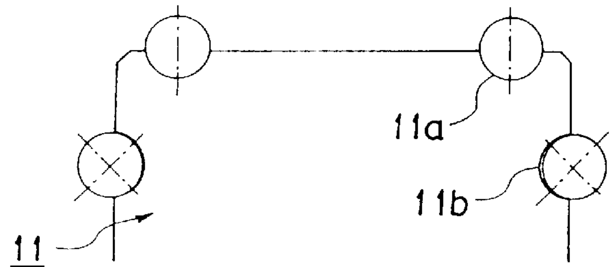


FIG. 12(a)

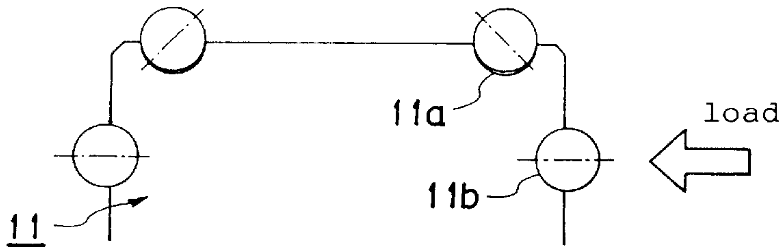


FIG. 12(b)

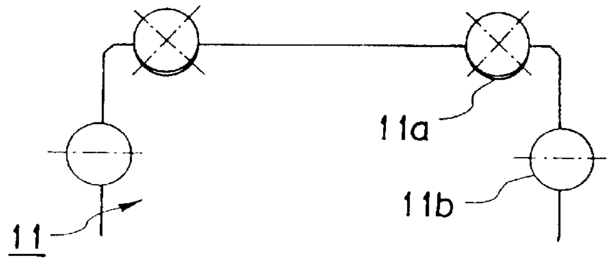


FIG. 13

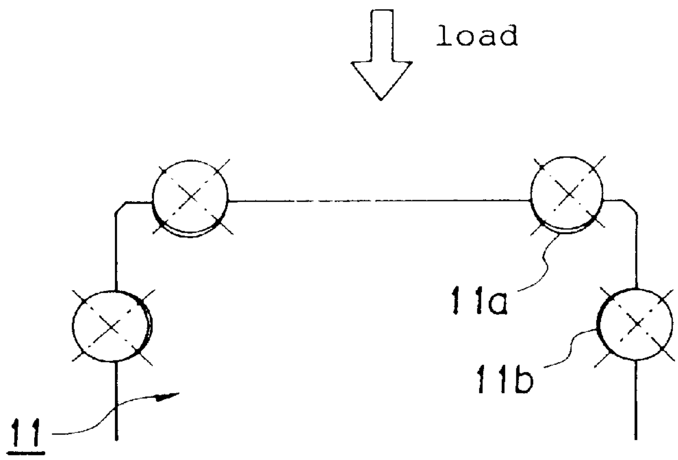


FIG.14

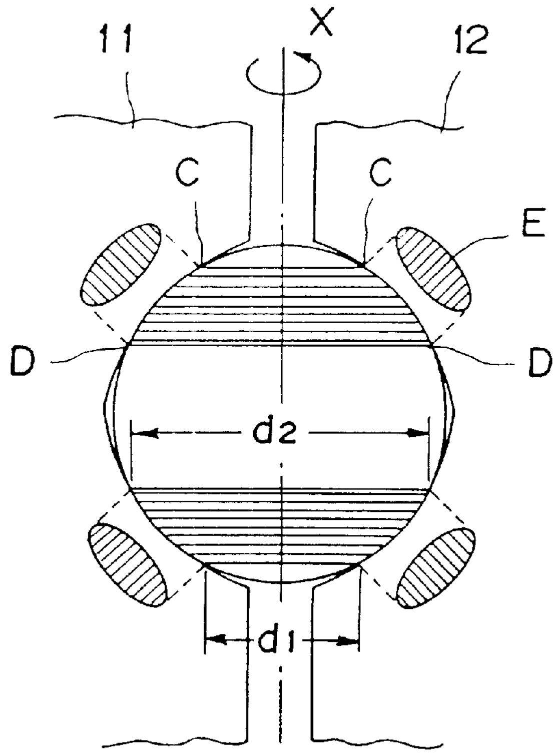


FIG. 15

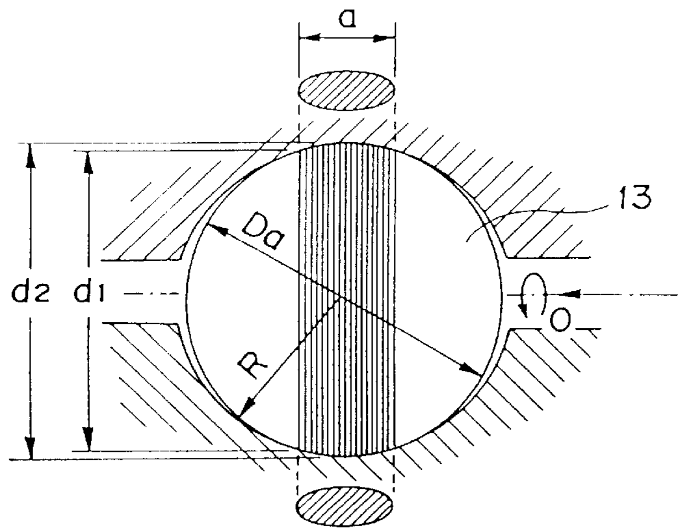


FIG. 16(a)

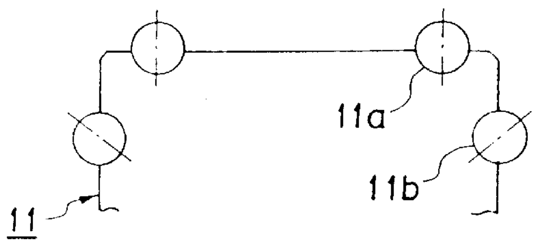


FIG. 16(b)

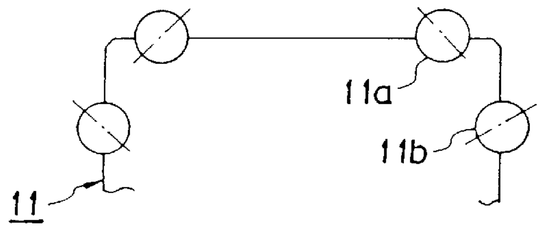


FIG. 16(c)

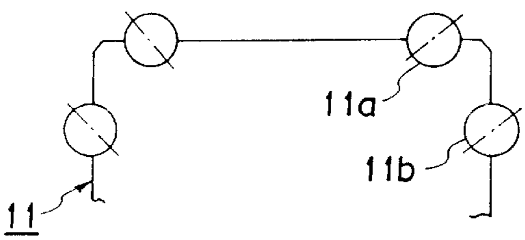


FIG. 16(d)

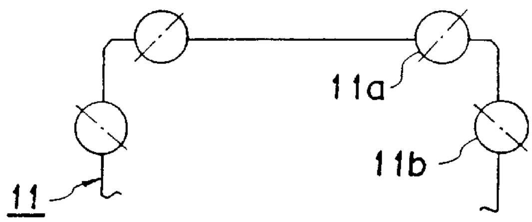


FIG. 16(e)

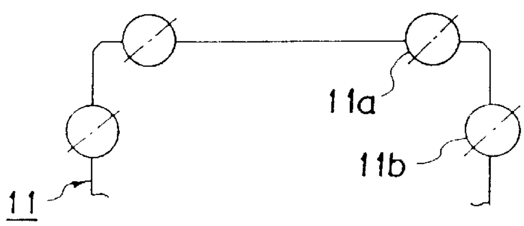


FIG. 17

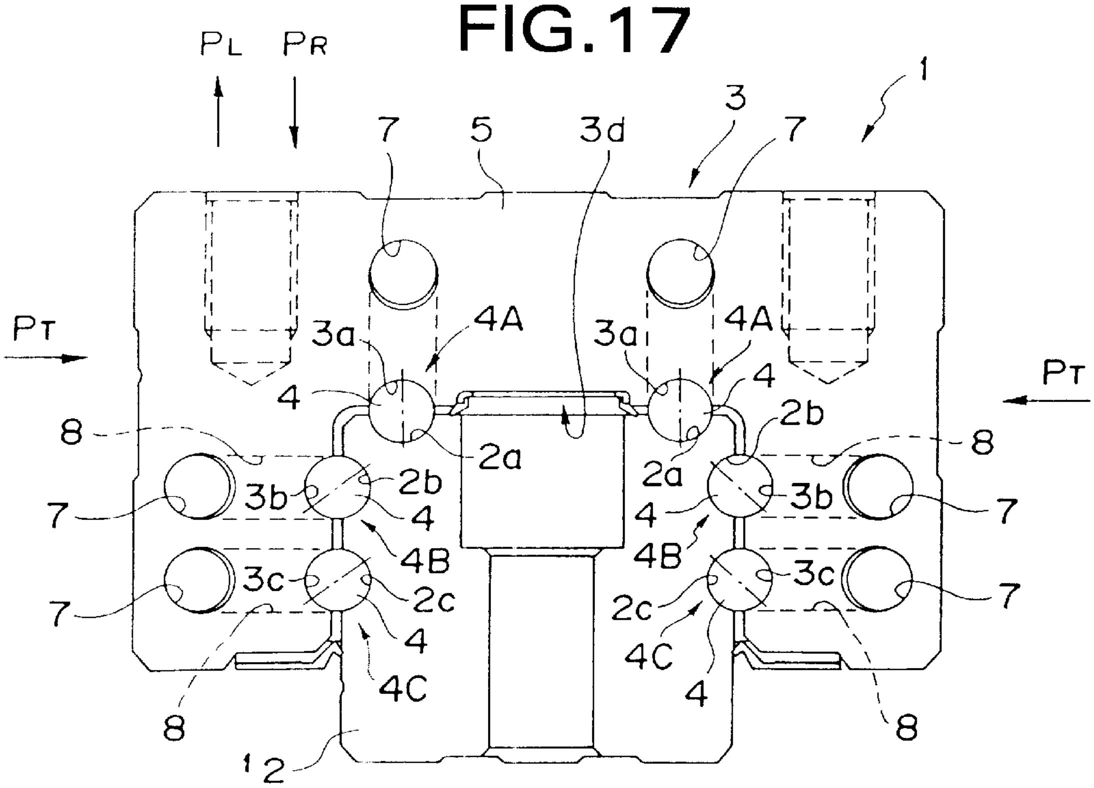

PL
PR
1
3
7
5
3d
7
PT
3a
4A
3a
4A
PT
4
4
2b
8
2a
2a
8
7
3b
2b
4
4
3b
7
4B
4B
7
3c
2c
2c
3c
7
4
4C
4
4C
8
4
8
2

FIG. 18

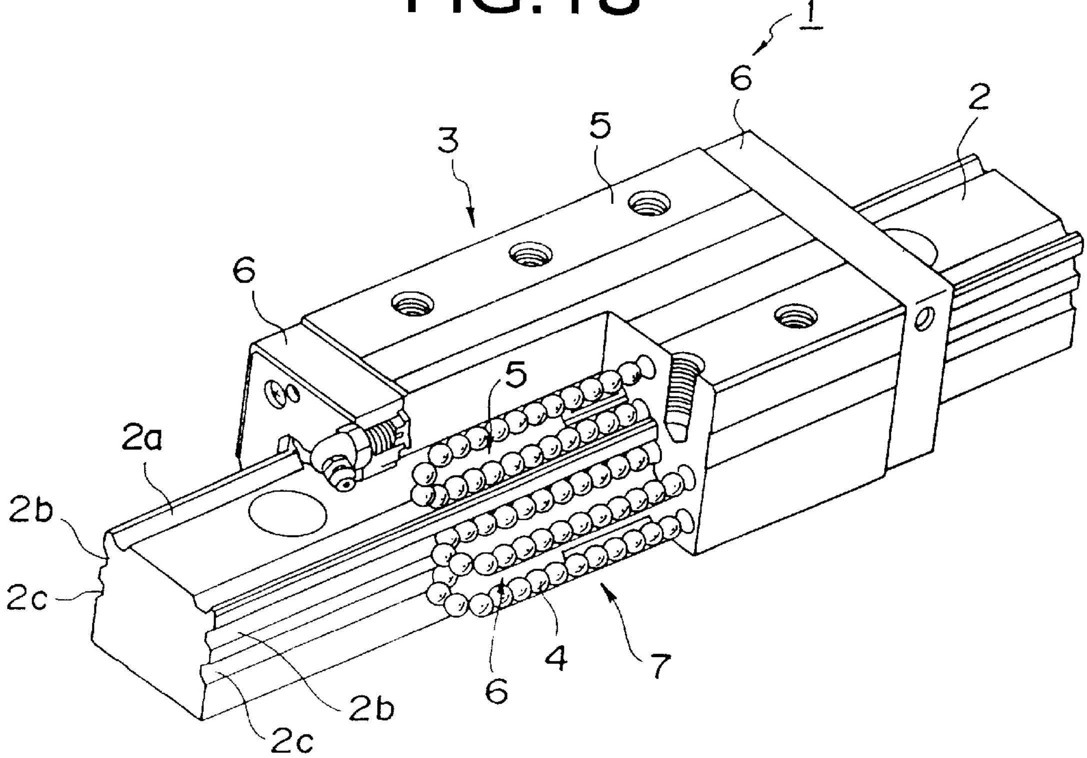

1
6
2
3
5
6
5
2a
2b
2c
4
7
6
2b
2c

FIG.19

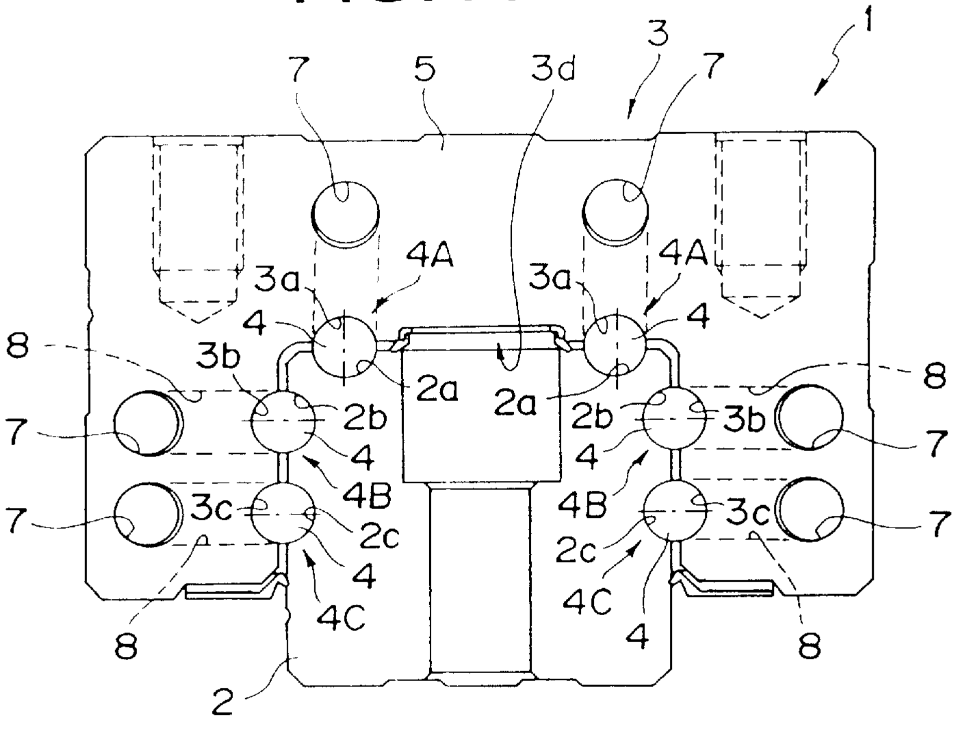

1
3
7
5
3d
7
4A
3a
4A
3a
4
4
8
3b
2a
2a
8
2b
2b
3b
7
4
4
7
4B
4B
7
3c
3c
7
2c
2c
4
4C
4C
4
8
8
2

FIG.20

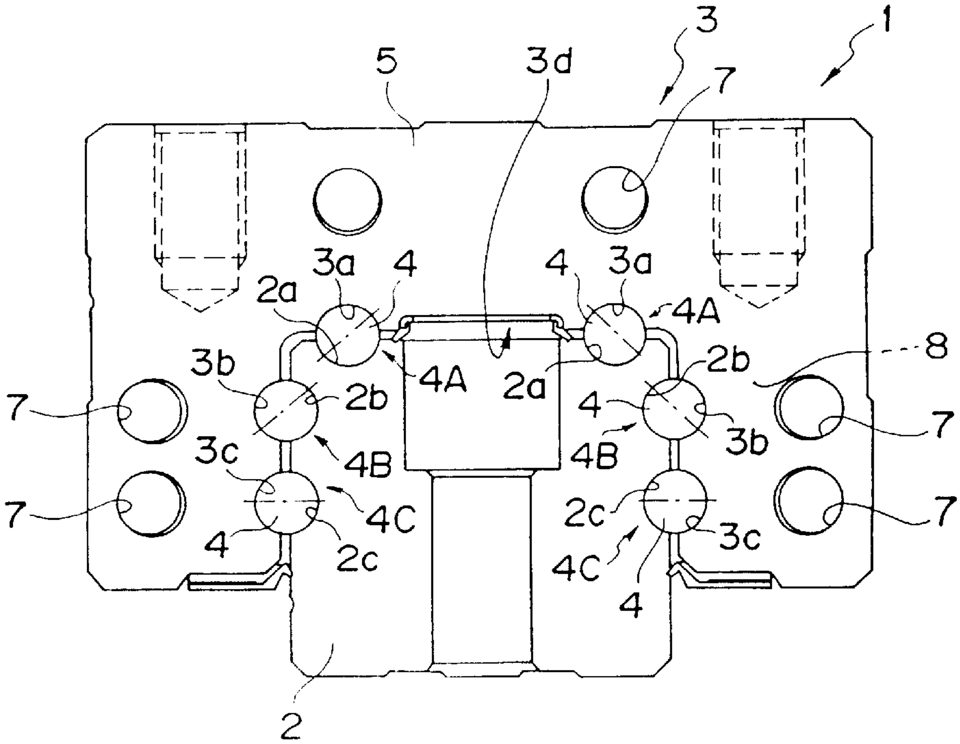

1
3
5
3d
7
3a
4
4
3a
2a
4A
4A
2a
8
3b
2b
2b
7
2b
4
7
3b
4B
4B
3c
7
4C
2c
7
4
3c
2c
4C
4
2

FIG.21

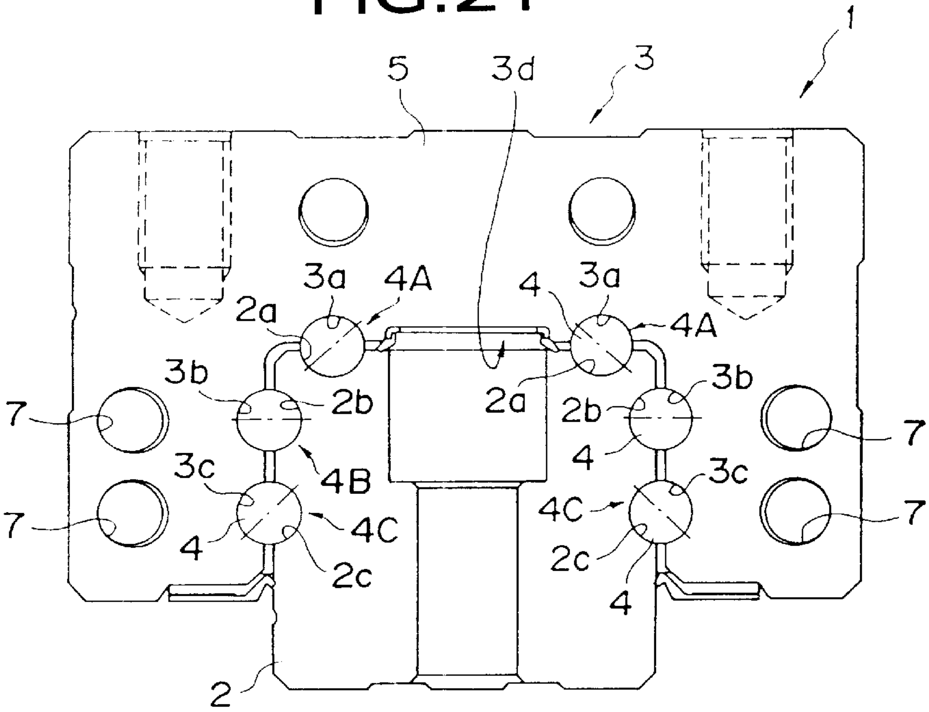


FIG.22(a)

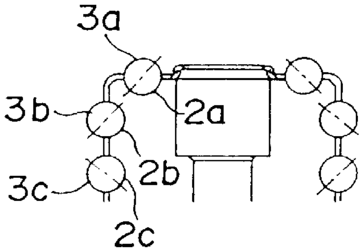


FIG.22(b)

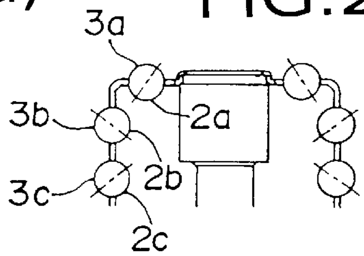


FIG.22(c)

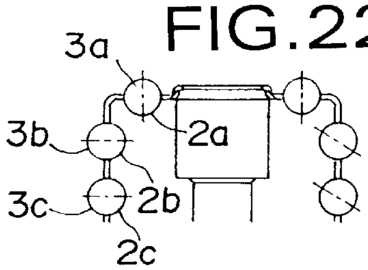
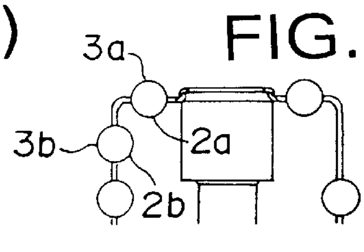


FIG.22(d)



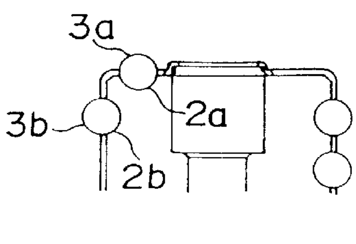


FIG.22(e)

FIG.23

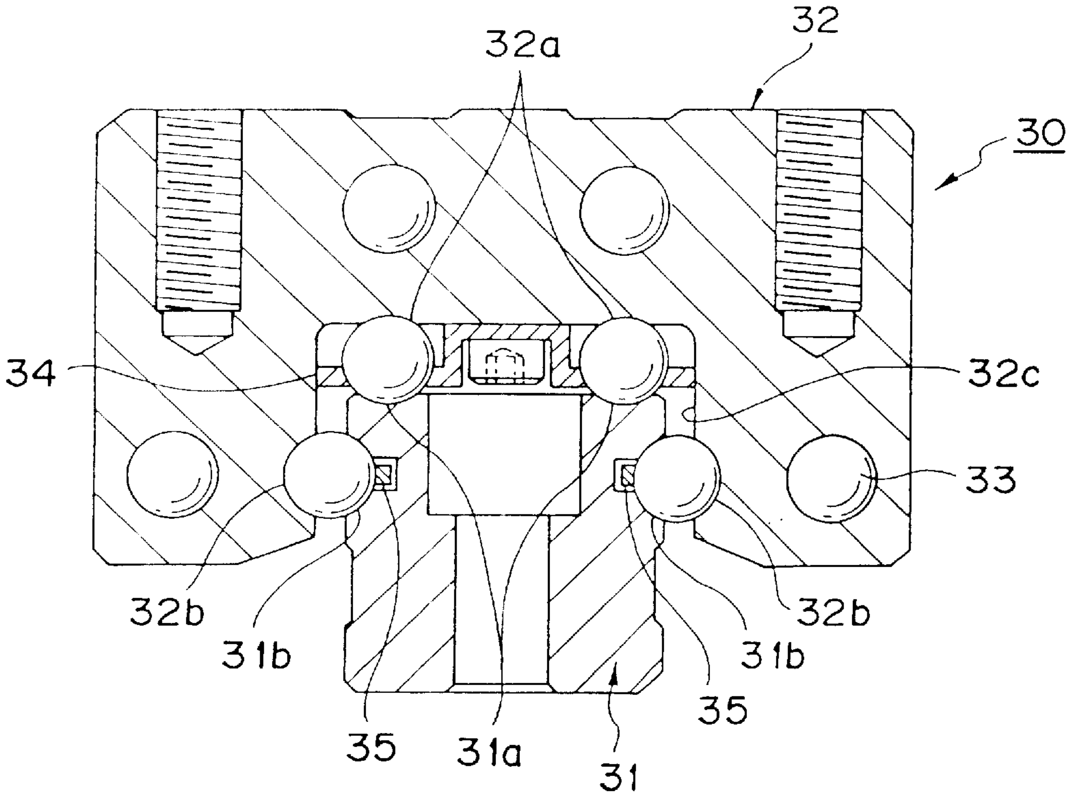

32a
32
30
34
32c
33
32b
31b
32b
31b
35
35
31a
31

FIG.24

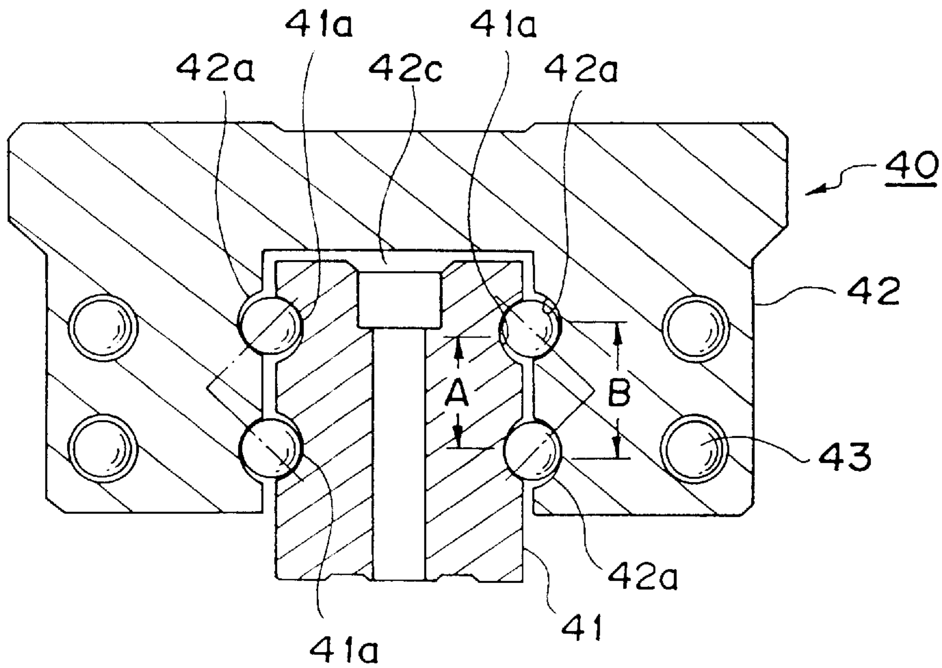

41a
41a
42a
42c
42a
40
42
A
B
43
42a
41
41a

FIG.25

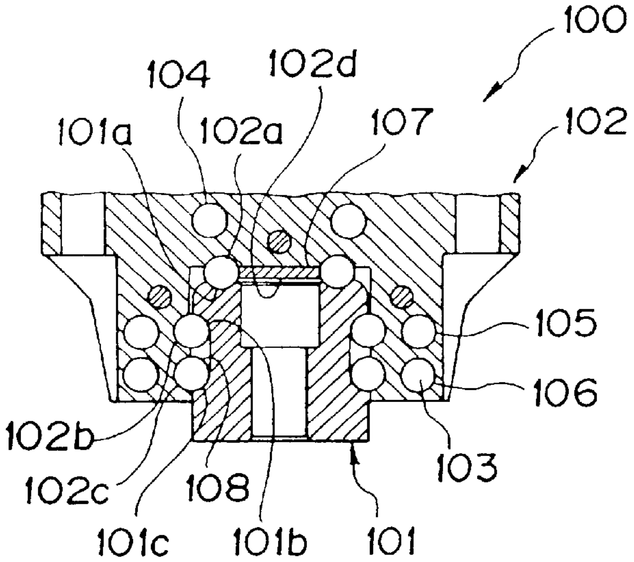

100
104
102d
101a
102a
107
102
105
106
102b
103
102c
108
101c
101b
101

FIG.26

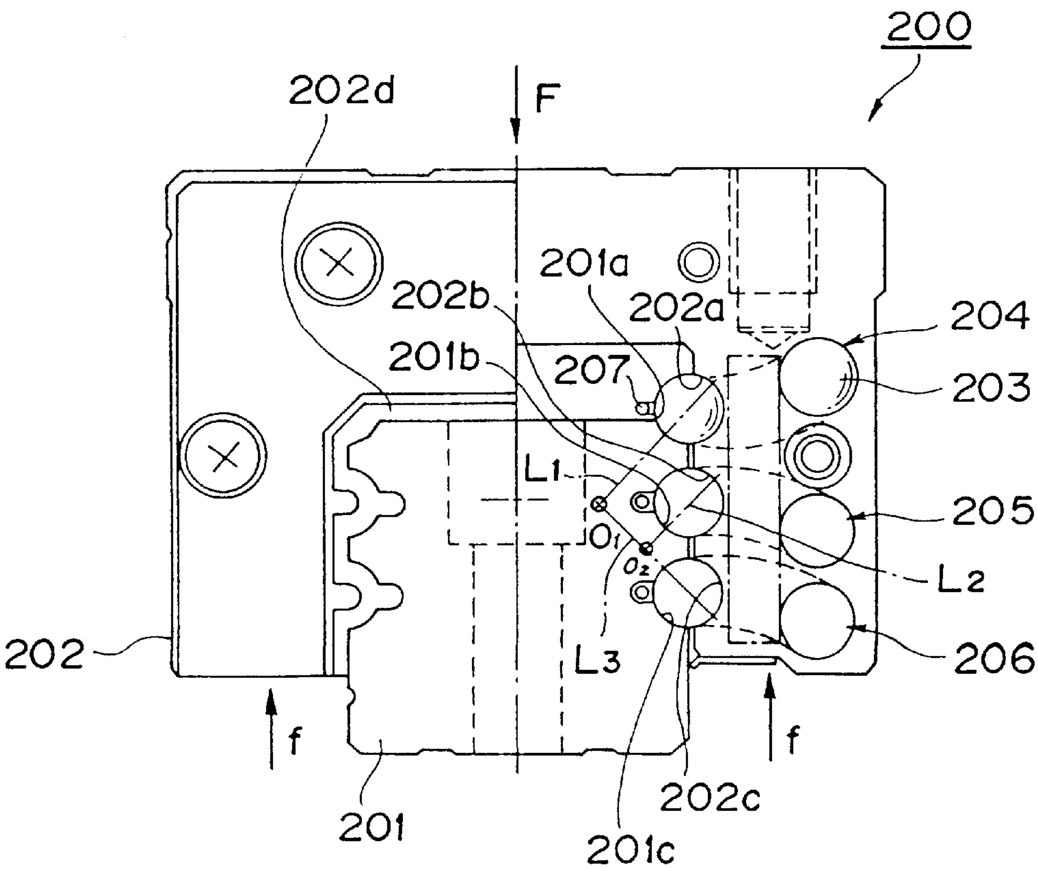
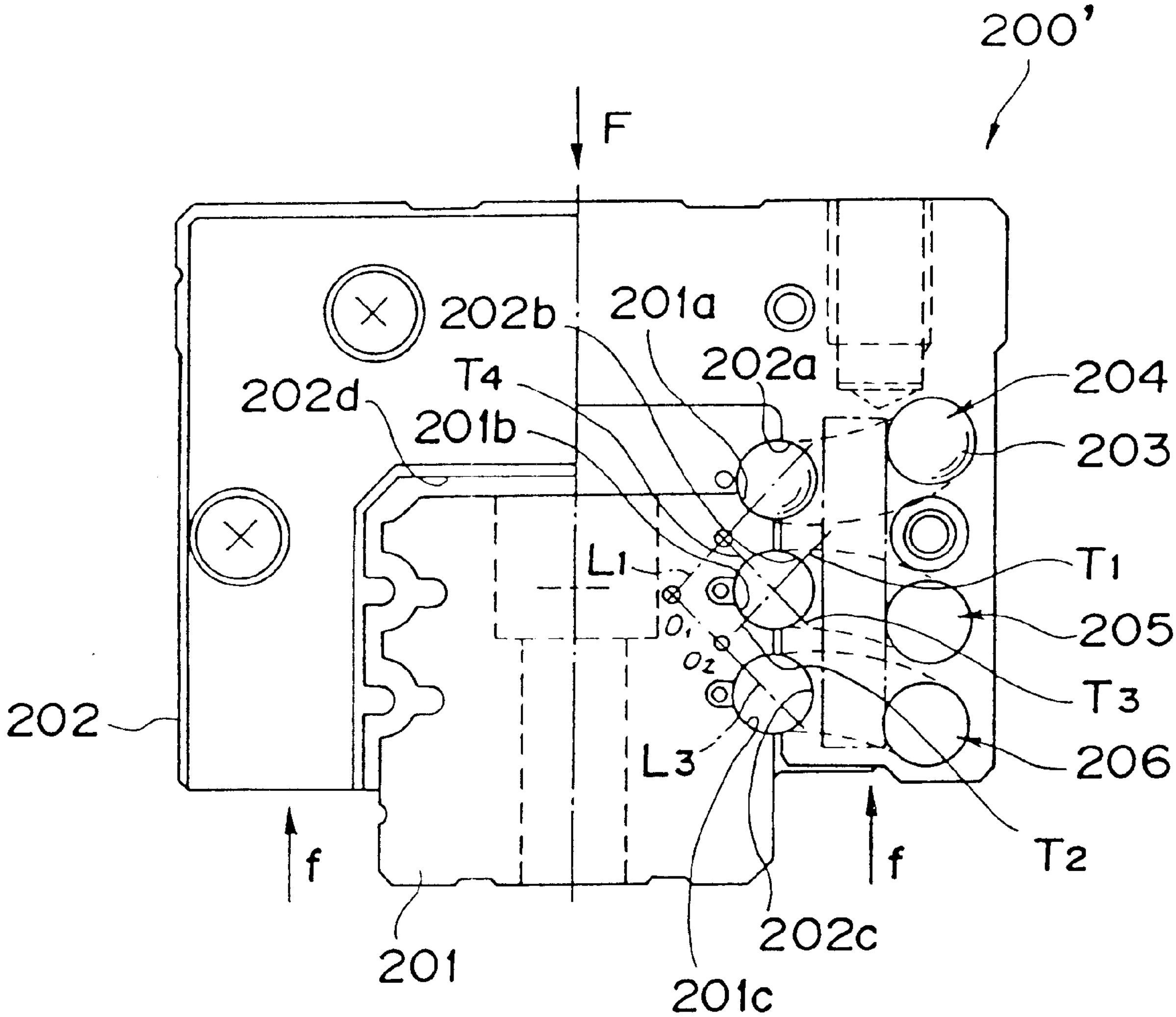

200
202d
F
201a
202b
202a
204
201b
207
203
L1
205
O1
O2
L2
L3
202
206
f
f
202c
201
201c

FIG.27


200'
F
202b
201a
202a
204
203
T4
202d
201b
L1
T1
205
O1
O2
T3
202
L3
206
f
f
T2
202c
201
201c

LINEAR MOVEMENT GUIDE APPARATUS AND METHOD FOR ASSEMBLING THE APPARATUS

TECHNICAL FIELD

The present invention relates to a linear movement guide apparatus, which is used to be applied to linear guide portions of, for instance, machine tools or robots for use in industrial purpose.

In such machine tools or robots, all kinds of load, i.e. load from a radial direction, load from a horizontal direction, load from a reversed-radial direction, and a moment load, are applied to the linear guide portion thereof, since the linear guide portion of the tools or robots is diversified. The present invention, particularly, relates to a linear movement guide apparatus and a method for assembling the apparatus, in which a common member is used to manufacture a tracking base and a sliding base of the apparatus without regard to the amount or the direction of load applied thereto, and suitable contact angles according to the directions, to which the loads are applied, can be obtained to give a maximum life time, a maximum stiffness and a maximum allowance of load to the apparatus.

BACKGROUND ART

First Prior Art

Such kind of linear movement guide apparatus is, for instance, disclosed in Japanese Utility Model Preliminarily Publication No. Hei 3-199710.

FIG. **23** is a schematic view showing an apparatus of the first prior art.

As shown in FIG. **23**, the linear movement guide apparatus **30** comprises a tracking base **31** having a square-shape cross-section, a sliding base **32** having a concave portion **32**, which also has a square-shaped cross section, for accepting said tracking base **31**, and four rows of indefinitely circulating balls **33**. On an upper surface of the tracking base **31** are provided two rows of ball rolling grooves **31***a*, and on each side surface of the tracking base **31** is arranged one row of ball rolling groove **31***b*, respectively. On an inside surface of said concave portion **32***c* of said sliding base **32**, are provided two rows of corresponding ball rolling grooves **32***a* so as to face to said two rows of ball rolling grooves **31***a* formed on the upper surface of the tracking base **31**, and one row of corresponding ball rolling groove **32***b* formed on each side surface thereof so as to face to the row of ball rolling groove **31***b* formed on the upper surface of the tracking base **31**, respectively. The ball rolling grooves **31***a* and **32***a*, which face to each other, are arranged as circular-ark shaped shallow grooves having a slightly larger dimension than that of the balls to be held therein. It should be noted that the ball rolling grooves **31***a* and **31***b*, which also face to each other, are arranged as Gothic ark-shaped grooves.

Holders **34** and **35** are provided in the apparatus in order to prevent that balls **33** are fallen down from the grooves when the sliding base **31** is taken off from the tracking base **32**.

Contact angles of balls, in the linear movement guide apparatus **30**, are arranged such that the contact angles in the upper two ball rows are substantially directed in a vertical direction, but in the lower two ball rows, the balls are made contact with the ball rolling grooves, which have their shapes of a combination of two circular-arks, at four points, i.e. at perspective upper points and perspective lower points, in a substantially even manner (hereinafter, such contact condition is called "complete four points contact"). In such a manner, above, in the linear movement guide apparatus **30**, the load applied from an upper direction is supported by the two rows of ball rolling grooves **31***a* and **32***a* having circular-ark shapes; and the load applied from a horizontal direction is supported by the ball rolling grooves **31***b* and **32***b* having Gothic-ark shapes by the complete four points contact.

Therefore, the apparatus has an excellent load supporting capability against the loads applied from not only an upper direction but also a lateral direction.

Second Prior Art

On the other hand, another linear movement guide apparatus **40** is disclosed in Japanese Utility Model Publication no. Sho 63-24258.

As shown in FIG. **24**, the linear movement guide apparatus **40** comprises a tracking base **41** having a square-shaped cross section, a sliding base **42** having a concave portion **42***c*, which also has a square-shaped cross section, for accepting the tracking base **41**, and four rows of infinite circulating balls **43**.

On side surfaces of the tracking base **41** are provided two rows of ball rolling grooves **41***a*, respectively; and on an inside surface of the concave portion **42***c* of the sliding base **42** are provided corresponding two rows of ball rolling grooves **42***a* so as to face to the ball rolling grooves **41***a* of the tracking base **42**. Therefore, four rows in total are formed in the apparatus. These ball rolling grooves **41**a and **42***a*, which face to each other, are designed as Gothic-ark shaped grooves, and the contact angle of balls in each ball row is arranged about 45 degrees with respect to a horizontal direction.

In the linear movement guide apparatus **40**, it is possible to have different constructions that the extended lines of the contact angles on the side surfaces of the tracking base **41** intersect with each other outside of the tracking base **41** (hereinafter, called as "DB structure"), or that the extended lines intersect with each other inside of the tracking base **41** (hereinafter, called as "DF structure"), by making a distance A between two rows of ball rolling grooves **41***a* and **41***a*, which are formed on the side surfaces of the tracking base **41**, larger or smaller than a distance B between the corresponding two rows of ball rolling grooves **42***a* and **42***a*, which are formed on the inside surface of the sliding base **42**.

In any way, in the linear movement guide apparatus **40**, when a small load is applied thereto from a vertical direction, the load is supported by one of the ball rows formed on the side surfaces, i.e. two ball rows in total; and when a large load is applied thereto from the vertical direction, the load is supported by two ball rows formed on the side surfaces, i.e. four ball rows in total. Since the number of ball rows for supporting the load is increased when a heavy load is applied, as stated in the above, a burden for the load in each ball rolling groove is reduced, so that the life time of the linear movement guide apparatus **40** becomes long.

Third Prior Art

Another linear movement guide apparatus, in which six ball rows in total are provided, is disclosed in, for instance, Japanese Patent Application Preliminarily Publication No.

Sho 62-141308. In this apparatus, two ball rows are formed on an upper surface side of a tracking base, and two ball rows are on the right and left side surfaces thereof, respectively.

As shown in FIG. **25**, the linear movement guide apparatus **100** comprises a tracking base **101**, a sliding base **102** having a concave portion **102***d* for accepting the tracking base **101** which is linearly guided along the tracking base **101**, and six rows of indefinite circulated balls **103** which are provided between the sliding base **102** and the tracking base **101** in a rotatable manner.

On an upper surface of the tracking base **101**, are provided a couple of ball rolling grooves **101***a*, and on each side surface thereof, are formed a couple of ball rolling grooves **101***b* and **101***c*, respectively. On the other hand, on an upper surface and each side surface of the concave portion **102***d* of the sliding base **102**, are formed corresponding ball rolling grooves **102***a*, **102***b* and **102***c*, facing to the ball rolling grooves **101***a*, **101***b* and **101***c* formed on the surface of the tracking base **101**, respectively.

In addition thereto, holders **107** and **108** are provided in the two ball rows **104** formed on the upper surface of the tracking base and in the two ball rows **105** and **106** formed on each side surface of the tracking base, respectively, in order to prevent that the balls **103** are fallen down when the sliding base **102** is taken off from the tracking base **101**.

In the linear movement guide apparatus **100**, the contact angles of balls in the ball rows **104** are arranged such that the contact angle a, which is defined as an angle formed by a contact line of the ball **103** held in the ball rolling groove **101***a* of the tracking base **101** with respect to a horizontal direction, is set at 90 degrees. And the contact angles are arranged in two ball rows **105**, **106** formed on each side surface of the tracking base such that a contact angle β, which is defined as an angle formed by contact lines of ball **103** in the upper and lower ball rolling grooves **101***b* and **101***c* with respect to the horizontal direction, is set at 45 degrees, which are inclined in upper and lower directions inside of the tracking base **101**, respectively. And thus, intersection points of these contact lines are located outside of the tracking base **101**.

In the thus constructed linear movement guide apparatus **100**, the vertical load applied from an upper direction against the sliding base **102** is supported by four ball rows in total, i.e. two ball rows **104** formed on the upper surface thereof and two ball rows **106** provided in the lower portion of side surfaces thereof.

Further, the lateral load applied from left and right directions is supported by either of upper two ball rows **105** or lower two ball rows **106** in accordance with the load applied direction. Furthermore, the load applied from a lower direction is supported by the upper two ball rows **105** formed on the side surfaces.

Fourth Prior Art

In Japanese Patent Preliminarily Publication No. Sho 64-53621, another linear movement guide apparatus **200** having six ball rows is further disclosed.

As shown in FIG. **26**, the linear movement guide apparatus **200** comprises a tracking base **201**, a sliding base **202** having a concave portion **202***d*, along which said tracking base **201** is guided, for accepting said tracking base **201**, and six indefinite circulated ball rows **203**, which are extended between the sliding base **202** and the tracking base **201** in a rotatable manner.

On each side surface of the tracking base **201**, are formed three rows of ball rolling grooves **201***a*, **201***b* and **201***c*; and on each inner side surface of the concave portion **202***d* of the sliding base **202** are provided corresponding three rows of ball rolling grooves **202***a*, **202***b* and **202***c* so as to face to the three rows of ball rolling grooves **201***a*, **201***b* and **201***c* of the tracking base **201**.

A holder **207** is provided in each ball row **204**, **205** and **206** formed on each side surface in order to prevent that the balls are fallen down when the sliding base **202** is taken from the tracking base **201**.

The contact angles of the balls **203** in the linear movement guide apparatus **200** are arranged such that the contact angles of the balls in the upper and middle rows are inclined in a lower direction toward inside of the tracking base **201** by about 45 degrees; and the contact angles of the balls in the lower rows are inclined in an upper direction toward inside of the tracking base **201** by about 45 degrees, so that the intersecting points **01** and **02** of the contact lines L1, L2 and L3 of the contact angles in upper, middle and lower rows are located inside of the tracking base **201**.

In the thus constructed linear movement guide apparatus **200**, since the contact lines L1 and L2 of the balls **203** in the upper and middle ball rows **204** and **205** are extended in a lower inside direction of the tracking base **201**, the radial load applied from the upper direction against the sliding base **202** is supported by the upper and middle ball rows **204** and **205**, and the reversed-radial load applied in the floating direction is supported by the lower ball rows **206**. Therefore, in this apparatus the stiffness for the radial load is much higher than that for the reversed-radial load. It is now defined that the stiffness means a performance that the bases are not apt to be deformed by the load effected between the sliding base and the tracking base, and are not apt to be unsteady. In the case of the fourth prior art, the apparatus is so designed as to make the stiffness for the load F applied in the radial direction large, to increase the capability to support a heavy load.

Fifth Prior Art

Furthermore, in Japanese Patent Preliminarily Publication No. Sho 64-53622, there is disclosed another linear movement guide apparatus **200'**, which is modified from the above-mentioned linear movement guide apparatus **200** in such a manner that the ball **203** in the middle ball rows **205** are arranged to be contact with the grooves at four points and the contact lines L21 and L22 are extended to lower inside and upper inside directions by about 45 degrees and intersect to each other at a portion inside of the tracking base **201**, as shown in FIG. **27**.

In the thus constructed linear movement guide apparatus **200'**, the radial load F is supported by the upper ball rows **204** and the reversed-radial load f is by the lower ball rows **206**.

On the other hand, the balls in the middle row of **205** are arranged to be made contact with the grooves at four points to support both the radial load and the reversed-radial load.

In the above-explained first to five conventional linear movement guide apparatuses, various performances are required to support the loads applied from all directions. That is to say, it is required to have a load supporting capability broken up with various ratios against the loads applied from upper, lower, left side and right side directions, in order to decrease vibration of machine, to which the apparatus is applied, by causing a differential sliding on the balls when a predetermined load or more is applied, or to roll the balls in a light manner in order to drive the apparatus in a high speed.

However, the conventional linear movement guide apparatuses mentioned in the above are designed to comply with only one of the requirements in such type of linear movement guide apparatuses, therefore the apparatuses can not satisfy all of the requirements mentioned in the above.

In the conventional apparatuses, the shapes of the tacking and sliding bases, the number of ball rows, and the contact angles are selected in accordance with the purpose of use of the apparatus, and the linear movement guide apparatuses are designed so as to obtain the performance to be required, manufactured in accordance with the design, and then supplied. The manufacturers accede to the various requirements of the users by manufacturing a large number of types of the linear movement guide apparatuses. However, it causes a lack of mass productivity and a low producing effect.

The present invention has been invented, taking the task of the prior arts into consideration; and has for its purpose to provide a linear movement guide apparatus having a suitable performance for supporting the load applied from each direction and a method for assembling the apparatus, in which pitches between the ball rolling grooves formed on the tracking base and the sliding base are changed in accordance with the load condition applied thereto in order to obtain ball rolling grooves having optimum contact angles.

DISCLOSURE OF INVENTION

A linear movement guide apparatus according to the present invention comprises a tracking base, a sliding base having a concave portion for accepting said tracking base and being linearly guided along said tracking base, and balls being held between said sliding base and said tracking base in a rotatable manner; said tracking base comprises at least one row of ball rolling groove on an upper surface thereof and at least one row of ball rolling groove on each side surface thereof; and said sliding base comprises corresponding ball rolling grooves, formed on upper and both side surfaces of said concave portion of the sliding base so as to face to the ball rolling grooves formed on said upper and side surfaces of said tracking base;

said apparatus is characterized in that a positional relationship of centers of the ball rolling grooves formed on the upper and side surfaces of either one of the tracking base or the sliding base are arranged to be coincident with or deviated from the corresponding ball rolling grooves formed on the corresponding tracking or sliding base, and the tracking base or the sliding base, in which said positional relationship of the centers of the grooves is coincident with or deviated from the corresponding ball rolling grooves, is mounted on the corresponding tracking base or the corresponding sliding base with an arbitrary combination.

The apparatus is characterized in that two rows of ball rolling grooves are provided on the upper surface of the tracking base and one row of ball rolling groove is provided on each of the left and right side surfaces of the tracking base, respectively.

The apparatus is further characterized in that a pair of rows of ball rolling grooves are provided on the upper surface of the tracking base and a pair of rows of ball rolling grooves are provided on the left and right side surfaces of the tracking base, respectively.

The apparatus is further characterized in that the tracking base has a square-shaped cross section, and a positional relationship of the centers of the ball rolling grooves formed on the tracking base and the sliding base is identified with each other or deviated from each other by changing a distance between the two rows of the ball rolling grooves formed on the upper surface of the tracking base and a distance between the ball rolling grooves formed on the upper surface and the ball rolling grooves formed on the side surfaces thereof with respect to the corresponding distances between the corresponding ball rolling grooves formed on the sliding base.

The apparatus is characterized in that the ball rolling grooves are arranged to have their depths by which the contact angles of balls to be held therein can be freely selected.

The apparatus is characterized in that the depths of the ball rolling grooves are arranged to be substantially ¼–½ of a diameter of ball to be held therein.

The apparatus is characterized in that the ball rolling grooves formed on the upper surface of the tracking base and the ball rolling grooves formed on the sliding base, which face to the grooves formed on the tracking base, have circular-ark shapes which are slightly larger than the ball to be mounted therein; and the ball rolling grooves formed on the side surfaces of the tracking base and the corresponding ball rolling grooves formed on the sliding base have their shapes that two circular-arks are combined.

The apparatus is characterized in that the ball rolling grooves formed on the upper surface of the tracking base and the corresponding ball rolling grooves formed on the sliding base facing thereto and the ball rolling grooves formed on side surfaces of the tracking base and the corresponding ball rolling grooves formed on the sliding base facing thereto have circular-ark shapes which are slightly larger than the balls to be mounted therein.

The apparatus is further characterized in that the ball rolling grooves formed on the upper surface of the tracking base and the corresponding ball rolling groove formed on the sliding base facing thereto, and the ball rolling grooves formed on side surfaces formed on the tracking base and the corresponding ball rolling grooves formed on the sliding base facing thereto have their shapes that two circular-arks are combined.

The apparatus is further characterized in that the ball rolling grooves formed on the upper surface of the tracking base and the corresponding ball rolling grooves formed on the sliding base to be facing thereto have their shapes that two circular arks are combined; but the ball rolling grooves formed on side surfaces of the tracking base and the corresponding ball rolling grooves formed on the sliding base facing thereto have circular-ark shapes which are slightly larger than the balls to be mounted therein.

The apparatus is further characterized in that the contact angles of the balls mounted in two rows of ball rolling grooves, which constitute a pair of rows mutually corresponding to each other, formed on the tracking an sliding bases are arranged to be 90 degrees with respect to a horizontal direction; and the contact angles of the balls mounted in two rows of ball rolling grooves, which constitute a pair of rows mutually corresponding to each other, formed on each surface side of the tracking and sliding bases are arranged to be about 45 degrees being inclined in an upper and inside direction of the tracking base with respect to a horizontal direction.

The apparatus is further characterized in that the contact angles of the balls mounted in two rows of ball rolling grooves, which constitute a pair of rows mutually corresponding to each other, formed on each side surface of the tracking and sliding bases are arranged to be substantially zero degrees with respect to a horizontal direction; and the contact angles of the balls mounted in two rows of the ball rolling grooves, which constitute a pair of rows mutually corresponding to each other, formed on the upper surfaces of the tracking and sliding bases, are arranged to be substantially 90 degrees with respect to a horizontal direction.

The apparatus is further characterized in that all of the ball rolling grooves formed on the tracking and sliding bases have their shapes of single circular-ark, which are slightly larger than the balls to be mounted therein, and at least one of the grooves has its cross section whose radius of curvature is set to be smaller than 0.52 of the diameter of the balls to be mounted in the groove.

The apparatus is further characterized in that said ball rolling grooves have their cross sections whose radius of curvature are set at about 0.51 of the diameter of the balls to be mounted in the grooves.

The method for assembling the linear movement guide apparatus according to the present invention is characterized in that the method comprises the following steps:

- a step for forming a first member having first ball rolling groove(s) on an upper surface thereof and second ball rolling groove(s) on left and right side surfaces thereof;
- a step for forming a plurality types of second members, which are arranged to be assembled to said first member in a slidable manner via a given number of ball rows, each member comprising third ball rolling groove(s), which are arranged such that a positional relationship of centers of the third ball rolling groove(s) is coincident with or deviated from the first ball rolling groove(s) formed on the first member, and fourth ball rolling groove(s), which are arranged such that a positional relationship of centers of the fourth ball rolling groove(s) is coincident with or deviated from the second ball rolling groove(s) formed on the first member; and
- a step for selecting a combination of the first and second members so as to obtain suitable contact angles for supporting loads applied from each direction and a moment load.

The assembling method is further characterized in that the method comprises the following steps:

- a step for forming a first member comprising a pair of first ball rolling grooves which are separated from each other in a width direction thereof by a first pitch, and a pair of second ball rolling grooves, which are separated from said first ball rolling grooves in a height direction thereof by a second pitch;
- a step for forming a plurality types of second members, which are arranged to be assembled to the first member in a slidable manner via four ball rows, comprising a pair of third ball rolling grooves, which are separated from each other in a width direction thereof by a third pitch, which is different from the first pitch, and a pair of fourth ball rolling grooves, which are separated from the third ball rolling grooves in a height direction by a fourth pitch, which is different from said second pitch; and
- a step for selecting a combination of said first and third pitches and said second and fourth pitches so as to obtain suitable contact angles for loads applied from each direction and a moment load.

The assembling method is further characterized in that depths of the ball rolling grooves are arranged such that the contact angles of the balls to be held therein can be freely selected.

The assembling method is further characterized in that the depths of the ball rolling grooves are arranged to be substantially ¼ to ½ of the diameter of balls to be mounted therein.

In the linear movement guide apparatus according to the present invention, it may be possible to arrange the ball rolling grooves so as to have circular-ark shapes which are slightly larger than the balls to be mounted therein, or Gothic-ark shapes; but the depths of the grooves should be in a range from about a quarter of the diameter of balls, which is suitable for the case that an angle deviation of the contact angles is small, to about a half of the diameter of the ball, which is suitable for the case that an angle deviation of the contact angles is large. Therefore, in the apparatus the balls are surely made contact with the circular ark-shaped ball rolling grooves at any portion, and thus it substantially allows to obtain all of the contact angles, which have been demanded in such type of conventional linear movement guide apparatuses.

The contact angle in each ball rolling groove can be set in an arbitrary manner by changing the pitch (distance) between the two rows of ball rolling grooves formed on the upper surface of the tracking base, and the pitch (distance) between said ball rolling grooves formed on the upper surface of the tracking base and the ball rolling grooves formed on side surfaces of the tracking base with respect to the pitch (distance) between the corresponding ball rolling grooves formed on the sliding base.

Particularly, in case that the ball rolling grooves are arranged to have circular-ark shapes which are slightly larger than the balls to be mounted therein, the contact angles are not limited to 45 degrees with respect to a horizontal direction but it is substantially possible to obtain the contact angles in an arbitrary manner.

Further, in case that the ball rolling grooves have their shapes of the combination of two circular-arks, it is possible to arrange such that the balls are made contact with the ball rolling grooves at two points, in order to cause a differential sliding for the first time that much more load beyond over the desired load is applied, or from the first.

There are provided balls between the ball rolling grooves formed on the upper and side surfaces of the tracking base and the corresponding ball rolling grooves formed on the sliding base. Therefore, it is possible to increase the stiffness of the linear movement guide apparatus by providing balls having dimensions slightly larger than the spaces between the ball rolling grooves to give a pre-load.

Further, since there are provided two rows of deep ball rolling grooves on the upper surface of the concave portion of the sliding base, it is possible to make the thickness of the upper portion of the sliding base large so that the stiffness of the block of the sliding base is increased.

Furthermore, since one row of the ball rolling groove is formed on each inside surface of the concave portion of the sliding base, it is possible to make the length of the side portion of the sliding base short to increase the stiffness of the linear movement guide apparatus. Therefore, the total height of the block of the sliding base becomes low and the height of the tracking base also becomes low because the position of the ball rows on the side surfaces thereof can be located in an upper portion. Therefore, the height of the linear movement guide apparatus as a whole becomes low and the size thereof compact.

Particularly, even in either cases that the grooves are designed as Gothic-ark style or as Circular ark style, a damping effect is improved by designing the depths of the grooves to be about 51% of the diameter of the balls to be held therein. Because, when the load, which is applied to the apparatus when the heavy machining is conducted, is applied, an amount of differential sliding is increased and thus the ball moves in the grooves in a mixed manner of the rolling movement and the sliding movement, causing that the rolling movement becomes like the sliding movement, and thus the damping effect (damping characteristic) is increased. Therefore, when the linear movement guide apparatus is used in machinery tools, it is possible to make the amount of slight waviness at machine as much as possible, and then the working accuracy is improved. Particularly, it is effective to set the contact angles of balls in the ball rotating grooves formed on the upper surfaces, at 90 degrees, which is an angle that the load is applied when the heavy cutting machining is conducted.

When the depths of the ball rolling grooves are set at 51% of the diameter of the balls to be held therein, the contact area of balls with respect to the general type of circular-ark shaped grooves becomes larger (the contact are becomes like that of the roller), so that the loading capacity for supporting a heavy load is rapidly increased in cooperation with the construction of said contacting angles, and a high stiffness and a stable linear movement can be obtained.

When the heavy machining is conducted, the apparatus works in a low speed. Therefore, even if some sliding is caused, the life time of the apparatus is not affected so much. Further, since the differential sliding is increased in proportion with the load to be applied, an extremely reasonable contact structure can be obtained.

BRIEF DESCRIPTION OF DRAWINGS

FIGS. **1** to **13** are schematic views showing embodiments of the linear movement guide apparatus according to the present invention, in which four ball rows are provided; and FIG. **1** is a perspective view having partially broken portion illustrating one of the embodiments of the apparatus.

FIG. **2** is a cross sectional view of FIG. **1** cut in a width direction

FIG. **3** is a schematic view for explaining a locational relationship of the ball rolling grooves in the linear movement guide apparatus shown in FIG. **1**.

FIG. **4** is a schematic view depicting one example of a machinery tool to which the linear movement guide apparatus according to the invention is applied.

FIG. **5** is schematic view illustrating directions of each load applied to the linear movement guide apparatus.

FIG. **6** is a schematic view for explaining a function in the linear movement guide apparatus according to the first embodiment of the present invention.

FIG. **7** is a schematic view for explaining a function in the linear movement guide apparatus according to the second embodiment of the present invention.

FIG. **8** is a schematic view for explaining a function in the linear movement guide apparatus according to the third embodiment of the present invention.

FIG. **9** is a schematic view for explaining a function in the linear movement guide apparatus according to the fourth embodiment of the present invention.

FIG. **10** is a schematic view for explaining a function in the linear movement guide apparatus according to the fifth embodiment of the present invention.

FIG. **11** is a schematic view for explaining a function in the linear movement guide apparatus according to the sixth embodiment of the present invention.

FIG. **12** is a schematic view for explaining a function in the linear movement guide apparatus according to the seventh embodiment of the present invention.

FIG. **13** is a schematic view for explaining a function in the linear movement guide apparatus according to the eighth embodiment of the present invention.

FIG. **14** is a schematic view for explaining a condition of the differential sliding caused in the apparatus having Gothic ark type grooves.

FIG. **15** is a schematic view for explaining a condition of the differential sliding caused in the apparatus having a circular ark type grooves.

FIG. **16** is a schematic view showing the other examples of the contact angle structure in the linear movement guide apparatus having four ball rows.

FIGS. **17** to **21** are schematic views showing the linear movement guide apparatuses according to the invention which have six ball rows, and FIG. **17** is a schematic view for explaining the ninth embodiment according to the invention.

FIG. **18** is a perspective view with partially broken portion illustrating a basic structure of the linear movement guide apparatus having six ball rows, shown in FIG. **17**.

FIG. **19** is a schematic view for explaining a function in the linear movement guide apparatus according to the tenth embodiment of the present invention.

FIG. **20** is a schematic view for explaining a function in the linear movement guide apparatus according to the eleventh embodiment of the present invention.

FIG. **21** is a schematic view for explaining a function in the linear movement guide apparatus according to the twelfth embodiment of the present invention.

FIGS. **22**(*a*) to (*c*) are schematic views showing each of other contact angle structures in the linear movement guide apparatus having six ball rows; and FIGS. **22**(*d*) and (*e*) are schematic views representing the linear movement guide apparatuses having other arrangements of ball rows.

FIGS. **23** to **27** are cross-sectional views cut in a width direction, illustrating constructions of the conventional linear movement guide apparatuses.

BEST MODE FOR CARRYING OUT THE INVENTION

The detail of the linear movement guide apparatus according to the present invention will be explained in the following with reference to the drawings.

FIGS. **1** and **2** are cross-sectional views, which are cut in a width direction, of one of the embodiments of the linear movement guide apparatus according to the invention.

The linear movement guide apparatus **10** according to the invention comprises a tracking base **11** having a square-shaped cross section, a sliding base **12** having a concave portion **12***c* for accepting said tracking base **11** and four ball rows **13** existing between the tracking base **11** and the sliding base **12** in a rotatable manner, as a summary.

The sliding base **12** comprises a sliding base block **14** having a high stiffness and side caps **15** which are fixed to both edge surfaces of said sliding base block **14**.

On an upper surface of the tracking base **11**, are provided two rows of ball rolling grooves **11**a and on each side surface thereof is formed one row of ball rolling groove **11***b*, respectively. On the other hand, on an inner surface of the concave portion **12***c* of the sliding base block **14** are formed corresponding ball rolling grooves **12***a* and **12***b*, respectively, so as to face to the rolling grooves **11***a* and **11***b*, and in the sliding base block **12** are formed ball relief bores **16**. In the side caps **15** are formed direction converting paths **17**, respectively, which connect the both ends of the ball paths formed between the ball rolling grooves **11***a*, **12***a* and **11***b*, **12***b* located in the load applied area and both ends of the ball relief bores **16**.

It should be noted that no retainer for preventing that the balls are fallen down when the sliding base **12** is taken off from the tracking base **11** is provided in the apparatus of the embodiment, due to the small space.

The ball rolling grooves **11***a*, **12***a* and **11***b*, **12***b*, which face to each other, may have so-called circular-ark type cross sections, consisting of a single circular-ark, as shown in FIG. **15**, or so-called Gothic ark type, consisting of a combination of two circular-arks, as shown in FIG. **14**; but the depths of the ball rolling grooves are set in such a manner that contacting angles of balls can be freely selected. In this embodiment, the depths of the ball rolling grooves are set at substantially half of the diameter of balls to be held therein. Thereby, the balls **13** should be made contact with any portion of the substantial semi-circular shaped ball rolling grooves **11***a*, **12***a* and **11***b*, **12***b*, respectively. Therefore, in the apparatus, almost all of the contact angles, which have been demanded in the conventional type of such linear movement guide apparatuses, can be obtained.

Particularly, when the circular-ark shaped ball rolling grooves are slightly larger than the balls to be held therein, the contact angles are not limited to 45 degrees with respect to a horizontal direction, but arbitrary angles can be obtained, substantially. When the variation of the contact angles is small, it is not necessary to make the depth of the ball rolling grooves about half of the diameter of the balls to be held therein. In such case, it may be possible to arrange the depths of the grooves to be about a quarter of the diameter of balls to be held therein.

Contrary to this, in the conventional linear movement guide apparatus **30** shown in FIG. **23**, the depths of the rolling grooves **31***a* and **32***a*, which are formed on the upper surface side of the sliding base and on the inner side of the concave portion of the corresponding tracking base, are arranged to be small and the circular-ark shapes of the grooves are designed to be slightly larger than the balls to be held therein. The apparatus **30** is not originally designed to have other contact angles excepting for the contact angle formed in a vertical direction. However, even if the contact angles extended in other directions than the vertical direction can be objected, the balls would be made contact with the ball rolling grooves at points located in the vicinity of edges of the ball rolling grooves. Therefore, the contact stress on the edge portions of the grooves would become extremely large, so that there would be a fear that ball rolling surfaces are destroyed.

According to the invention, it is possible to provide a linear movement guide apparatus as shown in FIG. **3** having various contact angles, shown in FIGS. **6** to **13**, by variably changing the pitch (distance) B1 between the two rows of ball rolling grooves formed on the upper surface of the tracking base **11**, and the pitch (distance) B2+B3 between said rows of the ball rolling grooves and the ball rolling grooves formed on the side surface of the tracking base, with respect to the pitches (distances) A1, A2, A3 between the corresponding ball rolling grooves formed on the sliding base. Such apparatuses have a suitable performance to support the load applied from each direction. It should be noted that only the tracking base, the balls and the contact angles are illustrated in a typical manner in FIGS. **6** to **13** in order to make the drawings much more understandable. The extending directions of the contact angles are shown by dotted broken lines in these figures. The lines connect the contact portions of balls in the ball rolling grooves facing to each other. Hereinafter, the lines will be called as contact angle lines.

All of the embodiments shown in the figures are basically designed so as to be able to support the loads applied from all directions being perpendicular to an axial direction of the tracking base **11**, which are represented by the loads applied from the four directions shown in FIG. **5**, i.e. a radial load PR applied from a direction, in which the sliding base **12** is urged against the tracking base **11** from an upper direction, a reversed radial load PL applied to a direction, in which the sliding base **12** is urged to be risen up against the tracking base **11**, and lateral loads PT applied to the sliding base **12** from left and right directions. Further, the apparatuses are designed so as to be basically able to support the moment Mc about the axial direction Z of the tracking base **11**, the moment Mb about a perpendicular axis Y, and the movement MA about a horizontal axis X. The apparatus is designed such that the stiffness in each direction is relatively varied in accordance to the specific load apply direction by selecting the proper contact angles of ball.

In the conventional linear movement guide apparatus **40** shown in FIG. **24**, the contact structure is also varied to be DB structure or to be DF structure by changing the distance A so as to become larger or smaller than the distance B. However, in this apparatus **40**, the contact angles per se are not varied, but keeping them about 45 degrees. Therefore, the conventional linear movement guide apparatus **40** does not have a performance for supporting the load applied from each direction, e.g. to change the load supporting capability in a width direction with respect to that in an upper and lower direction in an arbitrary manner.

In FIG. **6**, the linear movement guide apparatus according to the first embodiment of the present invention is illustrated.

In the first embodiment, the two rows of ball rolling grooves **11***a* formed on the upper surface of the tacking base **11** and the corresponding ball rolling grooves **12***a* formed on the sliding base **12** so as to face thereto, and one row of ball rolling grooves **11***b* formed on each side surface of the tracking base **11** and the corresponding ball rolling groove **12***b* on the sliding base **12** facing thereto, are designed to have circular-ark shapes consisting of a single circular-ark; and their depths are arranged to be substantially half of the diameter of balls to be held therein.

The contact angle lines in the upper ball rows are extended in a substantially vertical direction and the contact angle lines in the lower ball rows are inclined by 45 degrees with respect to the horizontal direction; and the contact angles lines of the lower ball rows intersect to each other at a point located on an upper side of the lower ball rows.

This type of the linear movement guide apparatus has a large load supporting capability for the main load, i.e. the load applied from an upper direction (radial load), and the apparatus is designed such that a large differential sliding is not caused so much. Therefore, this type of apparatus is suitably used when the apparatus is driven in a high speed. That is to say, in this apparatus, the radius of curvature of the cross-sections of the ball rolling grooves **11***a* and **12***a*; **11***b* and **12***b* are set at about 0.52 of the diameter of the balls to be held therein, which is a range for restricting the generation of the differential sliding small.

Further, when the radius of curvature of the ball rolling grooves having circular-ark shapes are arranged to be as almost the same size of the diameter of balls to be held therein, it becomes possible to obtain linear movement guide apparatuses having a various types of contact angles, in which the contact angles are varied only by slightly changing the pitches (distances) A1–A3 and B1–B3 between the ball rolling groove explained in the above.

It should be noted that the word of "differential sliding" means a sliding caused on the contact surface of balls held and rotated in the grooves. The sliding is caused by a difference between the inner contact diameter and the outer contact diameter of the circular-shaped contact surface of balls. The difference is generated when the balls are rolled because the balls are made contact with the ball rolling grooves in a circular-ark shaped condition. In the case of the ball rolling grooves having Gothic-ark type shapes, which are consisting of a combination of two circular-arks, the balls are made contact with the grooves at four points, as shown in FIG. **14**. When the balls are rolled in the grooves, being made contact with the grooves at four points, the difference between the inner contact diameter d**1** and the outer contact diameter d**2** becomes large; and further when the balls are rolled about the axis X, the difference between the inner contact point C and the outer contact point D becomes large, so that a large sliding is generated between the outer surface of the balls and the ball rolling grooves. Thereby, the balls are rolled in the grooves being slid, so that the rolling resistance, which is generated when the balls are rolled in the grooves, is increased. Therefore, when the sliding base **12** is moved along the tracking base **11**, a large friction resistance is generated. It should be noted that the reference symbol E in FIG. **14** represents an area where the balls and the rolling grooves are contacted to each other.

In case that the ball rolling grooves have circular-ark type shapes, which consist of only a single ark, the balls made contact with the grooves at tow points as shown in FIG. **15**. In this case, the contact width a is smaller in comparison with that of the Gothic-ark type ball rolling grooves. Therefore, it can be generally be said that only a small differential sliding is caused and thus the balls are rolled in the grooves in a preferred manner in the apparatus.

In FIG. **7**, there is depicted the linear movement guide apparatus according to the second embodiment of the present invention.

In the second embodiment, the two rows of ball rolling grooves **11***a* formed on the upper surface of the tracking base **11** and the corresponding ball rolling grooves **12***a* formed on the sliding base **12** facing thereto, and ball rolling grooves **11***b* formed on the side surfaces of the tracking base **11** and the corresponding ball rolling grooves **12***b* formed on the sliding base **12** facing thereto, are also designed as circular-ark type grooves having their depths of almost half of the diameter of balls to be held therein.

The contact angle lines in the upper ball rows are directed to a vertical direction and the contact angle lines in the lower ball rows are substantially extended into a horizontal direction.

The linear movement guide apparatus has a large load supporting capability for the main load, which is applied from the lateral directions; and is so designed that a differential sliding is not caused so much. Therefore, the apparatus is also suitably used when the apparatus is driven in a high speed.

When the tracking base and the sliding base are coupled so as to have the contact angles as shown in FIG. **7**(*a*), and a pre-load is given to the balls held in the ball rolling grooves, the contact angles of the balls are changed, and the contact angle lines are inclined as shown in FIG. **7**(*b*). Since the pre-load is applied to the balls with respect to a rotating direction of balls in the case that the sliding base is viewed from its axis direction, a linear movement guide apparatus having a high stiffness and no space in the rotating direction of balls can be obtained.

In FIG. **8**, a linear movement guide apparatus according to the third embodiment of the present invention is represented.

In the third embodiment, two rows of the ball rolling grooves **11***a* formed on the upper surface of the tracking base **11** and the corresponding ball rolling grooves formed on the sliding base **12** so as to face thereto, and the rows of the ball rolling grooves **11***b* formed on both the side surfaces of the tracking base **11** and the corresponding ball rolling grooves formed on the sliding base **12***b* facing thereto, are designed to have circular-ark shapes consisting of a single circular-ark, and to have depths of about half of the diameter of balls to be held therein.

In the apparatus shown in FIG. **8**, the contact angle lines in the upper ball rows are inclined by about 45 degrees with respect to the horizontal direction, respectively and intersect to each other at an upper point of the upper ball rows. Further, the contact angle lines in the lower ball rows are extended in a direction parallel to the contact angle lines of the upper ball rows.

The linear movement guide apparatus has a capability to support a large load applied from a lower direction (reversed radial load), and is designed such that the differential sliding is not caused so much. Therefore, the apparatus is suitably used when the apparatus is driven in a high speed.

When the tracking base is coupled with the sliding base having contact angles as shown in FIG. **8**(*a*) and a pre-load is given to the balls held between the ball rolling grooves, the contact angles are changed so that the angle formed by the contact angle lines in the grooves **11***a* and the angle formed by the contact angle lines in the grooves **11***b* and **11***b* become small. Since a pre-load is applied to the balls with respect to the rotating direction of balls when the sliding base is viewed from its axis direction, a linear movement guide apparatus having a high stiffness and no space in the ball rotating direction can be obtained. The pre-load can be applied to the balls by setting the distance between the ball rolling grooves, which are facing to each other, smaller than the diameter of the balls to be held therein. That is to say, when the pre-load is applied to the balls held in the grooves formed on the side surfaces of the bases, the tracking base is slightly deformed so as to be shrunk in a horizontal direction by a reaction force against the compression of the balls; but the sliding base is slightly deformed so as to be extended in a horizontal direction by the reaction force, so that the contact angles are changed.

In FIG. **9**, a linear movement guide apparatus according to the fourth embodiment of the present invention.

In the fourth embodiment, two rows of the ball rolling grooves **11***a* formed on the upper surface of the tracking base **11** and the corresponding ball rolling grooves **12***a* formed on the sliding base **12** so as to face thereto, and the rows of the ball rolling grooves **11***b* formed on the side surfaces of the tracking base **11** and the corresponding ball rolling grooves **12***b* formed on the sliding base **12** facing thereto, are designed to have circular-ark shapes consisting of a single circular-ark and to have their depths of half of the diameter of balls to be held therein.

In the fourth embodiment shown in FIG. **9**, the contact angle lines in the upper ball rows are inclined in a lower and inside direction with respect to the horizontal direction and intersect to each other at a lower point of the upper ball rolling grooves; and the contact angle lines in the lower ball rows are inclined to an upper and inside direction with respect to the horizontal line and intersect to each other at an upper point of the lower ball rolling grooves.

In this linear movement guide apparatus has a capability to support loads applied from all directions, i.e. radial load PR, lateral load PT applied from a horizontal direction, and reversed radial load PL applied from a lower direction, and is designed such that the differential sliding is not generated so much. Therefore, the apparatus is suitably used to be driven in a high speed.

In FIG. **10**, there is shown a linear movement guide apparatus according to the fifth embodiment of the present invention.

In the fifth embodiment, two rows of ball rolling grooves **11***a* formed on the upper surface of the tracking base **11**, and the corresponding ball rolling grooves **12***a* formed on the sliding base **12** facing thereto are arranged to have their depths about half of the diameter of balls to be held therein; and these grooves are designed as circular-ark type grooves having single circular-ark shaped cross section. Further, the rows of ball rolling grooves **11***b* formed on side surfaces of the tracking base **11** and the corresponding ball rolling grooves **12***b* formed on the sliding base **12** facing thereto are arranged to have their shapes that two circular-arks are combined, and the depths thereof are about half of the diameter of balls to be held therein.

In fifth embodiment shown in FIG. **10**, the contact angle lines in the upper ball rows are inclined by about 45 degrees with respect to the horizontal direction and the contact angle lines intersect to each other at an upper position of said ball rows. Further, the contact angle lines in the lower ball rows are also inclined to be substantially parallel to the lines in the upper ball rows, as like the embodiment shown in FIG. **8**.

This type of the linear movement guide apparatus has a large load supporting ability against the main load applied from the lower direction (reversed radial load); and is designed such that so-called differential sliding is not caused so much. Therefore, the apparatus can be suitably used to be driven in a high speed.

FIG. **11** depicts a linear movement guide apparatus according to the sixth embodiment of the present invention.

In this embodiment, two rows of ball rolling grooves **11***a* formed on the upper surface of the tracking base **11** and the corresponding ball rolling grooves **12***a* formed on the sliding base **12** facing thereto are arranged to have circular-ark shapes having depths of about half of the diameter of balls to be held therein; and the rows of ball rolling groove **11***b* formed on both side surfaces of the tracking base **11** and the corresponding ball rolling grooves **12***b* formed on the sliding base **12** facing thereto are arranged as Gothic-arc type grooves having their depths of almost half of the diameter of balls to be held therein.

In the sixth embodiment shown in FIG. **10**, the contact angle lines in the upper ball rows are directed in a substantially perpendicular direction and the contact angle lines in the lower ball rows are inclined by about 45 degrees with respect to the horizontal direction and then the lines intersect to each other in an upper position of the lower ball rows, as like as the embodiment shown in FIG. **6**.

This type of linear movement guide apparatus has a large load supporting ability against the main load applied from the upper direction (radial load). When a large radial load is applied to such linear movement guide apparatus, the balls held in the lower grooves are made contact with the grooves at four points, as shown in FIG. **11**(*b*).

In this apparatus, so-called differential sliding is caused thereby to decrease a mechanical vibration, which is generated when the working object W of the machinery tool is cut by a cutting tool TO shown in FIG. **4**. Therefore, the roughness of the cutting finish of the working object W and the accuracy of dimension thereof can be improved. Further, the thus caused differential sliding effects as a damper or a buffer means against a ball screw mechanism S. which is for driving the linear movement guide apparatus **10**, and a driving source therefor, i.e. a motor M. In FIG. **4**, an example is illustrated, in which the linear movement guide apparatus **10** according to the present invention is used in a movement guide section of a top table T for transporting the working object W.

In FIG. **12**, a linear movement guide apparatus according to the seventh embodiment of present invention is illustrated.

In this embodiment, two rows of ball rolling grooves **11***a* formed on the upper surface of the tracking base **11** and the corresponding ball rolling grooves **12***a* formed on the sliding base **12** facing thereto are arranged as Gothic arc type grooves having depths almost half of the diameter of balls to be held therein, but the rows of ball rolling groove **11***b* formed on both side surfaces of the tracking base **11** and the corresponding ball rolling grooves **12***b* formed on the sliding base **12** so as to face thereto are arranged to have circular-ark shapes, whose depths are almost half of the diameter of balls to be held therein.

In the seventh embodiment shown in FIG. **12**, the contact angle lines in the upper ball rows are inclined by about 45 degrees with respect to the horizontal direction and intersect to each other in an upper position of the upper ball rows; but the contact angle lines in the lower ball rows are directed in a substantially horizontal direction.

When a large load is applied to the linear movement guide apparatus from a horizontal direction, the balls held in one of the upper ball rows are made contact with the relevant groove at four points. Thereby, in this apparatus, so-called differential sliding is caused to decrease a mechanical vibration, which is generated when the working object of the machinery tool is subjected to be cut. Therefore, the roughness of cutting finish of the working object and the accuracy of dimension thereof can be improved. Further, the differential sliding effects as a damper or buffer means against a ball screw mechanism, which is for driving the linear movement guide apparatus **10** and a driving source therefor, i.e. a motor.

In FIG. **13**, a linear movement guide apparatus according to the eighth embodiment of the present invention is represented.

In this embodiment, not only two rows of ball rolling grooves **11***a* formed on the upper surface of the tracking base **11** and the corresponding ball rolling grooves **12***a* formed on the sliding base **12** so as to face thereto but also the rows of ball rolling groove **11***b* formed on side surfaces of the tracking base **11** and the corresponding ball rolling grooves **12***b* on the sliding base **12** so as to face thereto are arranged as Gothic-arc type grooves having their depths of almost half or less of the diameter of balls to be held therein.

In the eighth embodiment shown in FIG. **13**, the apparatus is designed such that the balls held in the ball rolling grooves **11***a* and **12***a* are made contact with the relevant ball rolling grooves formed on the tracking base **11** and **12** facing to each other at four points, when a large load is applied to the sliding base **12** from a lower direction.

Therefore, the apparatus is able to support a large load applied from the lower direction, and thus suitably used in a machinery, such as NC machinery or machining center, in which a comparatively heavy cutting process or a heavy grinding process is required.

In this apparatus, since the balls are made contact with the relevant ball rolling grooves formed in the tracking base **11** and the sliding base **12** at four points in a complete manner or at four points in an incomplete manner, in which the balls are made contact with the grooves with some deviation, an enough sliding resistance can be constantly obtained. The sliding resistance becomes larger, in response to the load applied from a lower direction. Therefore, the ball screw mechanism, for moving the sliding base **12** being applied a cutting load or a grinding lord, is not directly subjected to these loads. As a result, the apparatus has no drawback that the ball screw mechanism is damaged comparatively soon by a heavy cutting process or a heavy grinding process.

The sixth to eighth embodiments shown in FIGS. **11** and **13** in the above, the apparatuses are constructed such that the ball rolling grooves are designed as Gothic-arc type grooves consisting of a combination of two circular-arks and thus the balls are made contact with the relevant grooves at four points to obtain a differential friction when a heavy load is applied to the apparatus. However, even in case that the grooves are arranged as circular ark type grooves, consisting of a single circular-ark, it is possible to make the differential sliding large in order to increase the sliding resistance in the apparatus by the design that the radii of curvature of cross section of the grooves are close to the diameter of the balls to be held therein.

In this case, it is desired to set the radii of curvature R of the ball rolling grooves within a range smaller than about 0.52 of a diameter Da of ball to be held therein. However, if the radius of curvature is too small, a nimble rolling of balls, which is an inherent characteristic of such rolling guide apparatus, will be lost because the friction becomes too much large. Therefore, it is desired to set the radius of curvature in a range between 0.52 to 0.505, preferably at about 0.51.

In a rotary type ball and roller bearing, the radius of curvature of the cross section of the ball rolling groove is generally designed to be about 0.52 to 0.54 of a diameter of ball to be held therein, for the purpose of decreasing a rolling friction, which is caused on the rolling surface of the balls, particularly, for the purpose of preventing that a heat is generated when the balls are rolled in the grooves in a high speed. That is to say, when the radius of curvature of the ball rolling grooves becomes closer to 0.5 of the diameter of balls to be held therein, the contact width of the balls with respect to the ball rolling grooves becomes larger, so that a differential sliding between a center portion and the edge portions of the contact width becomes large. As a result, a friction resistance and the amount of heat generation also increase. Therefore, the radius of curvature of the groove is generally set at about 0.52 or more of the diameter of the ball to be held therein.

Further, in the case of a thrust ball bearing, the radii of curvature of cross sections of the ball rolling grooves formed on inner and outer races thereof are set at about 0.54 of the diameter of the balls to be held therein.

The basic idea of the linear rolling guide apparatus also exists on an extended line of this thinking. That is to say, the apparatus is generally designed in such a manner that the shapes of the cross sections of ball rolling grooves are arranged as so-called circular ark shaped grooves, which is consisting of a single circular-ark; and the radii of curvature of the cross sections thereof are generally set at about 0.52 to 0.54 of the diameter of balls to be held therein in order to restrain the increase of the friction resistance, as much as possible. In the above explained embodiments shown in FIGS. **3** to **11**, the radii of curvature of the cross section of the grooves are set within this range.

By converting this idea, the same effect as that of the Gothic arch type grooves, which are shown in FIGS. **11** and **13**, can be obtained. That is to say, the differential sliding caused in the ball rolling grooves having a cross section of a single circular-ark shapes is positively used to decrease the mechanical vibration, which is caused when the working object of the machinery tool is subjected to be cut.

That is to say, the cross sections of the grooves cut at a surface being perpendicular to an axis direction of the grooves have circular-ark shapes consisting of a single circular-ark, so that the all contact surfaces of the balls with respect to the ball rolling grooves become ellipse shaped circular ark surfaces whose longer axis is extended in a direction being perpendicular to the axis direction.

At each contact points along the longer axis of the ball contact surface, the distances from the rotating center axis of the balls are different from each other, and therefore, there are caused differential sliding on the ball contact surface. That is to say, when the balls are rotated, the balls are rolled and made contact with the grooves at some point on the longer axis of the ball contact surface without being slid, but at the other points, the balls are rolled and made contact with the grooves being slid. In the conventional apparatus, the differential sliding should be restricted as much as possible to decrease the friction. However, in the present invention, the differential sliding is used to control the friction caused in the axis direction, in order to obtain the stiffness and the damping, which are the characteristics required in the apparatus.

In other words, when the radius of curvature R of the ball rolling grooves is set at about 0.51 of the diameter D of the balls to be held therein, the differential sliding is increased therein by the load applied to the grooves when a heavy cutting is conducted; and thus the balls move in the grooves in a mixed condition of the rolling movement and the sliding movement. As a result, the rolling movement of the balls becomes like a sliding movement, so that the damping characteristic thereof is improved. Since the sliding and rolling phenomenon is generated between the balls and the ball rolling grooves and the movement of the balls becomes heavy, the damping characteristic is improved. Thus, it is possible to prevent that the amount of the slight waviness at machine is increased even when a heavy cutting is conducted.

Furthermore, in the apparatus having circular-ark type grooves, if the depths of the ball rolling grooves are set at 51% of the diameter of balls to be held therein, the contact area of balls becomes larger in comparison with the general circular ark type grooves. (In other words, the contact area becomes larger as like as that of rollers.) In this case, loading capability against a heavy load is rapidly improved, involving the construction of contact angles of balls explained in the above, and further a stable linear movement with a high stiffness can be obtained.

Next, a method for assembling linear movement guide apparatuses according to the first to eighth embodiment shown in FIGS. **6** to **13** will be explained in the above.

First, a common member is used to manufacture the tracking and sliding bases. These bases are manufactured by, for instance, a drawing method. On the other hand, dressers are prepared to form circular ark type grooves or Gothic-arc type grooves, whose depths are of about a quarter to a half of the diameter of balls to be held therein. It should be noted that pitches (distances) in width and height directions of each dresser are varied in accordance with the type of the contact angles of the linear movement guide apparatus.

That is to say, a pair of upper dressers, by which a predetermined-shaped grooves can be formed with a first pitch (distance) in its width direction, and a pair of lower dressers, by which a predetermined-shaped grooves can be formed to be separated from said upper dressers with a second pitch (distance) in a height direction, are used to manufacture the tracking base **11** from the common material having a square cross section. The thus manufactured tracking base **11** has a pair of ball rolling grooves **11***a*, **11***a* on an upper surface thereof, being separated from each other in its width direction by the first pitch (distance); and ball rolling grooves **11***b* on each side surface thereof being separated from said ball rolling grooves **11***a* by the second pitch (distance) in its height direction.

Next, a pair of upper dressers, by which a predetermined-shaped grooves can be formed being separated from each other by a third pitch (distance), which is different from said first pitch (distance), in its width direction, and a pair of lower dressers, by which a predetermined-shaped grooves can be formed being separated from said upper dressers in its height direction by a fourth pitch (distance), which is different from said second pitch (distance), are used to manufacture a plurality types of sliding bases **12** from the common member.

The thus manufactured sliding base **12** has a pair of ball rolling grooves **12***a*, **12***a* on an upper surface of a square shaped concave portion **12***c*, which are separated from each other by said third pitch (distance) in its width direction; and it also has ball rolling grooves **12***b*, which are separated from said ball rolling grooves **12***a* by said fourth pitch (distance) in its height direction on each side surface of said concave portion. It should be noted that these sliding bases are manufactured such that the third and fourth pitches (distances) are different from the first and second pitches formed on the tracking bases **11**; and a plurality types of sliding bases **12** having different pitches of the ball rolling grooves are manufactured with respect to one standard tracking base **11** by varying the differences between said third and fourth pitches from the first and second pitches.

Then, a suitable combination of the first and third pitches (distances) and the second and fourth pitches (distances) is selected so as to obtain suitable contact angles for loads applied from each direction or moment loads; and then the linear movement guide apparatus having desired contact angles and desired groove shapes is assembled.

In the assembling method of the linear movement guide apparatus mentioned in the above, a plurality types of sliding bases **12** are manufactured on the basis of one tracking base **11**. However, it may be possible to manufacture a plurality types of tracking bases **11** with respect to one basic sliding base **12**. The positional relationship of the ball rolling grooves should be as in the following. That is to say, the positional relationship between the centers of the grooves formed on the upper surface of the tracking base and the centers of the grooves formed on the side surfaces of the tracking base, and the positional relationship between the centers of the grooves formed on the upper surface of the sliding base and the centers of the grooves formed on the side surfaces of the sliding base are arranged to be coincident with each other or deviated from each other between the grooves facing to each other. It may be possible to set the standard surface for processing on the other surface than the upper surface of the tracking base.

FIGS. **16**(*a*) to (*e*), are illustrated the other types of constructions of the contact angles.

FIG. **16**(*a*) is one of the examples in which the contact angles of balls held in two rows of ball rolling grooves formed on the upper surface of the tracking base are set at about 90 degrees; and the contact angles of balls held in the rows of ball rolling grooves formed on the side surfaces of the tracking base are arranged such that the contact angle lines thereof are inclined in lower and inside direction with respect to a horizontal direction by a given degree. In this case, since the radial road is supported by not only the upper surface but also the side surfaces, the radial stiffness becomes large.

FIG. **16**(*b*) shows another example, in which the contact angles in upper ball rows of the tracking base are arranged such that the contact angle lines are inclined with respect to horizontal direction by about 45 degrees and intersect to each other at an upper point of the upper ball rows; and the contact angles of grooves formed on the side surfaces are arranged such that the contact angle lines are inclined in a lower and inside direction with respect to the horizontal direction by a given degree.

FIG. **16**(*c*) depicts another example, in which the contact angles in upper ball rows of the tracking base are arranged such that the contact angle lines are inclined with respect to horizontal direction by about 45 degrees and intersect to each other at a lower point of the upper ball rows; and the contact angles in both the side grooves are also arranged such that the contact angle lines are inclined in a lower and inside direction with respect to the horizontal direction by a given degree.

In the examples shown in FIGS. **16**(*b*) and (*c*), it is possible to support the load applied from lateral directions by the balls held in the grooves formed on the upper surfaces. Therefore, in these examples, the stiffness against the radial load and the load applied from the lateral directions is increased.

FIG. **16**(*d*) represents an embodiment, in which the contact angles in the upper ball rows of the tracking base are constructed such that both the contact angle lines are inclined in the same direction with 45 degrees being parallel to each other; and the contact angles in the side ball rows are arranged such that the contact angle lines are inclined by 45 degrees in a reversed direction of the lines in the upper ball rows, being parallel to each other.

FIG. **16**(*e*) illustrates another embodiment, in which the contact angles in the upper ball rows of the tracking base are constructed such that both the contact angle lines are inclined in the same direction by 45 degrees being parallel to each other; and the contact angles in the side ball rows are arranged such that both the contact angle lines are also inclined by 45 degrees in the same direction as the lines in the upper ball rows, being parallel to each other. In these embodiments shown in FIGS. **16**(*d*) and (*e*), since the contact angle lines in the upper ball rows are inclined to be parallel to each other, it is possible to support the load applied from the right side direction in the figures. And thus, the stiffness against the load applied from the right side direction in the figures particularly becomes high.

Furthermore, it may be possible to provide an apparatus in which the contact angle lines extended in the horizontal direction and the contact angle lines extended in the inclined direction are combined. Therefore, a various type of linear movement guide apparatuses having different contact angle constructions, by which the stiffness is made high in the relevant direction in accordance with the portion to be used, can be provided.

(Six Rows Type)

FIGS. **17** to **21** show six rows type linear movement guide apparatuses in which a pair of two rows of ball rolling grooves are formed on each surface of the tracking base, i.e.

on the upper surface, each side surface of the tracking base. Therefore, six ball rows in total are formed in the apparatus.

FIGS. **17** to **21** represent linear movement guide apparatuses according to the ninth to twelfth embodiments of the present invention. The basic construction of such linear movement guide apparatuses having six rows of ball rolling grooves will be first explained with reference to FIGS. **7** and **8**.

In these figures, the numerical reference **1** represents a linear movement guide apparatus as a whole, which comprises a tracking base **2** and a sliding base **3**. The sliding base **3** is so designed to be linearly guided along the tracking base **2** and to have a concave portion **3***d* for accepting the tracking base **2**. The apparatus comprises six ball rows, in which balls **4** are rotatable held in an endless manner, formed between the sliding base **3** and the tracking base **2**.

The tracking base **2** has a square-shaped cross section and is extended in a longitudinal direction. On the upper surface of the tracking base **2**, are provided a pair of two rows of ball rolling grooves **2***a* in a longitudinal direction; and a pair of two rows of ball rolling grooves **2***b* and **2***c* are extended on each side surface thereof.

The sliding base **3** comprises the concave portion **3***d* having a square-shaped cross section for accepting the tracking base **2**. The tracking base **2** also has a square shaped cross section. On upper and side surfaces of the concave portion **3***d*, are provided corresponding ball rolling grooves **3***a*, **3***b* and **3***c* so as to face to the ball rolling grooves **2***a*, **2***b* and **2***c*, of the tracking base **2**, respectively. It should be noted that the loads applied from the longitudinal and width directions are supported by these ball rolling grooves. The sliding base **3** is mounted on the tacking base **2** so as to traverse over the tracking base **2** by inserting the tracking base **2** into the concave portion **3***d*.

The sliding base **3** comprises a sliding base block **5** having a high stiffness, and side caps **6** fixed to each edge surface of the block **5**. And, the above said ball rolling grooves **3***a*, **3***b* and **3***c* and ball relief bores **7** are formed on the concave portion **3***d* of the sliding base block **5**. In the side caps **6**, are provided direction converting paths, by which both ends of the ball paths in load areas between the ball rolling grooves **2***a*, **3***a*, **2***b*, **3***b* and **2***c*, **3***c* facing to each other and both ends of the ball relief bores **7** are connected to each other.

Between the ball rolling grooves **2***a*, **2***b* and **2***c* on the tracking base **2** and the corresponding ball rolling grooves **3***a*, **3***b*, **3***c* on the sliding base **3**, which face to each other, a plurality of balls **4** are mounted in a rotatable manner. On the upper surface, are provided two ball rows **5**; and on each side surface, are provided two ball rows **6** and **7**, respectively. Therefore, six ball rows in total are provided in the apparatus.

Two ball rows **2***b*, **2***c* (or **3***b*, **3***c*) formed on both the side surfaces of either one of the tracking base **2** or the sliding base **3** are arranged such that the positional relationship between the center portions of the grooves are coincident with or deviated from the center portions of the corresponding ball rolling grooves **3***b*, **3***c* (or **2***b*, **2***c*) of either one of the tracking base or the sliding base **3** in upper and lower direction. Thus, the apparatus is constituted of the arbitrarily coupled tracking base **2** and sliding base **3**, in which the above stated positional relationships of the center portions of the grooves is coincident with each other or deviated from each other.

By coupling the tracking base **2** or the sliding base **3**, in which the corresponding positional relationship between the center portions of the grooves is coincident with or deviated from the corresponding tracking or sliding base in upper and lower directions, with the corresponding racking base **2** or the sliding base **3** in an arbitrary manner, as explained in the above, the contact angles of the balls **4** held in the ball rows **6** and **7** formed on the side surfaces can be adjusted. Thereby, the stiffness in upper and lower directions and right and left directions, which are required to support the loads applied from these directions, can be obtained, so that it is possible to provide a linear movement guide apparatus having a load supporting characteristic in accordance with the purpose of use thereof.

In order to adjust the above mentioned contact angles, it is preferred to design the ball rolling grooves as in the following.

That is to say, the ball rolling grooves **2***a*, **2***b*, **2***c*, **3***a*, **3***b* or **3***c* may be possible to have circular-ark type shapes or a Gothic-ark type shapes; however, it is desired to arrange such that at least each ball rolling groove **2***b*, **2***c* and **3***b*, **3***c* formed on side surfaces has its depth of about ½ of the diameter of balls **4** to be held therein. Thereby, the balls **4** held in the two ball rows **6** and **7**, which are formed on the side surfaces, are made contact with any place of the two rows of ball rolling grooves **2***b*, **2***c* or **3***b*, **3***c*, which have almost semi circular shapes. And thus, it is possible to obtain almost all contact angles. It should be noted that in case that the variation of the contact angles is small, it may be possible to arrange the depths of the grooves about ¼ of the diameter of balls **4**.

In the embodiments shown in FIGS. **17** to **21**, the linear movement guide apparatuses are constructed such that the positional relationship between the center portions of the grooves are coincident with or deviated from those of the corresponding grooves; and each type of contact angle construction is obtained by combining the tracking base **2** or the sliding base **3** with the corresponding tacking base **2** or the corresponding sliding base **3** in an arbitrary manner.

FIG. **17** is a schematic view showing the ninth embodiment according to the present invention. In the ninth embodiment, the centers OA of the ball rolling grooves **2***b* and **2***c* formed on side surfaces of the tracking base **2** are deviated from the centers OB of the corresponding ball rolling grooves **3***b* and **3***c* formed on the sliding base **3** in an upper direction, or the centers of OB of the ball rolling grooves **3***b* and **3***c* formed on side surfaces of the sliding base **3** are deviated from the centers OA of the corresponding ball rolling grooves **2***b* and **2***c* formed on the tracking base **2** in a lower direction; and thereby the contact angle lines of the balls **4** held in the ball rows **6** and **7** formed on the side surfaces are inclined by about 45 degrees in upper and inside direction of the tracking base **2** with respect to the horizontal direction. Such deviation can be obtained in the first to eighth embodiments by the same manner as in the above assembling method. In the ninth embodiment, the contact angles of balls **4** in the ball rows **5** formed on the upper surface, are arranged to be 90 degrees with respect to the horizontal direction.

In the ninth embodiment, the load applied from an upper direction against the sliding base **3** (radian load) PR is supported by the two ball rows **5** formed on the upper surface. And, the lateral load applied from left and right directions (horizontal direction load) PT is supported by either one of the two ball rows **6** and **7** formed on the side surfaces, according to the load applied direction. Further, the vertical load applied from the lower direction (reversed radial load) PL is supported by two ball rows **6** and **7** formed on the side surfaces.

Furthermore, the contact angles of the balls **4** in the two ball rows **6** and **7** formed on the side surfaces are arranged such that the contact angle lines are inclined in an upper and inside direction by 45 degrees with respect to the horizontal direction. Therefore, it is possible to support the load in a reversed radial direction and the load in a lateral direction in an even manner. Moreover, in such apparatus, the stiffness against the load applied from the lateral direction is much higher than that in the apparatus having only one ball row on each side surface.

Moreover, the load applied from the radial direction is supported by the two ball rows **5** formed on the upper surface, whose contact angles are about 90 degrees with respect to the horizontal direction. Therefore, a high stiffness can be obtained against the radial load.

Particularly, if the depths of the ball rolling grooves are set about 51% of the diameter of balls to be held therein, the contacting area of the balls against the general circular-ark type grooves becomes large (like a roller) and the supporting ability for the heavy load is rapidly improved, involving the construction of the contact angles, so that a high stiffness and a stable linear movement can be obtained.

That is to say, optimum and suitable combination of the tracking base and the sliding base can be obtained when the load are applied from a radial direction, a reversed direction and lateral (left and right) direction.

In FIG. **19**, is illustrated the linear movement guide apparatus according to the tenth embodiment of the present invention. In the linear movement guide apparatus **1***a*, the positional relationship between the centers of the grooves is arranged to be coincident with the corresponding grooves, i.e. the relationship between either one of two rows of ball rolling grooves **2***b* and **2***c* (or **3***b* and **3***c*) formed on side surfaces of the tracking base **2** or the sliding base **3** and the corresponding ball rolling grooves **3***b* and **3***c* (or **2***b* and **2***c*) formed on the tracking or sliding base **2** or **3**, so that the contact angles of balls **4** in the two ball rows **6** and **7** on the side surfaces become 0 degrees with respect to a horizontal direction. On the other hand, the contact angles of balls **4** in the two ball rows on the upper surface are arranged to be 90 degrees with respect to the horizontal direction.

In the tenth embodiment, the vertical load applied from the upper direction against the sliding base **3** (radial load) is supported by the two ball rows **5** formed on the upper surface. And the lateral load applied from left and right directions (horizontal direction load) is supported by two ball rows **6** and **7** formed on either of the side surfaces, according to the load applied direction.

Since the contact angles of balls **4** in the two ball rows on the side surfaces are arranged to be about 0 degrees with respect to the horizontal direction and the contact angles of balls **4** in the two ball rows **5** formed on the upper surface are arranged to be about 90 degrees with respect to the horizontal direction, a high stiffness can be obtained and it is possible to support the radial load and the lateral load in an even manner.

That is to say, the apparatus has a large stiffness against loads applied from not only the horizontal (left and right) direction but also the radial direction; and the combination of the tracking base and the sliding base is optimum in the case that the loads are applied from the radial direction and the horizontal (left and right) direction.

FIG. **20** is a schematic view showing a linear movement guide apparatus according to the eleventh embodiment of the present invention. In this embodiment, the contact angles of balls **4** in the upper ball rows **6** formed on the side surfaces are arranged to be about 45 degrees with respect to the horizontal direction and the contact angle lines in the upper ball rows intersect to each other at a point inside of the tracking base **2**; but the contact angles of the balls **4** in the lower ball rows **7** formed on the side surfaces are arranged to be about 0 degrees with respect to the horizontal direction.

On the other hand, the contact angles of balls **4** in the two ball rows formed on the upper surface are 45 degrees with respect to the horizontal direction and the intersecting point of the contact angle lines therein locate outside of the tracking base **2**.

Further, in FIG. **21**, is depicted a linear movement guide apparatus according to the twelfth embodiment according to the present invention. In this linear movement guide apparatus **1***c*, the relationship of the contact angles of balls in the ball rows **6** and **7** formed on the side surfaces are arranged to be reversed to that of the apparatus according to the eleventh embodiment. That is to say, the contact angles of balls **4** in the lower ball rows **7** of the side surfaces are arranged to be about 45 degrees with respect to the horizontal surface and the contact lines thereof intersect to each other at a point inside of the tracking base **2**; and the contact angles of the balls **4** in the upper ball rows **6** on the side surfaces are arranged to be about 0 degrees with respect to the horizontal direction.

Therefore, the combinations of the tracking base **2** and the sliding base **3** in the eleventh and twelfth embodiments are optimum for the case that a large load is applied from a reversed radial direction.

In FIGS. **22**(*a*) to (*c*), other examples of the constructions of contact angles of balls are shown. It should be noted that any other combination, which is not shown in these figures, are possible to be arranged.

In FIG. **22**(*d*), is provided another construction in which two ball rows are formed on one of the side surfaces but only one row is on the other side. In FIG. **22**(*e*), is provided still another construction in which two ball rows are formed on one of the side surfaces but only one is on the other side surface, in addition thereto, only one ball row is formed on the upper surface.

As stated in the above, it may be possible to combine the one ball row and two ball rows on the side surfaces, or to form only one ball row on each side surface and the upper surface. Furthermore, it may also be possible to arrange three ball rows or more on the side surfaces and the upper surface.

Further, in each embodiment explained in the above, no retainer for preventing that the balls **4** are fallen when the sliding base **3** is taken off from the tracking base **2** is provided. However, the present invention can be applied to the apparatus having such retainer.

Furthermore, in each embodiment, the tracking base has a square-shaped cross section and thus the concave portion formed in the sliding base also has a square-shaped cross section. However, the invention is not limited by the square-shaped bases.

According to the present invention, a necessary load supporting characteristic can be obtained in accordance with the amount and the direction of loads applied to the apparatus; and thus, it is possible to provide an apparatus having a large load supporting capacity in accordance with the purpose of use thereof.

INDUSTRIAL APPLICABILITY

In the linear movement guide apparatus according to the present invention, the contact angle in each ball rolling groove can be set arbitrarily by changing the distance between the two rows of ball rolling grooves formed on the upper surface of the tracking base and the distance between said ball rolling grooves and the ball rolling grooves formed on side surfaces of the tracking base, with respect to the distances between the corresponding ball rolling grooves formed on the sliding base. Therefore, it is possible to provide an apparatus having a suitable performance for the load applied thereto from each direction, by changing the pitches between the ball rolling grooves in accordance with the condition of load applied to the apparatus to form ball rolling grooves having the most optimum contact angles.

The cross sections of the ball rolling grooves may be possible to arrange as a single circular-ark shape or as a combination of two circular-arks, but the depth of the grooves should be set up so as to be able to select an arbitrary ball contact angles. It is preferred to set up the depth about ¼ to ½ of the balls to be held therein. In such construction, the balls held in the grooves surely made contact with any portion of the grooves, so that it is possible to obtain almost all contact angles, which have been required in the conventional linear movement guide apparatuses of this type.

According to the assembling method of the present invention, the common material can be used to manufacture the tracking base and the sliding base. And, a plurality types of linear movement guide apparatuses can be obtained only by changing the type of the dressers and pitches (distance) thereof, i.e. the pitches between the ball rolling grooves formed by the dressers, in accordance with the load condition. Then, the productivity of the apparatus is extremely improved.

What is claimed is:

1. A method of assembling a linear movement guide apparatus comprising the steps of:

forming a tracking base having substantially a square cross section and formed, at an upper surface thereof, with a pair of arcuate first ball rolling grooves separated from each other by a first pitch in a width direction thereof and each having a depth approximately half of a diameter of a ball as a rolling member and formed, at each of bilateral side surfaces thereof, with a pair of arcuate second ball rolling grooves separated from each other by a second pitch in a height direction thereof;

forming a plurality kinds of sliding bases formed with recessed portions in which said tracking base is mounted to be slidable with respect to the tracking base through six rows of rolling balls and provided with a pair of third ball rolling grooves separated from each other by a third pitch different from the first pitch in a width direction thereof and a pair of fourth ball rolling grooves separated from each other by a fourth pitch with respect to the third ball rolling grooves different from the second pitch in a height direction thereof; and

assembling a linear movement guide apparatus, by selecting a combination of said first and third pitches and a combination of said second and fourth pitches, having one of following first to fourth contact angle structures: first contact angle structure in which a contact angle of a ball disposed between said first and third ball rolling grooves is 90° with respect to a horizontal line and a contact angle of a ball disposed between said second and fourth ball rolling grooves is 45° in an upward oblique direction towards the tracking base with respect to the horizontal line; second contact angle structure in which a contact angle of a ball disposed between said first and third ball rolling grooves is 90° with respect to a horizontal line and a contact angle of a ball disposed between said second and fourth ball rolling grooves is 0°; third contact angle structure in which a contact angle of a ball disposed between said first and third ball rolling grooves is 45° in a downward oblique direction towards a central portion with respect to a horizontal line and a contact angle of a ball disposed between said second and fourth ball rolling grooves is 45° in an upward oblique direction towards the tracking base with respect to the horizontal line; and fourth contact angle structure in which a contact angle of a ball disposed between said first and third ball rolling grooves is 45° in an upward oblique direction towards a central portion with respect to a horizontal line and a contact angle of a ball disposed between said second and fourth ball rolling grooves is 45° in an upward oblique direction towards the tracking base with respect to the horizontal line.

2. A method of assembling a linear movement guide apparatus according to claim **1**, wherein said first to fourth ball rolling grooves each has a depth approximately corresponding to ¼ to ½ of the diameter of the ball.

3. A method of assembling a linear movement guide apparatus comprising the steps of:

forming a tracking base having substantially a square cross section and formed, at an upper surface thereof, with a pair of bilateral two arcuate first ball rolling grooves separated from each other by a predetermined pitch in a width direction thereof and each having a depth approximately half of a diameter of a ball as a rolling member and formed, at each of bilateral side surfaces thereof, with a pair of two arcuate second ball rolling grooves separated from each other by a predetermined pitch in a height direction thereof;

forming a plurality kinds of sliding bases formed with recessed portions in which said tracking base is mounted to be slidable with respect to the tracking base through six rows of rolling balls and provided with arcuate third ball rolling grooves composed of a pair of bilateral two ball rolling grooves in a manner of being disposed at an upper bottom surface of the recessed portions in the same manner as that for the first ball rolling grooves in the width direction or in a shifted manner with respect thereto and arcuate fourth ball rolling grooves composed of a pair of vertical two ball rolling grooves in a manner of being disposed at both inside surfaces of the recessed portions in the same manner as that for the second ball rolling grooves formed to both side surfaces of the tracking base or in a shifted manner with respect thereto; and

assembling a linear movement guide apparatus, by selecting a combination of phases of said first and third ball rolling grooves and a combination of phases of said second and fourth ball rolling grooves, having one of following first to fourth contact angle structures: first contact angle structure in which a contact angle of a ball disposed between said first and third ball rolling grooves is 90° with respect to a horizontal line and a contact angle of a ball disposed between said second and fourth ball rolling grooves is 45° in an upward oblique direction towards the tracking base with respect to the horizontal line; second contact angle structure in which a contact angle of a ball disposed between said first and third ball rolling grooves is 90° with respect to a horizontal line and a contact angle of a ball disposed between said second and fourth ball rolling grooves is 0°; third contact angle structure in which a contact angle of two ball rows disposed between said first and third ball rolling grooves is 45° in an upward oblique direction towards a central portion with respect to a horizontal line, a contact angle of upper two ball rows disposed between said second and fourth ball rolling grooves is 45° in an upward oblique direction towards the tracking base with respect to the horizontal line, and a contact angle of lower two ball rows disposed therebetween is 0° with respect to the horizontal line; and fourth contact angle structure in which a contact angle of two ball rows disposed between said first and third ball rolling grooves is 45° in an upward oblique direction towards a central portion with respect to a horizontal line, a contact angle of upper two ball rows disposed between said second and fourth ball rolling grooves is 0° with respect to the horizontal line and a contact angle of lower two ball rows disposed therebetween is 45° in an upward oblique direction towards the tracking base with respect to the horizontal line.

* * * * *

US006217217B1

(12) United States Patent
Teramachi

(10) **Patent No.:** **US 6,217,217 B1**

(45) **Date of Patent:** **Apr. 17, 2001**

(54) **LINEAR ROLLER GUIDE**

(75) Inventor: **Hiroshi Teramachi**, Tokyo (JP)

(73) Assignee: **THK Co., Ltd.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/029,322**

(22) PCT Filed: **May 13, 1997**

(86) PCT No.: **PCT/JP97/01606**

§ 371 Date: **Nov. 25, 1998**

§ 102(e) Date: **Nov. 25, 1998**

(87) PCT Pub. No.: **WO97/43554**

PCT Pub. Date: **Nov. 20, 1997**

(30) **Foreign Application Priority Data**

May 13, 1996 (JP) 8-142253
May 13, 1996 (JP) 8-142256

(51) **Int. Cl.**[7] **F16C 29/06**
(52) **U.S. Cl.** **384/44**
(58) **Field of Search** 384/44, 43, 45; 464/168

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

0 296 538	12/1988	(EP) .
50-119829	9/1975	(JP) .
51-156345	12/1976	(JP) .
60-143225	7/1985	(JP) .
63-91722	6/1988	(JP) .
63-172016	7/1988	(JP) .
64-26017	1/1989	(JP) .
1-136716	9/1989	(JP) .
2-142918	6/1990	(JP) .
5-280537	10/1993	(JP) .
7-317762	12/1995	(JP) .

Primary Examiner—Lenard A. Footland
(74) *Attorney, Agent, or Firm*—Armstrong, Westerman, Hattori, McLeland & Naughton, LLP

(57) **ABSTRACT**

A first invention of the subject application aims to smoothly circulate the rollers by integrally molding at least one member of the roller returning passage, the roller end surface guide wall and the direction changing portion with the block body.

Namely, at least one member of the roller returning passage forming member **91** for forming the roller returning passage **9**, the roller end surface guide wall **13** and the direction changing passage inner periphery portion forming member **12** for forming the direction changing passage inner periphery portion **10***b* is integrally molded by inserting the block body into a molding die.

A second invention of the subject application aims to realize a smooth circulation and movement of the rollers, and to prevent the running-out of the roller chain during the circulation of the roller.

9 Claims, 15 Drawing Sheets

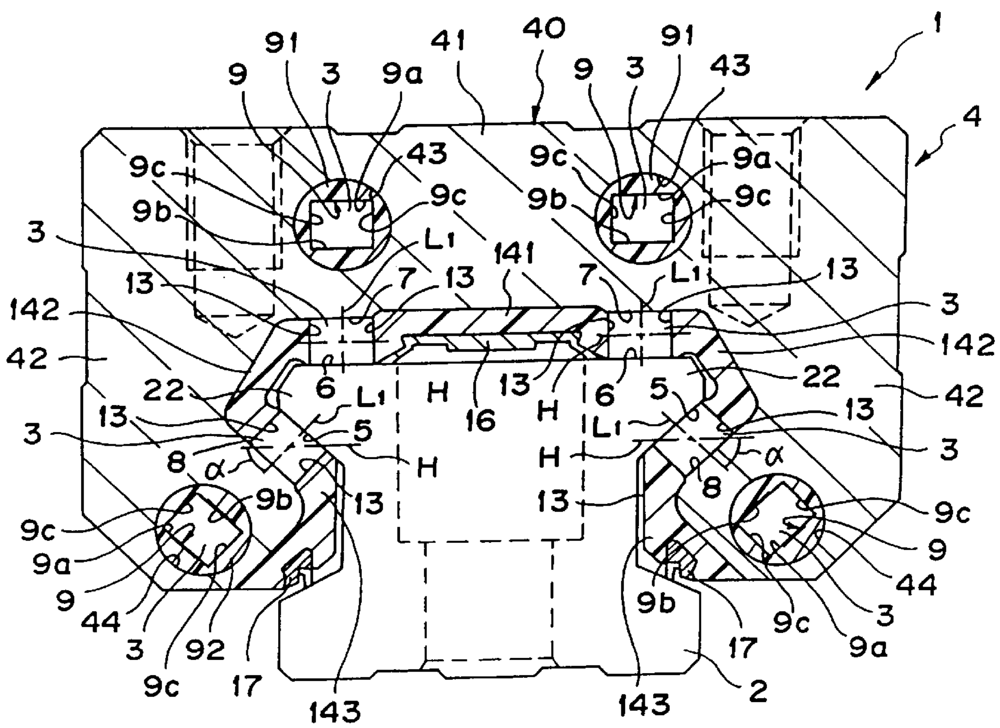


FIG. 1(a)

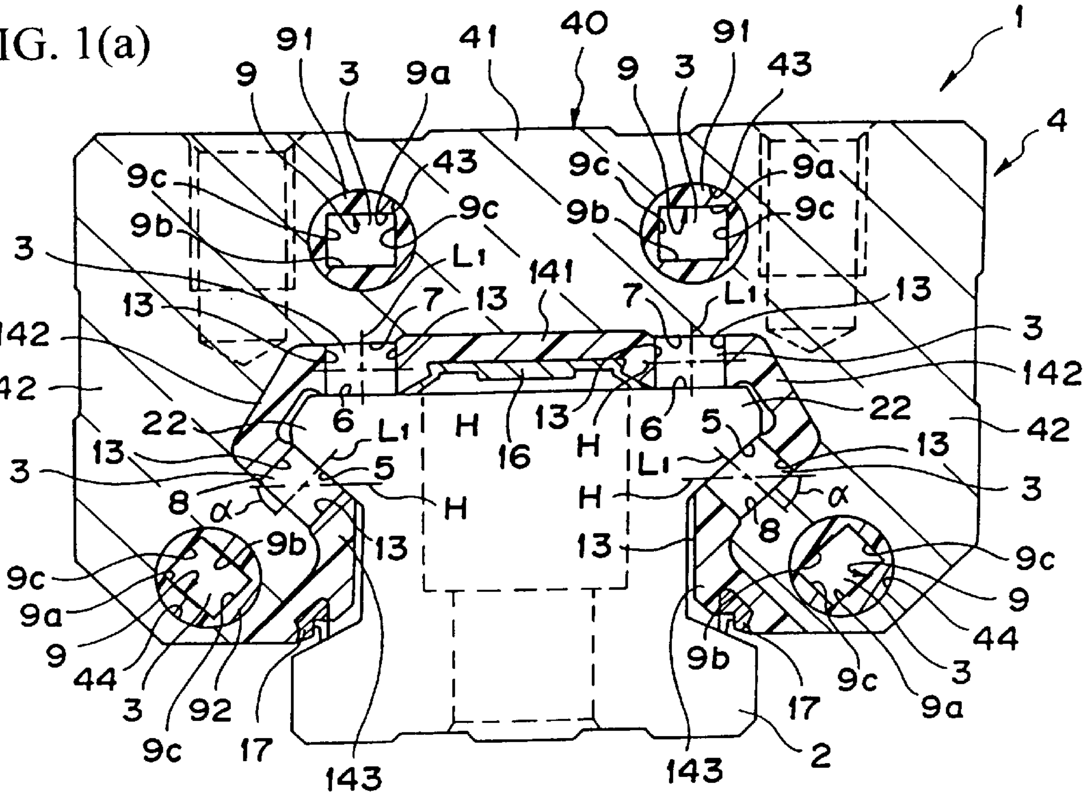


FIG. 1(b)

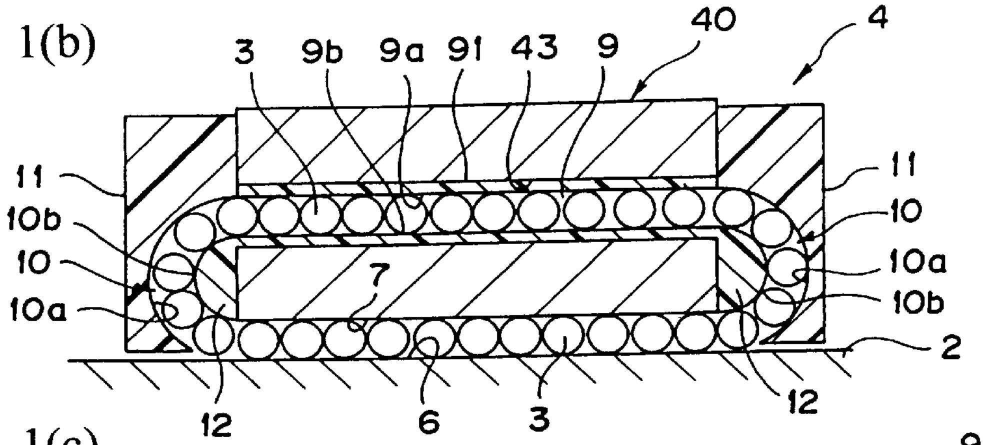
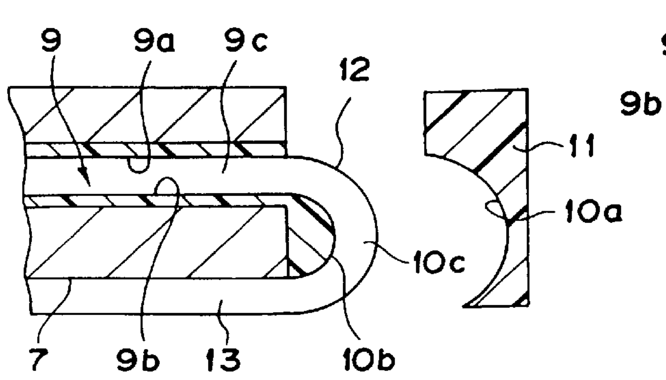


FIG. 1(c)



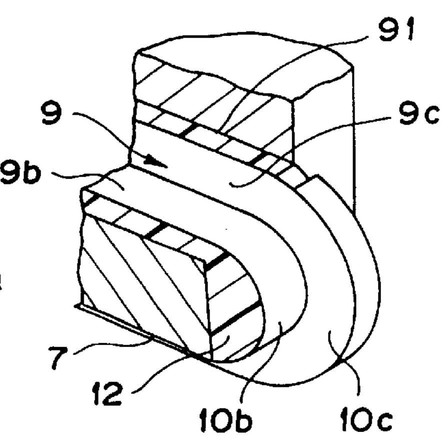


FIG. 1(d)

FIG. 2(a)

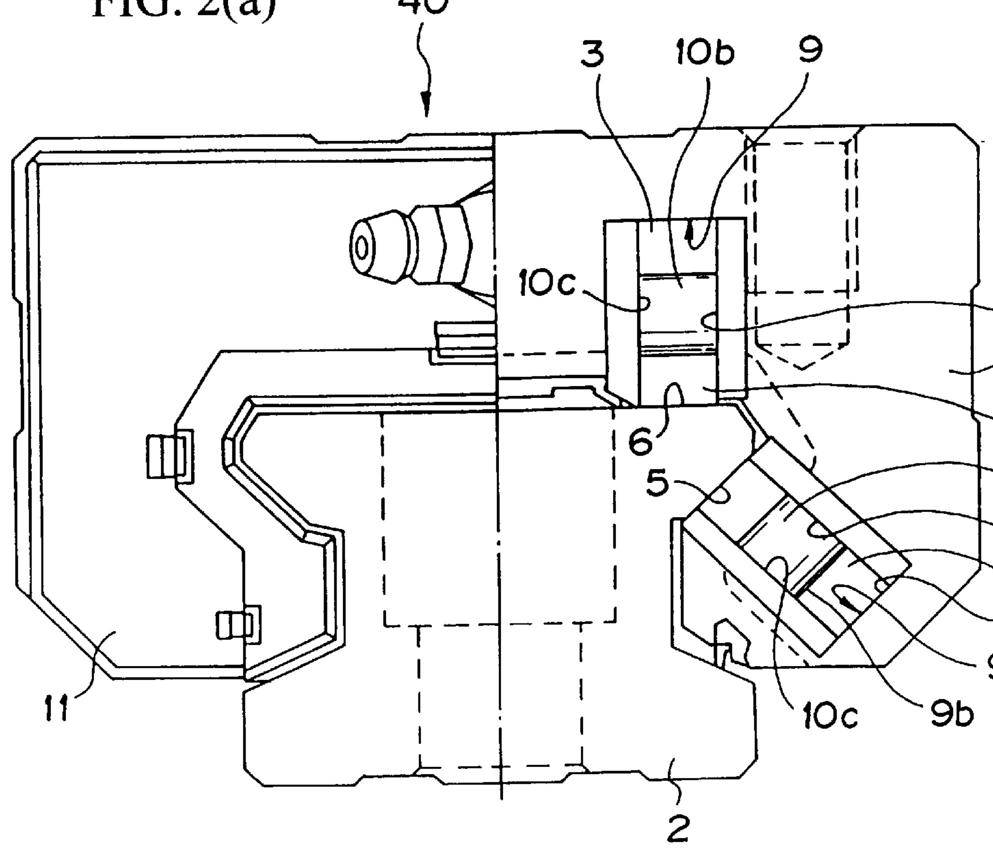

40
3
10b
9
10c
10c
42
3
6
5
10b
10c
3
9a
9
11
10c
9b
2

FIG. 2(b)

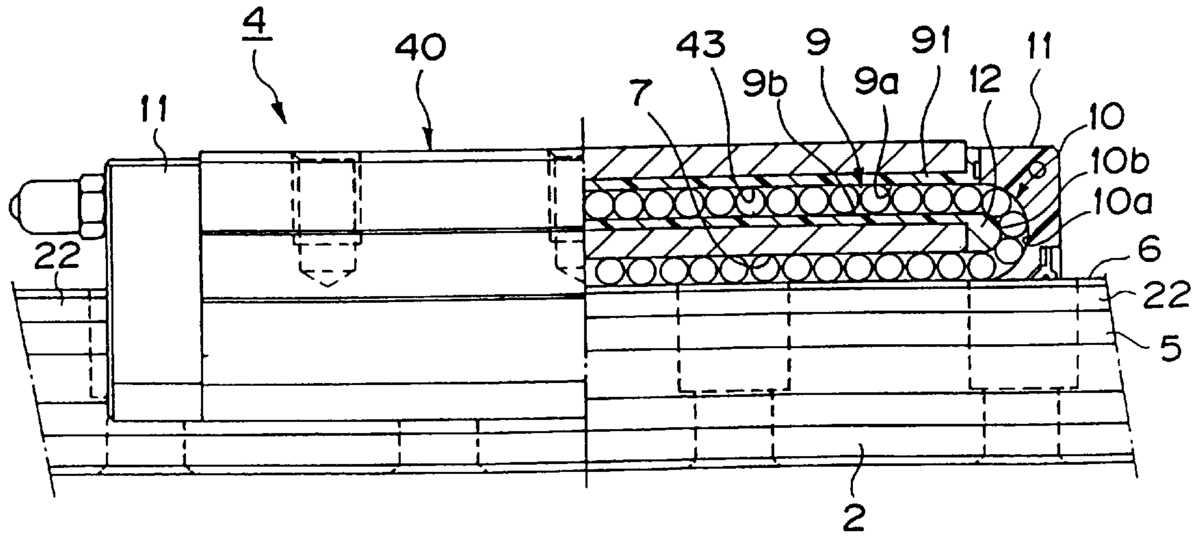

4
40
43
9
91
11
7
9b
9a
12
10
11
10b
10a
22
6
22
5
2

FIG. 3(a)

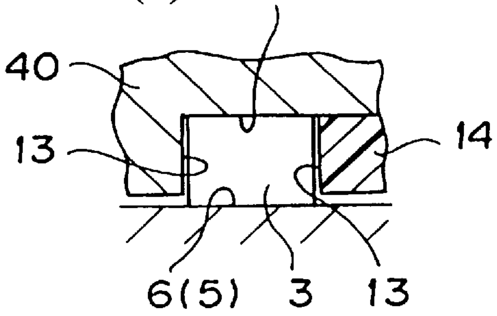


FIG. 3(d)

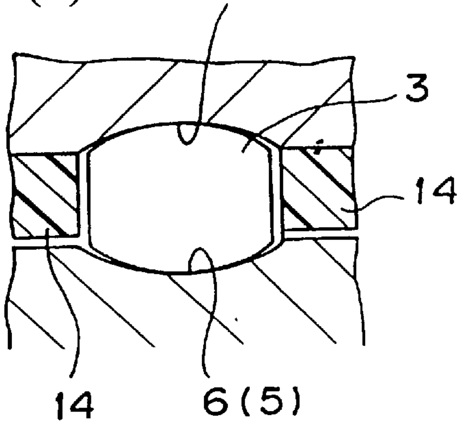


FIG. 3(b)

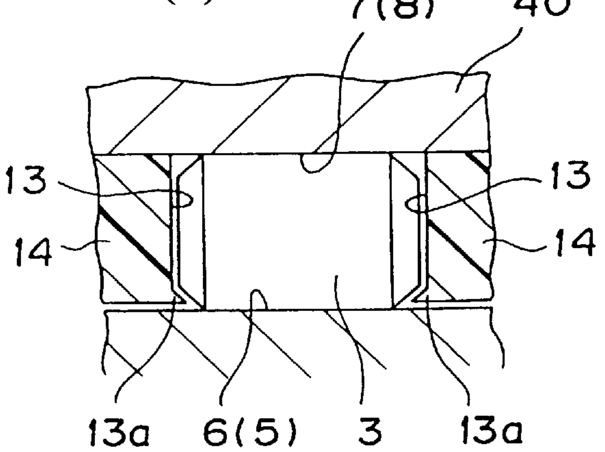


FIG. 3(e)

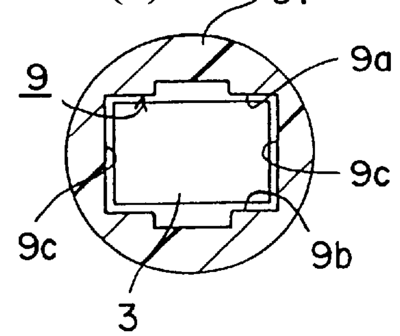


FIG. 3(c)

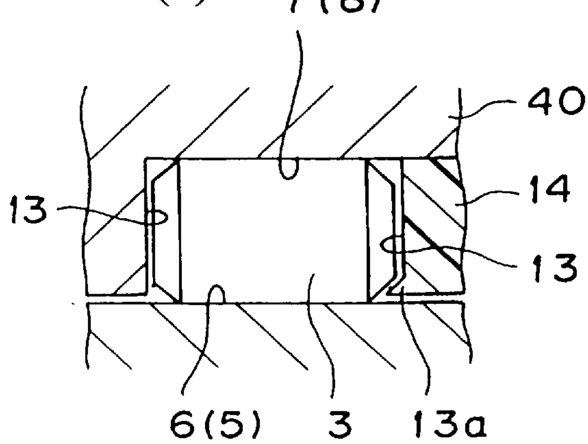


FIG. 3(f)

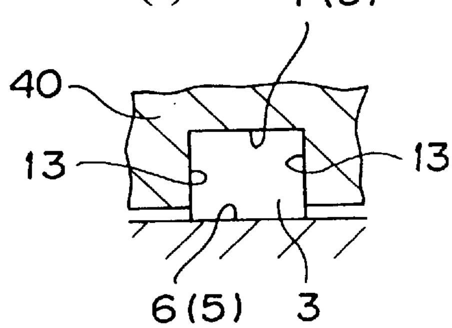


FIG. 4(a)

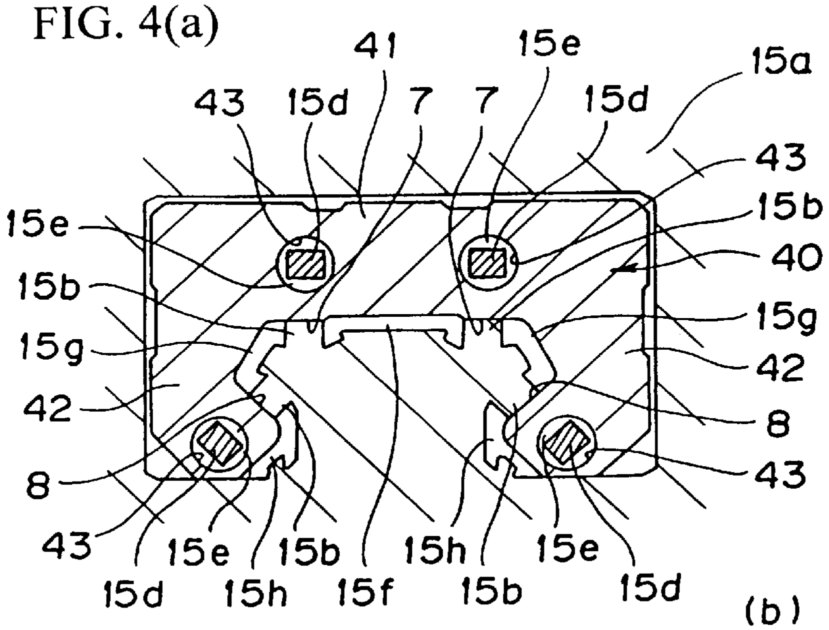


FIG. 4(b)

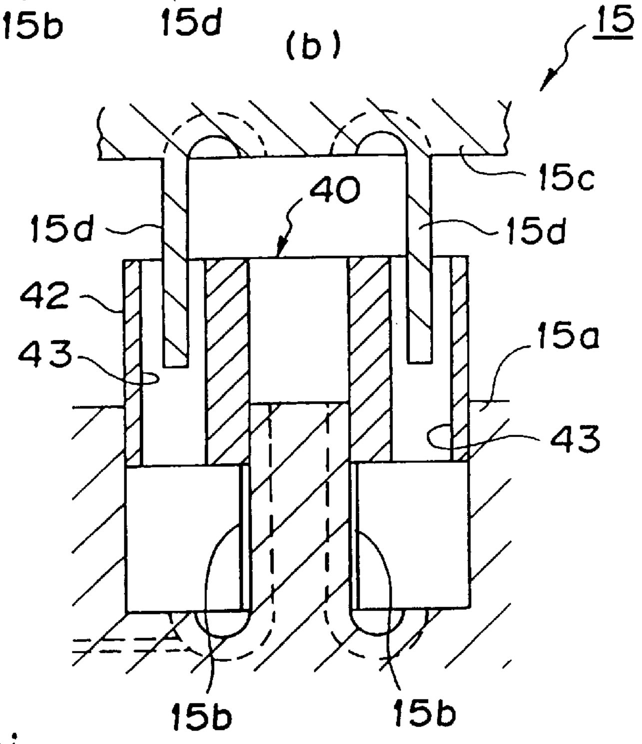


FIG. 4(c)

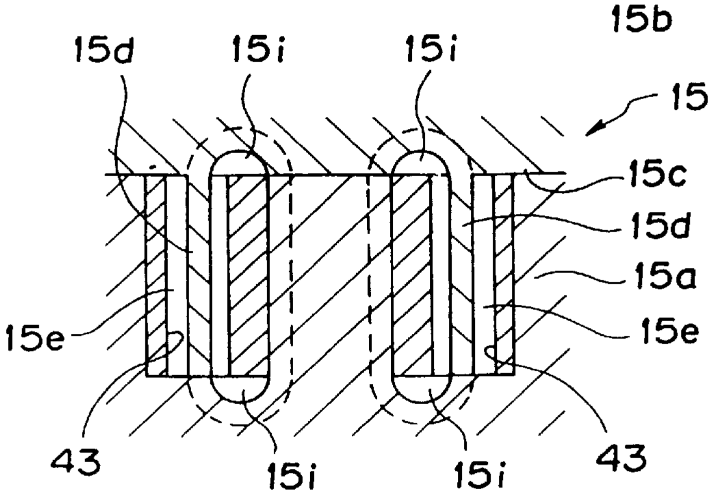


FIG. 5

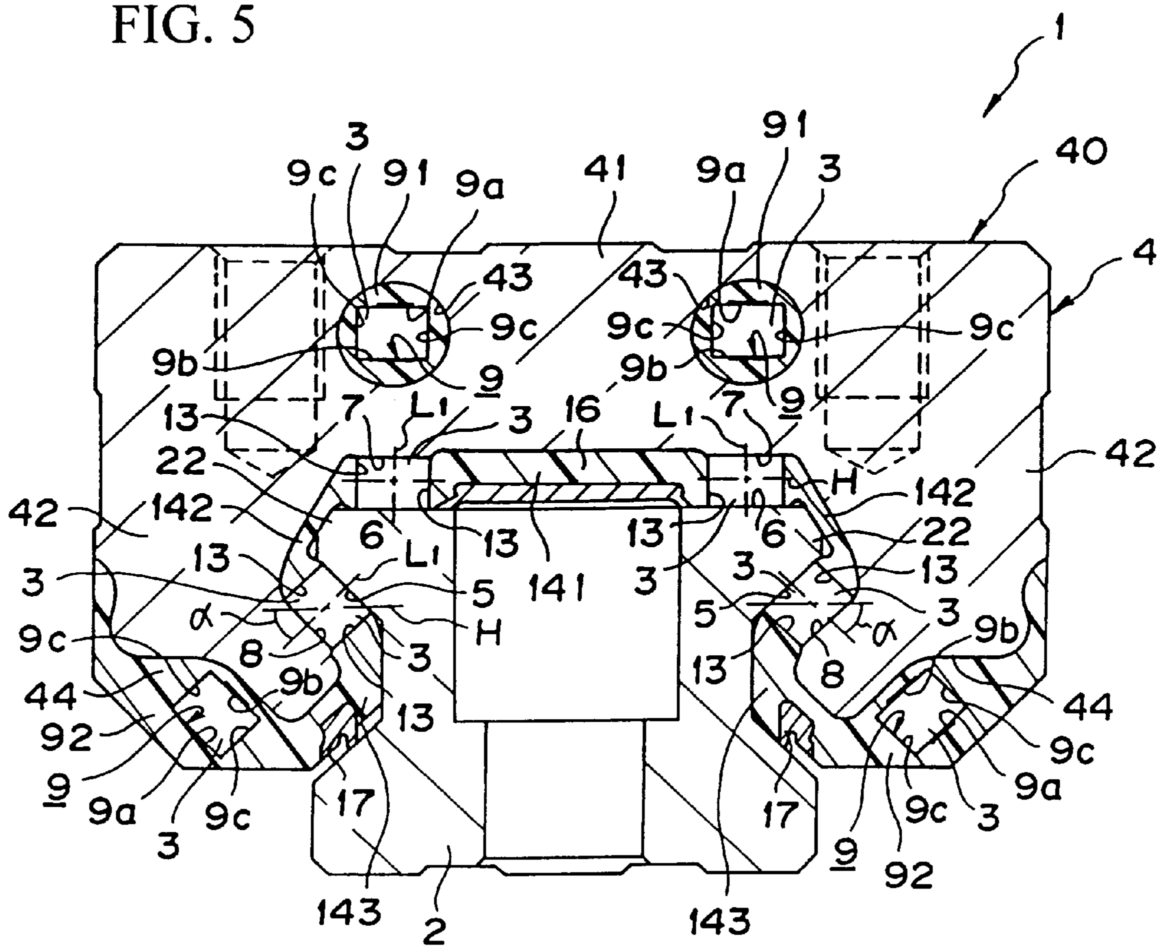

1
40
4
41
3
91
9a
9c
43
9b
9
13
22
42
142
7
L1
16
141
6
5
H
α
8
44
92
17
143
2

FIG. 6

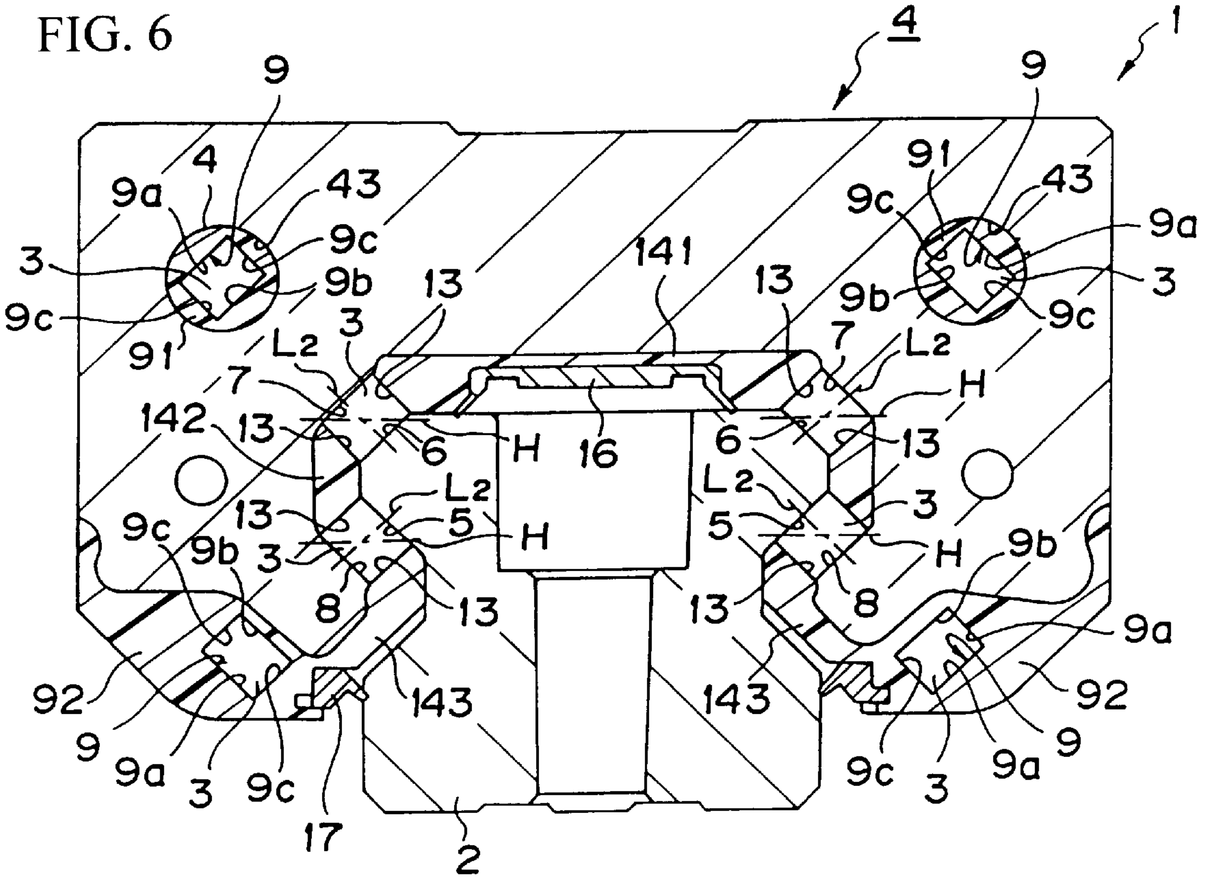

4
1
9
9
4
9a
43
9c
3
9b
9c
91
91
9c
43
9a
3
9b
9c
141
13
13
L2
3
7
L2
7
H
142
13
6
H
16
6
13
L2
L2
13
5
H
5
3
3
H
9c
9b
8
13
13
8
9b
9a
92
143
143
92
9
9a
3
9c
17
2
9c
3
9a
9

FIG. 7(a)

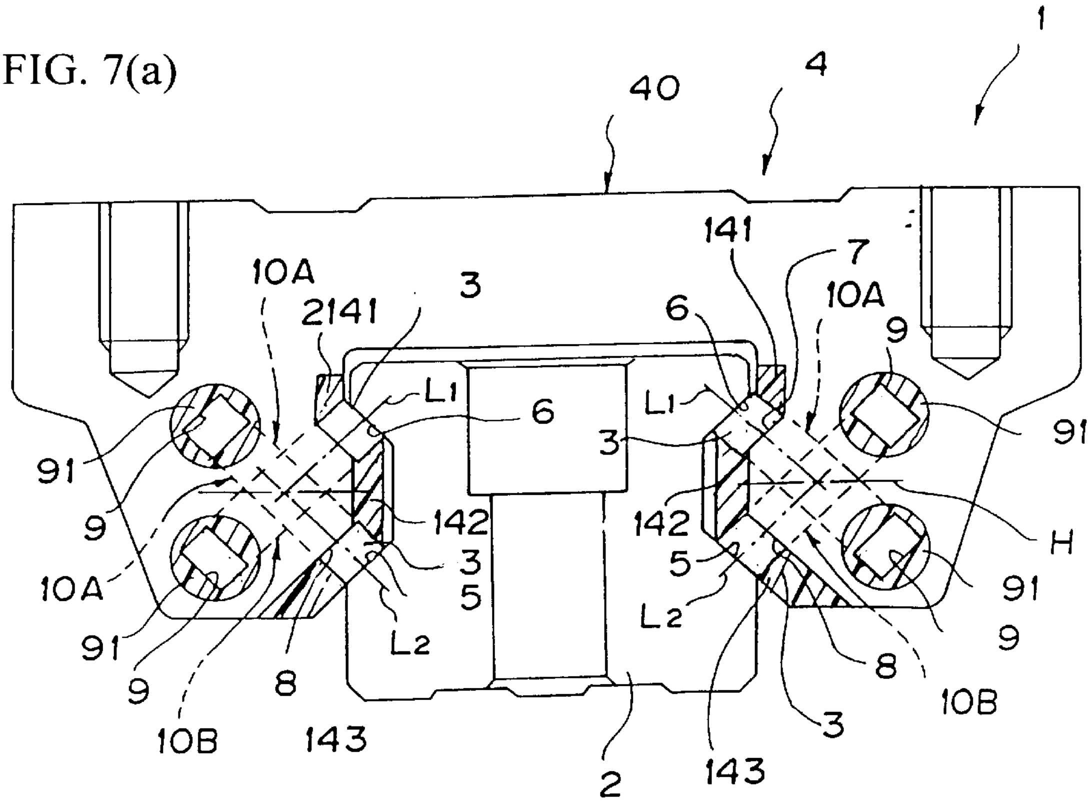

1
4
40
141
7
10A
2141
3
6
L1
9
91
142
H
5
L2
8
10B
143
2

FIG. 7(b)

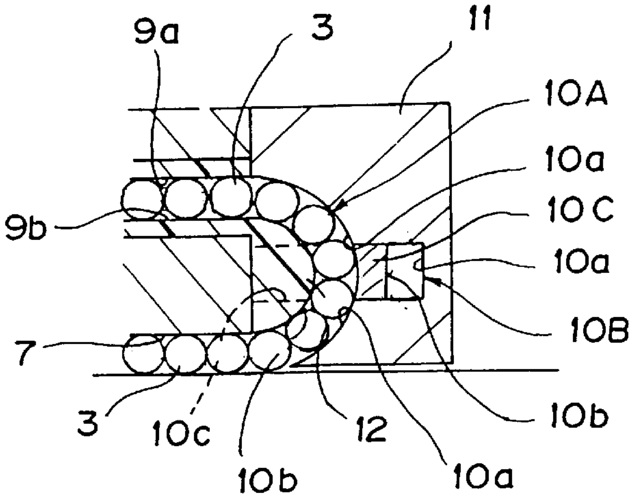

9a
3
11
10A
10a
10C
9b
10B
7
10b
10c
12

FIG. 8(a)

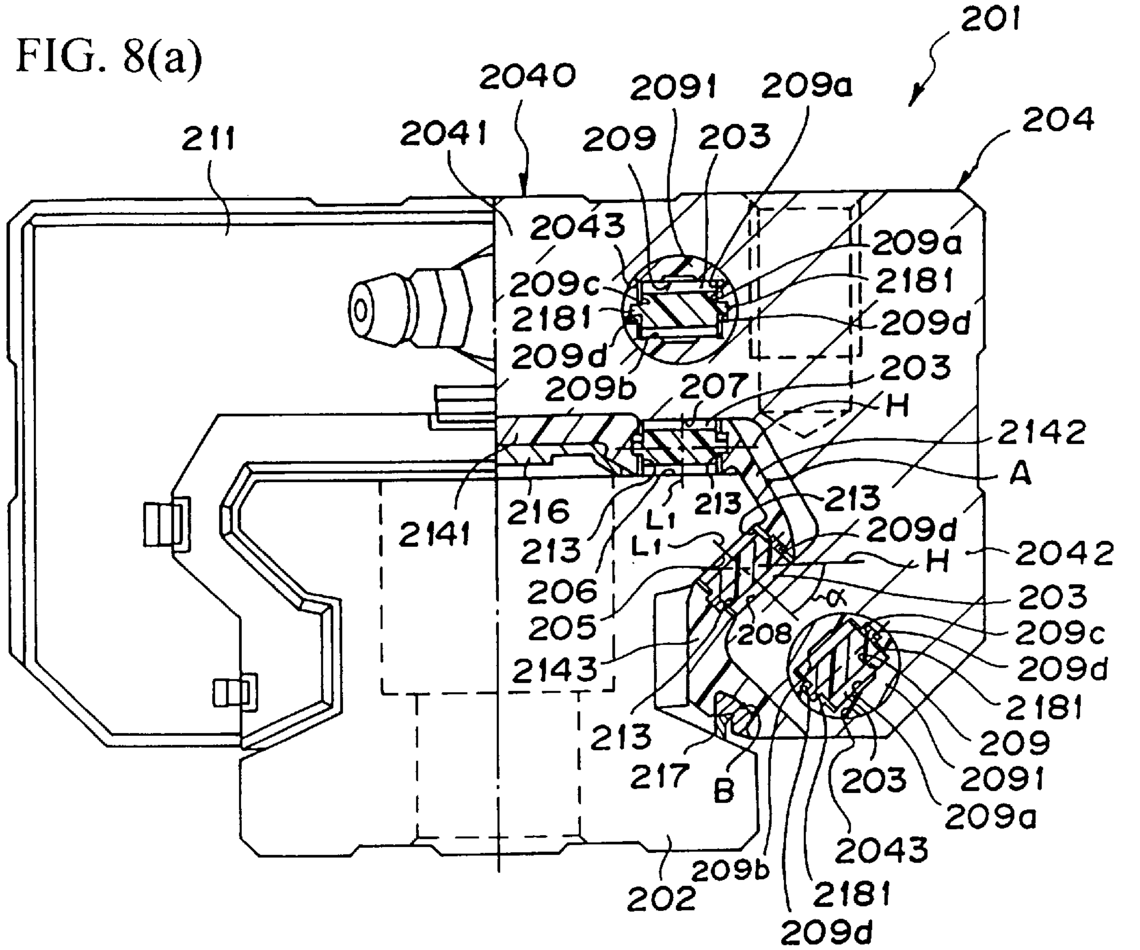

201
2040
2091
209a
204
211
2041
209
203
2043
209a
209c
2181
2181
209d
209d
209b
207
203
H
2142
A
2141
216
213
L1
213
209d
L1
2042
213
H
206
203
α
205
208
209c
2143
209d
2181
213
209
217
B
203
2091
209a
2043
209b
2181
202
209d

FIG. 8(b)

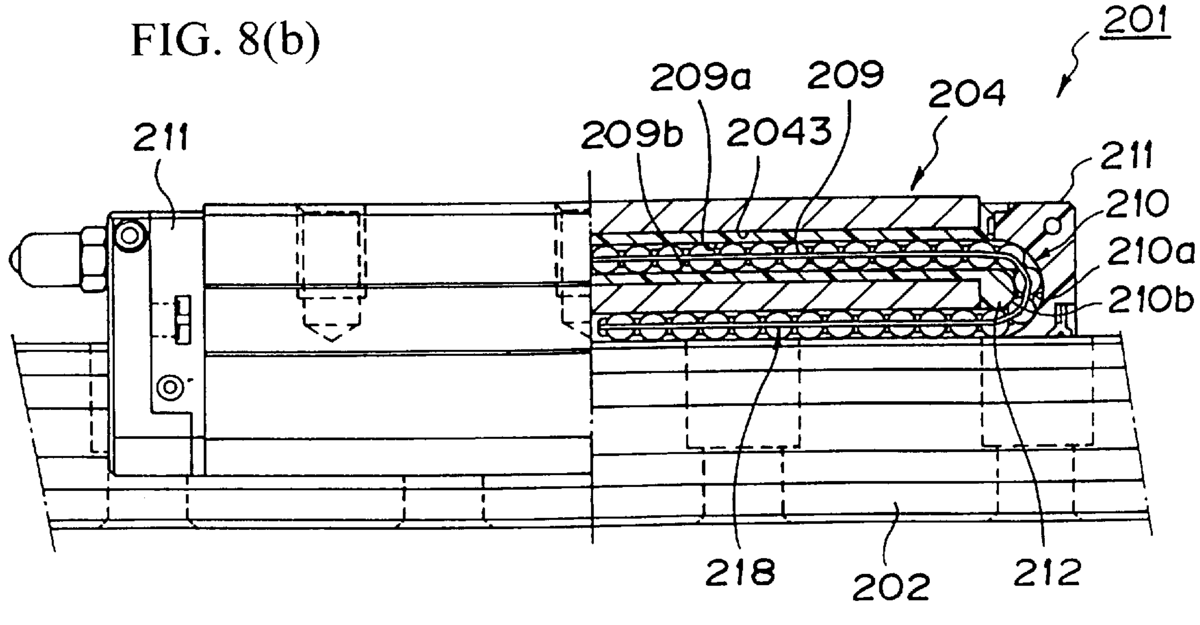

201
209a
209
204
211
209b
2043
211
210
210a
210b
218
202
212

FIG. 9(a)

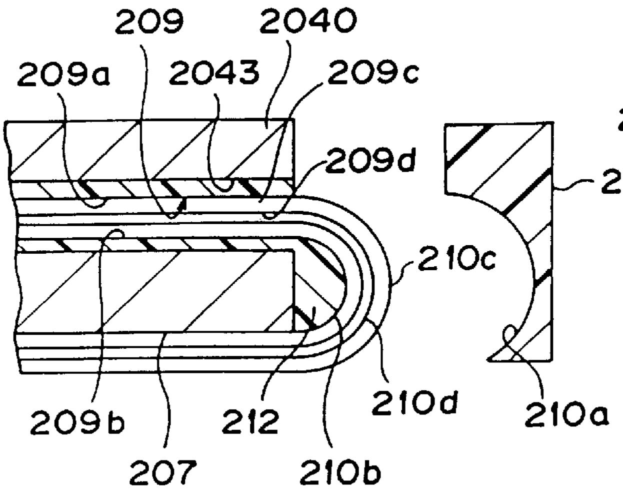


FIG. 9(b)

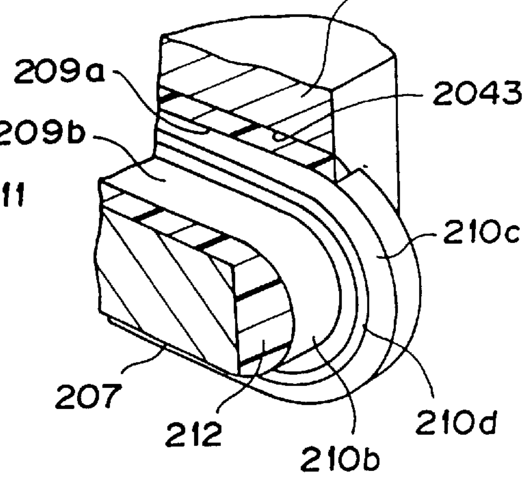


FIG. 9(c)

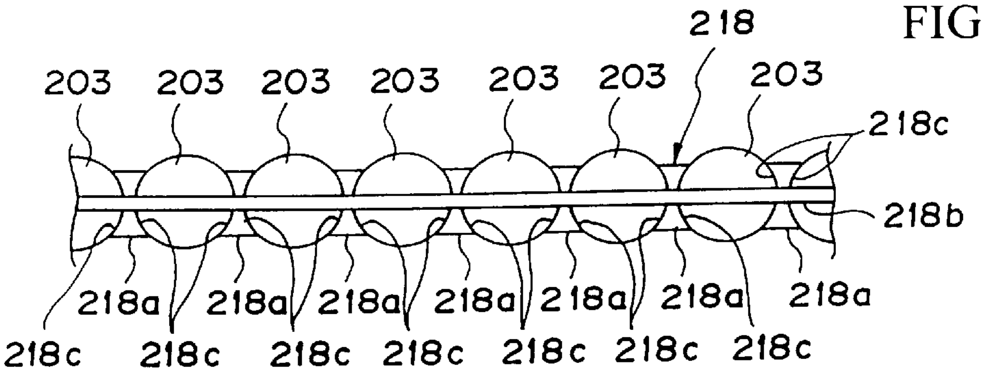


FIG. 9(d)

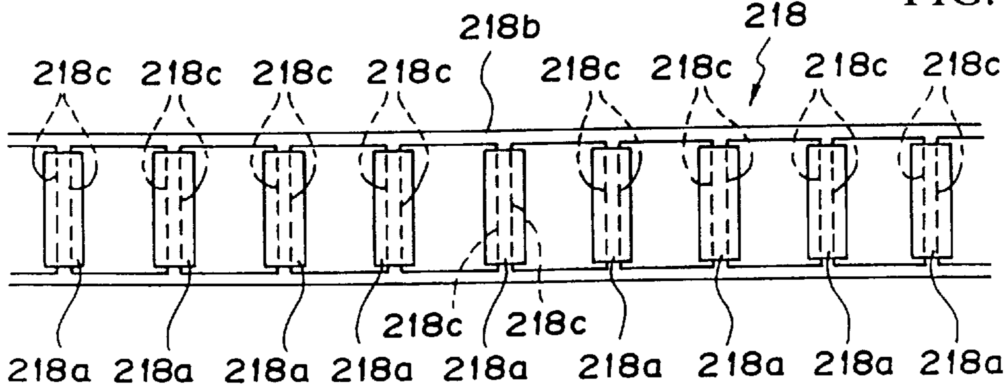


FIG. 9(e)

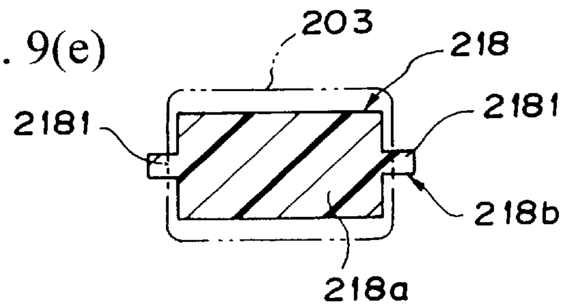


FIG. 10(a)

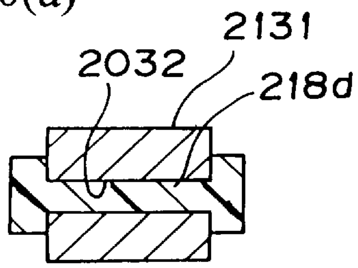


FIG. 10(b)

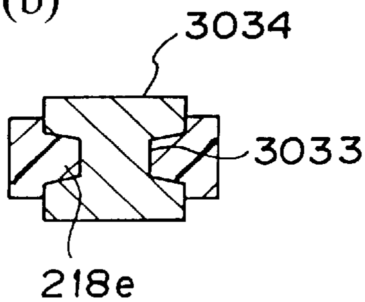


FIG. 10(c)

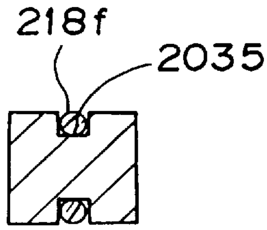


FIG. 10(d)

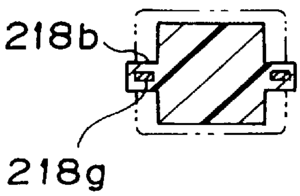


FIG. 11(a)

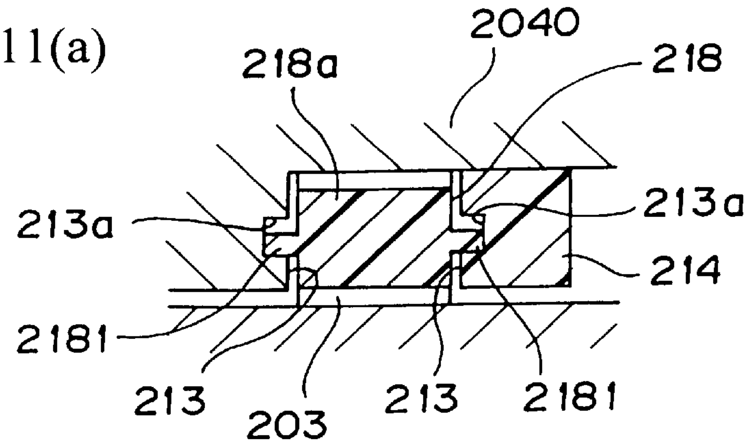


FIG. 11(b)

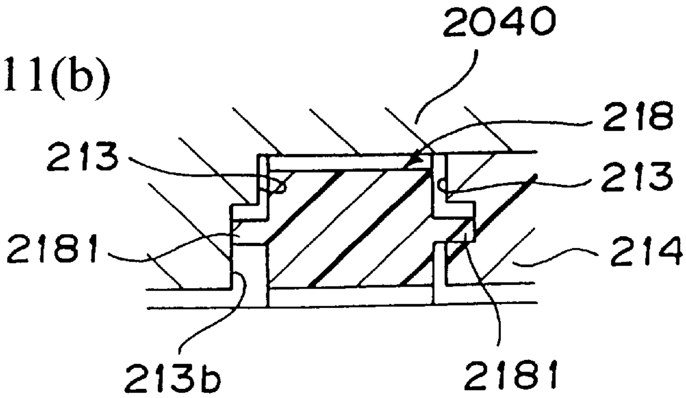


FIG. 11(c)

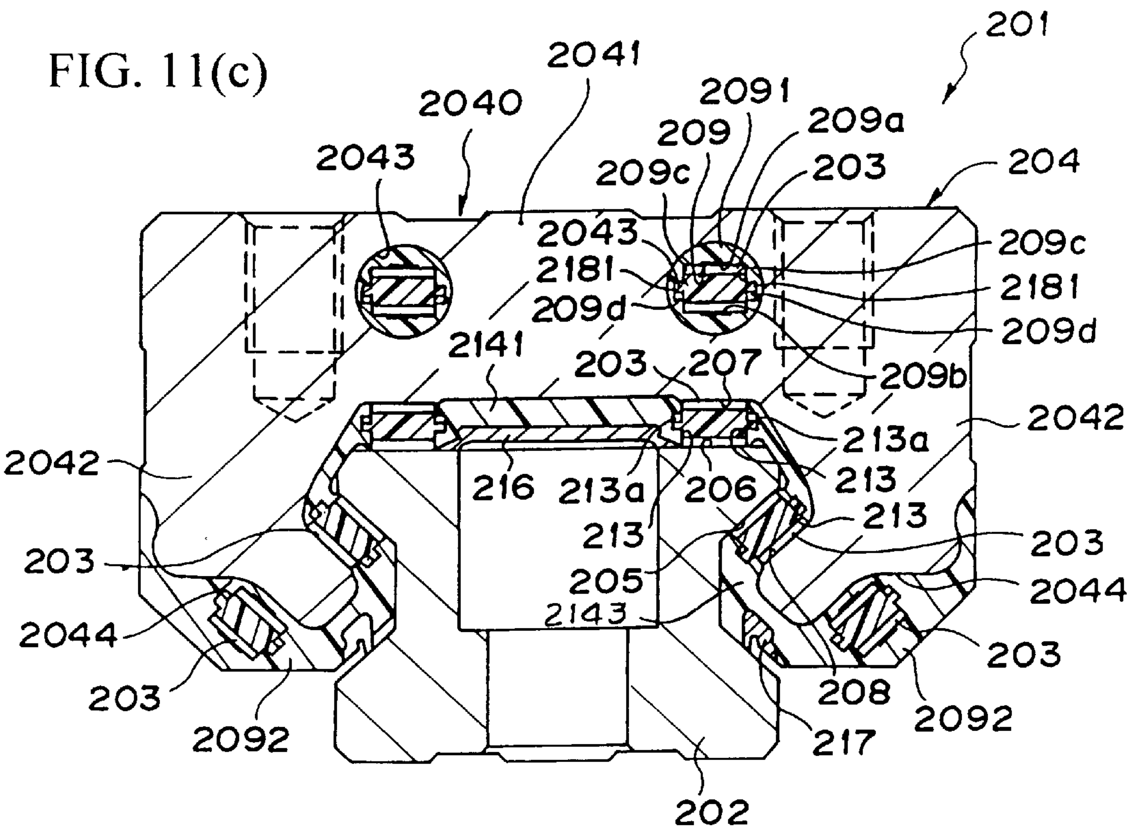


FIG. 12(a)

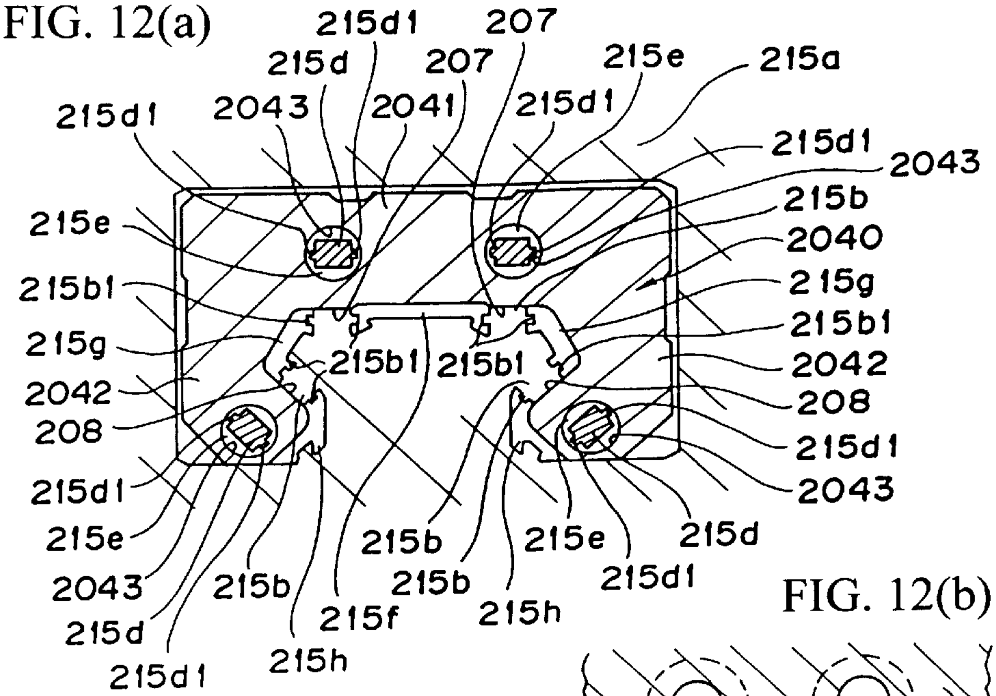


FIG. 12(b)

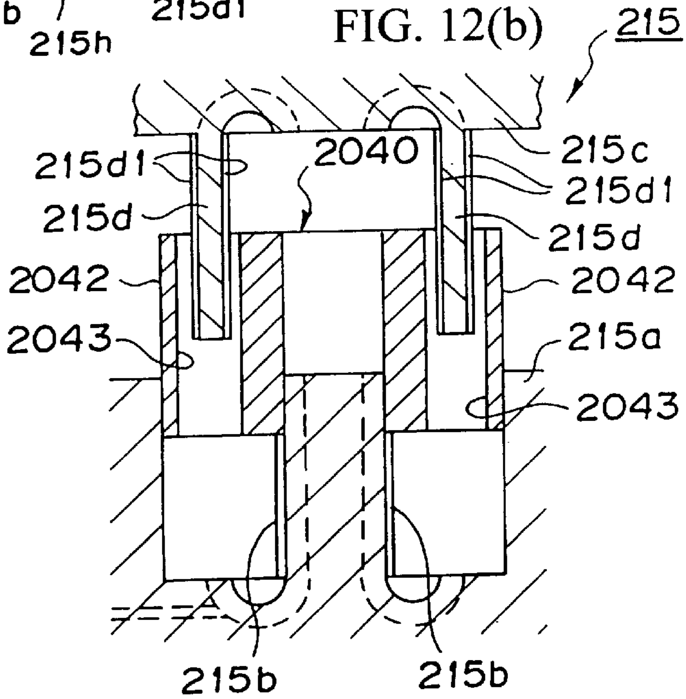
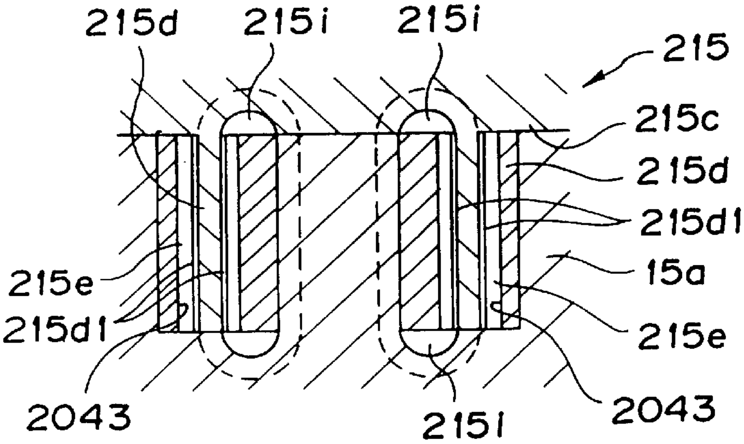


FIG. 12(c)



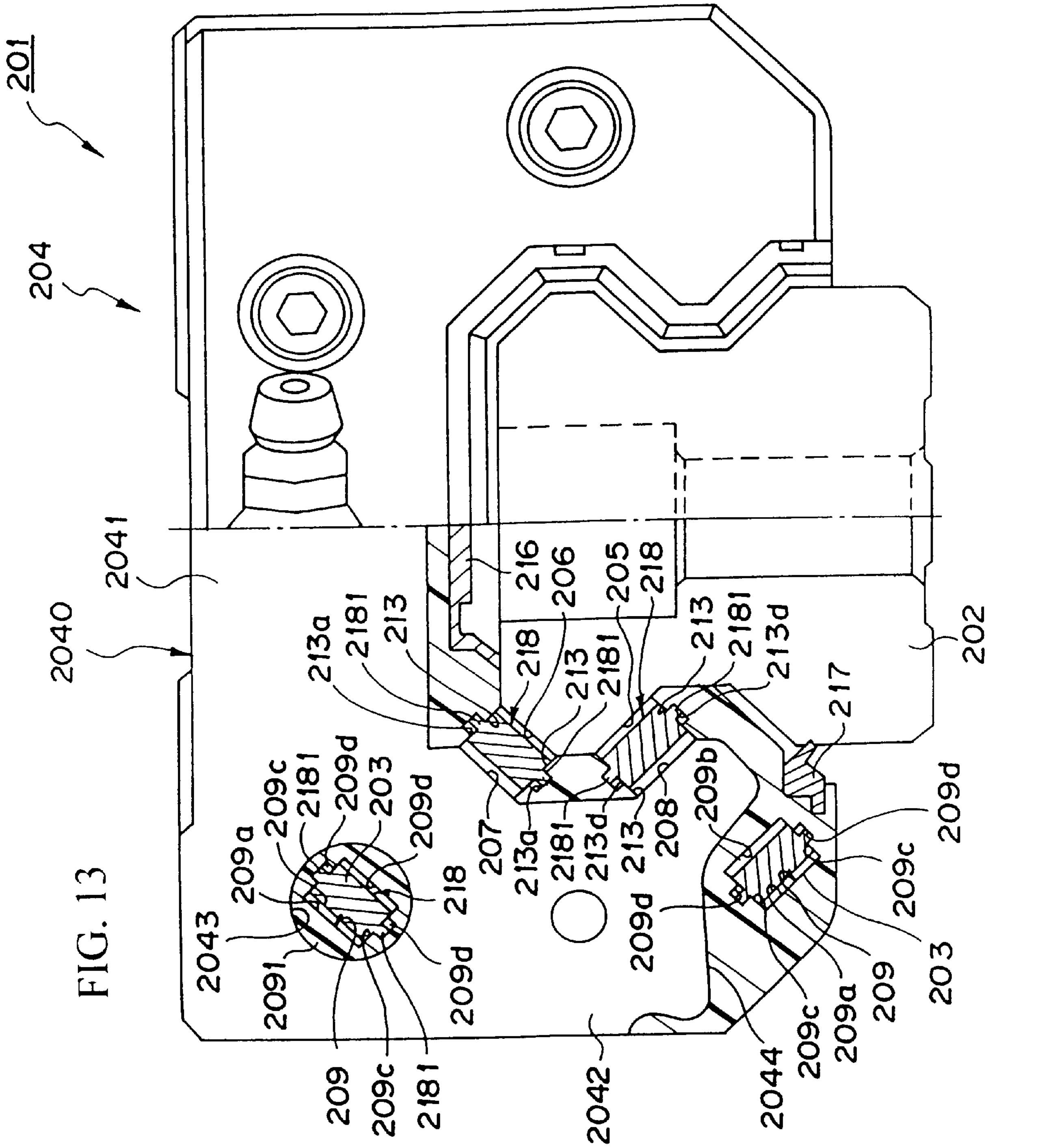

201
204
2040
2041
2042
2043
2044
2091
202
203
205
206
207
208
209
209a
209b
209c
209d
213
213a
213d
216
217
218
2181

FIG. 13

FIG. 14(a)

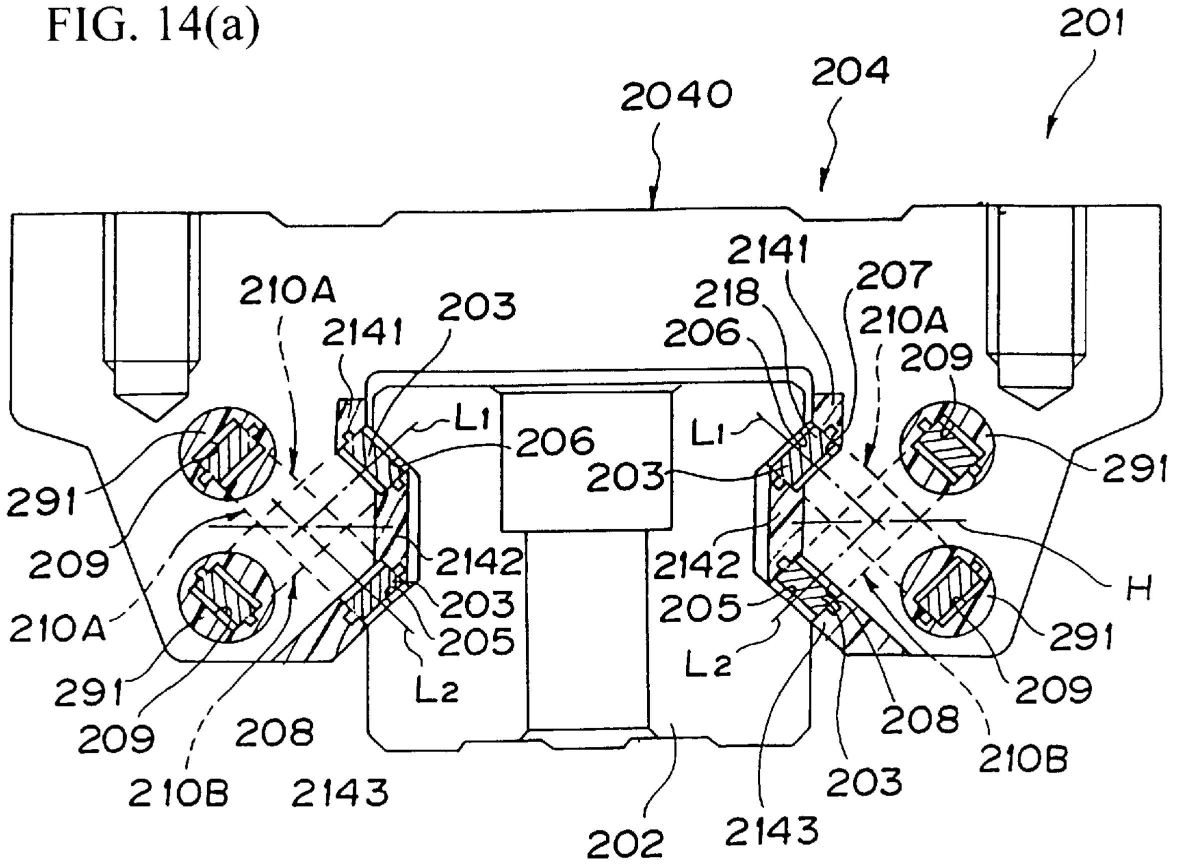


FIG. 14(b)

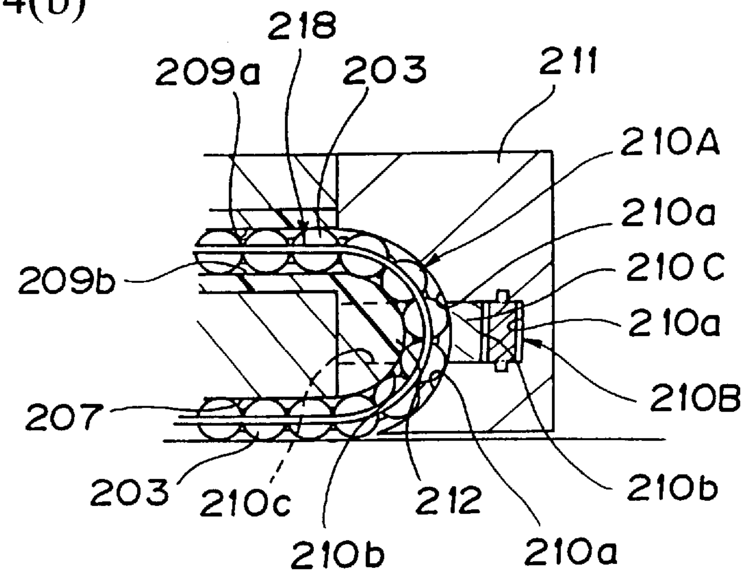


FIG. 15(a)

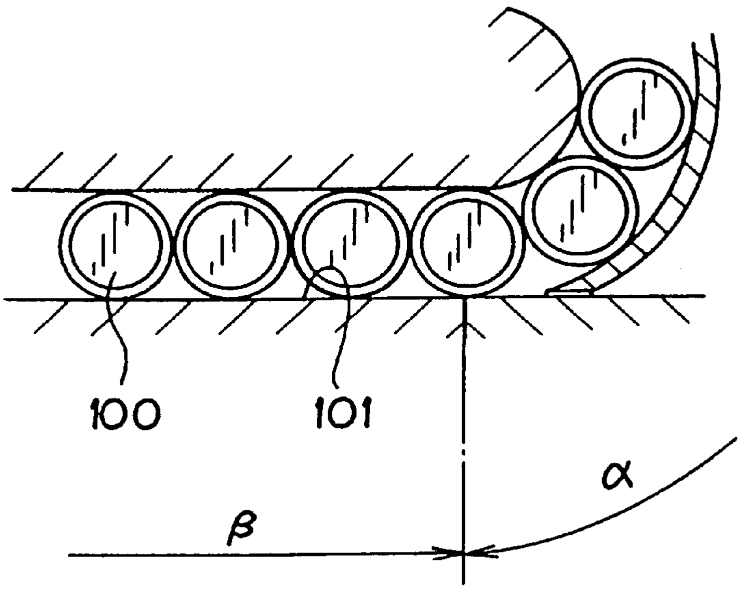


FIG. 15(b)

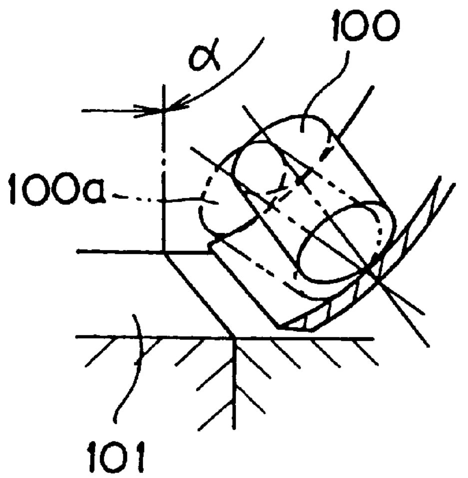
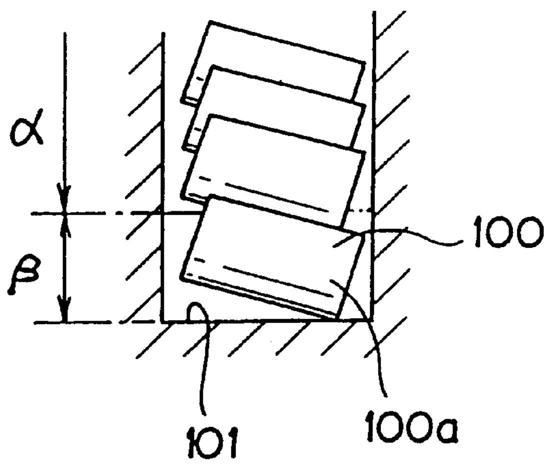


FIG. 15(c)



LINEAR ROLLER GUIDE

TECHNICAL FIELD

The present invention relates to a linear motion guide device, and more particularly, to a linear roller guide device using rollers as rolling elements.

BACKGROUND ART

The conventional linear roller guide device of this type generally has a structure in which a movable block is movably supported on a track rail through a number of rollers. The guide device using rollers has an advantage of high rigidity and high load bearing ability in comparison with the guide device using balls. The movable block comprises a block body and side covers to be attached to both end portions of the block body. The block body is provided with a roller rolling surface and a roller returning passage for endlessly circulating a roller row, and the side cover is provided with a direction changing passage for connecting the roller rolling surface side to the roller returning passage.

Both sides of the roller rolling surface of the movable member are provided with a roller end surface guide wall for guiding an end surface of the roller, and each of the roller returning passage and the direction changing passage is also provided with a guide wall which is formed to be continuous to the roller end surface guide wall. whereby the end surfaces of the roller are guided in entire circulating passage so as to orderly circulate the rollers.

Conventionally, as to structural members such as the roller returning passage, the side cover and the roller end surface guide wall or the like, an attempt to reduce a manufacturing cost has been made by employing resin moldings as the structural members.

However, the above conventional linear roller guide devices entail drawbacks as described hereunder:

(1) The manufacturing process is complicated.

That is, each of the resin molded members is a molded member which is formed separately from the block body, so that a process of assembling the respective resin molded members is required after separately forming the respective members.

(2) The circulating defects of the roller at the roller rolling surface are liable to occur.

Namely, when assembled the resin molded members, irregularities are liable to occur at a connecting portion between the roller returning passage and the direction changing passage, and at a connecting portion between the roller rolling surface and the direction changing passage, so that there may be posed a problem, for example, that a smooth circulation of the rollers is obstructed and a problem of generation of an abnormal noise.

(3) The circulating defects of the roller at the roller end surface are liable to occur.

In particular, in case of the roller, it is required to prevent skew of the roller (i.e. blurring of a rotational axis of the roller). In order to prevent the skew, it is required to guide the end surface of the roller not only in a range of a loaded area of the roller rolling surface but also in all around of an endlessly circulating passage ranging from the direction changing passage to the non-loaded area of the roller returning passage.

FIG. **15**(*a*) shows a state that the roller **100** changes a rolling direction thereof form an unloaded area α to a loaded area β of the direction changing passage. At the time of direction changing of the roller **100**, for example, as schematically shown in FIGS. **15**(*b*) and **15**(*c*), when the roller **100** moves from the loaded area α, and then enters into the loaded area β in a skewed state, one end portion of the roller **100***a* of the roller **100** will firstly collide against the roller rolling surface **101** in the loaded area, so that the smooth movement of the roller **100** is obstructed. In addition, an edge load may occur at the end portion **100***a* of the roller **100** entering into the loaded area β, so that the roller **100** per se and the roller rolling surface **101** are damaged thereby to deteriorate durability of the guide device. Further, vibration of the roller and changes in rolling resistance during the circulation of the rollers will occur thereby to obstruct the smooth circulation of the rollers.

In order to prevent such problems, hitherto, the end surface of the roller is formed so as to be guided by the roller end surface guide wall provided at both sides of the roller rolling surface and passage walls provided at the direction changing passage and the roller returning passage. However, since the guide system is formed by connecting the discontinuous roller end surface guide wall, direction changing passage and roller returning passage, a sticking of the roller is liable to occur due to non-uniformity in a width of the respective passages and the irregularities of the connected portions thereby to also obstruct the smooth circulation of the rollers.

(4) A falling-out of the roller is required to be prevented.

On the other hand, hitherto, in order to prevent the roller from falling out from the movable block when the movable block is detached from the track rail, there is a well known structure in which a chamfered portion is provided at end portion of the roller and an engaging projection with which the chamfered portion is engaged is provided at the roller end surface guide wall formed along the roller rolling surface.

However, in case of such roller retaining system, when the engaging projection interferes with the roller during the circulation of the roller, the smooth circulation of the roller is obstructed. Therefore, when assembling the guide device, it is required to provide a small gap or clearance between the roller and the engaging projection so as not to interfere the engaging projection with the roller. However, it was difficult to provide the engaging projection to an accurate position.

In addition, the chamfered portion is required to be provided, so that an effective length for bearing the load is disadvantageously shortened in a length corresponding to the length of the chamfered portion, thereby to lower the load bearing ability.

On the other hand, there is also another well-known roller retaining system in which a number of rollers are retained in form of a chain by linking the rollers in a roller chain. However, in the case of such rollers retained in the roller chain, a problem of a running-out of the roller chain will arise during the circulation of the rollers. Therefore, it is necessary to guide the roller chain along the predetermined track. However, it was difficult to accurately guide the roller chain.

The first invention has been achieved for solving the problems described above, and an object of this invention is to provide a linear roller guide device enabling to reduce the assembling processes, to accurately position the structural members to a predetermined positions of the block body, and to secure the smooth circulation of the rollers by integrally forming at least one of the roller returning passage, roller end surface guide wall and direction changing passage with the block body.

An object of the second invention is, in addition to the object described above, to provide a linear roller guide device enabling to securely prevent the roller chain from running-out during the circulation of the rollers linked by the roller chain.

DISCLOSURE OF THE INVENTION

In order to achieve the afore-mentioned object, the first invention provides a linear roller guide device comprising a track rail and a movable block assembled to the track rail through a number of rollers,

the movable block comprising:

- a roller rolling surface on which the rollers roll;
- a block body having a roller returning passage corresponding to the roller rolling surface;
- a direction changing passage inner periphery portion formed to both end surfaces of the block body;
- a pair of roller end surface guide walls formed to both sides of the roller rolling surface of the block body and adapted to guide both the end surfaces of the roller; and
- side covers each having a direction changing passage outer periphery portion for forming a direction changing passage by fitting the side cover into the direction changing passage inner periphery portion formed to both end surfaces of the block body,
- the track rail including a roller rolling surface extending in an axial direction corresponding to the roller rolling surface of the block body, and
- the rollers circulating in an endless circulating passage constituted by a loaded area between the roller rolling surface of the block body and the roller rolling surface corresponding to the track rail, the direction changing passage and the roller returning passage,
- wherein at least one of a roller returning passage forming member for forming the roller returning passage, a roller end surface guide wall forming member for forming at least one of the paired roller end surface guide wall and a direction changing passage inner periphery portion forming member for forming the direction changing passage inner periphery portion is formed as a molded body integrally formed with the block body by inserting the block body into a molding die.

According to the structure described above, the assembling of the roller end surface guide wall forming member, the roller returning passage forming member and the direction changing passage inner periphery portion forming member is not required, thus eliminating the assembling process for the members.

In addition, the roller end surface guide wall, the roller returning passage and the direction changing passage inner periphery portion can be formed at accurate positions with respect to the block body.

After the rollers are rolled from a starting end to a terminal end of the roller rolling surface of the block body, the rollers are rolled and moved to the roller returning passage through the direction changing passage, moved along the roller returning passage, and thereafter, supplied to the starting end side of the roller rolling surface through the direction changing passage formed at the other side of the roller rolling surface.

When the direction changing passage inner periphery portion forming member is integrally formed with the block body, it becomes possible to eliminate the irregularities to be formed at the connected portion between the roller rolling surface and the direction changing passage inner periphery portion. In addition, as to the roller returning passage forming member, when it is integrally formed with the block body, it also becomes possible to eliminate the irregularities to be formed at the connected portion between the direction changing passage inner periphery portion and the roller returning passage.

Further, in one aspect of this invention, the device may have a structure in which the roller returning passage and the direction changing passage inner peripheral portion are provided with guide walls for guiding the end surface of the roller, the guide wall being continuous to the roller end surface guide wall, and the roller returning passage, the roller end surface guide wall of at least one of the paired roller end surface guide walls and the direction changing passage inner peripheral portion are integrally formed with the block body.

According to the structure described above, the roller end surface guide walls of the roller returning passage and the direction changing passage in an unloaded area and the roller end surface guide wall to be formed along the roller rolling surface in loaded area can be continuously molded, so that the irregularities are not formed at the connected portions in all around the endless circulating passage, thus enables the end surface of the roller to smoothly move.

In addition, the gap or clearance between the guide wall and the roller end surface can be formed with high accuracy in all around the endless circulating passage, so that the generation of the skew of the roller can be securely prevented.

In another aspect of this invention, the device may have a structure in which a chamfered portion is provided at least one end portion of the roller and an engaging projection with which the chamfered portion of the roller is engaged is provided at the roller end surface guide wall integrally molded with the block body so as to prevent the roller from falling out.

As described above, when such engaging projection is provided at the roller end surface guide wall to be integrally molded with the block body, the engaging projection can be accurately positioned with respect to the block body, so that the falling-out of the roller can be securely prevented even if the bearing block is detached from the track rail. In addition, there is not the slightest fear of interference of the block body with the roller during the circulation of the roller.

The guide device has a structure having four rows of rollers in total in which a pair of right and left rows of rollers are disposed to be rollable between the upper surface of the track rail and a lower surface of a horizontal portion of the block body and other two rows of the rollers each is disposed between the right and left side surfaces of the track rail and an inside surfaces of a suspending portion of the block body, respectively.

In this case, it is preferable that a contact angle line constituted by a line connecting two contact points of the roller disposed between the corresponding roller rolling surfaces formed to the upper surface of the track rail and the horizontal portion of the block body is set to vertically extend with an inclination angle of about with respect to a horizontal line, while a contact angle line of the roller disposed between the corresponding roller rolling surfaces formed to the right and left side surfaces of the track rail and the inside surfaces of the suspending portion of the block body is set to obliquely extend downwards and is formed so as to incline with an inclination angle of 30° with respect to a horizontal line.

In still another aspect of this invention, the guide device has a structure having four rows of rollers in total in which two rows of rollers are vertically disposed to be rollable between a right side surface of the track rail and a right inside surface of the suspending portion of the block body, and vertically disposed to be rollable between a left side surface of the track rail and a left inside surface of the suspending portion of the block body, respectively.

Among the two rows of the rollers arranged vertically at upper and lower portions, it is preferable that the upper row of rollers is formed so that a contact angle line of the roller is set to obliquely extend upwards from a side of the track rail to sides of the right and left suspending portions of the block body, and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line, while the lower row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards, and is formed so as to incline with an inclination angle of almost 45°, or that the upper row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards from a side of the track rail to sides of the right and left suspending portions of the block body, and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line, while the lower row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards, and is formed so as to incline with an inclination angle of almost 45°.

In particular, at a time of an insert molding, when a block supporting portion corresponding to the roller rolling surface of the block body is provided to an inner periphery of a molding die and the roller rolling surface is contacted to the block supporting portion, the block body can be effectively positioned in the molding die.

According to such structure, a pair of right and left roller rolling grooves (surfaces) of the block body will contact to the block supporting portion. As a result, the block body is supported by the paired right and left block supporting portions so that the block body is clamped from every four directions and supported by four points. Therefore, even if an injection pressure of a molding material is applied to the block body from every directions, the block body can be held unmoved, and the burr is not formed at a portion between the roller rolling surface and the block supporting portion.

In a second invention, there is provided a linear roller guide device comprising a track rail and a movable block assembled to the track rail through a number of rollers,

the movable block comprising:

a block body having a roller rolling surface and a roller returning passage corresponding to the roller rolling surface;

a direction changing passage inner periphery portion formed to both end surfaces of the block body; and

side covers each having a direction changing passage outer periphery portion for forming a direction changing passage by fitting the side cover into the direction changing passage inner periphery portion formed at both end surfaces of the block body,

the track rail including a roller rolling surface extending in an axial direction corresponding to the roller rolling surface of the block body,

the rollers circulating in an endless circulating passage constituted by a loaded area between the roller rolling surface of the block body and the roller rolling surface corresponding to the track rail, the direction changing passage and the roller returning passage, and the rollers are linked to each other by a roller chain inserted to be movable in the endless circulating passage,

wherein the roller returning passage and the direction changing passage inner periphery guide portion are provided with a roller chain guide portion for guiding a track of the roller chain onto a predetermined track,

wherein at least one of the roller returning passage forming member for forming the roller returning passage and the direction changing passage inner periphery portion forming member for forming the direction changing passage inner periphery portion is integrally molded by inserting the block body into a molding die.

According to the structure described above, the rollers can be smoothly rolled and moved in the endless circulating passage while being kept in a state where center axes of the respective rollers are retained in parallel to each other and intervals of adjacent rollers are retained in a predetermined distance, thus enabling to prevent the skew-generation.

In addition, the roller chain is guided onto the predetermined track by the roller chain guide portions formed to the roller returning passage and the direction changing passage, and the rollers shall be accurately guided by the roller chain guided by the roller chain guide portion. Further, a run-out of the roller chain can be prevented by the roller chain guide portion.

In addition, when the roller returning passage forming member for forming the roller returning passage and the direction changing passage inner periphery portion forming member for forming the direction changing passage inner periphery portion to which the roller chain guide portions are formed are integrally molded with the block body, the roller chain guide portions can be formed on accurate positions of the track.

In addition, when the direction changing passage inner periphery portion forming member is integrally formed with the block body, it becomes possible to eliminate the irregularities to be formed at the connected portion between the roller rolling surface and the direction changing passage inner periphery portion. Further, as to the roller returning passage, when it is integrally formed with the block body, it also becomes possible to eliminate the irregularities to be formed at the connected portion between the direction changing passage inner periphery portion and the roller returning passage. As a result, the rollers can be further smoothly circulated and moved in cooperation with the guiding function of the roller chain.

Furthermore, when the roller chain is formed so as to have an endless structure and is provided with a falling-out preventing portion for the rollers, the falling-out of the rollers can be prevented by the roller chain even if the movable block is detached from the track rail.

Further, the roller chain is preferably provided with a guide projecting portion so as to project from the end surface of the roller in an axial direction of the roller, while the roller returning passage and the direction changing passage inner peripheral portion are preferably provided with guide grooves with which the guide projecting portion is engaged. In addition, at least one side of the roller rolling surfaces formed to the block body is preferably provided with a guide wall having the guide groove extending in parallel to the roller rolling surface for guiding the guide projecting portion in parallel to the roller rolling surface. As to this guide wall, it is also preferable to integrally mold the guide wall with the block body by using an insert molding method and to continuously form the guide groove to the roller returning passage, the direction changing passage inner periphery portion and the guide wall so that the guide groove ranges to all around the endless circulating passage.

According to the structure described above, when the roller chain is circulated and moved, the guide projecting portion is engaged with the guide groove formed to the roller returning passage and the direction changing passage inner peripheral portion, so that the run-out of the roller chain is suppressed. As a result, the rollers can be rolled and moved in orderly arranged state in all around the endless circulating passage.

In addition, in a case where the roller chain is formed in a striped-shape having no connected portion at both ends thereof, when the movable block is detached from the track rail, the guide projecting portion is engaged with the guide groove, thus enabling to prevent a sagging or slack of an end portion of the roller chain. Further, also in a case of the roller chain having an endless structure, the sagging or slack of an intermediate portion of the roller chain can be prevented.

In still another aspect of this invention, the roller chain comprises spacer portions disposed between the adjacent rollers and connecting portions for connecting the respective spacer portions, and the guide projecting portion is provided to the connecting portion.

Accordingly, each of the rollers is arranged and circulated in a state where the rollers are retained by the spacer portions form back and forth in the arranging direction thereof.

Further, when a falling-out preventing portion for the roller is provided to the spacer portion so as to prevent the falling-out of the roller from back and forth of the roller, it becomes unnecessary to chamfer the end portion of the roller, so that an effective length of the roller for bearing the load can be increased.

Furthermore, since only the spacer portion is disposed between the adjacent rollers, a pitch of the rollers can be formed as small as possible, so that a number of the rollers to be disposed per unit length for bearing the load can be increased as many as possible, thus improving the load bearing ability of the roller.

In still another aspect of this invention, the connecting member and the spacer portion disposed between the adjacent rollers are formed as resin moldings, the roller is formed to have a hollow portion, and the roller is retained by inserting a resin portion into the hollow portion of the roller.

According to the structure described above, the falling-out of the roller can be surely prevented and a degree of parallelization between the adjacent rollers can be accurately maintained.

In addition, the roller may be retained in such a manner that a recessed portion is formed to both end portions of the roller and the resin portion is inserted into the recessed portion or in a manner that a grooved portion is formed to a center peripheral portion of the roller and the resin portion is fitted into the grooved portion.

When the roller chain moves at portion between the roller rolling surfaces and the unloaded roller rolling passage, the roller chain takes a linear shape. In contrast, when the roller chain moves in the direction changing passage, the roller chain is deformed from linear-shape to a curved-shape. As a result, the roller chain is repeatedly deformed in accordance with the movement of the movable block.

In view of this point, it is preferable to reinforce the roller chain by inserting a wire or thin plate into the connecting member.

In the guide device of the present invention, the number of rollers and arrangement thereof are optional. However, the following arrangements are more effective.

That is, the guide device may have a structure having four rows of rollers in total in which a pair of right and left rows of rollers are disposed to be rollable between the upper surface of the track rail and a lower surface of a horizontal portion of the block body, and one row of the roller is disposed between the right and left side surfaces of the track rail and inside surfaces of a suspending portion of the block body, respectively.

In this case, it is preferable that a contact angle line constituted by a line connecting two contact points of the roller disposed between the corresponding to the roller rolling surfaces formed to the upper surface of the track rail and the horizontal portion of the block body is set to vertically extend with an inclination angle of about 90° with respect to a horizontal line, while a contact angle line of the roller disposed between the corresponding roller rolling surfaces formed to the right and left side surfaces of the track rail and the inside surfaces of the suspending portion of the block body is set to obliquely extend downwards and is formed so as to incline with an inclination angle of 30° with respect to a horizontal line.

In addition, the guide device may have a structure having four rows of rollers in total in which two rows of rollers are vertically disposed at upper and lower portions to be rollable between a right side surface of the track rail and a right inside surface of the suspending portion of the block body, and vertically disposed to be rollable between a left side surface of the track rail and a left inside surface of the suspending portion of the block body, respectively.

Among the two rows of the rollers arranged vertically, it is preferable that the upper row of rollers is formed so that a contact angle line of the roller is set to obliquely extend upwards from a side of the track rail to sides of the right and left suspending portions of the block body and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line, while the lower row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards, and is formed so as to incline with an inclination angle of almost 45°; or that the upper row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards from a side of the track rail to sides of the right and left suspending portions of the block body and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line, while the lower row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards and is formed so as to incline with an inclination angle of almost 45°.

In particular, at a time of an insert molding, when a block supporting portion corresponding to the roller rolling surface of the block body is provided to an inner periphery of a molding die and the roller rolling surface is contacted to the block supporting portion, the block body can be effectively positioned in the molding die.

According to such structure, a pair of right and left roller rolling grooves (surfaces) of the block body will contact to the block supporting portion. As a result, the block body is supported by the paired right and left block supporting portions so that the block body is clamped from every four directions and supported by four points. Therefore, even if an injection pressure of a molding material is applied to the block body from every directions, the block body can be held unmoved, and the burr is not formed at a portion between the roller rolling surface and the block supporting portion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view showing one embodiment of a linear roller guide device according to the first invention.

FIG. **2** is also a view showing one embodiment of the first invention.

FIG. **3** is a view showing various modifications of the roller end surface guide walls and roller retaining s structures for the linear roller guide device shown in FIG. **1**.

FIG. **4** is an explanatory view showing a molding method of a movable block for the linear roller guide device shown in FIG. **1**.

FIG. **5** is a view showing a modification of a roller returning passage forming member shown in FIG. **1**.

FIG. **6** is a view showing another roller contact angle structure of the embodiment according to the first invention.

FIG. **7** is a view showing still another roller contact angle structures of the embodiment according to the first invention in which

FIG. **7**(*a*) is a cross sectional view of the linear roller guide device and

FIG. **7**(*b*) is a cross sectional view showing a direction changing passage.

FIG. **8** is a view showing one embodiment of a linear roller guide device according to the second invention in which a roller chain is used.

FIG. **9** is a view showing structures of chain guide portions and roller chains in FIG. **8**.

FIG. **10** is a view showing another embodiment of the roller chain shown in FIG. **9**.

FIG. **11** is a view showing a modification of the roller end surface guide wall for the linear roller guide device shown in FIG. **8** and another structure of the roller returning passage forming member.

FIG. **12** is a view showing a molding method of a movable block shown in FIG. **8**.

FIG. **13** is a view showing another roller contact angle structure of the embodiment according to the second invention.

FIG. **14** is a view showing another roller contact angle structure of the embodiment according to the second invention.

FIG. **15** is an explanatory view showing a state where a roller-skew occurs in a conventional linear roller guide device.

BEST MODE FOR EMBODYING THE INVENTION

[The First Invention]

Hereunder, the first invention will be explained with reference to the accompanying drawings.

FIGS. **1** and **2** are views showing an embodiment of a linear roller guide device according to the first invention. The linear roller guide device **1** comprises a track rail **2**, four rows of rollers **3** in total of which two rows of rollers are disposed to an upper side surface of the track rail **2** and one row of rollers is disposed to both right and left side surfaces of the track rail **2** respectively, and a movable block **4** assembled to be movable through the four rows of rollers **3**.

The track rail **2** is an elongated member formed to have a rectangular shape in section, an upper portion of both the side surfaces of the track rail being formed to have tapered surfaces which gradually expand outwardly in upward direction, and each of the right and left tapered surfaces is provided with one row of roller rolling surface **5**, respectively. In addition, the upper surface of the track rail **2** is formed to be a plain surface of which both right and left end portions are provided with one row of roller rolling surface **6**, respectively, i.e., two rows of the roller rolling surfaces **6** in total.

The movable block **4** comprises a block body **40** formed of metal, and side covers **11** to be attached to both end surfaces of the block body **40**.

The block body **40** has a U-shaped cross section and high rigidity, and comprises a horizontal portion **41** opposing to the upper surface of the track rail **2**, a pair of suspending portions **42** and **42** suspending from the right and left end portions of the horizontal portion **41** so as to clamp both the right and left side surfaces of the track rail **2**. A lower surface of the horizontal portion **41** is provided with a pair of roller rolling surfaces **7, 7** corresponding to the paired roller rolling surfaces **6, 6** formed to the upper surface of the track rail **2**, while each of inner side surfaces of the right and left suspending portions **42, 42** is provided with a roller rolling surface **8** corresponding to the respective roller rolling surfaces **5, 5** formed to the right and left side surfaces of the track rail **2**.

A number of rollers **3** are disposed between four pairs of roller rolling surfaces **5, 8**; **6, 7**, corresponding to each other, that are formed to opposing surfaces between the track rail **2** and the movable block **4**, whereby roller rows for bearing a load to be applied to portions between the track rail **2** and the movable block **4** are assembled. A predetermined pre-load is applied to respective rollers **3**. The roller **3** is formed as a cylindrical roller. However, as shown in FIG. **3**(*d*), a barrel-shaped roller having a circular-arc shaped cross section in axial direction can be also available as the roller **3**.

Each of the rollers **3** linearly contacts to the roller rolling surfaces **5, 8**; **6, 7**. A contact angle line L1 constituted by a line connecting two contact portions of the roller disposed between the corresponding to the roller rolling surfaces **5, 8**; **6, 7** formed to the upper surface of the track rail **2** and the horizontal portion **41** of the block body **40** is set to vertically extend with an inclination angle of about 90° with respect to a horizontal line passing through a center of the roller **3**, while a contact angle line of the roller **3** disposed between the corresponding to the roller rolling surfaces formed to the right and left side surfaces of the track rail **2** and the inside surfaces of the right and left suspending portions **42, 42** of the block body **40** is set to obliquely extend toward a center of the track rail **2** and is formed so as to upwardly incline with a predetermined angle of α with respect to a horizontal line H passing through a center of the roller **3**, thereby to form a structure in which both the right and left corner portions **22, 22** of an upper portion of the track rail **2** are clamped by the two rows of rollers **3, 3** disposed to the right and left sides of the track rail **2** and by the two rows of rollers **3, 3** disposed to the upper surface side of the track rail **2**. In the embodiment shown in Figure, the angle of α is set to about 30°.

The block body **40** is provided with four rows of the roller returning passages **9** for circulating and guiding the four rows of rollers **3**. The roller returning passage **9** linearly extend in parallel to the respective roller rolling surfaces **5, 6** formed to the block body **40**. Two rows of the roller returning passages **9** are provided to the horizontal portion **41**, while two rows of the roller returning passages **9** are respectively provided to the right and left suspending portions of the block body **40**. The roller returning passage **9** is formed from a roller returning passage forming member **91** composed of resin.

The roller returning passage forming member **91** is integrally bonded to an inner peripheral portion of a penetration bore **43** penetrating through the horizontal portion **41** and the suspending portion **42** of the block body **40**. An outer peripheral shape of the roller returning passage forming member **91** is formed to have a cylindrical shape which conforms to an inner peripheral shape of the penetration bore **43**. The inner periphery of the roller returning passage forming member **91** is provided with a roller returning passage **9** having a rectangular cross section for guiding the roller **3**.

The roller returning passage **9** comprises a pair of unloaded roller guide surfaces **9***a*, **9***b* extending in parallel to each other for guiding a cylindrical outer periphery surface of the roller **3**, and a pair of unloaded roller end surface guide surfaces **9***c*, **9***c* extending in parallel to each other for guiding end surfaces of the roller **3**.

A gap or clearance between the paired unloaded roller guide surfaces **9***a*, **9***b* is set to slightly larger than a diameter of the roller **3** so as to form a small gap therebetween, while a gap or clearance between the paired unloaded roller end surface guide surfaces **9***c*, **9***c* is set to slightly larger than a length of the roller **3** so as to form a small gap therebetween, thus resulting in a structure enabling to smoothly move the rollers **3** (see FIG, **3**(*e*)).

FIG. **5** shows another embodiment of a roller returning passage forming member **92** to be formed to the suspending portion **42** of the block body **40**. Namely, the roller returning passage forming member **92** is integrally bonded to a recessed portion **44** formed to a lower end portion of the right and left suspending portions **42** of the block body **40**. The roller returning passage forming member **91** is integrally connected to a third loaded roller end surface guide wall forming member **143** provided to the inner peripheral side of the suspending portion **42**.

According to the structure described above, the block body **40** is required to be provided with only two penetration bores **43** to be formed to the horizontal portion **41**, thus enabling to simplify the manufacturing of the device.

In addition, as shown in FIGS. **1**(*b*), (*c*) and **2**, both end portions of the block body **40** are provided with side covers **11** constituting a direction changing passage **10** for changing the rolling direction of the roller **3** to the roller returning passage **9**, the roller **3** being disposed between the loaded roller rolling surfaces **5**, **8**; **6**, **7** formed to the track rail **2** and the block body **40**.

The direction changing passage **10** is formed to be a pipe having a U-shape. The side cover **11** is formed with only a direction changing passage inner periphery portion **10***a* of the direction changing passage **10**. while a direction changing passage inner periphery portion forming member **12** is integrally bonded to both end portions of the block body **40**.

This direction changing passage **10** has a rectangular shaped cross section, and both side portions of the direction changing passage outer periphery portion **10***a* and the inner periphery portion **10***b* for guiding the outer periphery surface of the roller **3** are provided with direction changing roller end surface guide walls **10***c*, **10***c* for guiding the end surfaces of the roller **3**. This direction changing roller end surface guide walls **10***c* together with the direction changing passage inner periphery portion **10***b* are formed to the direction changing passage inner periphery portion forming member **12**. Then, when the side cover **11** formed with the direction changing passage outer periphery portion **10***a* is fitted into the end surface of the block body **40** formed with the direction changing passage inner periphery portion **10***b* and the direction changing roller end surface guide walls **10***c*, the direction changing passage **10** having a U pipe shape is formed.

In this regard, the direction changing roller end surface guide walls **10***c*, **10***c* together with the direction changing passage outer periphery portion **10***a* may be provided to the side cover **11**. In another way, one direction changing roller end surface guide wall **10***c* together with the direction changing passage inner periphery portion **10***b* may be provided to a side of the direction changing passage inner periphery portion forming member **12**, while the other direction changing roller end surface guide walls **10***c* together with the direction changing passage outer periphery portion **10***a* may be provided to the side cover **11**.

In still another way, the direction changing roller end surface guide wall **10***c* is divided into two portions i.e. an inner periphery side portion and an outer periphery side portion, and then, the outer periphery side portion may be formed to the side cover **11**, while the inner periphery side portion may be provided to the direction changing passage inner periphery portion forming member **12**.

Further, as shown in FIG. **1**(*a*). along the respective four rows of roller rolling surfaces **7**, **8** of the block body **40**, there is provided with a loaded roller end surface guide wall **13** for guiding the end surfaces of the roller in the loaded area. In order to form the loaded roller end surface guide wall **13**, the block body **40** comprises a first end surface guide wall forming member **141** to be integrally bonded to a lower surface of the horizontal portion **40**, right and left second end surface guide wall forming members **142** to be integrally bonded to recessed corner portions between the horizontal portion **41** and the right and left suspending portions **42**, and right and left third end surface guide wall forming members **143** to be integrally bonded to a lower portion of inner side surface of the right and left suspending portions **42**.

The both end portions of the first end surface guide wall forming member **141** and an upper end portion of the second end surface guide wall forming members **142** are provided with loaded roller end surface guide walls **13**, **13**; **13**, **13** for guiding the end surfaces of the roller **3** rolling on the roller rolling surfaces **7**, **7** formed to the lower surface of the horizontal portion **41** of the block body **40**.

In addition, the lower end portions of the right and left second end surface guide wall forming member **142** and an upper end portion of the third end surface guide wall forming members **143** are provided with loaded roller end surface guide walls **13**, **13**; **13**, **13** for guiding the end surfaces of the roller **3** rolling on the roller rolling surfaces **8**, **8** formed to the suspending portion **42** of the block body **40**.

A gap or clearance between the paired loaded roller end surface guide walls **13**, **13** is set to slightly larger than a length of the roller **3** so as to form a small gap between the end surface of the roller **3** and the guide wall **13**.

Further, a first seal member **15** for sealing the gap formed between the horizontal portion **41** of the block body **40** and the upper surface of the track rail **2** is attached to the first end surface guide wall forming member **141**, while a second seal member **16** for sealing the gap formed between the suspending portion **42** of the block body **40** and the right and left side surfaces of the track rail **2** is attached to the third end surface guide wall forming member **143**.

In this embodiment, the loaded roller end surface guide walls **13** for guiding both end surfaces of the roller **3** is formed by the first to third end surface guide wall forming members **141**–**143** that are all composed of resin.

However, as shown in FIG. **3**(*a*), the loaded roller end surface guide walls **13** for guiding one end surface of the roller **3** may be formed by the block body **40** per se, while the loaded roller end surface guide wall **13** for guiding the other end surface of the roller **3** may be formed by the loaded roller end surface guide wall forming member **14**. In another way, as shown in FIG. **3**(*f*), both side of the loaded roller end surface guide walls **13** can be also formed by the block body **40**.

In this first embodiment, all of the roller returning passage forming member **91**, the roller end surface guide wall forming members **141**–**143** and the direction changing passage inner periphery portion forming member **12** are formed by integrally molding with the movable block.

Accordingly, the unloaded roller guide surfaces **9***a*, **9***b* of the roller returning passage **9** and both the inner and outer periphery portions **10***a*, **10***b* of the direction changing passage can be continuously and integrally molded. Further, the direction changing passage inner periphery portion **10***b* and the roller rolling surfaces **7**, **8** in the loaded area can be also integrally molded.

In addition, the roller end surface guide wall **9***c* of the roller returning passage **9**, the direction changing roller end surface guide wall **10***c* of the direction changing passage **10** and the loaded area roller end surface guide wall **13** are continuously formed by being integrally molded, so that the roller end surface guide wall can be continuously formed in all around the endless circulating passage.

According to the linear roller guide device of this invention, the assembling of the loaded roller end surface guide wall forming member **14**, the roller returning passage forming member **91** and the direction changing passage inner periphery portion forming member **12** is not required, thus enabling to omit the assembling process for the members.

In addition, the roller end surface guide wall **13**, the roller returning passage **9** and the direction changing passage inner periphery portion **10***b* can be provided at accurate positions with respect to the block body **40**.

As a result, after the rollers **3** are rolled from a starting end to a terminal end of the roller rolling surfaces **7**, **8** in the loaded area of the block body **40**, the rollers **3** are moved to the roller returning passage **9** through the direction changing passage **10** then moved along the roller returning passage **9**, and thereafter, supplied to the starting end side of the roller rolling surfaces **7**, **8** through the direction changing passage **10** formed at the other end of the roller rolling surfaces **7**, **8**,

When the direction changing passage inner periphery portion forming member **12** is integrally formed with the block body **40**, it becomes possible to eliminate the irregularities to be formed at the connected portion between the roller rolling surfaces **7**, **8** and the direction changing passage inner periphery portion **10***b*. In addition, as to also the roller returning passage forming member **91**, when the member **91** is integrally formed with the block body **40**, it also becomes possible to eliminate the irregularities to be formed at the connected portion between the direction changing passage inner periphery portion **10***b* and the roller returning passage **9**.

Further, when the roller returning passage forming member **91** and the direction changing passage inner peripheral portion forming member **12** are provided with unloaded roller end surface guide wall **9***c* and the direction changing roller end surface guide wall **10***c* for guiding the end surface of the roller, the guide walls being continuous to the loaded roller end surface guide wall **13** and these roller end surface guide walls are integrally formed with the block body **40**, the loaded roller end surface guide wall **13**, the direction changing roller end surface guide wall **10***c* and the unloaded roller end surface guide wall **9***c* can be continuously molded in all around the endless circulating passage without forming the irregularities at the connected portions of the guide walls, thus enabling the end surface of the roller to smoothly move.

In addition, the gaps or clearances between the the loaded roller end surface guide wall **13**, the direction changing roller end surface guide wall **10***c*, the unloaded roller end surface guide wall **9***c* and the roller end surfaces can be accurately maintained to constant values, so that the gaps or clearances can be limited to a small value, and the skew of the roller **3** can be securely prevented.

In addition, as shown in FIGS. **3**(*b*) and **3**(*c*), the device may have a structure in which a chamfered portion **3***a* is provided at least one end portion of the roller **3** while an engaging projection **13***a*, with which the chamfered portion **3***a* of the roller **3** is engaged, is provided at the loaded roller end surface guide wall **13** integrally molded with the block body **40** so as to prevent the roller **3** from falling out when the movable block **4** is detached from the track rail **2**. A small gap is formed between the engaging projection **13***a* and the roller **3** so that the engaging projection **13***a* would not interfere with the roller **3** when the rollers **3** roll and move between the roller rolling surfaces **6**, **7**; **5**, **8**.

As described above, when the engaging projection **13***a* is provided at the roller end surface guide wall **13** to be integrally molded with the block body **40**, the engaging projection **13***a* can be accurately positioned with respect to the block body **10**, and the gap between the engaging projection **13***a* and the chamfered portion **3***a* of the roller **3** can be accurately maintained to a constant value, whereby there is no fear of interference of the engaging projection **13***a* with the roller during the circulation of the roller **3**.

The integrally molding of the roller returning passage forming member **91**, the direction changing passage inner peripheral portion forming member **12** and the loaded roller end surface guide wall **13** with the block body **40** is performed in accordance with an insert molding method comprising the steps of disposing the block body **40** into a molding die **15** on the basis of the roller rolling surfaces **7**, **8** formed to the block body **40**, forming cavities corresponding to the respective resin molded portions to be formed between an inner wall of the molding die **15** and the block body **40**, and injecting a molding material into the respective cavities to form the resin molded portions.

FIG. **4** is a schematic view showing the block body **40** and states where the molding dies **15** are clamped or opened at the time of the insert molding. Namely, a fixed molding die **15***a* is provided with block supporting portions **15***b* to which the roller rolling surfaces **7**, **7**; **8**, **8** are fitted for positioning, while a movable molding die **15***c* is provided with pins **15***d* for forming the roller returning passage.

The block supporting portions **15***b* have plain shapes corresponding to the roller rolling surfaces **7**, **7**; **8**, **8** and linearly extend in parallel to each other. In this regard, FIGS. **4**(*b*) and **4**(*c*) show only a circumference of the roller returning passage **9** of a side of the suspending portion **42**.

Cavities **15***e* for forming the roller returning passage forming member **91** are provided to inside the penetration bores **43** formed in the horizontal portion **41** and the suspending portion **42** of the block body **40**, respectively. Further, cavities **15***f*–**15***h* for forming the first to third loaded roller end surface guide wall forming members **141**–**143** are provided to inner periphery portions of the horizontal portion **41** and the suspending portion **42**. respectively. Furthermore, cavities **15***i* for forming the direction changing passage inner periphery portion forming members **12** are provided to both front and back end portions of the block body **40**, respectively.

In this embodiment, the paired right and left roller rolling surfaces **7**, **7**: **8**, **8** of the block body **40** are supported at four points by the block supporting portions **15***b* of the molding die **15**. As a result, the block body **40** can be supported unmoved by the block supporting portions **15***b*, even if an injection pressure of a molding material is applied to the block body **40** from every directions, whereby the roller returning passage **9**, the direction changing inner periphery portion **10***b* and the first to third loaded roller end surface guide walls **131**–**133** can be accurately formed at predetermined positions.

In addition, since the block body **40** is stably positioned in the molding die **15**, the burr is not formed at portions between the roller rolling surfaces **7**, **7**; **8**, **8**.

It is preferable that the block supporting portions **15***b* closely contact to the roller rolling surfaces **7**, **8**. However, even the block supporting portions **15***b* and the roller rolling surfaces **7**, **8** are moved in a small distance due to a small gap formed therebetween, the small gap can be allowed as far as a dimension accuracy is within an allowable range and the resin material would not penetrate through the gap.

[Modifications of Roller Contact Angles]

Though the explanation described above has been made by taking an example of a case in which total four rows of rollers are disposed between corresponding portions i.e., the right and left two rows of rollers being disposed between the upper surface of the track rail **2** and the lower surface of the horizontal portion **41** of the block body **40** while one row of rollers being disposed between the right and left side surfaces of the track rail **2** and the inner side surfaces of the right and left suspending portions **42** respectively, a number and an arrangement of the roller rows are optional.

For example, as shown in FIGS. **6** and **7**, the device may have a structure having four rows of rollers in total of which right and left two rows of rollers are disposed between the right and left side surfaces of the track rail **2** and the inner side surfaces of the right and left suspending portions **42** of the block body **40**, respectively.

FIG. **6** shows an example having a structure in which the upper row of rollers **3** among the two rows of the rollers **3** arranged vertically is formed so that a contact angle line **L1** of the roller **3** is set to obliquely extend upwards from a side of the track rail **2** to the right and left suspending portions **42** of the block body **40** and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line H, while the lower row of rollers **3** is formed so that a contact angle line L2 of the roller **3** is set to obliquely extend downwards, and is formed so as to incline with an inclination angle of almost 45°.

FIG. **7** shows an example having a structure in which the upper row of rollers **3** among the two rows of the rollers **3** arranged vertically is formed so that a contact angle line **L1** of the roller **3** is set to obliquely extend downwards from a side of the track rail to sides of the right and left suspending portions **42**, **42** of the block body **40** and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line, while the lower row of rollers **3** is formed so that a contact angle line L2 of the roller **3** is set to obliquely extend upwards, and is formed so as to incline with an inclination angle of almost 45°.

In the case of this embodiment, the direction changing passages **10**A, **10**B of vertically arranged two rows of rollers **3** disposed to both end portions of the block body **40** are arranged alternately with a predetermined interval in an axial direction so as to intersect to each other. In this case, the direction changing passage inner peripheral portion forming member **12** formed to the end surface of the block body **40** is provided with the direction changing passage inner periphery portion **10***b* of the direction changing passage **10**A of a side close to the block body **40** and the direction changing roller end surface guide wall **10***c*, the inner periphery portion **10***b* and the guide wall **10***c* being integrally molded with the block body **40**.

As to the direction changing passage **10**B far from H the block body **40**, at least one portion of the loaded roller rolling surfaces **7**, **8** of an end surface side of the block body **40**, the direction changing passage inner periphery portion **10***b* of a part which is connected to an end portion of the roller returning passage **9** and the direction changing roller end surface guide wall **10***c* are integrally molded with the block body **40**. While, a round piece **10**C formed with the direction changing passage inner periphery portion **10***b* is attached to a part far from the direction changing passage **10**A. An inner periphery of this round piece **10**C is formed with a part of an outer periphery guide portion of the inside direction changing passage **10**A. The side cover **11** is formed with the direction changing passage outer peripheral portions **10***a*, **10***a* for both the direction changing passages **10**A, **10**B arranged vertically.

According to the first invention described above. the assembling of the roller end surface guide wall, the roller returning passage and the direction changing passage inner periphery portion is not required, thus eliminating the assembling process for the members.

In addition, the roller end surface guide wall, the roller returning passage and the direction changing passage inner periphery portion can be formed at accurate positions with respect to the block body.

When the direction changing passage inner periphery portion is integrally formed with the block body, it becomes possible to eliminate the irregularities to be formed at the connected portion between the roller rolling surface and the direction changing passage inner periphery portion. In addition, as to the roller returning passage, when it is integrally formed with the block body, it also becomes possible to eliminate the irregularities to be formed at the connected portion between the roller rolling changing passage inner periphery portion and the roller returning passage.

Further, when the roller returning passage and the direction changing passage inner peripheral portion are provided with guide walls for guiding the end surface of the roller, the guide wall being continuous to the roller end surface guide wall, and the roller returning passage. the roller end surface guide wall of at least one the paired roller end surface guide walls and the direction changing passage inner peripheral portion are integrally formed with the block body, so that the roller returning passage, the guide walls of the direction changing passage inner periphery portions and the roller end surface guide walls can be continuously molded, whereby irregularities are not formed at the connected portions, thus enabling the end surface of the roller to smoothly move.

In addition, the guide walls for the roller end surfaces can be integrally formed in continuous in all around the endless circulating passage and a gap between the guide wall and the end surface of the roller can be formed with a high accuracy, so that the skew of the roller can be securely prevented.

In addition, when the engaging projection for preventing the roller from falling out by engaging with the chamfered portion of the roller is provided at the roller end surface guide wall to be integrally molded with the block body, the engaging projection can be accurately positioned with respect to the block body, so that the falling-out of the roller can be surely prevented even if the bearing blocks is detached from the track rail. In addition, there is no fear of interference of the block body with the roller during the circulation of the roller.

In addition, at a time of an insert molding, when a block supporting portion having a shape obtained by cutting an outer peripheral portion of the roller with a cross section passing through a center axis of the roller is provided to an inner periphery of a molding die so as to correspond to the roller rolling surface of the block body and the block body is positioned in the molding die by contacting the roller rolling surface to the block supporting portion, the burr would not occur at the roller rolling surfaces.

In particular, when the paired right and left roller rolling surfaces of the block body are supported by the block supporting portions of the molding die, the block body is clamped from every four directions and supported by the paired right and left block supporting portions at four points. Therefore, even if an injection pressure of a molding material is applied to the block body from every directions, the block body can be held unmoved, and the block body can be accurately positioned.

[Second Invention]

Next, an embodiment of a second invention will be explained hereunder with reference to the accompanying drawings.

FIGS. **8** and **9** disclose embodiments of linear roller guide devices according to the second invention, respectively.

The linear roller guide device **201** comprises a track rail **202** and a movable block **204** assembled to be movable on an upper surface of the track rail **202** through four rows of rollers **203** in total of which two rows of rollers are disposed on an upper surface side of the track rail **202** and one row of rollers is disposed on the right and left side surface sides of the track rail **202**, respectively.

Each of the four rows of the rollers **203** circulates in an endless circulating passage constituted by the loaded area between the roller rolling surfaces **206, 207; 205, 208** of the block body **2040** and corresponding to the track rail **202**, the direction changing passage **210** and the roller returning passage **209**. In this regard, the embodiment of this second invention is different form that of the first invention in a point where the rollers **203** are linked to each other by a roller chain **218** inserted to be movable in the endless circulating passage.

The roller chain **218** is a resin molded product, as shown in FIGS. **9**(*c*)–(*e*), and comprises spacer portions **218***a* disposed between the adjacent rollers **203** and connecting bands (plates) **218***b* as connecting members for connecting the respective spacer portions **218***a*, the connecting bands **218***b* being flexible and having a thin plate-shape.

Both side surfaces of the spacer portion **218** is provided with a retaining recessed portion **218***c* for constituting the falling-out preventing portion having a circular-arc shape corresponding to a cylindrical surface of the roller **203**. The connecting plates **218***b* are positioned on a virtual surface connecting the center axes of the respective rollers **203**.

The spacer portion **218***a* is a member having a rectangular parallelepiped shape and a predetermined thickness so as to be disposed between the rollers **203** and has almost the same length in axial direction as that of the roller **203** and a width shorter than a diameter of the roller **203**. In addition, side surfaces in a thickness direction of the spacer portion **218***a* to which the roller **203** contacts are formed with retaining recessed portions **218***c* having a circular-arc shape corresponding to the shape of the roller **203**.

Both side end portions in axial direction of the roller of the connecting band **218***b* of the roller chain **218** project from the end surfaces of the roller in axial direction of the roller thereby to form guide projecting portions **2181**.

Each of the rollers **203** is retained from back and forth in an arranging direction by the respective spacer portions **218***a* of the roller chain **218**, so that it becomes unnecessary to form the chamfered portion to the end portion of the roller. As a result, a load can be supported by an entire length of the roller **203**, and an effective length of the roller **203** for bearing the load can be increased.

Furthermore, since only the spacer portion **218***a* is disposed between the adjacent rollers **203**, a pitch of the rollers **203** can be formed as small as possible, so that a number of the rollers **203** to be disposed per unit length for bearing the load can be increased as many as possible, thus improving the load bearing ability of the roller **203**.

FIG. **10**(*a*) shows an example of the roller chain **218** of a case where the roller **2031** has a hollow structure having a penetration bore **2032**. In the case of the roller **203** having the hollow structure, a pre-load can be easily applied in comparison with a case of a solid roller **203**, thus resulting in advantage.

A shaft portion **218***d* to be inserted into the penetration bore **2032** is formed to the roller chain **218**, whereby the roller chain **218** is integrated with the roller **203**. According to the structure described above, the falling-out of the roller **203** can be securely prevented, and the degree of parallelization between the respective rollers **203** can be accurately maintained.

FIG. **10**(*b*) shows an example of the roller chain **218** of a case where the roller **2034** has a structure having recessed portions **2033** at its both ends.

The roller chain **218** is provided with convex portions **218***e* to be rotatively inserted into the recessed portions **2033** formed to both the end portions of the roller **203**. According to this structure, the falling-out of the roller **2034** can be surely prevented, and the degree of parallelization between the respective rollers **2034** can be accurately maintained.

FIG. **10**(*c*) shows an example of the roller chain **218** of a case where the roller **2036** has a structure having a circular groove **2035** at a center of outer periphery of the roller **2036**.

The roller **203** is retained by fitting a ring member **218**f formed to the roller chain **218** into the circular groove **2035** of the roller chain **218**.

On the other hand. FIG. **10**(*d*) shows an example of the roller chain **218** of a case where the connecting plate **218***b* of the roller chain **218** is reinforced. Namely, the roller **218** is moved in the endless circulating passage having a track shape in accordance with the movement of the movable block **204**, and the roller chain **218** is repeatedly subjected to deformations from a linear-shape to a curved-shape, so that it is required to increase a fatigue strength of the roller chain **218**.

In view of this point, it is preferable to reinforce the connecting plate **218***b* for linking the roller **203** by inserting reinforcing members **218***g* such as wire, thin plate or the like into the connecting plate **218***b*.

The track rail **202** is an elongated member formed to have a rectangular shape in section, an upper portion of both the side surfaces of the track rail being formed to have tapered surfaces which gradually expand outwardly in upward direction, and each of the right and left tapered surfaces is provided with one row of roller rolling surface **205**, respectively. In addition, the upper surface of the track rail **202** is formed to be a plain surface of which both right and left end portions are provided with one row of roller rolling surface **206**, respectively, i.e., two rows of the roller rolling surfaces **206** in total.

The movable block **204** comprises a block body **2040** formed of metal, and side covers **211** to be attached to both end surfaces of the block body **2040**.

The block body **2040** has a U-shaped cross section and high rigidity and comprises a horizontal portion **2041** opposing to the upper surface of the track rail **202**, a pair of suspending portions **2042, 2042** suspending from the right and left end portions of the horizontal portion **2041** so as to clamp both the right and left side surfaces of the track rail **202**. A lower surface of the horizontal portion **2041** is provided with a pair of roller rolling surfaces **207, 207** corresponding to the paired roller rolling surfaces **206, 206** formed to the upper surface of the track rail **202**, while each of inner side surfaces of the right and left suspending portions **2042, 2042** is provided with roller rolling surface **208, 208** corresponding to the respective roller rolling surfaces **205, 205** formed to the right and left side surfaces of the track rail **202**.

A number of rollers **203** are disposed between four pairs of roller rolling surfaces **205, 208; 206, 207** corresponding to each other, that are formed to opposing surfaces between the track rail **202** and the movable block **204**, whereby roller rows for bearing a load to be applied to portions between the track rail **202** and the movable block **204** are assembled. A predetermined pre-load is applied to respective rollers **203**.

Each of the rollers **203** linearly contacts to the roller rolling surfaces **205, 208; 206, 207**. A contact angle a line L1 constituted by a line connecting two contact portions of the roller disposed between the corresponding roller rolling surfaces **205, 208; 206, 207** formed to the upper surface of the track rail **202** and the horizontal portion **2041** of the block body **2040** is set to vertically extend with an inclination angle of about 90° with respect to a horizontal line passing through a center of the roller **203**, while a contact angle line of the roller **203** disposed between the corresponding to the roller rolling surfaces formed to the right and left side surfaces of the track rail **202** and the inside surfaces of the right and left suspending portions **2042, 2042** of the block body **2040** is set to obliquely extend toward a center of the track rail **202** and is formed so as to upwardly incline with a predetermined angle of α with respect to a horizontal line H passing through a center of the roller **203**, thereby to form a structure in which both the right and left corner portions **2022, 2022** of an upper portion of the track rail **202** are clamped by the two rows of rollers **203, 203** disposed to the right and left sides of the track rail **202** and by the two rows of rollers **203, 203** disposed to the upper surface side of the track rail **202**. In the embodiment shown in Figure, the inclination angle of α is set to about 30°.

The block body **2040** is provided with four rows of the roller returning passages **209** for circulating and guiding the four rows of rollers **203**. The roller returning passage **209** linearly extend in parallel to the respective roller rolling surfaces **205, 206** formed to the block body **2040**. Two rows of the roller returning passages **209** are provided to the horizontal portion **2041**, while two rows of the roller returning passages **209** are respectively provided to the right and left suspending portions **2042** of the block body **2040**. The roller returning passage **209** is formed of a roller returning passage forming member **2091** composed of resin.

The roller returning passage forming member **2091** is integrally bonded to an inner peripheral portion of a penetration bore **2043** penetrating through the horizontal portion **2041** and the suspending portion **2042** of the block body **2040**. An outer peripheral shape of the roller returning passage forming member **2091** is formed to have a cylindrical shape which conforms to an inner peripheral shape of the penetration bore **2041**. The inner periphery of the roller returning passage forming member **2091** is provided with a roller returning passage **209** having a rectangular cross section for guiding the roller **203**.

The roller returning passage **209** comprises a pair of unloaded roller guide surfaces **209*a*, 209*b*** extending in parallel to each other for guiding a cylindrical outer periphery surface of the roller **203**, and a pair of unloaded roller end surface guide surfaces **209*c*, 209*c*** extending in parallel to each other for guiding end surfaces of the roller **203**.

A gap or clearance between the paired unloaded roller guide surfaces **209*a*, 209*b*** is set to slightly larger than a diameter of the roller **203** so as to form a small gap therebetween, while a gap or clearance between the paired roller end surface guide walls **209*c*, 209*c*** is set to slightly larger than a length of the roller **203** so as to form a small gap therebetween, thus resulting in a structure enabling to smoothly move the rollers **3**.

The unloaded roller end surface guide walls **209*c*, 209*c*** are formed with guide grooves **209*d*** with which the guide projecting portions **2181** of the roller chain **218** are engaged.

FIG. **11** shows another embodiment of a roller returning passage forming member **2092** to be formed to the suspending portion **2042** of the block body **2040**. Namely, the roller returning passage forming member **2092** is integrally bonded to a recessed portion **2044** formed to a lower end portion of the right and left suspending portions **2042** of the block body **2040**. The roller returning passage forming member **2091** is integrally connected to a third loaded roller end surface guide wall forming member **2143** provided to the inner peripheral side of the suspending portion **2042**.

According to the structure described above, the block body **2040** is required to be provided with only two penetration bores **2043** to be formed to the horizontal portion **2041**, thus making simple the manufacturing of the device.

In addition, as shown in FIGS. **8**, **9**(*a*) and **9**(*b*) both end portions of the block body **2040** are provided with side covers **211** constituting a direction changing passage **210** for changing the rolling direction of the roller **203** to the roller returning passage **209**, the roller **203** being disposed between the loaded roller rolling surfaces **205, 208; 206, 207** formed to the track rail **202** and the block body **2040**.

The direction changing passage **210** is formed to be a pipe having a U-shape. The side cover **211** is formed with only a direction changing passage inner periphery portion **210*a*** of the direction changing passage **210**, while a direction changing passage inner periphery portion forming member **212** is integrally bonded to both end portions of the block body **2040**.

This direction changing passage **210** has a rectangular shaped cross section, and both side portions of the direction changing passage outer periphery portion **210*a*** and the inner periphery portion **210*b*** for guiding the outer periphery surface of the roller **203** are provided with direction changing roller end surface guide walls **210*c*, 210*c*** for guiding the end surfaces of the roller **203**. This direction changing roller end surface guide walls **210*c*** together with the direction changing passage inner periphery portion **210*b*** are formed to the direction changing passage inner periphery portion forming member **212**. Then, when the side cover **211** formed with the direction changing passage outer periphery portion **210*a*** is fitted into the end surface of the block body **2040** formed with the direction changing passage inner periphery portion **210*b*** and the direction changing roller end surface guide walls **210*c***, the direction changing passage **210** having a U pipe shape is formed.

The direction changing roller end surface guide walls **210*c*, 210*c*** are formed with guide grooves **210*d*** with which the guide projecting portions **2181** of the roller chain **218** are engaged.

In this regard, the direction changing roller end surface guide walls **210*c*, 210*c*** together with the direction changing passage outer periphery portion **210*a*** may be provided to the side cover **211**. In another way, one direction changing roller end surface guide wall **210*c*** together with the direction changing passage inner periphery portion **210*b*** may be provided to a side of the direction changing passage inner periphery portion forming member **212**, while the other direction changing roller end surface guide walls **210*c*** together with the direction changing passage outer periphery portion **210***a* may be provided to the side cover **211**.

In still another way, the direction changing roller end surface guide wall **210***c* is divided into two portions i.e., an inner periphery side portion and an outer periphery side portion, and then, the outer periphery side portion may be formed to the side cover **211**, while the inner periphery side portion may be provided to the direction changing passage inner periphery portion forming member **212**.

Further, as shown in FIG. **8**(*a*) along the respective four rows of roller rolling surfaces **207**, **208** of the block body **240**, there is provided with a loaded roller end surface guide wall **213** for guiding the end surfaces of the roller in the loaded area.

The loaded roller end surface guide walls **213** are formed with guide grooves **213***a* with which the guide projecting portions **2181** of the roller chain **218** are engaged. In order to form the loaded roller end surface guide wall **213**, the block body **240** comprises a first end surface guide wall forming member **2141** to be integrally bonded to a lower surface of the horizontal portion **2040**, the right and left second end surface guide wall forming members **2142** to be integrally bonded to recessed corner portions between the horizontal portion **2041** and the right and left suspending portions **2042**, and right and left third end surface guide wall forming members **2143** to be integrally bonded to a lower portion of inner side surface of the right and left suspending portions **2042**.

Both the end portions of the first end surface guide wall forming member **2141** and an upper end portion of the second end surface guide wall forming members **2142** are provided with loaded roller end surface guide walls **213**, **213**; **213**, **213** for guiding the end surfaces of the roller **203** rolling on the roller rolling surfaces **207**, **207** formed to the lower surface of the horizontal portion **2041** of the block body **2040**.

In addition, the lower end portions of the right and left second end surface guide wall forming members **2142** and an upper end portion of the third end surface guide wall forming members **2143** are provided with loaded roller end surface guide walls **213**, **213**; **213**, **213** for guiding the end surfaces of the roller **203** rolling on the roller rolling surfaces **208**, **208** formed to the suspending portion **2042** of the block body **2040**.

A gap or clearance between the paired loaded roller end surface guide walls **213**, **213** is set to slightly larger than a length of the roller **203** so as to form a small gap between the end surface of the roller **203** and the guide wall **213**.

Further, a first seal member **216** for sealing the gap formed between the horizontal portion **2041** of the block body **2040** and the upper surface of the track rail **202** is attached to the first end surface guide wall forming member **2141**, while a second seal member **217** for sealing the gap formed between the suspending portion **2042** of the block body **2040** and the right and left side surfaces of the track rail **202** is attached to the third end surface guide wall forming member **2143**.

In this embodiment, the loaded roller end surface guide walls **213** for guiding both end surfaces of the roller **203** is formed by the first to third end surface guide wall forming members **2141**–**2143** that are all composed of resin.

However, as shown in FIG. **11**(*a*), the loaded roller end surface guide walls **213** for guiding one end surface of the roller **203** may be formed by the block body **2040** per se, while the loaded roller end surface guide wall **213** for guiding the other end surface of the roller **203** may be formed by the loaded roller end surface guide wall forming member **214**. In this case, the loaded roller end surface guide walls **213** may be formed with guide grooves with which the guide projecting portions **2181** of the roller chain **218** are engaged. In another way, as shown in FIG. **11**(*b*), a cutout **213***b* can be also formed in place of the guide groove.

In this second embodiment, all of the roller returning passage forming member **2091**, the roller end surface guide wall forming members **2141**–**2143** and the direction changing passage inner periphery portion forming member **212** is formed by integrally molding with the movable block **2040**.

Accordingly, the unloaded roller guide surfaces **209***a*, **209***b* of the roller returning passage **209** and both the inner and outer periphery portions **210***a*, **210***b* of the direction changing passage can be continuously and integrally molded. Further, the direction changing passage inner periphery portion **210***b* and the roller rolling surfaces **207**, **208** in the loaded area can be also integrally molded.

In addition, the roller end surface guide wall **209***c* of the roller returning passage **209**, the direction changing roller end surface guide wall **210***c* of the direction changing passage **210** and the loaded area roller end surface guide wall **213** are continuously formed by being integrally molded, so that the roller end surface guide wall can be continuously formed in all around the endless circulating passage. In addition, the guide groove for engaging with the guide projecting portion **2181** of the roller chain **218** can be continuously formed in all around the endless circulating passage.

According to the linear roller guide device of this invention, the roller returning passage forming member **2091** and the direction changing passage inner periphery portion forming member **212** are not required, thus enabling to omit the assembling process for the members. In addition, the roller returning passage **209** and the direction changing passage inner periphery portion **210***a* can be provided at accurate positions with respect to the block body **2040**.

When the direction changing passage inner periphery portion forming member **212** is integrally formed with the block body **2040**, it becomes possible to eliminate the irregularities to be formed at the connected portion between the roller rolling surfaces **207**, **208** and the direction changing passage inner periphery portion **210***b*. In addition, as to the roller returning passage **209**, when the member **91** is integrally formed with the block body **2040**, it becomes also possible to eliminate the irregularities to be formed at the connected portion between the direction changing passage inner periphery portion **210***b* and the unloaded roller guide surface **209***b* of the roller returning passage **209**.

On the other hand, the rollers **203** can be smoothly rolled and moved from the roller returning passage **209** in the unloaded area and the direction changing passage **210** to the loaded area between the roller rolling surfaces **206**, **207**; **205**, **208** while being held in a state where the center axes of the respective rollers **203** are retained in parallel to each other and intervals of adjacent rollers **203** are retained in a predetermined distance by the roller chain **218**.

In particular, when the roller chain **218** is circulated and moved, the guide projecting portions **218***a* formed to the roller chain **218** are guided in all around the circulating passage by the guide grooves **209***d*, **210***d* and **213***a* formed to the guide walls **213** provided to both sides of the roller returning passage **209**, the direction changing inner periphery portion **210***b* and the roller rolling surfaces **207**, **208**, so that the run-out of the roller chain **218** during the circulation can be suppressed in all around the circulating passage. Accordingly, the roller chain **218** can circulate and move on a predetermined track in all around the endless circulating passage. As a result, the rollers **203** can accurately roll and move, thus preventing the skew-generation of the rollers **203**.

Furthermore, in this embodiment, the gaps between the guide walls **213**, the direction changing roller end surface guide wall **210***c* in the loaded area and the unloaded roller end surface guide wall **209***c* and the roller end surfaces can be accurately maintained to a predetermined value, so that the gap can be reduced to a sufficiently small value. As a result, the skew of the rollers **203** can be securely prevented in cooperation with the retaining function of the roller chain **218**.

Furthermore, when the movable block **204** is detached from the track rail **202**, the rollers **203** are retained by the roller chain **218**.

The integrally molding of the roller returning passage forming member **2091**, the direction changing passage inner peripheral portion forming member **212** and the loaded roller end surface guide wall **213** with the block body **2040** is performed in accordance with an insert molding method comprising the steps of disposing the block body **2040** into a molding die **215** on the basis of the roller rolling surfaces **207**, **208** formed to the block body **2040**, forming cavities corresponding to the respective resin molded portions to be formed between an inner wall of the molding die **215** and the block body **2040**, and injecting a molding material into the cavities to form the resin molded portions.

FIG. **12** is a schematic view showing the block body **2040** and states where the molding dies **215** are clamped or opened at the time of the insert molding. Namely, a fixed molding die **215***a* is provided with block supporting portions **215***b* to which the roller rolling surfaces **207**, **207**; **208**, **208** are fitted for positioning, while a movable molding die **215***c* is provided with pins **215***d* for forming the roller returning passage. The block supporting portions **215***b* and the pins **215***d* are formed with projecting portions **215***b***1**, **215***d***1** corresponding to the guide projecting portion **2181** of the roller chain **218**.

The block supporting portions **215***b* have plain shapes corresponding to the roller rolling surfaces **207**, **207**: **208**, **208** and linearly extend in parallel to each other. In this regard, FIGS. **12**(*b*) and **12**(*c*) shows only a circumference of the roller returning passage **209** of a side of the suspending portion **2042**.

Cavities **215***d* for forming the roller returning passage forming member **2091** are provided inside the penetration bores **2043** formed in the horizontal portion **2041** and the suspending portion **2042** of the block body **2040**, respectively. Further, cavities **215***e* for forming the first to third loaded roller end surface guide wall forming members **213** are provided to inner periphery portions of the horizontal portion **2041** and the suspending portion **2042**, respectively. Furthermore, cavities **215***f* for forming the direction changing passage inner periphery portion forming members **212** are provided to both front and back end portions of the block body **2040**, respectively.

In this embodiment, the paired right and left roller rolling surfaces **207**, **207**; **208**, **208** of the block body **2040** are supported at four points by the block supporting portions **215***b* of the molding die **215**. As a result, the block body **2040** can be supported unmoved by the block supporting portions **215***b*, even if an injection pressure of a molding material is applied to the block body **2040** from every directions, whereby the roller returning passage **209**, the direction changing inner periphery portion **210***b* and the first to third loaded roller end surface guide walls **2131**–**2133** can be accurately formed at predetermined positions.

In addition, since the block body **2040** is stably positioned in the molding die **215**, the burr is not formed at portions between the roller rolling surfaces **207**, **207**; **208**, **208**.

It is preferable that the block supporting portions **215***b* closely contact to the roller rolling surfaces **207**, **208**. However, even the block supporting portions **215***b* and the roller rolling surfaces **207**, **208** are moved in a small distance due to a small gap formed therebetween, the small gap shall be allowed as far as a dimension accuracy is within an allowable range and the resin material would not penetrate through the gap.

[Modifications of Roller Contact Angles]

Though the explanation described above has been made by taking into consideration an example of a case in which total four rows of rollers are disposed between corresponding portions i.e., the right and left two rows of rollers being disposed between the upper surface of the track rail **202** and the lower surface of the horizontal portion **2041** of the block body **2040** while one row of rollers being disposed between the right and left side surfaces of the track rail **202** and the inner side surfaces of the right and left suspending portions **2042** respectively, a number and an arrangement of the roller rows are optional.

For example, as shown in FIGS. **13** and **14**, the device may have a structure having four rows of rollers in total in which right and left two rows of rollers are disposed between the right and left side surfaces of the track rail **202** and the inner side surfaces of the right and left suspending portions **2042** of the block body **2040**, respectively.

FIG. **13** shows an example having a structure in which the upper row of rollers **203** among the two rows of the rollers **203** arranged vertically is formed so that a contact angle line of the roller **203** is set to obliquely extend upwards from a side of the track rail **202** to the right and left suspending portions **2042** of the block body **2040** and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line, while the lower row of rollers **203** is formed so that a contact angle line of the roller **203** is set to obliquely extend downwards and is formed so as to incline with an inclination angle of almost 45°.

FIG. **14** shows an example having a structure in which the upper row of rollers **203** among the two rows of the rollers **203** arranged vertically is formed so that a contact angle line L1 of the roller **203** is set to obliquely extend downwards from a side of the track rail to sides of the right and left suspending portions **2042**, **2042** of the block body **2040** and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line H, while the lower row of rollers **203** is formed so that a contact angle line L2 of the roller **203** is set to obliquely extend upwards and is formed so as to incline with an inclination angle of almost 45°.

In the case of this embodiment, the direction changing passages **210**A, **210**B of vertically arranged two rows of rollers **3** disposed to both end portions of the block body **2040** are arranged alternately with a predetermined interval in an axial direction so as to intersect to each other. In this case, the direction changing passage inner peripheral portion forming member **212** formed to the end surface of the block body **2040** is provided with the direction changing passage inner periphery portion **210***b* of the direction changing passage **210**A of a side close to the block body **2040** and the direction changing roller end surface guide wall **210***c*, the inner periphery portion **210***b* and the guide wall **210***c* being integrally molded with the block body **2040**.

As to the direction changing passage **210**B far from the block body **2040**, at least one portion of the loaded roller rolling surfaces **207**, **208** of an end surface side of the block body **2040**, the direction changing passage inner periphery portion **210***b* of a part which is connected to an end portion of the roller returning passage **209** and the direction changing roller end surface guide wall **210***c* are integrally molded with the block body **2040**. While, a round piece **210**C formed with the direction changing passage inner periphery portion **210***b* is attached to a part far from the direction changing passage **210**A. An inner periphery of this round piece **210**C is formed with a part of an outer periphery guide portion of the inside direction changing passage **210**A. The side cover **211** is formed with the direction changing passage outer peripheral portions **210***a*, **210***a* for both the direction changing passages **210**A, **210**B arranged vertically.

According to the second invention described above, since the rollers are circulated in a state of being retained by the roller chain, the rollers are rolled and moved in a state where center axes of the respective rollers are retained in parallel to each other by the roller chain. Therefore, the generation of skew can be prevented and the rollers can be smoothly rolled and moved,

In addition, since the roller chain is guided on a predetermined track through the roller chain guide portions formed to the roller returning passage and the direction changing passage, the rollers retained by the roller chain can be also accurately guided.

In addition, the running-out of the roller chain can be prevented by the roller chain guide portions.

In particular, when the roller returning passage to be formed with the roller chain guide portions, the roller returning passage forming member to be formed with the direction changing inner periphery portion and the direction changing passage inner periphery portion forming member are integrally molded with the block body, the roller chain guide portions can be accurately formed on the track.

In addition, when the direction changing passage inner periphery portion forming member is integrally formed with the block body, it becomes possible to eliminate the irregularities to be formed at the connected portion between the roller rolling surface and the direction changing passage inner periphery portion. In addition, as to the roller returning passage, when it is integrally formed with the block body, it also becomes possible to eliminate the irregularities to be formed at the connected portion between the direction changing passage inner periphery portion and the roller returning passage, whereby the rollers can be further smoothly circulated and moved in cooperation with the guiding function of the roller chain.

Furthermore, when the roller chain is formed so as to have an endless structure and is provided with a falling-out preventing portion for the rollers, the falling-out of the rollers can be prevented by the roller chain even if the movable block is detached from the track rail.

In addition, the roller chain is provided with a guide projecting portion, while the roller returning passage and the direction changing passage inner peripheral portion are provided with guide grooves. In addition, a side of the roller rolling surface in the loaded area is provided with a guide wall having the guide groove, and the guide wall is integrally molded with the block body by using an insert molding method, so that the roller chain can be accurately guided in all around the endless circulating passage, thus enabling the rollers to further smoothly circulate and move.

According to the structure described above, when the roller chain is circulated and moved, the guide projecting portion is engaged with the guide groove formed to the roller returning passage and the direction changing passage inner peripheral portion, so that the run-out of the roller chain during the circulation is suppressed. As a result, the rollers can be rolled and moved in orderly arranged state in all around the endless circulating passage.

In addition, in a case where the roller chain is formed in a striped-shape having no connected portion at both ends thereof, when the movable block is detached from the track rail, the guide projecting portion is engaged with the guide groove, thus enabling to prevent a sagging or slack of an end portion of the roller chain. Further, a also in the case of the roller chain having an endless structure, the sagging or slack of an intermediate portion of the roller chain can be prevented.

When the roller chain comprises spacer portions disposed between the adjacent rollers and connecting members for connecting the respective spacer portions, each of the rollers is arranged and circulated in a state where the rollers are retained by the spacer portions from back and forth in the arranging direction thereof.

Further, when a falling-out preventing portion for the roller is provided to the spacer portion so as to prevent the roller falling-out from back and forth of the roller, it becomes unnecessary to chamfer the end portion of the roller, so that an effective length of the roller for bearing the load can be increased, thus enabling to improve the load bearing ability.

Furthermore, since only the spacer portion is disposed between the adjacent rollers, a pitch of the rollers can be formed as small as possible, so that a number of the rollers required to be disposed per unit length for bearing the load can be increased as many as possible, thus further improving the load bearing ability of the roller.

In addition, when the roller is formed to have a hollow structure and the roller is retained by inserting a resin portion into the hollow portion of the roller, the falling-out of the roller can be securely prevented and a degree of parallelization between the adjacent rollers can be accurately maintained.

In addition, as an example of a case where the hollow portion does not penetrate, the roller may be retained in such a manner that a recessed portion is formed to both end portions of the roller and the resin portion is inserted into the recessed portion or in a manner that a grooved portion is formed to a center peripheral portion of the roller and the resin portion is fitted into the grooved portion.

In addition, when the roller chain is reinforced by inserting a wire or thin plate into the connecting member for linking the rollers, a fatigue strength and life duration of the roller chain can be increased.

In addition, at a time of the insert molding, when a block supporting portion having a shape obtained by cutting an outer peripheral portion of the roller with a cross section passing through a center axis of the roller is provided to an inner periphery of a molding die so as to correspond to the roller rolling surface of the block body, and the block body is positioned in the molding die by contacting the roller rolling surface to the block supporting portion, the burr would not occur at the roller rolling surfaces.

In particular, when the paired right and left roller rolling surfaces of the block body are supported by the block supporting portions of the molding die, the block body is clamped from every four directions and supported by the paired right and left block supporting portions at four points. Therefore, even if an injection pressure of a molding material is applied to the block body from every directions, the block body can be held unmoved, thus the block body can be accurately positioned.

INDUSTRIAL APPLICABILITY

As described above, the linear roller guide device according to the present invention is widely applicable to linear guide mechanisms for various industrial equipments such as machine tool, robot operating system, measuring apparatus or the like.

What is claimed is:

1. A linear roller guide device comprising a track rail and a movable block assembled to the track rail through a number of rollers, said movable block comprising:

a roller rolling surface on which said rollers roll;

a block body having a roller returning passage corresponding to the roller rolling surface;

a direction changing passage inner periphery portion formed to both end surfaces of the block body;

a pair of roller end surface guide walls formed to both sides of the roller rolling surface of the block body and adapted to guide both the end surfaces of the roller; and

side covers each having a direction changing passage outer periphery portion for forming a direction changing passage by fitting the side cover into the direction changing passage inner periphery portion formed to both end surfaces of the block body,

said track rail including a roller rolling surface extending in an axial direction corresponding to the roller rolling surface of the block body, and

said rollers circulating in an endless circulating passage constituted by a loaded area between the roller rolling surface of the block body and the roller rolling surface corresponding to the track rail, the direction changing passage and the roller returning passage,

wherein at least one of a roller returning passage forming member for forming the roller returning passage, which is of one-piece construction with a guide wall guiding a roller end surface, a direction changing passage inner periphery portion forming member for forming the direction changing passage inner periphery portion, which is of one-piece construction with the guide wall and a roller end surface guide wall forming member for forming at least one of the paired roller end surface guide walls, is formed as a molded body integrally formed with the block body by inserting the block body into a molding die.

2. A linear roller guide device according to claim **1**, wherein said roller returning passage forming member and said direction changing passage inner peripheral portion forming member are provided with guide walls for guiding the end surfaces of the rollers, the guide walls being continuous to the roller end surface guide wall, and said roller returning passage forming member, said roller end surface guide wall forming member of at least one of the paired roller end surface guide wall forming members and said direction changing passage inner peripheral portion forming member are integrally molded with the block body.

3. A linear roller guide device according to any one of claims **1** and **2**, wherein a block supporting portion having a shape obtained by cutting an outer peripheral portion of the roller with a cross section passing through a center axis of the roller is formed to an inner periphery of a molding die so as to correspond to the roller rolling surface of the block body at a time of an insert molding, and the block body is positioned in the molding die by contacting the roller rolling surface to the block supporting portion.

4. A linear roller guide device according to any one of claims **1**, **2** and **6** wherein said device has a structure having four rows of rollers in total in which a paired right and left rows of rollers are disposed to be rollable between the upper surface of the track rail and a lower surface of a horizontal portion of the block body and two rows of the rollers each is disposed between the right and left side surfaces of the track rail and inside surfaces of a suspending portion of the block body, respectively.

5. A linear roller guide device according to claim **4**, wherein a contact angle line constituted by a line connecting two contact points of said roller disposed between the roller rolling surfaces formed to the upper surface of the track rail and the horizontal portion of the block body is set to vertically extend with an inclination angle of approximately 90° with respect to a horizontal line, while a contact angle line of the roller disposed between the roller rolling surfaces formed to the right and left side surfaces of the track rail and the inside surfaces of the suspending portion of the block body is set to obliquely extend downwards and is formed so as to incline with an inclination angle of approximately 30° with respect to a horizontal line.

6. A linear roller guide device according to claim **1**, wherein said roller is provided with a chamfered portion formed to at least one end portion of the roller, and an engaging projection with which said chamfered portion of the roller is engaged is provided at the roller end surface guide wall integrally molded with the block body so as to prevent the roller from falling-out.

7. A linear roller guide device according to any one of claims **1**, **2** and **6**, wherein said guide device has a structure having four rows of rollers in total in which two rows of rollers are vertically disposed to be rollable at upper and lower portions between a right side surface of the track rail and a right inside surface of the suspending portion of the block body, respectively, while the remaining two rows of rollers are vertically disposed to be rollable at upper and lower portions between a left side surface of the track rail and a left inside surface of the suspending portion of the block body, respectively.

8. A linear roller guide device according to claim **7**, wherein said upper row of rollers is formed so that a contact angle line of the roller is set to obliquely extend upwards from a side of the track rail to sides of the right and left suspending portions of the block body and is formed so as to incline with an inclination angle of approximately 45° with respect to a horizontal line, while said lower row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards and is formed so as to incline with an inclination angle of approximately 45° with respect to a horizontal line.

9. A linear roller guide device according to claim **7**, wherein said upper row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards from a side of the track rail to sides of the right and left suspending portions of the block body, and is formed so as to incline with an inclination angle of approximately 45° with respect to a horizontal line, while the lower row of rollers is formed so that a contact angle line of the roller is set to obliquely extend downwards and is formed so as to incline with an inclination angle of almost 45° with respect to a horizontal line.

* * * * *

US006210039B1

(12) **United States Patent**
Teramachi

(10) **Patent No.: US 6,210,039 B1**
(45) **Date of Patent: Apr. 3, 2001**

(54) **LINEAR MOTION GUIDE UNIT AND TABLE GUIDE APPARATUS UTILIZING THE SAME**

(75) Inventor: **Hiroshi Teramachi**, Tokyo (JP)

(73) Assignee: **THK Co., Ltd.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **08/981,396**

(22) PCT Filed: **May 1, 1997**

(86) PCT No.: **PCT/JP97/01508**

§ 371 Date: **Jun. 14, 1999**

§ 102(e) Date: **Jun. 14, 1999**

(87) PCT Pub. No.: **WO97/41363**

PCT Pub. Date: **Nov. 6, 1997**

(30) **Foreign Application Priority Data**

May 1, 1996 (JP) 8-134213

(51) **Int. Cl.**[7] **F16C 31/06**

(52) **U.S. Cl.** **384/45**; 384/43; 384/44; 384/49

(58) **Field of Search** 384/43, 44, 45, 384/49

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,008,774 * 11/1961 Morris et al. 384/45
4,595,244 * 6/1986 Teramachi 384/15
5,137,371 8/1992 Osawa 384/45
5,240,331 * 8/1993 Ninomiya et al. 384/45
5,362,156 * 11/1994 Hara 384/45
5,375,931 * 12/1994 Teramachi 384/45

FOREIGN PATENT DOCUMENTS

14 25 120 B 1/1970 (DE) .
76 22 992 U 7/1976 (DE) .
43 31 014 C2 3/1995 (DE) .
296 00 917 U1 4/1996 (DE) .
55-46045 3/1980 (JP) .
55-46046 3/1980 (JP) .
60-40818 3/1985 (JP) .
2-142918 6/1990 (JP) .
5-52214 3/1993 (JP) .
6-323331 11/1994 (JP) .
8-21440 1/1996 (JP) .

* cited by examiner

Primary Examiner—Thomas R. Hannon
(74) *Attorney, Agent, or Firm*—Armstrong, Westerman, Hattori, McLeland & Naughton

(57) **ABSTRACT**

An object of this invention is to provide a linear motion guide device and a table guide device having an automatic controllability and to realize a load bearing structure having a high rigidity. The device is characterized in that a movable block **(4)** is formed to provide an L-shape in section, rolling ball rows (B1–B4) are disposed to be rollable between ball rolling grooves formed to an upper surface of a track rail **(1)** and a horizontal portion of the movable block **(4)** and between ball rolling grooves formed to a side surface of the track rail **(1)** and a suspending portion **(3)**, wherein each of the ball rolling grooves has a circular-arc-shape in section having a deep-groove shape having a groove depth of approximately ⅓ to ½ of a diameter of the rolling ball.

20 Claims, 9 Drawing Sheets

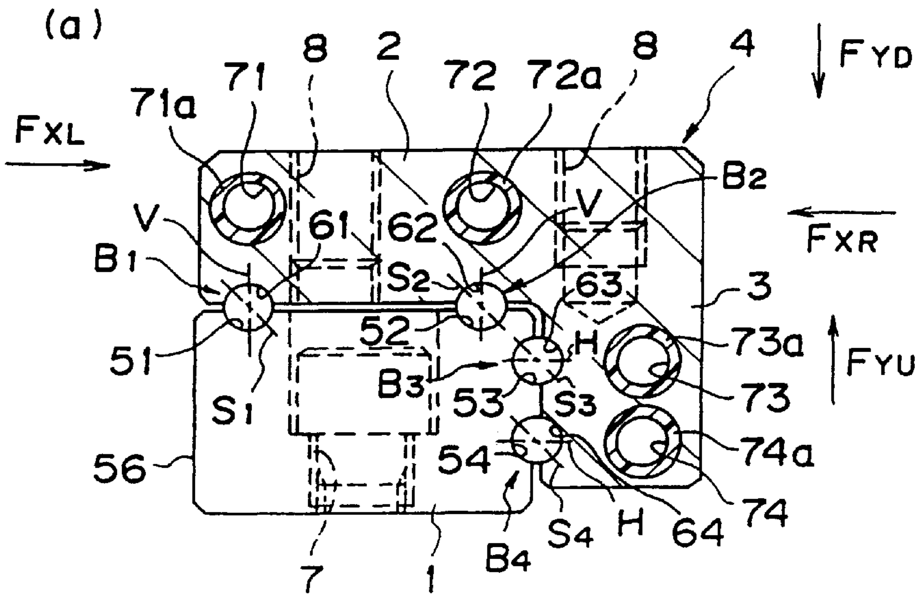


FIG. 1

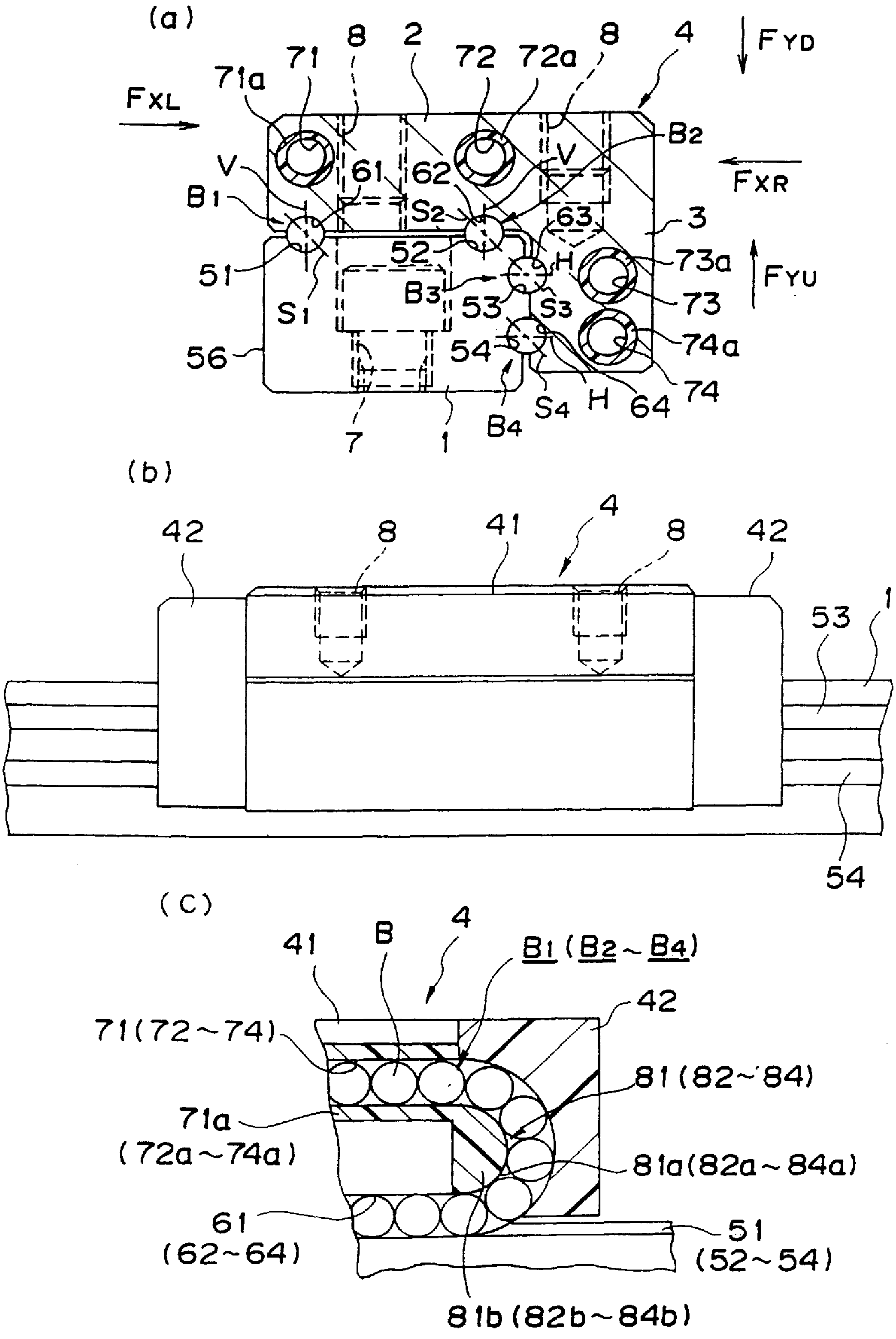

(a)
(b)
(c)
FXL
FXR
FYD
FYU
71a
71
8
2
72
72a
4
B2
V
B1
61
62
S2
63
3
51
52
H
73a
73
B3
53
S3
S1
56
54
74a
74
7
1
B4
S4
64
42
41
53
54
B
B1 (B2~B4)
71(72~74)
81(82~84)
71a
(72a~74a)
81a(82a~84a)
61
(62~64)
51
(52~54)
81b(82b~84b)

FIG. 2

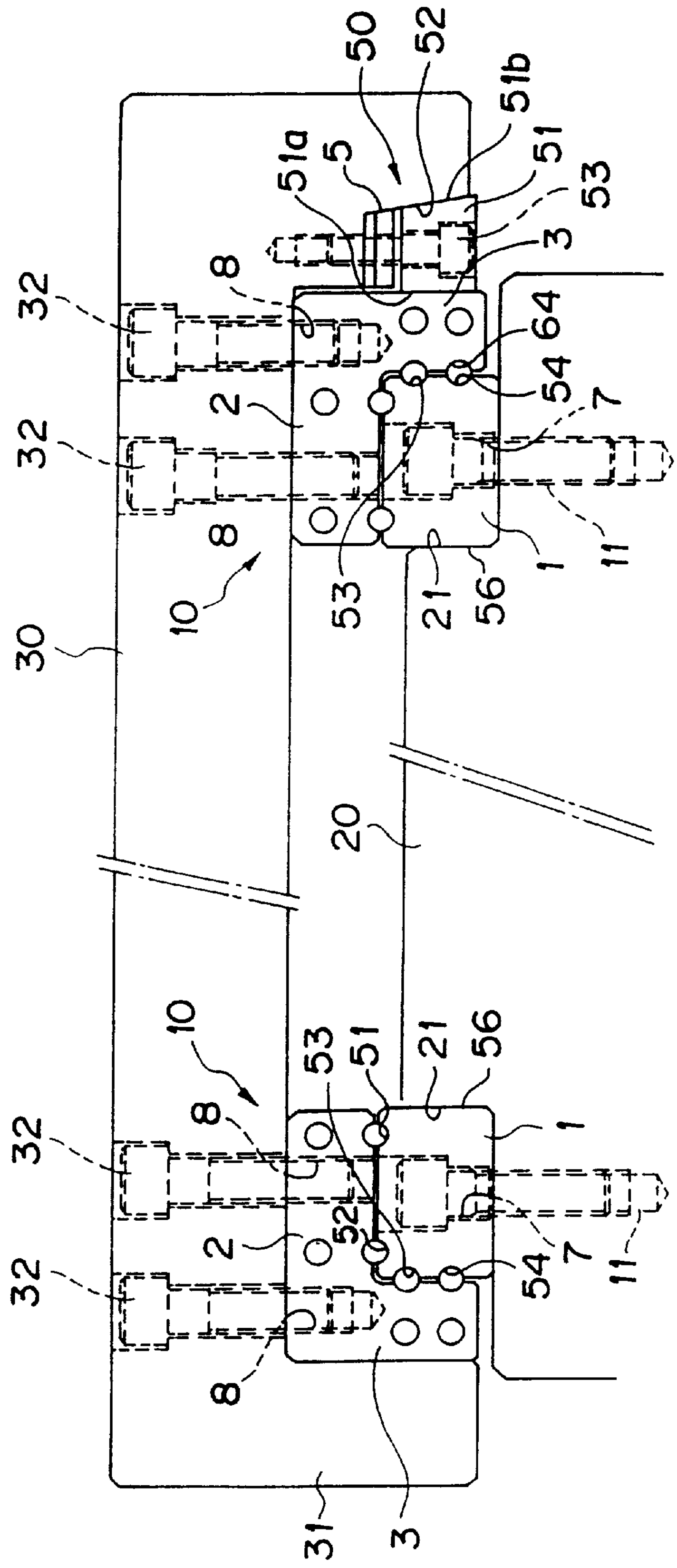

50
52
51b
51a
5
51
53
3
8
32
64
54
7
2
32
8
11
1
56
21
53
10
30
20
10
53
51
21
56
8
1
32
52
2
7
11
54
32
8
31
3

FIG. 3

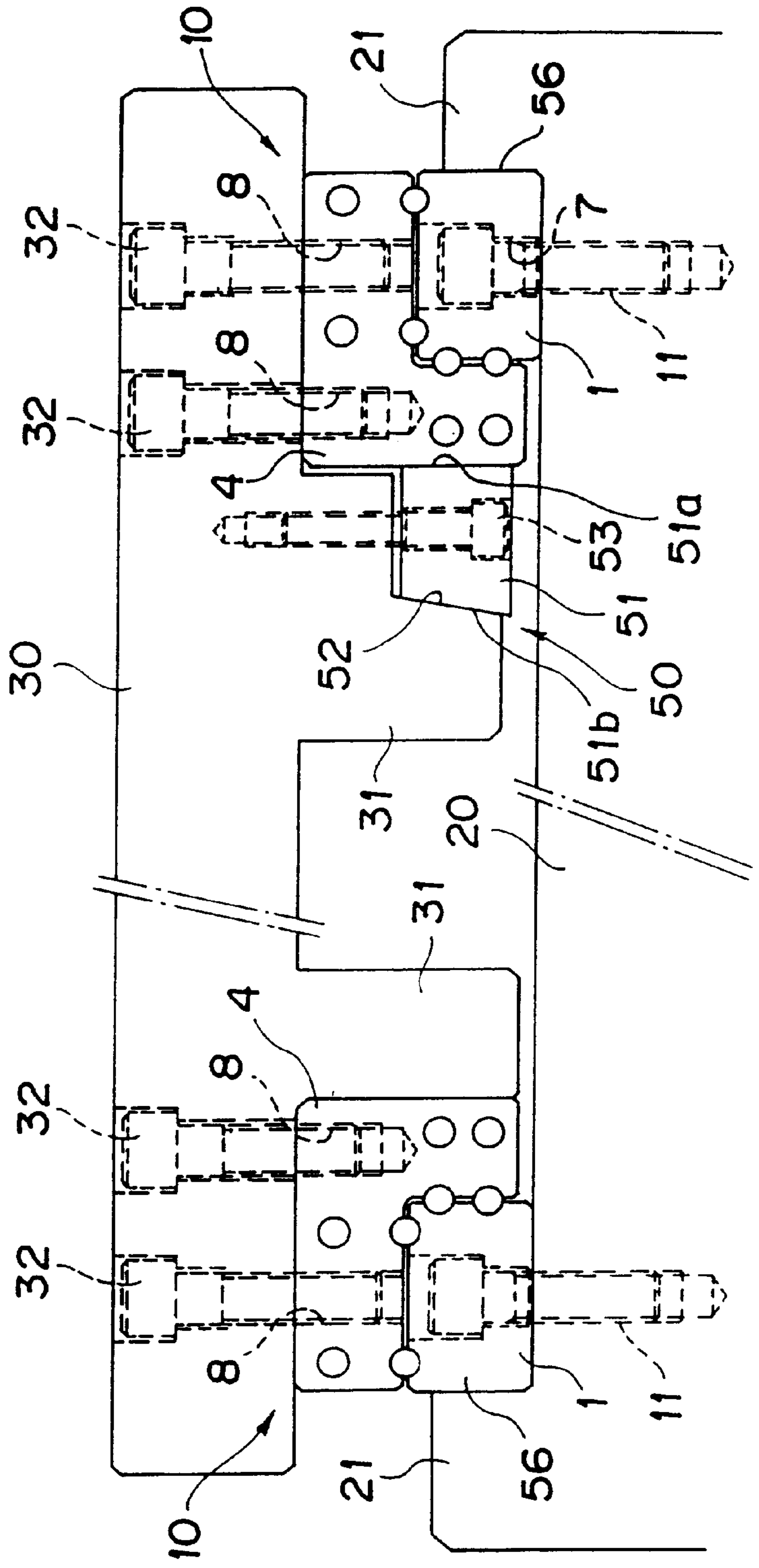


FIG. 4

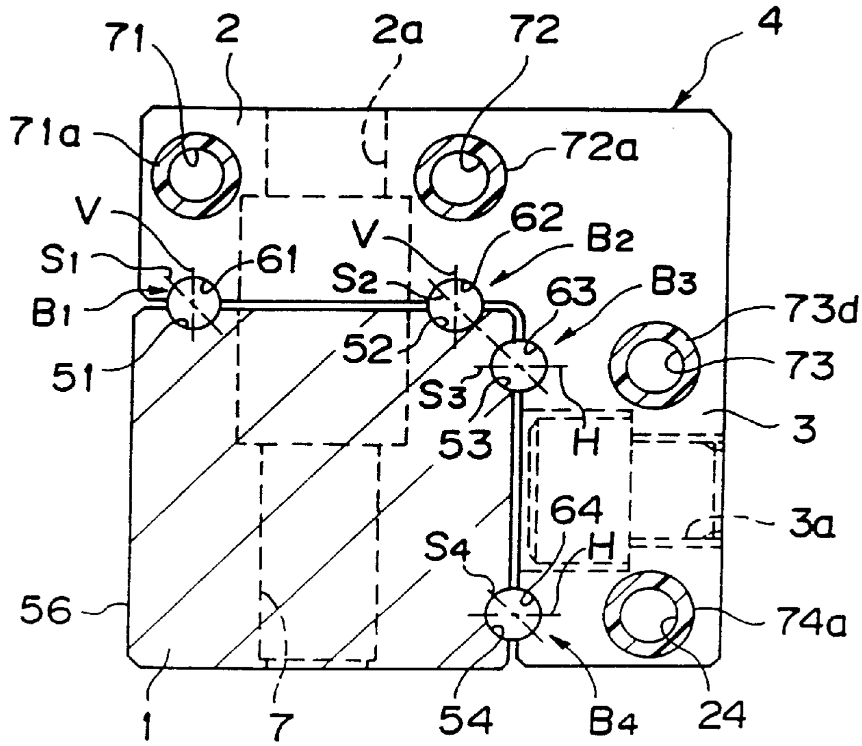

71
2
2a
72
4
71a
72a
V
62
B2
S1
61
V
S2
B3
63
73d
B1
73
52
51
S3
3
53
H
64
3a
S4
H
56
74a
1
7
54
B4
24

FIG. 6

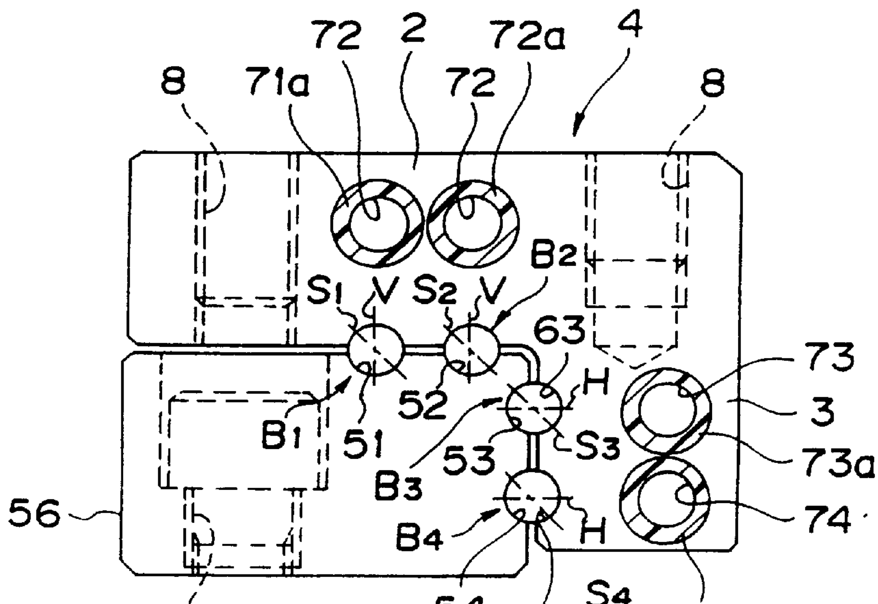

72
2
72a
4
8
71a
72
8
B2
S1
V
S2
V
63
73
H
52
3
B1
51
S3
73a
53
B3
56
74
B4
H
S4
54
8
64
74a

FIG. 5

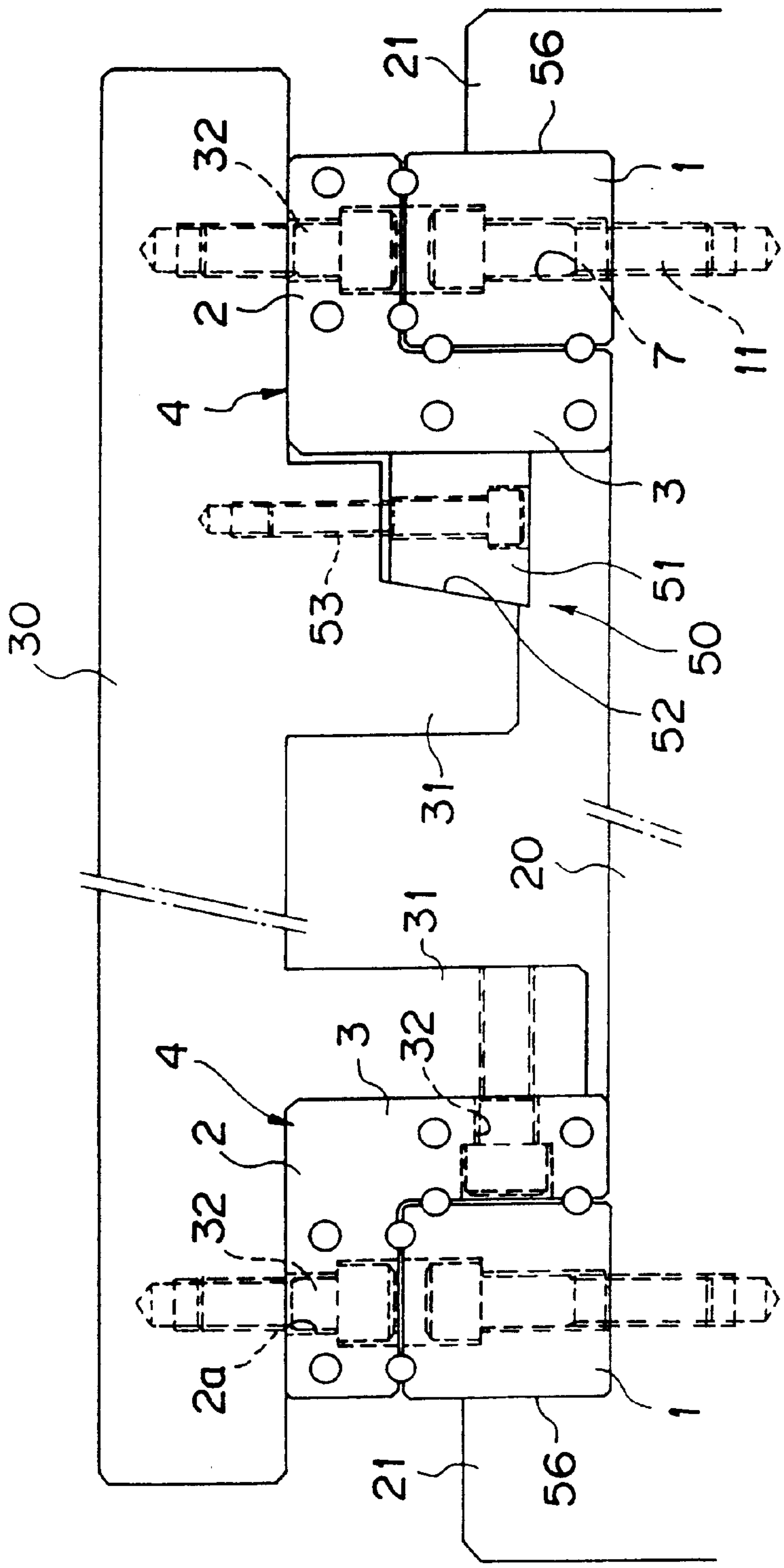


FIG. 7

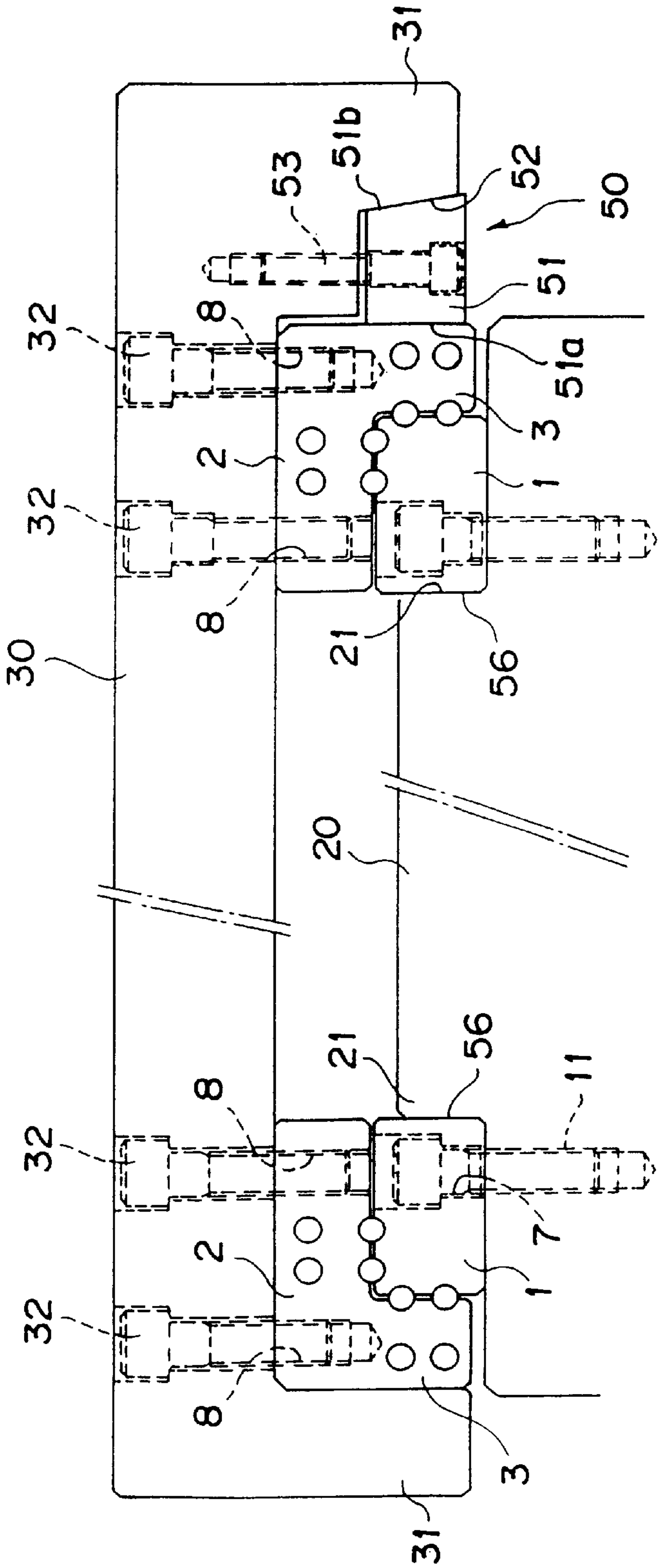

31
51b
53
52
50
51
32
8
51a
3
2
1
32
8
21
56
30
20
21
56
11
8
32
2
7
1
32
8
3
31

FIG. 8

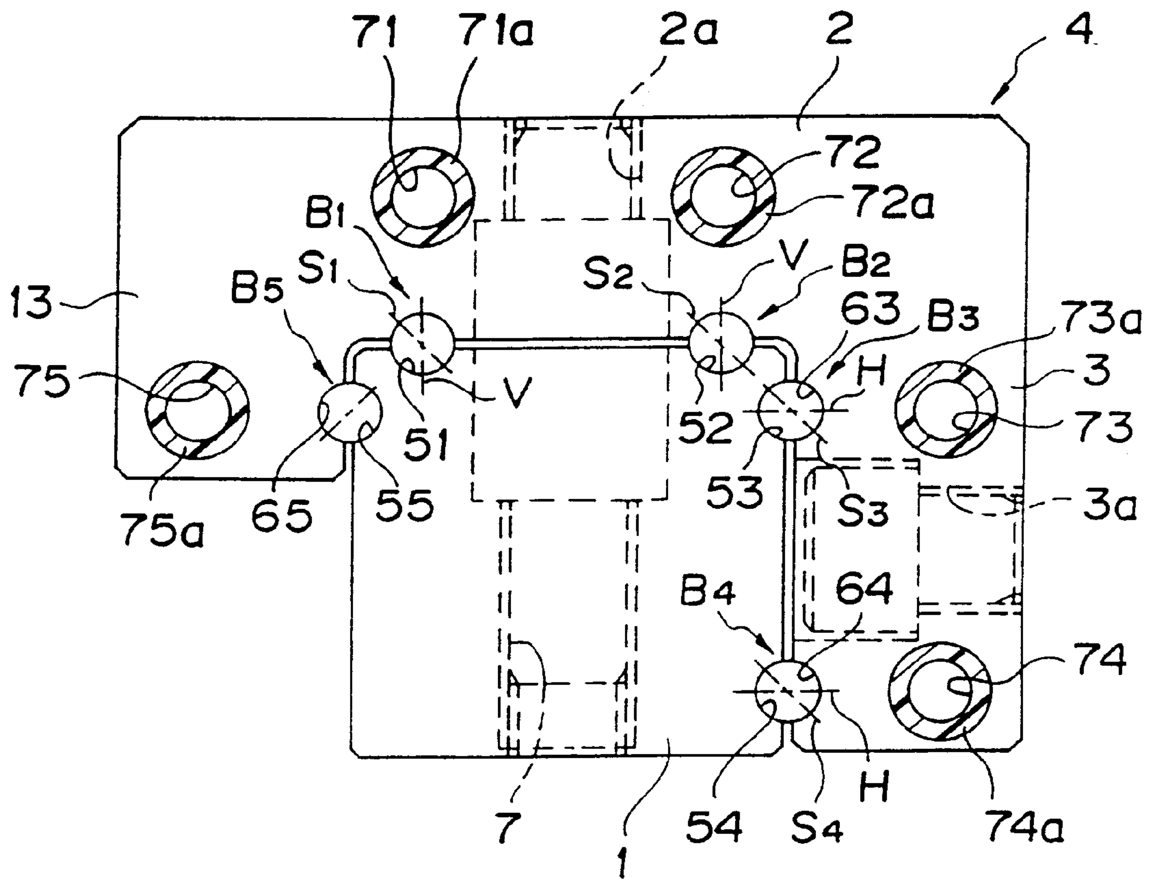

71
71a
2a
2
4
72
72a
B1
S1
B5
13
S2
V
B2
63
B3
73a
3
75
V
H
73
51
52
65
55
53
S3
3a
75a
B4
64
74
7
1
54
S4
H
74a

FIG. 9

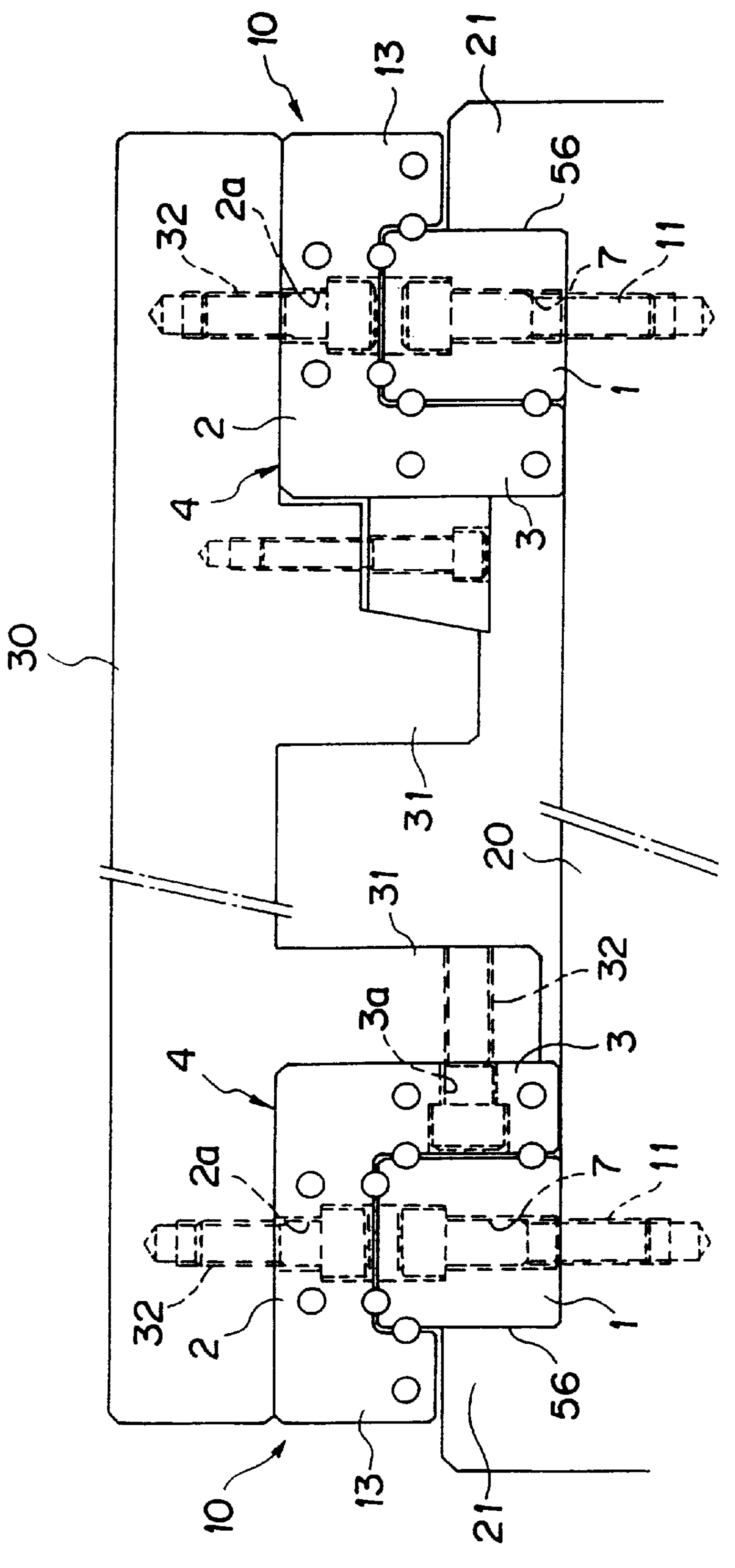
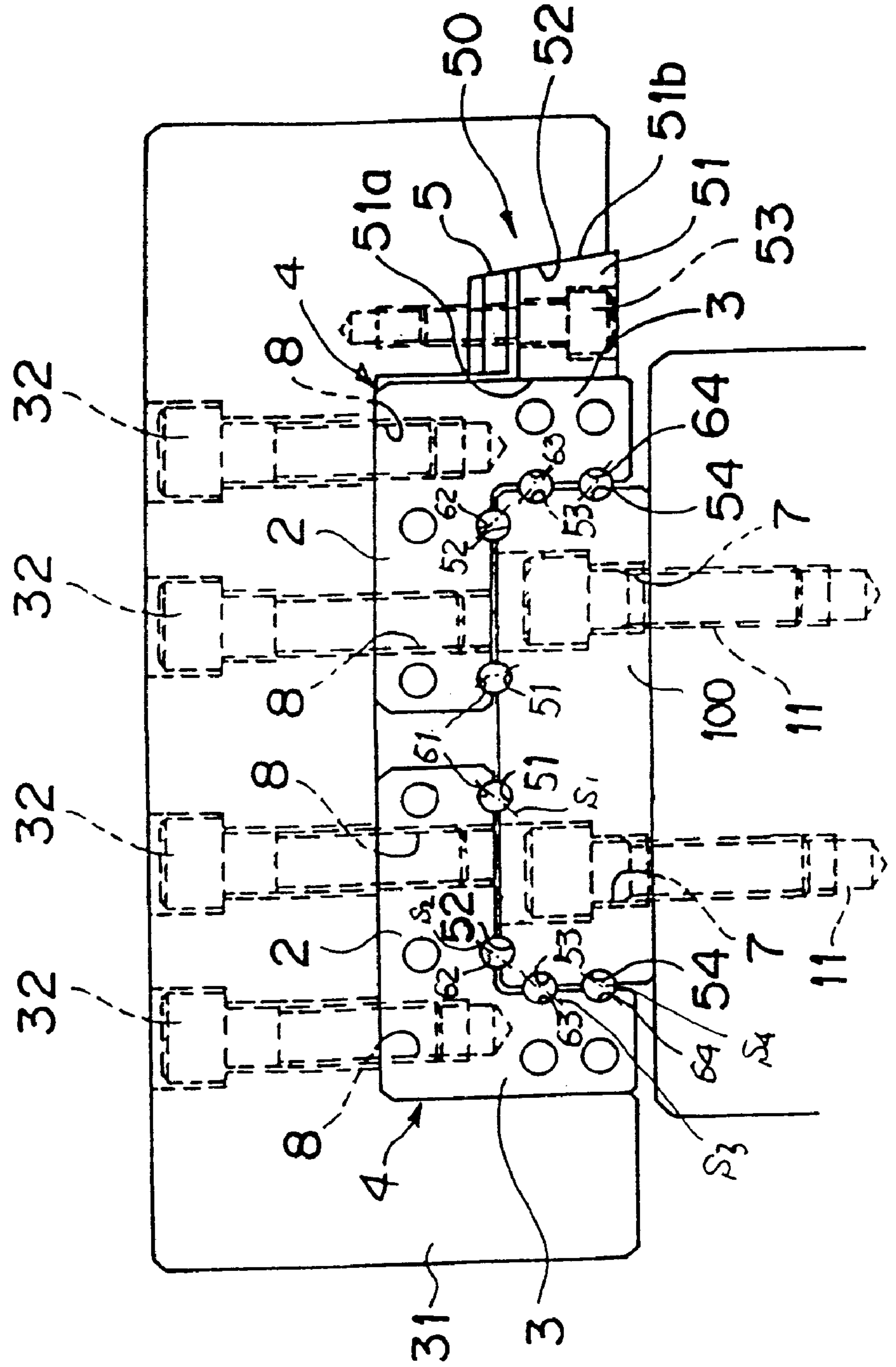


FIG. 10


50
52
51b
51
53
5
51a
4
3
8
32
64
63
62
54
53
52
2
7
32
8
51
100
11
61
51
S_1
8
32
S_2
52
2
53
54
7
11
62
63
64
S_4
32
8
S_3
4
31
3

LINEAR MOTION GUIDE UNIT AND TABLE GUIDE APPARATUS UTILIZING THE SAME

TECHNICAL FIELD

The present invention relates to a linear motion guide device using rolling balls and to a table guide device using the linear motion guide device.

BACKGROUND ART

As examples of the conventional linear motion guide device of this type, for example, the devices disclosed in Japanese Patent Laid-Open Publication No. SHO 55-46045 and No. SHO 55-46046 are well known. That is, each of the devices comprises a track rail and a movable block having an L-shape in section, and the movable block further comprises a horizontal portion opposing to an upper surface of the track rail and a suspending portion opposing to one side surface of the track rail.

Two rows of rolling balls were disposed to be rollable between two opposing surfaces of the upper surface of the track rail and the horizontal portion of the movable block, and between two opposing surfaces of the one side surface of the track rail and the suspending portion of the movable block, respectively.

The conventional linear motion guide device of this type has a following contact-angle structure. Namely, in the two rows of rolling balls provided on the upper surface of the track rail, a contact angle line constituted by a line connecting the two contact points of the rolling balls to the ball rolling grooves corresponding to the respective ball rows is set to extend toward the track rail and is formed so as to incline toward a side of the suspending portion with respect to a vertical line passing a center of the rolling ball in a case of the ball row positioned close to the suspending portion side, while the other contact angle line in a case of a ball row positioned at the other side of the suspending portion is set to extend toward the track rail and is formed so as to incline toward an opposing side of the suspending portion.

In contrast, in the pair of rolling balls provided on the side surface of the track rail, a contact angle line constituted by a line connecting the two contact points of the rolling balls to the ball rolling grooves corresponding to the respective ball rows is set to extend toward the track rail and is formed so as to incline toward a side of the horizontal portion with respect to a horizontal line passing a center of the rolling ball in a case of the ball row positioned close to a side of the horizontal portion, while the other contact angle line in a case of a ball row positioned at the other side of the horizontal portion is set to extend toward the track rail and is formed so as to incline toward an opposing side of the horizontal portion.

Due to an employment of such contact-angle structure, a load-bearing capacity against loads to be applied from various directions including vertical and horizontal directions can be enhanced. In particular, it becomes possible to increase a supporting rigidity against a moment in a direction for rotating the movable block around the track rail.

In the prior art technics described above, however, since the supporting rigidity against the moment in the direction for rotating the movable block around the track rail is high, there were posed following problems. Namely, when the movable block in a state having a working error in attaching surfaces thereof is fixed to a table and then the track rail is fixed to a fixed bed, a misalignment is caused between the track rail and the movable block and an excessive force is

applied to the track rail and the movable block, thus resulting in increasing of sliding resistance and promoting early wear of the ball rolling grooves and rolling balls per se. Such misalignment will be avoided by increasing working precision of the respective members of the device. However, the working precision has a limit itself and involves a cost increasing.

The present invention is achieved for solving the afore-mentioned problems and an object of the present invention is to provide a linear motion guide device and a table guide device using the linear motion guide device which has an automatic controllability and enables to realize a supporting structure having a high rigidity.

DISCLOSURE OF THE INVENTION

In order to achieve the afore-mentioned object, the present invention provides a linear motion guide device comprising:

a track rail having a rectangular-shape in section and at least one ball rolling groove formed respectively to an upper surface and one side surface of the track rail;

a movable block having a L-shape in section, comprising a horizontal portion provided with ball rolling grooves corresponding to ball rolling grooves formed to the upper surface of the track rail and a suspending portion provided with ball rolling grooves corresponding to ball rolling grooves formed to the one side surface of the track rail; and

a row of rolling balls disposed to be rollable between corresponding ball rolling grooves formed to the upper surface of the track rail and the horizontal portion of the movable block and between corresponding ball rolling grooves formed to the side surface of the track rail and the suspending portion of the movable block, respectively;

wherein each of the ball rolling grooves has a circular-arc-shape in section having a deep-groove shape having a groove depth set to approximately ⅓ to ½ of a diameter of the rolling ball.

According to the present invention, the movable block is formed in L-shape in section and has a supporting construction in which only the upper surface and one side surface of the track rail are supported by the horizontal portion and the suspending portion at a right angle, so that it becomes possible to increase a degree of freedom in a direction for inclining the horizontal portion and the suspending portion around a corner portion between the horizontal portion and the suspending portion. Therefore, even if the track rail and the movable block are formed with a working error or the device is formed with an error in a degree of parallelism between a mating surface to which the track rail is attached and a mating surface to which the movable block is fixed, a position of the movable block can be automatically adjusted and controlled by displacements of the contact points of the rolling balls rolling in the ball rolling grooves.

In addition, each of the ball rolling grooves is formed so as to have a deep-grooved shape. Therefore, even if the contact points of the rolling balls are displaced by the automatically controlling function, the rolling ball contacts to intermediate portions of an inner circumferential surface of the ball rolling groove, the intermediate portions being far deep positions from a side peripheral edge portion of the ball rolling groove. As a result, a load to be applied to the rolling ball can be dispersed and supported by the inner circumferential surface of the ball rolling groove, and there is no fear of edge-load being applied to the side peripheral edge portion of the ball rolling groove, thus achieving a high automatic controllability.

Further, the movable block is formed to be opened at one side thereof, so that the movable block can be subjected to a grinding work using a large-sized grinding stone to form the ball rolling grooves. In addition, even in a case of the deep-grooved type, the grinding work can be performed at a high efficiency, thus improving the productivity of the device.

Furthermore, the movable block is formed in an L-shape and has no under-cut portion, and the track rail is also formed in a simple rectangular-shape in section, so that the movable block can be easily formed by a drawing operation and the productivity can be improved.

In one aspect of this invention, there can be also provided a linear motion guide device in which a contact angle line constituted by a line connecting the two contact points of the rolling ball disposed between the corresponding ball rolling grooves formed to the horizontal portion of the movable block and the upper surface of the track rail is set to extend toward the track rail and is formed so as to incline toward a side of the suspended portion with respect to a vertical line passing a center of the rolling ball, and

a contact angle line constituted by a line connecting the two contact points of the rolling ball disposed between the corresponding ball rolling grooves formed to the suspending portion of the movable block and the side surface of the track rail is set to extend toward the track rail and is formed so as to incline toward a side of the horizontal portion with respect to a horizontal line passing a center of the rolling ball.

Due to an employment of such contact-angle structure described above, a load in a horizontal direction for moving the suspending portion close to the side surface of the track rail is supported by the rolling balls disposed at the side surface of the track rail, while a load in a horizontal direction for moving the suspending portion away from the side surface of the track rail is supported by the rolling balls disposed at the upper surface of the track rail.

Further, a load in a direction for pressing the suspending portion on to the track rail from an upper direction is supported by the rolling balls disposed at the upper surface of the track rail, while a load in a direction for lifting the suspending portion from the track rail is supported by the rolling balls disposed at the side surface of the track rail.

In another aspect of this invention, each of the upper surface and the side surface of the track rail is arranged with at least two rows of rolling balls, respectively, and the respective at least two rows of the rolling balls disposed at the upper surface and the side surface of the track rail have a contact-angle structure in which the contact angle lines of the respective rolling balls are inclined in the same direction.

According to this construction, the load bearing ability can be increased without impairing the automatic controllability.

In another aspect of this invention, the horizontal portion of the movable block may be provided with a skirt portion having a length shorter than that of the suspending portion, the skirt portion being formed at a side surface opposing to the side surface of the horizontal portion to which the suspending portion is formed, and a row of rolling balls is disposed to be rollable between corresponding a pair of ball rolling grooves formed to the skirt portion and the side surface of the track rail.

According to such construction described above, even if a load in a direction for lifting the movable block from the track rail is applied to the device, the movable block is firmly supported by not only one side surface but also both side surfaces of the track rail, so that the load bearing ability against the lifting load can be increased.

The movable block may also be constructed so as to comprise a movable block body having a loaded ball rolling groove and a ball returning passage for returning the ball in the loaded ball rolling groove from one end to the other end of the loaded ball rolling groove and side covers provided for both end portions of the movable block body, the side cover constituting a ball turning passage for changing the ball rolling direction by receiving the ball from the loaded ball rolling groove and then guiding the ball to the ball returning passage,

wherein at least one of a return passage constituting the ball returning passage structure and an inner circumferential portion constituting an inner circumferential structure of the ball turning passage is formed of a molding-shaped portion which is integrally formed to the movable block body by an insert molding method in which the mold-shaping is performed by inserting the movable block body into a shaping mold.

According to this construction, the mold-shaping operation of the movable block can be easily performed.

In another aspect of this invention, the device is characterized in that the horizontal portion of the movable block is provided with two rows of ball rolling grooves while the suspending portion is also provided with two rows of ball rolling grooves, and bolt holes for inserting attaching-bolts are formed to both central portions between the two rows of the ball rolling grooves of the horizontal portion and the suspending portion, respectively.

When the horizontal portion and the suspending portion are fastened to a table in a manner described above, the movable block is reinforced by the table, so that the rigidity of the device can be increased.

In another aspect of this invention, the device is characterized in that a plural rows of ball rolling grooves to be formed on the upper surface of the track rail are locally disposed close to one side surface side of the track rail and a bolt hole for inserting the attaching bolt is formed to a region on the upper surface of the track rail close to the other side surface side of the track rail.

As described above, when the position of the ball rolling grooves to be formed on the upper surface of the track rail is set to one side and the bolt inserting hole for fastening the track rail is formed at the other side portion, it can be possible to prevent an extraneous substance from invading into the ball rolling grooves.

On the other hand, a table guide device according to the present invention is characterized by comprising a fixed bed, a pair of linear motion guide devices arranged in parallel with the fixed bed and table to be assembled through the paired linear motion guide devices;

wherein the linear motion guide device described above is used as the linear motion guide device, the paired track rails of the paired linear motion guide devices are symmetrically disposed on the upper surface of the fixed bed so that the side surfaces of the track rails to which the ball rolling grooves are formed are faced to inside or outside to each other, the side surface of the track rail opposing to the side surface to which the ball rolling grooves are formed is set to be a reference surface for attachment, and the fixed bed is formed to have a reference wall for supporting the reference surface for attachment of the track rail.

In addition, the device is characterized in that a height of the reference wall is set to a height corresponding to that of the ball rolling groove formed to the side surface opposing to the reference surface of attachment.

According to the table guide device of this invention, a pair of right and left movable blocks are fixed to the table, so that the device, as a whole, has a structure in which the side surfaces of the right and left track rails are clamped by the suspending portions of the respective right and left movable blocks. Therefore, as a whole, the rigidity in the direction for rotating the movable blocks around the track rails is increased, and there can be realized a table guide device having a high load bearing performance against the loads in every direction including horizontal and vertical directions.

Further, even if the working errors or the like are caused to attaching surfaces of the track rails and the movable blocks, the automatic controlling function of the linear motion guide device is effected as described above, so that the misalignment between the track rail and the movable block is absorbed and automatically controlled by the displacements of the contact points of the balls rolling within the ball rolling grooves. As a result, the table can be smoothly guided.

In addition, the ball rolling grooves can be simultaneously formed by a grinding operation in a state where the two rows of track rails are fixed in parallel to each other, so that the parallel tracks and grooves having a high accuracy can be obtained.

Furthermore, when the table is provided with supporting walls for supporting rear surfaces of the suspending portions of the respective right and left movable blocks, the load in a horizontal direction applied to the table is directly transferred to the movable blocks not through the attaching bolts but through the supporting walls, and then transferred from the movable blocks to the track rails thereby to be directly supported by the reference walls of the fixed bed. Accordingly, the load in a horizontal direction would not apply from a shearing direction to the attaching bolt for fastening the movable block or the attaching bolt for fastening the track rail, so that there can be provided a table guide device with a structure having an extremely high rigidity.

In addition, the table guide device in another aspect of this invention may comprise a preload controlling mechanism provided between at least one of the supporting walls and the suspending portion of the movable block, the preload controlling mechanism is constructed in a manner that the movable block is forcibly pressed to the track rail side by utilizing the supporting wall as a supporting member so as to increase a preload of the balls disposed between the movable blocks and track rails, a reaction force applied to the supporting wall as a reaction force of the pressing force is applied to another supporting wall through the table, then a suspending portion of another movable block is pressed to another track rail by the reaction force thereby to increase the preload of the balls. When the preload controlling mechanism described above is provided to the table guide device, the supporting rigidity of the whole of the table can be increased.

In particular, when a tapered gib formed of a block body to be face-contacted to the rear surface of the suspending portion is used as the preload controlling mechanism and disposed between the supporting wall and the suspended portion of the movable block, it is possible to uniformly impart the preload to the ball rows. In addition, the rigidity between the suspending portion and the supporting wall can also be maintained to a high level.

Further, in another aspect of this invention, the linear motion guide device is characterized in that the track rail is provided with at least one ball rolling groove to be formed to the upper surface and another side surface of the track rail, respectively, and the movable block defined in claim **1** is

assembled to right and left corner portions between the upper surface and lateral side surfaces of the track rail.

That is, the linear motion guide device is characterized by comprising:

a track rail provided with at least one ball rolling groove formed to right and left half portions of an upper surface and lateral side surfaces of the track rail, respectively;

a pair of movable blocks provided on a right and a left corner portions between the upper surface and the lateral side surfaces of the track rail, each of the movable blocks having an L-shape cross section and further comprising a horizontal portion provided with a ball rolling groove corresponding to the ball rolling groove formed to the right and left half portions of the upper surface of the track rail and a suspending portion provided with a ball rolling groove corresponding to the ball rolling groove formed to the lateral side surfaces of the track rail;

a row of rolling balls disposed to be rollable between the ball rolling grooves formed to the upper surface of the track rail and the horizontal portions of the paired movable blocks; and

a row of rolling balls disposed to be rollable between the ball rolling grooves formed to the lateral side surfaces of the track rail and the suspended portions of the paired movable blocks;

wherein each of the ball rolling grooves is formed to be a deep-grooved shape having a circular-arc-shape in section, and a groove depth is set to approximately ⅓ to ½ of a diameter of the rolling ball.

In another aspect of this invention, there can be also provided a linear motion guide device in which a contact angle line constituted by a line connecting the two contact points of the rolling ball disposed between the corresponding ball rolling grooves formed to the horizontal portions of the paired movable blocks and the upper surface of the track rail is set to extend toward the track rail and is formed so as to incline toward the respective suspending portions of the paired movable blocks with respect to a vertical line passing a center of the rolling ball, and

a contact angle line constituted by a line connecting the two contact points of the rolling ball disposed between the corresponding ball rolling grooves formed to the suspending portions of the paired movable blocks and the side surfaces of the track rail is set to extend toward the track rail and is formed so as to incline toward a side of the horizontal portion of the respective movable blocks with respect to a horizontal line passing a center of the rolling ball.

Further, the linear motion guide device is characterized in that each of the ball rows disposed at the right and left half portions of the upper surface and right and left side surfaces of the track rail consists of two rows of rolling balls and the respective two rows of rolling balls have a contact angle arrangement so that the contact angle lines thereof are inclined to the same direction to each other.

Furthermore, the linear motion guide device is characterized in that the track rail is a rail having a wide width.

Furthermore, the table guide device is characterized by comprising a fixed bed and a linear motion guide device formed by combining aforementioned one track rail and the paired movable blocks, wherein the track rail of the linear motion guide device is fixed to the fixed bed and a table is fixed to the paired first and second movable blocks.

According to the arrangement described above, even in a case of assembling the table guide device, a pair of guide rails are not required and it is sufficient to prepare only one track rail, whereby an applicable range of the table guide device can be broadened. In particular, in a case where a pair of the track rails are used, the paired track rails are required to have a high attaching performance. However, the requirement for such attaching accuracy can be neglected in this case, because of using one track rail.

Further, it is preferable to use a rail having a wide width as the track rail, because the stability of the device can be improved by using such wide-width track rail. In addition, due to the wide-width track rail, the load bearing ability with respect to an angular moment around a center axis of the track rail can be increased.

The characteristics and functions of the features that the movable block is formed to provide an L-shape in section and the ball rolling groove is formed to be a deep-grooved shape have been described hereinabove.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view showing one embodiment of a linear motion guide device according to the present invention, in which FIG. **1** (*a*) is a cross sectional view of the linear motion guide device, FIG. **1** (*b*) is a side view of the linear motion guide device and FIG. **1** (*c*) is a partially sectional view showing a ball recirculating passage of the linear motion guide device.

FIG. **2** is a cross sectional view showing one embodiment of a table guide device according to the present invention in which the linear motion guide device shown in FIG. **1** is used.

FIG. **3** is a cross sectional view showing another embodiment of a table guide device according to the present invention in which the linear motion guide device shown in FIG. **1** is used.

FIG. **4** is a cross sectional view showing another embodiment of a linear motion guide device according to the present invention.

FIG. **5** is a cross sectional view showing one embodiment of a table guide device according to the present invention in which the linear motion guide device shown in FIG. **4** is used.

FIG. **6** is a cross sectional view showing further embodiment of a linear motion guide device according to the present invention.

FIG. **7** is a cross sectional view showing one embodiment of a table guide device according to the present invention in which the linear motion guide device shown in FIG. **6** is used.

FIG. **8** is a cross sectional view showing still further embodiment of a linear motion guide device according to the present invention.

FIG. **9** is a cross sectional view showing one embodiment of a table guide device according to the present invention in which the linear motion guide device shown in FIG. **8** is used.

FIG. **10** is a cross sectional view showing one embodiment of a table guide device according to the present invention in which still further embodiment of the linear motion guide device is used.

BEST MODE FOR EMBODYING THE INVENTION

In order to explain the present invention in more detail, the preferred embodiments of the invention will be be described hereunder with reference to the accompanying drawings.

FIG. **1** is a view showing a first embodiment of a linear motion guide device according to the present invention. The linear motion guide device comprises a track rail **1** having a rectangular shape in section, a movable block **4** having an L-shape in section, the movable block **4** further comprising a horizontal portion **2** opposing to an upper surface of the track rail **1** and a suspending portion **3** opposing to one side surface of the track rail **1** and ball rows B**1**, B**2**, B**3** and B**4** each consisting of two rows of a number of rolling balls disposed to be rollable between the upper surface of the track rail **1** and the horizontal portion **2** of the movable block **4** and between the side surface of the track rail **1** and the suspending portion **3**.

The track rail **1** is formed to provide a rectangular shape in section so that each of upper and lower surfaces and lateral right and left side surfaces of the track rail **1** has a plain surface. Two rows of ball rolling grooves **51** to **54** are formed to the upper surface and one side surface of the track rail **1**, respectively. The ball rolling grooves **51** and **52** formed to the upper surface are provided at portions close to the lateral right and left end portions so as to be symmetric with respect to a center of the track rail **1**. At the center portion of the track rail **1**, there is formed a bolt inserting hole **7** for inserting an attaching bolt for fixing the track rail **1** so as to vertically pass through the track rail **1**. Ball rolling grooves **53** and **54** are also formed to the side surface of the track rail **1** so as to be symmetric in vertical direction. An interval of adjacent ball rolling grooves **53** and **54** formed to the side surface of the track rail **1** is smaller than that of the ball rolling grooves **51** and **52** formed to the upper surface of the track rail **1**.

At a lower surface of the horizontal portion **2** of the movable block **4** is provided with two rows of ball rolling grooves **61** and **62** corresponding to the ball rolling grooves **51** and **52** formed to the track rail **1**, while the suspending portion **3** is provided with two rows of ball rolling grooves **63** and **64** corresponding to the ball rolling grooves **53** and **54** formed to the one side surface of the track rail **1**. A bolt hole **8** for fixing the movable block **4** is respectively formed to a portion between the two rows of ball rolling grooves **61** and **62** of the horizontal portion **2** and at an upper portion of the suspending portion **3**.

Each of the ball rolling grooves **51**–**54** and **61**–**64** of the track rail **1** and the movable block **4** has a circular-arc shape in section and formed to provide a deep-grooved shape having a groove depth of approximately ⅓ to ½ of a diameter of the rolling ball.

In addition, each of the contact angle lines S**1** and S**2** each constituted by a line connecting two contact points of the ball rows B**1** and B**2** disposed between the corresponding ball rolling grooves **51**, **61**; **52**, **62** formed to the horizontal portion **2** of the movable block **4** and the upper surface of the track rail **1** is set to extend toward the track rail **1** and is formed so as to incline toward a side of the suspending portion **3** with respect to a vertical line V passing a center of the rolling ball. When the ball diameter of the respective ball rows B**1** and B**2** is set to a large diameter larger than a distance between the two contact points of the rolling ball which contacts to the respective ball rolling grooves, a preload can be imparted to the rolling balls of the respective ball rows B**1** and B**2**.

On the other hand, each of the contact angle lines S**3** and S**4** each constituted by a line connecting the two contact points of the ball rows B**3** and B**4** disposed between the corresponding ball rolling grooves **53**, **63**; **54**, **64** formed to the suspending portion **3** of the movable block **4** and the side surface of the track rail **1** is set to extend toward the track rail **1** and is formed so as to incline toward a side of the horizontal portion **2** of the movable block **4** with respect to a horizontal line H passing a center of the rolling ball. Further, in this case, when the ball diameter of the respective ball rows B3 and B4 is set to a diameter larger than a distance between the two contact points of the rolling ball which contacts to the respective ball rolling grooves **53**, **63**; **54**, **64**, a preload can be imparted to the rolling ball of the respective ball rows B1 and B2.

The movable block **4** comprises a movable block body **41** having loaded ball rolling grooves **61**–**64** and ball return passages **71**–**74** for returning the balls from one end to the other end of the loaded ball rolling grooves **61**–**64** and side covers **42** and **42** provided at both end portions of the movable block body **41**, each of the side covers **42** and **42** constituting ball rolling direction turning passages **81**–**84** for receiving the ball B from the loaded ball rolling grooves **61**–**64** and then guiding the ball B to the ball return passages **71**–**74**.

In addition, at least one of return passage members **71***a*–**74***a* constituting the ball return passages **71**–**74** and an inner circumferential portion member **81***b*–**84***b* constituting inner peripheral guide portions **81***a*–**84***a* of the ball rolling direction turning passages **81**–**84** is formed of a molding-shaped portion which is integrally formed with the movable block body **41** by an insert-molding method in which the mold-shaping operation is performed by inserting the movable block body **41** into a shaping mold.

Under certain circumstances, there may be a case where a ball retainer (not shown) is provided at a side peripheral portion of the loaded ball rolling grooves **61**–**64** so as to prevent the ball B from dropping off from the movable block **4** when the movable block **4** is detached from the track rail **1**. In this case, the ball retainer may also be integrally formed with the movable block body **41** together with the inner peripheral guide portion members **81***b*–**84***b* and the ball returning passage members **71***a*–**74***a*.

According to the present invention, a load FXR in the horizontal direction for moving the suspending portion **3** close to the side surface of the track rail **1** is born by the two rows of rolling balls B3 and B4 disposed at the side surface of the track rail **1**, while a load FXL in a horizontal direction for moving the suspending portion **3** away from the side surface of the track rail **1** is born by the two rows of rolling balls B1 and B2 disposed at the upper surface of the track rail.

Further, a load FYD in the vertical direction for pressing the movable block **4** onto the upper surface of the the track rail **1** from an upper direction is born by the two rows of rolling balls B1 and B2 disposed at the upper surface of the track rail **1**, while a load FYU in the vertical direction for lifting the movable block **4** from the track rail **1** is born by the two rows of rolling balls B3 and B4 disposed at the side surface of the track rail **1**. Accordingly, the loads in four directions can be born by one movable block **4**.

On the other hand, the movable block **4** is formed to have a load bearing construction in which the upper surface and the one side surface of the track rail **1** are born by the horizontal portion **2** and the suspending portion **3** of the movable block **4** at a right angle, and both of the contact angle lines S1 and S2 of the two rows of rolling balls B1 and B2 disposed at the upper surface are formed to extend toward the track rail **1** and to incline toward a side of the suspending portion **3** with respect to a vertical line V, while both of the contact angle lines S3 and S4 of the two rows of the rolling balls B3 and B4 disposed at the side surface are are formed to extend toward the track rail **1** and to incline toward a side of the horizontal portion **2** with respect to a horizontal line H. Therefore, the rigidity in the direction for rotating the movable block **4** around a center axis of the track rail **1** is small.

Accordingly, even if the track rail **1** and the movable block **4** are formed with a working error or the device is formed with an angular error between a mating surface to which the track rail **1** is attached and a mating surface to which the movable block **4** is fixed, a position of the movable block **4** can be automatically controlled by displacements of the contact points of the rolling balls B rolling in the ball rolling grooves **51**–**54** and **61**–**64**.

In addition, each of the ball rolling grooves **51**–**54** and **61**–**64** is formed so as to have a deep-groove shape. Therefore, even if the contact points of the rolling balls B are displaced by the automatically controlling function, the rolling balls B1–B4 contact to intermediate portions of an inner circumferential surface of the ball rolling grooves **51**–**54** and **61**–**64**, the intermediate portions being far deep positions from a side peripheral edge portions of the ball rolling grooves **51**–**54** and **61**–**64**. As a result, a load to be applied to the rolling ball B can be dispersed and born by the inner circumferential surface of the ball rolling grooves **51**–**54** and **61**–**64**, and there is no fear of the ball contacting to the side peripheral edge portion of the ball rolling grooves **51**–**54** and **61**–**64**, thus achieving a high automatic controllability.

Further, the movable block **4** is formed to be opened at one side thereof, so that the movable block **4** can be subjected to a grinding work using a large-sized grinding stone to form the ball rolling grooves **61**–**64**. In addition, even in a case of the deep-groove type, the grinding work can be performed at a high efficiency, thus improving the productivity of the device.

Furthermore, the movable block **4** is formed in an L-shape in section and has no under-cut portion, and the track rail **1** is also formed in a simple rectangular-shape in section, so that the movable block **4** can be easily formed by a drawing operation, thus improving the productivity.

FIG. **2** is a view showing a table guide device in which aforementioned linear motion guide device is used.

This table guide device comprises a fixed bed **20**, a pair of linear motion guide devices **10** and **10** arranged in parallel with the fixed bed **20** and a table **30** to be assembled through the paired linear motion guide devices **10** and **10**.

The linear motion guide device described above is used as the linear motion guide devices **10** and **10** and a pair of track rails **1** and **1** of the paired linear motion guide devices **10** and **10** are symmetrically arranged on the upper surface of the fixed bed **20** so that the side surfaces of the track rails **1** and **1** to which the ball rolling grooves **53** and **54** are formed are faced to outside to each other. The side surfaces of the respective track rails **1** and **1** opposing to the side surfaces, to which the ball rolling grooves **53** and **54** are formed, are set as reference surfaces **56** and **56** for attachment, and the fixed bed **20** is formed with a pair of parallel reference walls **21** and **21** for supporting the reference surfaces **56** and **56** for attaching the track rails **1** and **1**. Each of heights of the reference walls **21** and **21** is set to a height corresponding to that of the ball rolling grooves **53** and **54** formed to the side surfaces opposing to the reference surfaces **56** and **56** for attachment. Accordingly, the reference surfaces **56** and **56** for attaching the track rails **1** and **1** can be set to an almost the same height of the movable block **4**, thus assembling the table structure in sufficiently small size.

According to the table guide device of the present invention, a pair of right and left movable blocks **4** and **4** are fixed to the table **30**, so that the device as a whole has a structure in which the side surfaces of the right and left track rails **1** and **1** are clamped by the suspending portions **3** and **3** of the respective right and left movable blocks **4** and **4**. Therefore, as a whole, the rigidity in the direction for rotating the movable blocks **4** and **4** around the track rails **1** and **1** is increased. As a result, there can be realized a table guide device having a high load bearing performance against the loads in every direction including horizontal and vertical directions.

Further, even if there is caused a working error or the like to attaching surfaces of the track rail **1** and the movable block **4**, the automatic controlling function of the linear motion guide device is effected as described above, so that the misalignment between the track rail **1** and the movable block **4** is absorbed and automatically controlled by the displacements of the contact points of the balls B rolling within the ball rolling grooves **51–54** and **61–64**. As a result, the table **30** can be smoothly guided.

In addition, the ball rolling grooves **51–54** can be simultaneously formed by a grinding operation in a state where the two rows of track rails **1** and **1** are fixed in parallel to each other, so that the parallel tracks having a high accuracy can be obtained.

Furthermore, the table **30** is provided with supporting walls **31** and **31** for supporting rear surfaces of the suspending portions **3** and **3** of the respective right and left movable blocks **4** and **4**. The supporting walls **31** and **31** support the respective suspending portions **3** and **3** in an entire range corresponding to a height of the suspending portion **3**, and are constructed so as to oppose to the reference wall **21** of the fixed bed **20** through the suspending portions **3**, **3** and the track rails **1**, **1** in the horizontal direction at the same height as that of the reference wall **21**.

Since the supporting wall **31** is provided, the load in a horizontal direction applied to the table **30** is directly transferred to the movable block **4** not through the attaching bolt **32** but through the supporting wall **31**, and then transferred from the movable blocks **4**, **4** to the track rails **1**, **1** thereby to be directly supported by the reference wall **21** of the fixed bed **20**. Accordingly, the load in a horizontal direction would not apply from a shearing direction to the attaching bolt **32** for fastening the movable block **4** or the attaching bolt **11** for fastening the track rail **1**, so that there can be provided a table guide device with a construction having an extremely high rigidity.

In addition, the suspending portion **3** of the movable block **4** is reinforced by the supporting wall **31**, so that a bending deformation of the suspending portion **3** due to a moment load can be sufficiently prevented.

On the other hand, the table guide device is provided with a preload controlling mechanism installed between one side of the supporting wall **31** of the table **20** and the suspending portion **3** of the movable block **4**, the preload controlling mechanism being constructed in a manner that the movable block **4** is forcibly pressed to a side of the track rail **1** by utilizing the supporting wall **31** as a supporting member so as to increase a preload to be applied to the ball rows B**3** and B**4** disposed between the movable block **4** and track rail **1**, a reaction force applied to the supporting wall **31** as a reaction force of the pressing force is applied to another supporting wall **31** through the table **30**, and then a suspending portion **3** of another movable block **4** is pressed to another track rail **1** by the reaction force thereby to increase the preload of the ball rows B**3** and B**4**.

As the preload controlling mechanism described above, various constructions will be applicable. In this embodiment, a tapered gib **51** composed of a block body face-contacting to a rear surface of the suspending portion **3** is provided between the supporting wall **31** of the table **30** and the suspending portion **3** of the movable body **4**.

That is, the preload controlling mechanism **50** comprises the tapered gib **51**, a tapered groove **52** having a tapered surface into which the tapered gib **51** is inserted and a bolt **53** for fixing the tapered gib **51**. The tapered gib **51** is composed of the block body having a high rigidity, one side surface thereof is formed to be a plain vertical surface **51***a* face-contacting to the rear surface of the suspending portion **3** of the movable block **4**, while the other side surface thereof is formed to be a tapered surface **51***b* of which width decreases along an upper direction as viewed. In contrast, the tapered groove **52** provided to the supporting wall **31** of the table **30** is formed to have an inclined surface against which the tapered surface **51***b* of the tapered gib **51** abuts.

When the tapered gib **51** face-contacting to the suspending portion **3** is used, it becomes possible to uniformly impart the preload to the ball rows B**3** and B**4**. In addition, the rigidity between the suspended portion **3** and the supporting wall **31** can also be maintained to a high level.

In this regard, in the embodiment of the table guide device described above, the paired linear motion guide devices are arranged so that the suspending portions **3** and **3** of the respective movable blocks are positioned outside the track rails **1** and **1**. However, as shown in FIG. **3**, the paired linear motion guide devices can also be arranged so that the suspending portions **3** and **3** of the paired movable blocks **4** and **4** are positioned inside the track rails **1** and **1**, this arrangement being reverse to that of the embodiment described above.

In this case, the reference wall **21** of the fixed bed **20** is positioned outside the respective track rails **1** and **1**, while the supporting wall **31** of the table **30** is formed inside of the respective movable blocks **4** and **4**. In addition, the preload controlling mechanism **50** is also provided inside the movable blocks **4** and **4**.

OTHER EMBODIMENTS

FIGS. **4–9** show the other embodiments of the linear motion guide device and the table guide device using the linear motion guide device according to the present invention.

Further, in the following explanations, only the points different from those of the above embodiment will be explained. Namely, detailed explanations regarding to the same constitutional elements or parts as those in the embodiment will be omitted by adding the same reference numerals to the corresponding elements or parts.

In the embodiment of the linear motion guide device shown in FIG. **4**, the horizontal portion **2** of the movable block **4** is provided with two rows of ball rolling grooves **61** and **62** while the suspending portion **3** is also provided with two rows of ball rolling grooves **63** and **64**, and bolt holes **2***a* and **3***a* for inserting attaching-bolts are provided at corresponding central portions between the two rows of the ball rolling grooves **61** and **62** of the horizontal portion **2** and the suspending portion **3**, respectively.

FIG. **5** shows a construction of a table guide device to which the linear motion guide device of this type is applied so that the suspending portions **3** and **3** of the paired right and left movable blocks **4** and **4** are positioned inside the track rails **1** and **1**. As like this case, when the horizontal portion **2** and the suspending portion **3** are fastened to the table **30**, the movable block **4** is reinforced by the table **30**, so that the rigidity of the device can be increased.

As a matter of course, it is also possible to adopt a construction in which the suspending portion **3** of the movable block **4** is positioned outside the track rail **1**.

FIG. **6** shows a construction of a linear motion guide device in which a plurality rows of the ball rolling grooves **61** and **62** to be formed to the upper surface of the track rail **1** are collectively positioned at the upper surface close to the one side surface to which the ball rolling grooves **63** and **64** are formed, and a bolt hole **8** for inserting the attaching bolt is formed at a region on the upper surface close to the other side surface of the track rail **1**.

As like this manner, when the positions of the ball rolling grooves **61** and **62** are arranged to one side of the upper surface of the track rail **1** and the bolt hole **8** for fastening the track rail **1** is formed at the other side portion, it becomes possible to prevent an extraneous substance from invading into the ball rolling grooves **61** and **62**.

FIG. **7** shows a structure of a table guide device to which the linear motion guide device of this type is applied so that the suspending portions **3** and **3** of the paired right and left movable blocks **4** and **4** are positioned inside the track rails **1** and **1**. As a matter of course, the suspending portions **3** and **3** of the movable blocks **4** and **4** can be also positioned outside the track rail **1**.

FIG. **8** shows a structure of a linear motion guide device in which the horizontal portion **2** of the movable block **4** is provided with a skirt portion **13** having a length shorter than that of the suspending portion **3**, the skirt portion **13** being formed at a side surface opposing to the side surface of the horizontal portion to which the suspending portion **3** is formed, and a row of rolling balls B**5** is disposed to be rollable between corresponding a pair of ball rolling grooves **55** and **65** formed to the skirt portion **13** and the side surface of the track rail **1**.

According to such structure described above, even if a load in a direction for lifting the movable block **4** from the track rail **1** is applied to the device, the movable block **4** is firmly born by not only one side surface but also both side surfaces of the track rail **1**, so that the load bearing ability against the lifting load can be increased.

FIG. **9** shows a construction of a table guide device to which the linear motion guide device of this type is applied so that the suspending portions **3** and **3** of the paired right and left movable blocks **4** and **4** are positioned inside of the track rails **1** and **1**. As a matter of course, the suspending portions **3** and **3** of the movable blocks **4** and **4** can be also positioned outside of the track rail **1**.

FIG. **10** shows a construction of a table guide device in which the paired track rails of the linear motion guide devices shown in FIG. **2** are replaced with a track rail **100** having a wide width. It is to be noted that the structure of the movable block **4** is substantially the same as that of the movable block **4** shown in FIG. **1**, so that the detailed structure of the device shall be referred to FIG. **1** and corresponding explanations, if necessary. In such case, the explanations shall be read upon replacing the term "track rail **1**" with "track rail **100**".

That is, the device is constructed by comprising a track rail **100** having a wide width and rectangular shape in section to which at least one row of ball rolling groove, i.e., two rows of ball rolling grooves in this case as shown in FIG. **10**, are formed at right and left half portions of the upper surface and the right and left side surfaces of the track rail **100** and a pair of movable blocks **4** and **4** to be assembled to both right and left corner portions of the track rail **100**.

That is, the linear motion guide device comprises:

a track rail provided with at least one ball rolling groove, i.e., a pair of two rows of ball rolling grooves **51**, **52**, **53** and **54** formed to the right and left half portions of the upper surface and the right and left side surfaces of the track rail **100** having a wide width, respectively;

a pair of movable blocks **4** and **4** provided on right and left corner portions between the upper surface and the right and left side surfaces of the track rail **100**, each of the movable blocks **4** and **4** having an L-shaped cross section and further comprising a horizontal portion **2** provided with ball rolling grooves **61** and **62** corresponding to the ball rolling grooves **51** and **52** formed to the right and left half portions of the upper surface of the track rail **100** and a suspending portion **3** provided with ball rolling grooves **63** and **64** corresponding to the ball rolling grooves **53** and **54** formed to the right and left side surfaces of the track rail **100**;

rows of rolling balls B**1** and B**2** disposed to be rollable between the upper surface of the track rail **100** and the ball rolling grooves **51** and **64** formed to the horizontal portions **2** and **2** of the paired movable blocks **4** and **4**; and

rows of rolling balls B**3** and B**4** disposed to be rollable between the right and left side surfaces of the track rail **100** and the ball rolling grooves **54** and **64** formed to the suspending portions **3** and **3** of the paired movable blocks **4** and **4**.

In addition, each of the ball rolling grooves **51**, **61**; **52**, **62**; **53**, **63**; **54**, **64** is formed to provide a deep-grooved shape having a circular-arc-shape in section, and a groove depth is set to approximately ⅓ to ½ of a diameter of the rolling ball.

In addition, each of the contact angle lines S**1** and S**2** each constituted by a line connecting the two contact points of the rolling ball disposed between the corresponding ball rolling grooves **51**, **61**; **52**, **62** formed to the horizontal portions **2** and **2** of the paired movable blocks **4** and **4** and the upper surface of the track rail **100** is set to extend toward the track rail **100** and is formed so as to incline toward a side of the respective suspending portions **3** and **3** of the paired movable blocks **4** and **4** with respect to a vertical line V passing a center of the rolling ball, while each of the contact angle lines S**3** and S**4** each constituted by a line connecting the two contact points of the rolling balls B**3** and B**4** disposed between the corresponding ball rolling grooves **53**, **63**; **54**, **64** formed to the suspending portions **3** and **3** of the paired movable blocks **4** and **4**, and the side surfaces of the track rail **100** is set to extend toward the track rail **100** and is formed so as to incline toward a side of the horizontal portion **2** of the respective movable blocks **4** and **4** with respect to a horizontal line H passing a center of the rolling ball.

Further, each of the right and left half portions of the upper surface and the right and left side surfaces of the track rail **100** is provided with two rows of ball rows B**1**, B**2**; B**3**, B**4** which has a contact angle arrangement so that the contact angle lines thereof are inclined to the same direction to each other.

In addition, bolt holes **8** and **8** for inserting attaching-bolts are provided at corresponding central portions between the two rows of the ball rolling grooves **61** and **62** of the horizontal portions **2** and **2**, and the bolt holes **8** and **8** are also provided at base portions of the suspending portions **3** and **3**, respectively.

As described above, the structure of the movable blocks **4** and **4** is substantially the same as that of the movable block **4** shown in FIG. **1**, and the movable blocks **4** and **4** can be subjected to a grinding work using a large-sized grinding stone with a high efficiency to form the deep-groove type ball rolling grooves **61–64**.

In addition, the track rail **100** is fixed to the fixed bed **20**, and the the table **30** is fixed to the paired movable blocks **4** and **4**. The track rail **100** is a rail having a wide width thereby to increase the stability of the device.

Further, due to an employment of the track rail **100** having wide width, the load bearing ability with respect to an angular moment around a center axis of the track rail **100** can be increased.

Furthermore, even in a case of assembling the table guide device, a pair of guide rails are not required and it is sufficient to prepare only one track rail **100**, whereby an applicable range of the table guide device can be broadened. In particular, in a case where a pair of the track rails are used, the paired track rails are required to have a high attaching performance. However, the requirement for such attaching accuracy can be neglected in this case because of using one track rail.

Further, in a case where such paired movable blocks **4** and **4** are assembled to one track rail **100**, as a matter of course, the movable block shown in FIGS. **4** and **6** will also be applicable to the device as the movable blocks **4**.

According to the present invention as described above, the movable block is formed in an L-shape in section and has a load bearing structure in which only the upper surface and one side surface of the track rail are supported by the horizontal portion and the suspending portion at a right angle, so that it becomes possible to increase a degree of freedom in a direction for inclining the horizontal portion and the suspending portion around a corner portion between the horizontal portion and the suspending portion. Therefore, even if the track rail and the movable block are formed with a working error or the device is formed with an error in a degree of parallelism between a mating surface to which the track rail is attached and a mating surface to which the movable block is fixed, a position of the movable block can be automatically controlled or adjusted by displacing the contact points of the rolling balls rolling in the ball rolling grooves.

In addition, each of the ball rolling grooves is formed so as to have a deep-grooved shape. Therefore, even if the contact points of the rolling balls are displaced by the automatically controlling function, the rolling balls will contact to intermediate portions of an inner circumferential surface of the ball rolling groove, the intermediate portions being far deep positions from a side peripheral edge portion of the ball rolling groove. As a result, a load to be applied to the rolling ball can be dispersed and supported by the inner circumferential surface of the ball rolling groove, and there is no fear of edge-load being applied to the side peripheral corner portion of the ball rolling groove, thus achieving a high automatic controllability.

Further, the movable block is formed to be opened at one side thereof, so that the movable block can be subjected to a grinding work using a large-sized grinding stone to form the ball rolling grooves. In addition, even in a case of the deep-groove type, the grinding work can be performed at a high efficiency, thus improving the productivity of the device.

Furthermore, the movable block is formed in an L-shape and has no under-cut portion, and the track rail is also formed in a simple rectangular-shape in section, so that the movable block can be easily formed by a drawing operation and the productivity can be improved.

On the other hand, a contacting direction of the ball row disposed at the ball rolling grooves formed to the upper surface of the track rail is set to extend toward the track rail and is formed so as to incline toward a side of the suspending portion of the movable block with respect to a vertical line passing a center of the rolling ball, while a contact direction of the ball row disposed at the side surface of the track rail is set to extend toward the track rail and is formed so as to incline toward a side of the horizontal portion of the movable block with respect to a horizontal line passing a center of the rolling ball. Due to the structure described above, a load to be applied in four directions can be born by a single movable block.

In addition, when each of the upper surface and the side surface of the track rail is arranged with at least two rows of rolling balls respectively and at least two rows of the rolling balls arranged at the upper surface and the side surface of the track rail have a contact-angle structure in which the contact angle lines of the respective rolling balls are inclined in the same direction, the load bearing ability can be increased without impairing the automatic controllability between the track rail and the movable block.

In addition, when at least one of a return passage constituting the ball returning passage structure and an inner circumference guide portion constituting an inner circumferential guide structure of the ball rolling direction turning passage is formed of a molding-shaped portion which is integrally formed to the movable block body by an insert molding method in which the mold-shaping operation is performed by inserting the movable block body into a shaping mold, the mold-shaping of the movable block can be easily performed.

In addition, when the horizontal portion and the suspended portion are fastened to a table, the movable block is reinforced by the table, so that the rigidity of the device can be increased.

Further, when the position of the ball rolling grooves to be formed on the upper surface of the track rail is arranged to one side portion and the bolt inserting hole for fastening the track rail is formed at the other side portion, it can be possible to prevent an extraneous substance from invading into the ball rolling grooves.

Furthermore, when the horizontal portion of the movable block is provided with a skirt portion having a length shorter than that of the suspending portion, the skirt portion being formed at a side surface opposing to the side surface of the horizontal portion to which the suspending portion is formed, and a row of rolling balls are disposed to be rollable between corresponding a pair of ball rolling grooves formed to the skirt portion and the side surface of the track rail, even if a load in a direction for lifting the movable block from the track rail is applied to the device, the movable block is firmly supported by not only one side surface but also both side surfaces of the track rail, so that the load bearing ability against the lifting load can be increased.

On the other hand, according to the table guide device of this invention, a pair of right and left movable blocks are fixed to the table, so that the device as a whole has a construction in which the side surfaces of the right and left track rails are clamped by the suspended portions of the respective right and left movable blocks. Therefore, as a whole, the rigidity in the direction for rotating the movable blocks around the track rails is increased, and there can be realized a table guide device having a high load bearing performance against the loads in every direction including the horizontal and vertical directions.

Further, even if there are working errors or the like to attaching surfaces of the track rails and the movable blocks, the automatic controlling function of the linear motion guide device is effected as described above, so that the misalignment between the track rail and the movable block is absorbed and automatically controlled by the displacements of the contact points of the balls rolling within the ball rolling grooves. As a result, the table can be smoothly guided.

In addition, the ball rolling grooves can be simultaneously formed by a grinding operation in a state where the two rows of track rails are fixed in parallel to each other, so that the parallel tracks and grooves having a high accuracy can be obtained.

Furthermore, when the table is provided with supporting walls for supporting rear surfaces of the suspending portions of the respective right and left movable blocks, the load in a horizontal direction applied to the table is directly transferred to the movable blocks not through the attaching bolts but through the supporting walls, and then the load is transferred from the movable blocks to the track rails thereby to be directly supported by the reference walls of the fixed bed. Accordingly, the load in a horizontal direction would not apply from a shearing direction to the attaching bolt for fastening the movable block or the attaching bolt for fastening the track rail, so that there can be provided a table guide device with a structure having an extremely high rigidity.

In addition, a preload controlling mechanism is provided between at least one of the supporting walls and the suspending portion of the movable block, the preload controlling mechanism being constructed in a manner that the movable block is forcibly pressed to a side of the track rail by utilizing the supporting wall as a supporting member so as to increase a preload of the balls disposed between the movable blocks and track rails, a reaction force applied to the supporting wall as a reaction force of the pressing force is applied to another supporting wall through the table, then a suspending portion of another movable block is pressed to another track rail by the reaction force, thereby to increase the preload of the balls. When the preload controlling mechanism described above is provided for the table guide device, the supporting rigidity of the whole table can be increased.

In particular, when a tapered gib formed of a block body face-contacting to the rear surface of the suspending portion is used as the preload controlling mechanism and disposed between the supporting wall and the suspending portion of the movable block, it is possible to uniformly impart the preload to the ball rows. In addition, the rigidity between the suspending portion and the supporting wall can also be maintained to a high level.

INDUSTRIAL APPLICABILITY

As described above, the linear motion guide device and the table guide device using the linear motion guide device according to the present invention are valuable as a linear guide mechanism for various industrial equipments such as machine tool, inspection instrument, robot operating system or the like.

What is claimed is:

1. A linear motion guide device comprising:

a track rail having a rectangular-shape in section and at least one ball rolling groove formed to both an upper surface and one side surface of the track rail, respectively;

a movable block having an L-shape in section, comprising a horizontal portion provided with ball rolling grooves corresponding to ball rolling grooves formed to the upper surface of the track rail and a suspending portion provided with ball rolling grooves corresponding to ball rolling grooves formed to the one side surface of the track rail; and

a row of rolling balls disposed to be rollable between corresponding ball rolling grooves formed to the upper surface of the track rail and the horizontal portion of the movable block and between corresponding ball rolling grooves formed to the side surface of the track rail and the suspending portion of the movable block, respectively;

wherein each of the ball rolling grooves has a circular-arc-shape in section having a deep-groove shape having a groove depth of approximately ⅓ to ½ of a diameter of the rolling ball.

2. A linear motion guide device according to claim **1**, wherein a contact angle line constituted by a line connecting two contact points of the rolling ball disposed between the corresponding ball rolling grooves formed to the horizontal portion of the movable block and the upper surface of the track rail is set to extend toward the track rail and is formed so as to incline toward a side of the suspended portion with respect to a vertical line passing a center of the rolling ball, and

a contact angle line constituted by a line connecting the two contact points of the rolling ball disposed between the corresponding ball rolling grooves formed to the suspending portion of the movable block and the side surface of the track rail is set to extend toward the track rail and is formed so as to incline toward a side of the horizontal portion with respect to a horizontal line passing a center of the rolling ball.

3. A linear motion guide device according to claim **2**, wherein said upper surface and the side surface of the track rail are arranged with at least two rows of rolling balls respectively, and said at least two rows of the rolling balls disposed at the upper surface and the side surface of the track rail have a contact-angle structure in which the contact angle lines of the respective rolling balls are inclined in the same direction.

4. A linear motion guide device according to claim **3**, wherein said horizontal portion of the movable block is provided with a skirt portion having a length shorter than that of the suspending portion, the skirt portion being formed at a side surface opposing to the side surface of the horizontal portion to which the suspending portion is formed, and a row of rolling balls is disposed to be rollable between a pair of ball rolling grooves formed to the opposing surfaces of the skirt portion and the side surface of the track rail.

5. A linear motion guide device according to any one of claims **1**, **2** and **3**, wherein said movable block comprise a movable block body having a loaded ball rolling groove and a ball returning passage for returning the ball in the loaded ball rolling groove from one end to the other end of the loaded ball rolling groove and side covers provided for both end portions of the movable block body, the side cover constituting a ball turning passage for changing a ball rolling direction by receiving the rolling ball from the loaded ball rolling groove and then guiding the rolling ball to the ball returning passage,

wherein at least one of a ball returning passage constituting the ball returning passage structure and an inner circumferential portion constituting an inner circumferential structure of the ball turning passage is formed of a molding-shaped portion which is integrally formed to the movable block body by an insert molding method in which the mold-shaping operation is performed by inserting the movable block body into a shaping mold.

6. A linear motion guide device according to any one of claims **1**, **2**, **3** and **4**, wherein said horizontal portion of the movable block is provided with two rows of ball rolling grooves while said suspending portion is also provided with two rows of ball rolling grooves, and bolt holes for inserting attaching-bolts are formed to both central portions between said two rows of the ball rolling grooves of the horizontal portion and the suspending portion, respectively.

7. A linear motion guide device according to any one of claims **1**, **2**, **3** and **4**, wherein said plural rows of ball rolling grooves to be formed on the upper surface of the track rail are locally disposed to one side surface side of the track rail and a bolt hole for inserting the attaching bolt is formed in a region on the upper surface of the track rail close to the other side surface of the track rail.

8. A table guide device comprising a fixed bed, a pair of linear motion guide devices arranged in parallel with the fixed bed and a table to be assembled through said paired linear motion guide devices,

wherein each of said linear motion guide devices comprises: a track rail having a rectangular-shape in section and at least one ball rolling groove formed to both an upper surface and one side surface of the track rail to be fixed to said fixed bed; a movable block having an L-shape in section, comprising a horizontal portion provided with ball rolling grooves corresponding to ball rolling grooves formed to the upper surface of the track rail and a suspending portion provided with ball rolling grooves corresponding to ball rolling grooves formed to the one side surface of the track rail; and a row of rolling balls disposed to be rollable between corresponding ball rolling grooves formed to the upper surface of the track rail and the horizontal portion of the movable block and between corresponding ball rolling grooves formed to the side surface of the track rail and the suspended portion of the movable block, respectively, in which each of said ball rolling grooves has a circular-arc-shape in section having a deep-groove shape having a groove depth of approximately ⅓ to ½ of a diameter of the rolling ball; and

wherein said paired track rails of said paired linear motion guide devices are symmetrically disposed on the upper surface of said fixed bed so that the side surfaces of the track rails to which the ball rolling grooves are formed are faced to inside or outside to each other, said side surface of the track rail opposing to the side surface to which the ball rolling grooves are formed is set to be a reference surface for attachment, and said fixed bed is provided with a reference wall for supporting said reference surface for attachment of the track rail.

9. A table guide device according to claim **8**, wherein said reference wall is formed so as to have a height corresponding to a height of said ball rolling groove formed to the side surface opposing to the reference surface for attachment.

10. A table guide device according to claim **8**, wherein a contact angle line constituted by a line connecting two contact points of said rolling ball disposed between the corresponding ball rolling grooves formed to the horizontal portion of said movable block and the upper surface of said track rail is set to extend toward the track rail and is formed so as to incline toward a side of the suspended portion of the movable block with respect to a vertical line passing a center of the rolling ball, and

a contact angle line constituted by a line connecting the two contact points of the rolling ball disposed between the corresponding ball rolling grooves formed to the suspending portion of the movable block and the side surface of the track rail is set to extend toward the track rail and is formed so as to incline toward a side of the horizontal portion of the movable block with respect to a horizontal line passing a center of the rolling ball.

11. A table guide device according to any one of claims **8**, **9** and **10** wherein said table is provided with supporting walls for supporting rear surfaces of said suspending portions of the respective right and left movable blocks.

12. A table guide device according to claim **11**, wherein said table guide device further comprises a preload controlling mechanism provided between at least one of said supporting walls and said suspending portion of the movable block, the preload controlling mechanism being constructed in a manner that the movable block is forcibly pressed to a side of the track rail by utilizing the supporting wall as a supporting member so as to increase a preload of the balls disposed between the movable blocks and track rails, a reaction force applied to the supporting wall as a reaction force of the pressing force is applied to another supporting wall through the table, then a suspending portion of another movable block is pressed to another track rail by the reaction force thereby to increase the preload of the balls.

13. A table guide device according to claim **12**, wherein said preload controlling mechanism is disposed between said supporting wall and said suspending portion of the movable block and is composed of a tapered gib formed of a block body face-contacting to a rear surface of said suspending portion.

14. A table guide device according to claim **8**, wherein each of said upper surface and said side surface of the track rail is provided with at least two rows of rolling balls, and the respective two rows or more of rolling balls formed to the upper surface and the side surface of said track rail have a contact angle arrangement so that the contact angle lines thereof are inclined to the same direction to each other.

15. A table guide device according to claim **8**, wherein said horizontal portion of the movable block is provided with a skirt portion having a length shorter than that of the suspending portion, said skirt portion being formed at a side surface opposing to the side surface of said horizontal portion to which the suspending portion is formed, and a row of rolling balls is disposed to be rollable between corresponding a pair of ball rolling grooves formed to said skirt portion and the side surface of the track rail.

16. A linear motion guide device comprising:

a track rail provided with at least one ball rolling groove formed respectively to right and left half portions of an upper surface and lateral right and left side surfaces of said track rail;

a pair of movable blocks provided on right and left corner portions between the upper surface and lateral side surfaces of said track rail, each of said movable blocks having an L-shaped cross section and further comprising a horizontal portion provided with ball rolling grooves corresponding to the ball rolling grooves formed to the right and left half portions of the upper surface of said track rail and a suspending portion provided with ball rolling grooves corresponding to the ball rolling grooves formed to said lateral side surfaces of the track rail;

a row of rolling balls disposed to be rollable between the ball rolling grooves formed to the upper surface of said track rail and the horizontal portions of the paired movable blocks and between the ball rolling grooves formed to the lateral side surfaces of the track rail and the suspending portions of the paired movable blocks;

wherein each of said ball rolling grooves is formed to be a deep-grooved shape having a circular-arc-shape in section, and a groove depth is set to approximately ⅓ to ½ of a diameter of the rolling ball.

17. A linear motion guide device according to claim **16**, wherein a contact angle line constituted by a line connecting two contact points of the rolling ball disposed between the corresponding ball rolling grooves formed to the horizontal portions of the paired movable blocks and the upper surface of the track rail is set to extend toward the track rail and is formed so as to incline toward a side of the respective suspending portions of the paired movable blocks with respect to a vertical line passing a center of the rolling ball, and

a contact angle line constituted by a line connecting two contact points of the rolling ball disposed between the corresponding ball rolling grooves formed to the suspending portions of the paired movable blocks and the side surface of the track rail is set to extend toward the track rail and is formed so as to incline toward a side of the horizontal portion of the respective movable blocks with respect to a horizontal line passing a center of the rolling ball.

18. A linear motion guide device according to claim **17**, wherein each of right and left half portions of said upper surface and said lateral right and left side surfaces of the track rail is provided with at least two rows of rolling balls, and the respective two rows or more of rolling balls formed to said upper surface and the lateral side surfaces of said track rail have a contact angle arrangement so that the contact angle lines thereof are inclined to the same direction to each other.

19. A linear motion guide device according to any one of claims **16**, **17** and **18**, wherein said track rail is a rail having a wide width.

20. A table guide device comprising a fixed bed to which a track rail of a linear motion guide device according to any one of claims **16** to **18** having a first and a second movable blocks is fixed and a table fixed to the first and second movable blocks.

* * * * *

US006196138B1

(12) **United States Patent**
Sakai et al.

(10) **Patent No.: US 6,196,138 B1**
(45) **Date of Patent: Mar. 6, 2001**

(54) **MOVABLE TABLE UNIT**

(75) Inventors: **Junichi Sakai**; **Yoichi Fukasawa**; **Satoru Okamura**, all of Tokyo (JP)

(73) Assignee: **THK Co., LTD**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/291,379**

(22) Filed: **Apr. 14, 1999**

(30) **Foreign Application Priority Data**

Apr. 15, 1998 (JP) 10-105181

(51) **Int. Cl.**[7] **A47B 85/00**

(52) **U.S. Cl.** **108/22**; 108/140; 108/143; 74/490.08

(58) **Field of Search** 108/22, 20, 137, 108/139, 140, 143; 74/490.08

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,155,383 * 11/1964 Whitmore 108/143
4,729,536 * 3/1988 Scala .... 108/143 X
4,988,261 * 1/1991 Blatt .... 108/143 X
4,993,673 * 2/1991 Hirose .... 108/143 X
5,117,761 * 6/1992 Kasai et al. 108/22
5,323,712 * 6/1994 Kikuiri .... 74/490.08 X
5,456,134 * 10/1995 Bouwer et al. .... 108/143 X
5,481,936 * 1/1996 Yanagisawa 74/490.08
5,804,932 * 9/1998 Yanagisawa .... 108/143 X
5,980,192 * 11/1999 Arai .... 108/143 X

FOREIGN PATENT DOCUMENTS

62-282294 12/1987 (JP) .
1-240246 9/1989 (JP) .
1-242989 9/1989 (JP) .
0024032 * 1/1990 (JP) 108/143
2-202031 8/1990 (JP) .
3-56895 3/1991 (JP) .
4-2435 1/1992 (JP) .
4-210347 7/1992 (JP) .
4-354637 12/1992 (JP) .
5-77125 3/1993 (JP) .
6-31563 2/1994 (JP) .
406117513 * 4/1994 (JP) 108/140
7-219636 8/1995 (JP) .
8-99243 4/1996 (JP) .
2515316 8/1996 (JP) .
8-211173 8/1996 (JP) .
8-252733 10/1996 (JP) .
9-42405 2/1997 (JP) .
9-155666 6/1997 (JP) .
9-216138 8/1997 (JP) .

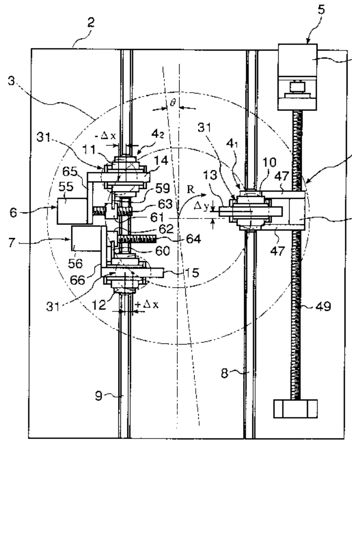
* cited by examiner

Primary Examiner—Peter M. Cuomo
Assistant Examiner—Hanh V. Tran
(74) *Attorney, Agent, or Firm*—Arent Fox Kintner Plotkin & Kahn, PLLC

(57) **ABSTRACT**

A movable table unit capable of carrying out an operation for rotating a movable table at a position other than an original point and an operation for moving it in parallel after rotating at a predetermined angle by a simple control, capable of moving the rotation center linearly along two axes easily, and further moving the movable table largely along a single axis, is provided. The movable table unit for achieving this object comprises a table base plate, a movable table supported movably on the table base plate, a plurality of moving members joined to a bottom surface of the movable table, a plurality of two-axis guiding systems for guiding each of the moving members along two axes intersecting with each other on the table base plate and for guiding largely along an axis, rotation systems for supporting the movable table or moving members rotatably relative to each of the two-axis guiding systems and a plurality of driving systems for moving each of the moving members selectively along any one of the two axial directions so as to provide the movable table with a linear motion along the two axes and for providing the movable table with a rotation motion around an axis perpendicular to the table base plate.

5 Claims, 13 Drawing Sheets



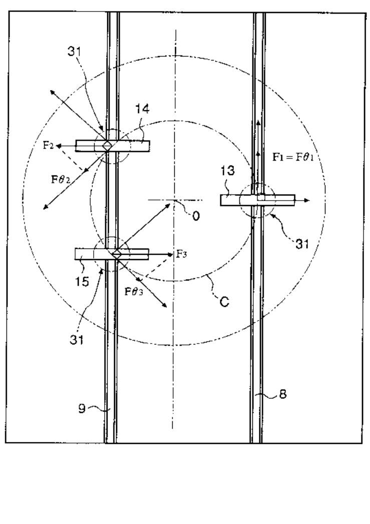
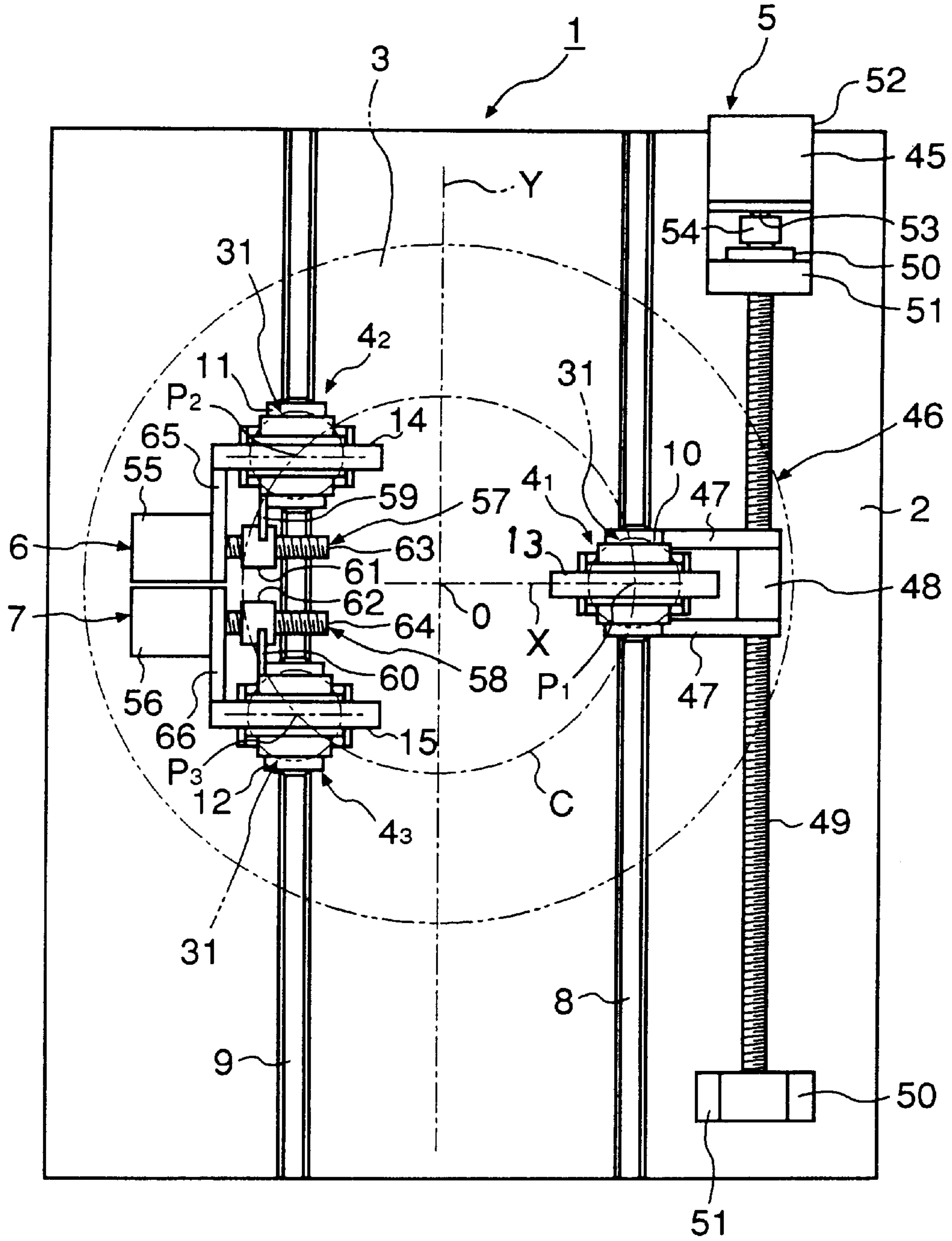


Fig 1


1
3
5
52
45
Y
54
53
50
51
31
4_2
11
P_2
14
65
55
31
46
10
4_1
47
2
59
57
6
63
13
61
48
62
7
64
0
X
60
58
P_1
47
56
66
15
P_3
12
C
4_3
49
31
8
9
50
51

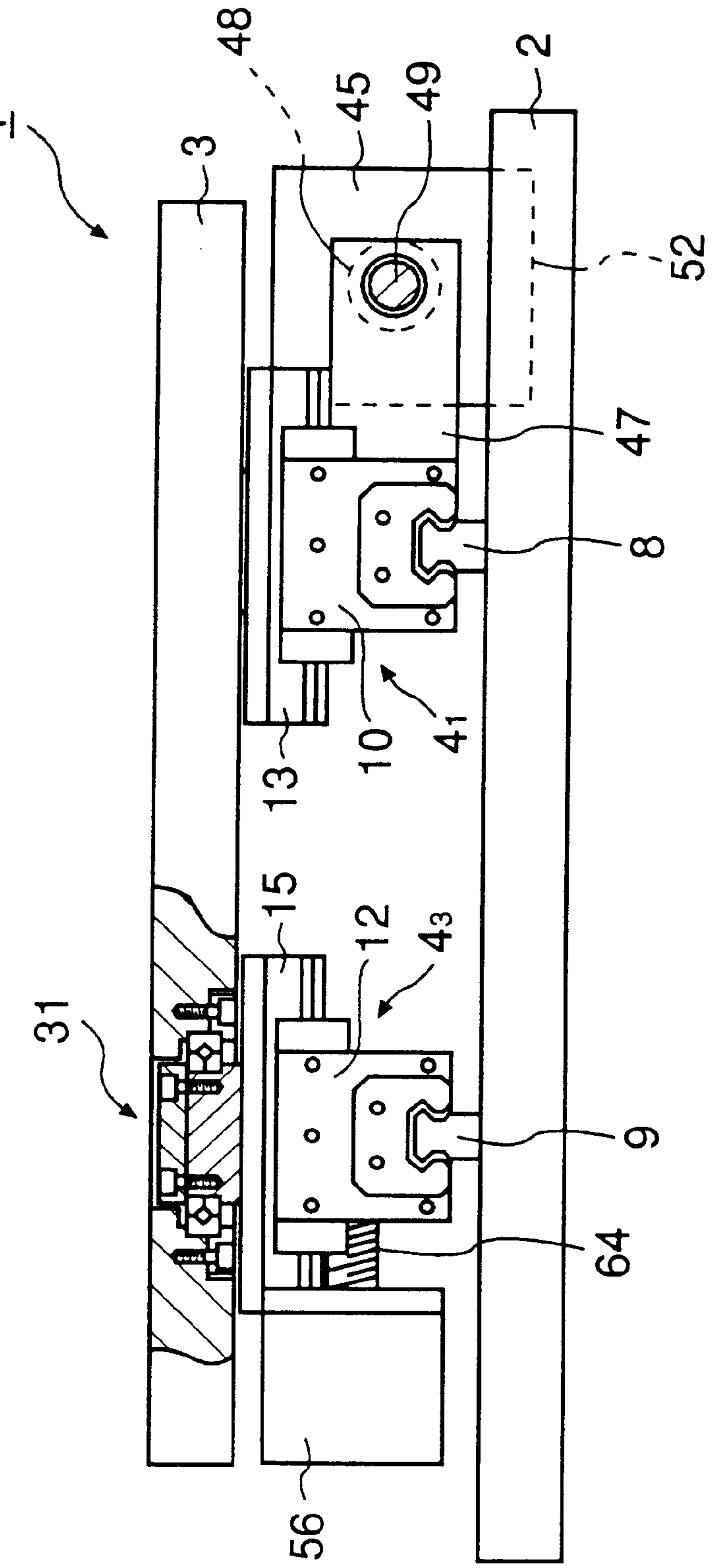


Fig 2

Fig. 3

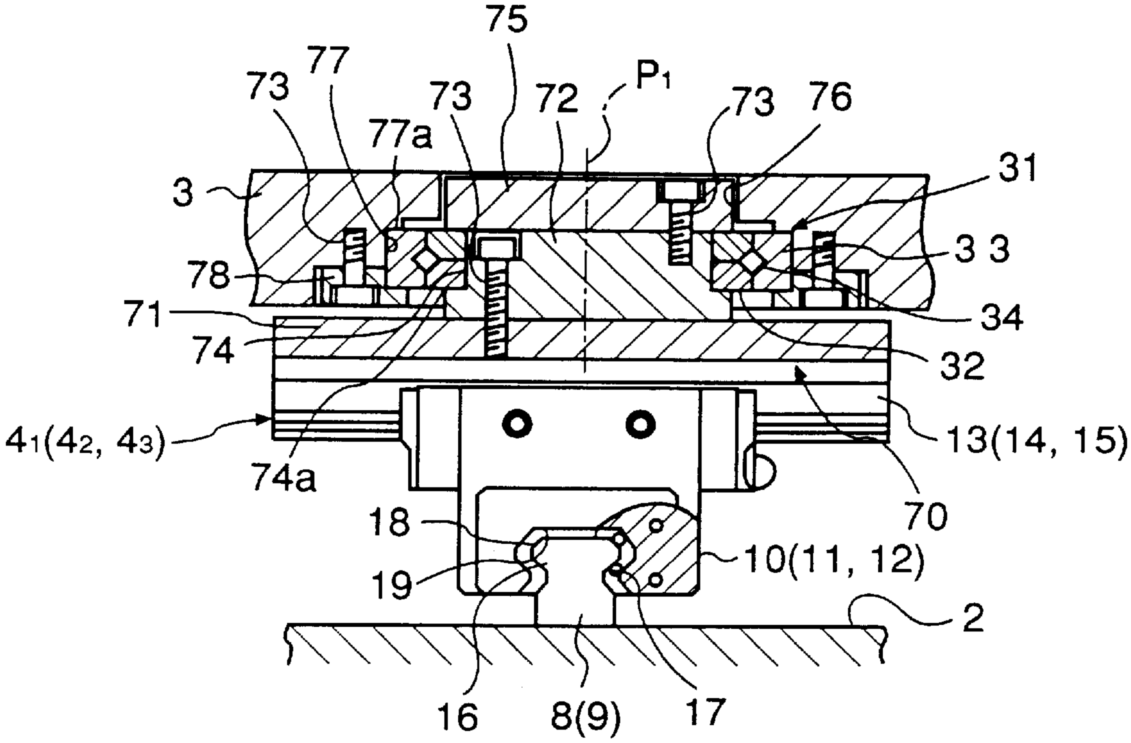

75
P1
77
73
73
72
73
76
77a
31
3
33
78
34
71
74
32
41(42, 43)
13(14, 15)
74a
70
18
10(11, 12)
19
2
16
8(9)
17

Fig. 4

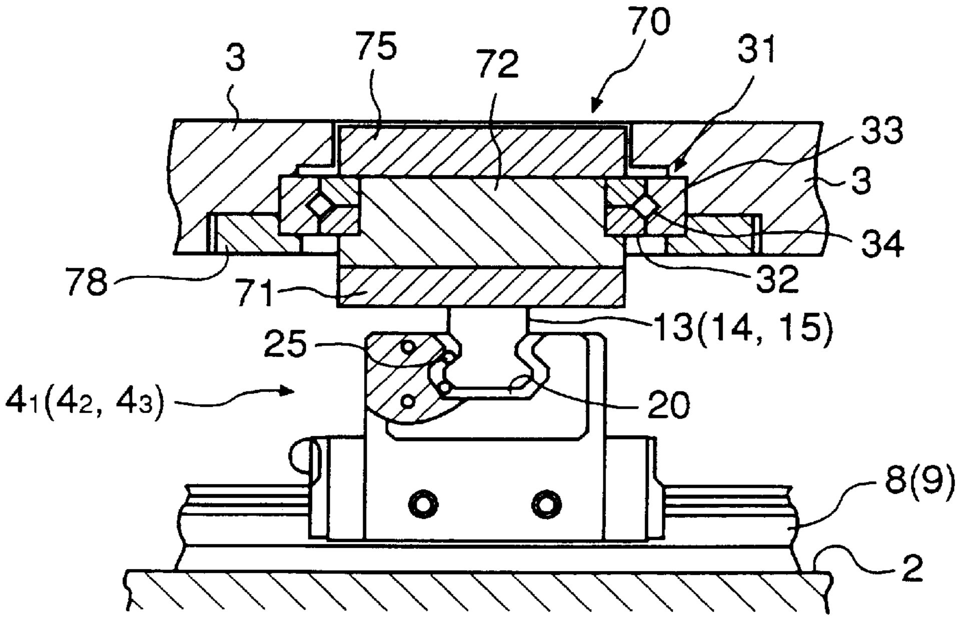
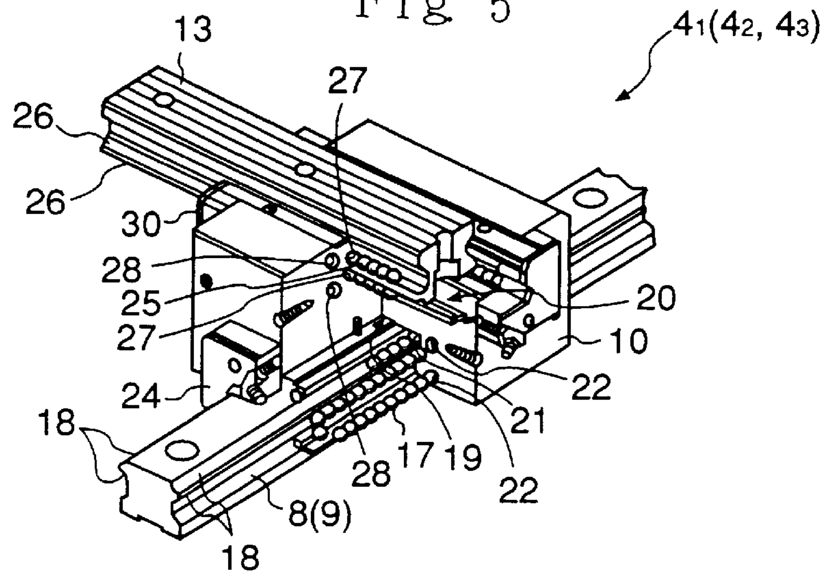

70
3
75
72
31
33
3
34
78
32
71
13(14, 15)
25
41(42, 43)
20
8(9)
2

Fig 5



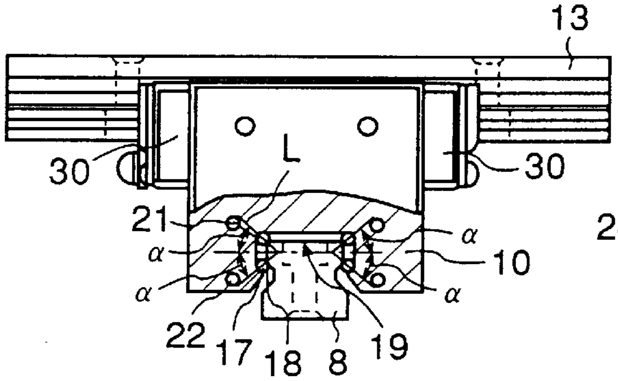


Fig 6

Fig 7

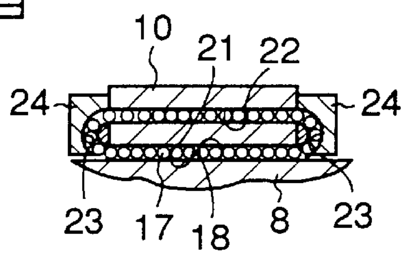


Fig 8

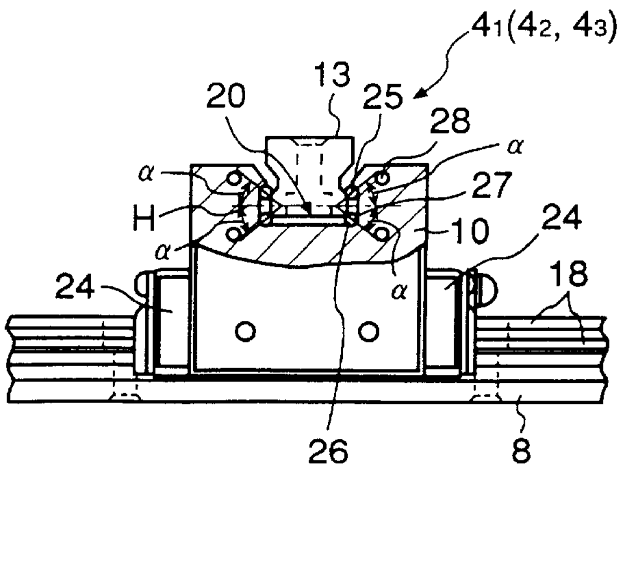


Fig 9

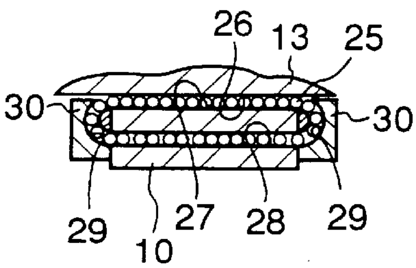


Fig 10

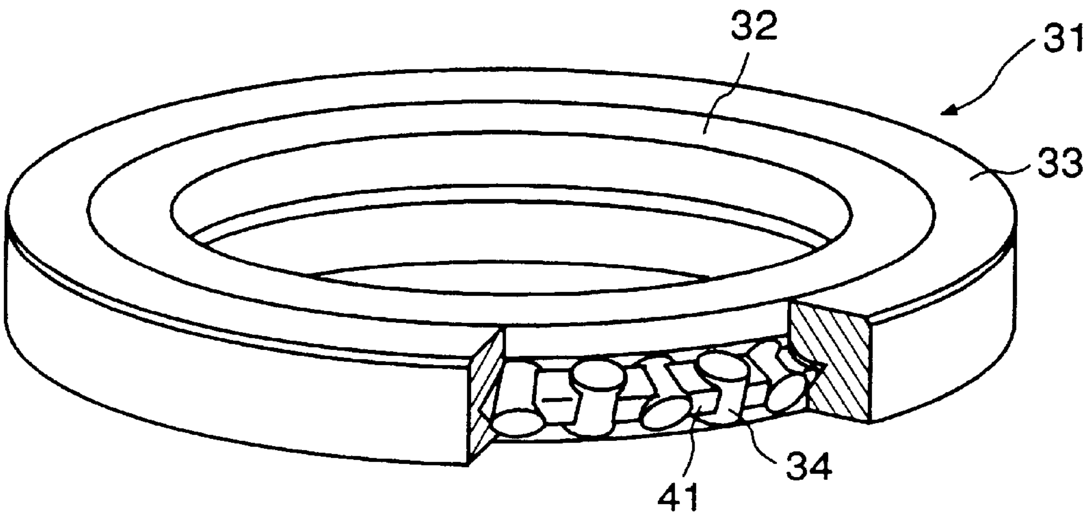

32
31
33
34
41

Fig 11

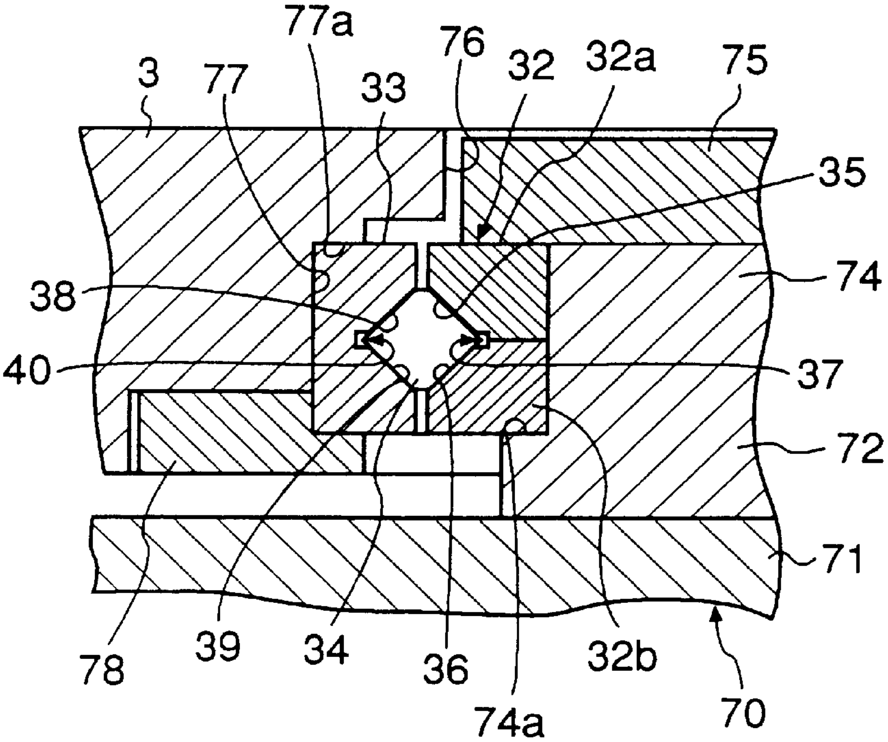

77a
3
77
33
76
32
32a
75
35
74
38
40
37
72
71
78
39
34
36
32b
74a
70

Fig 12

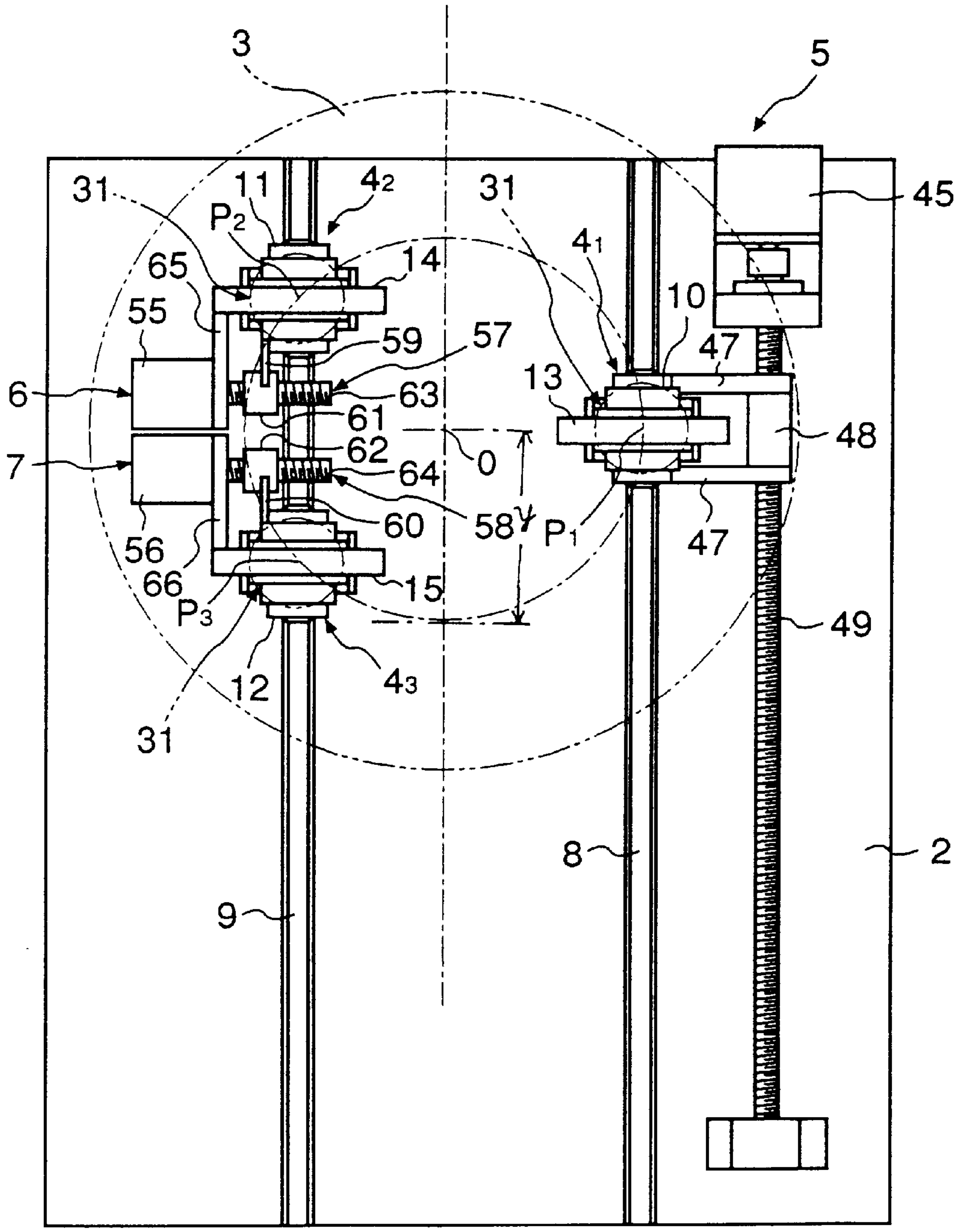
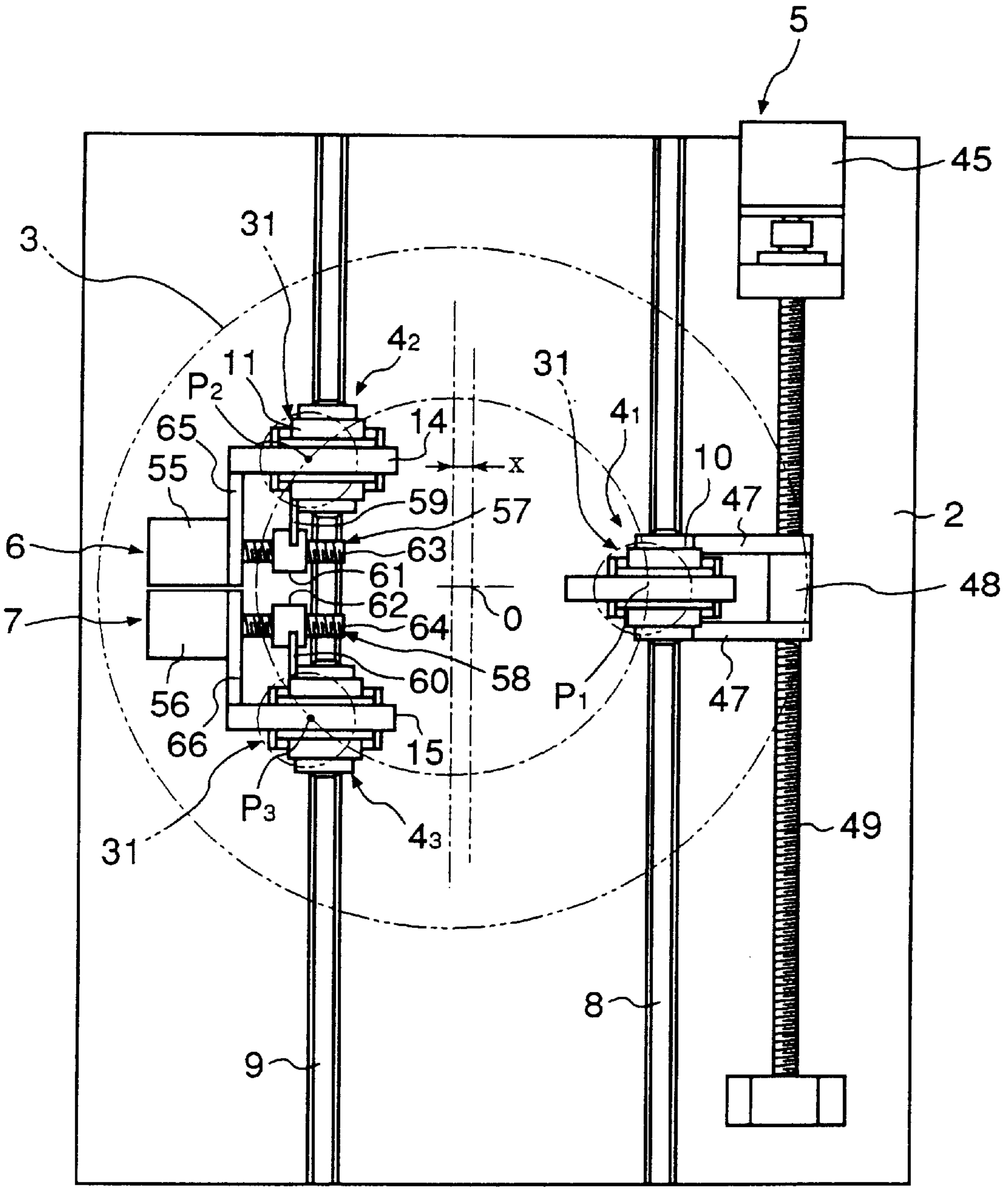

3
5
45
31
11
4_2
P_2
31
4_1
65
14
10
55
59
57
47
13
6
63
61
48
62
0
7
64
58
P_1
60
47
56
66
15
P_3
49
12
4_3
31
8
2
9

Fig 13



5
45
3
31
4_2
11
P_2
65
14
x
55
31
4_1
10
47
2
59
57
6
63
61
48
0
62
7
64
60
58
P_1
47
56
66
15
P_3
4_3
31
49
8
9

Fig 14

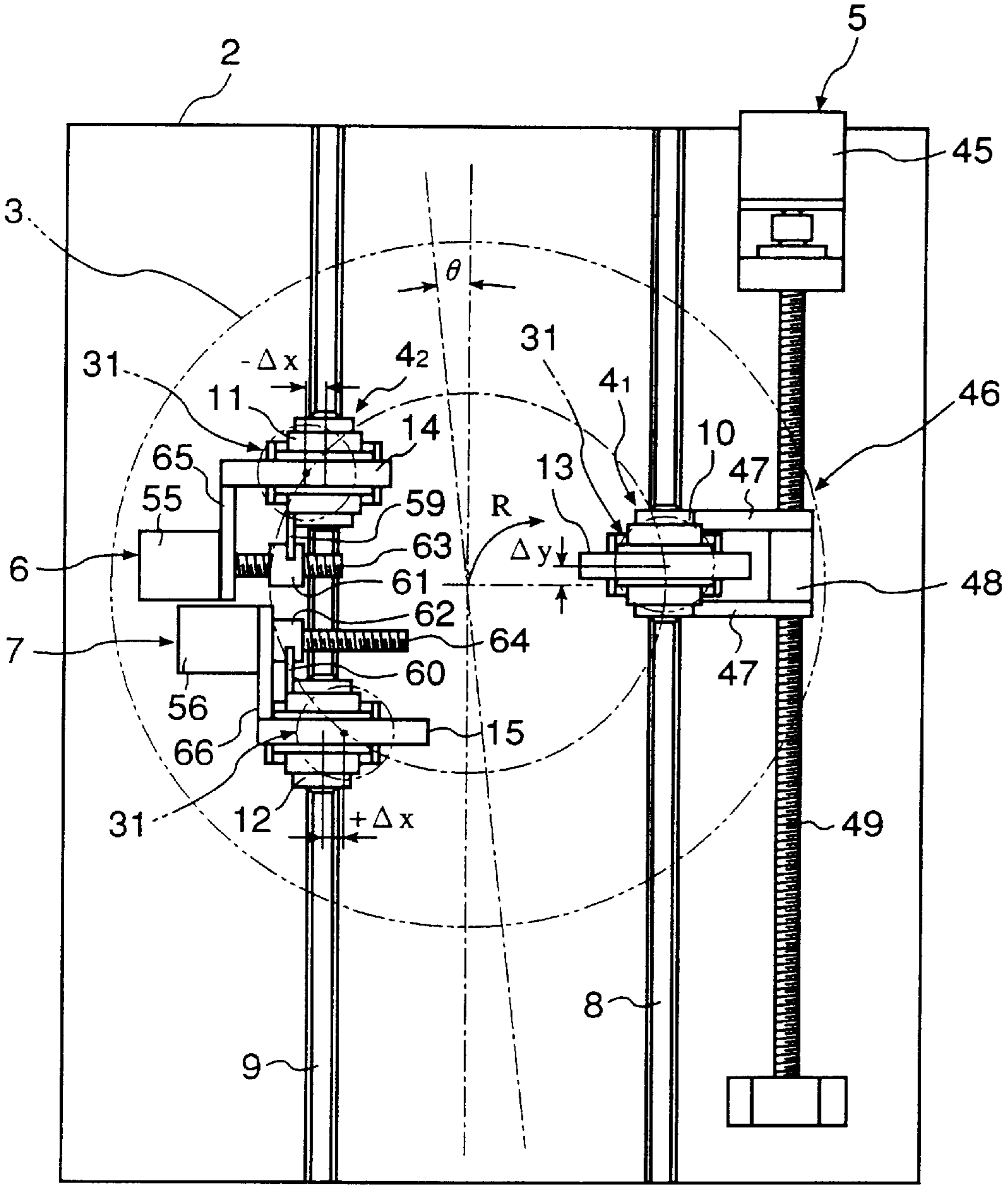

2
3
5
45
46
47
48
49
31
11
4_2
14
65
55
6
7
56
66
12
$-\Delta x$
$+\Delta x$
θ
59
63
61
62
64
60
15
R
13
4_1
10
Δy
8
9

Fig 15

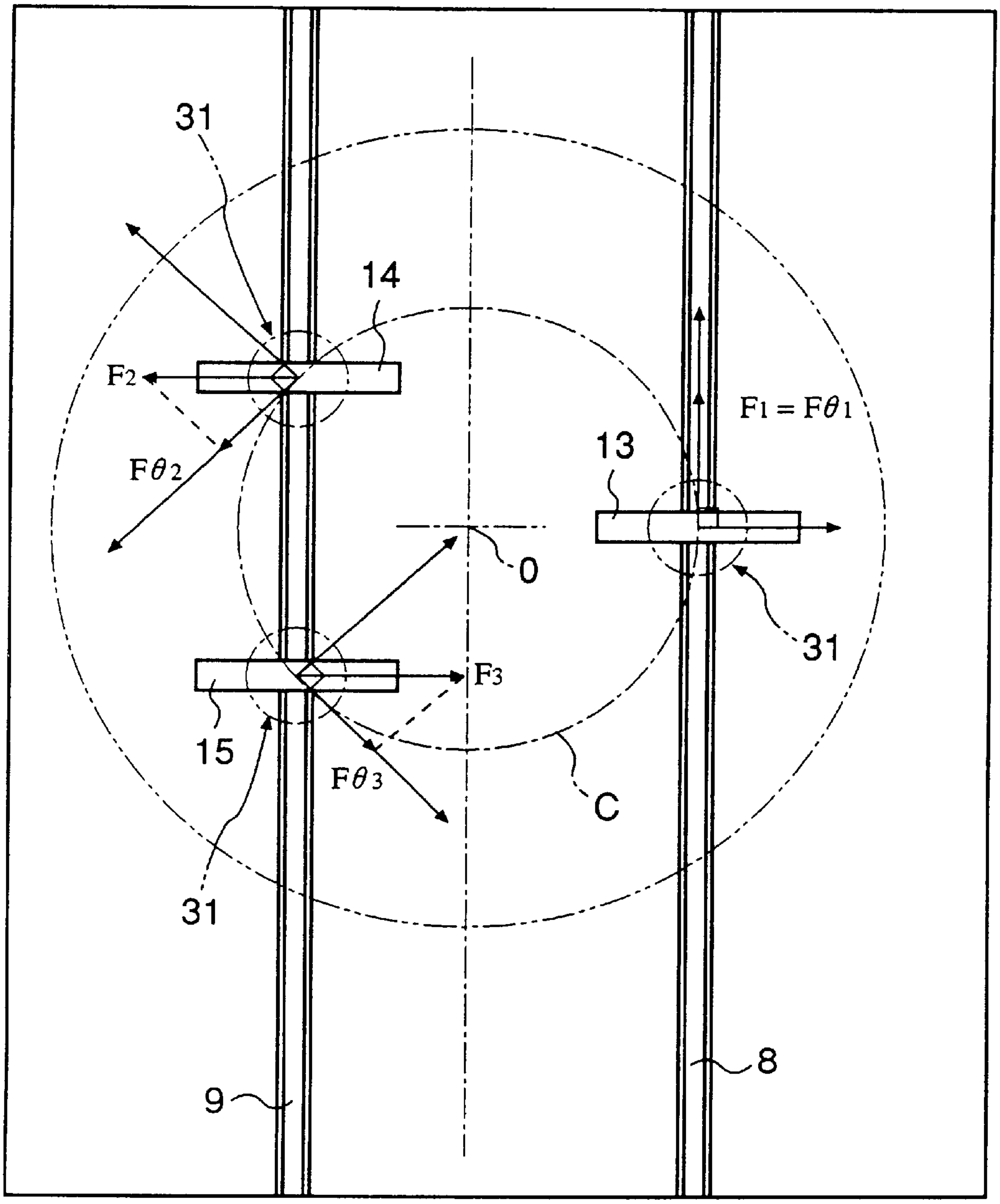


Fig 16

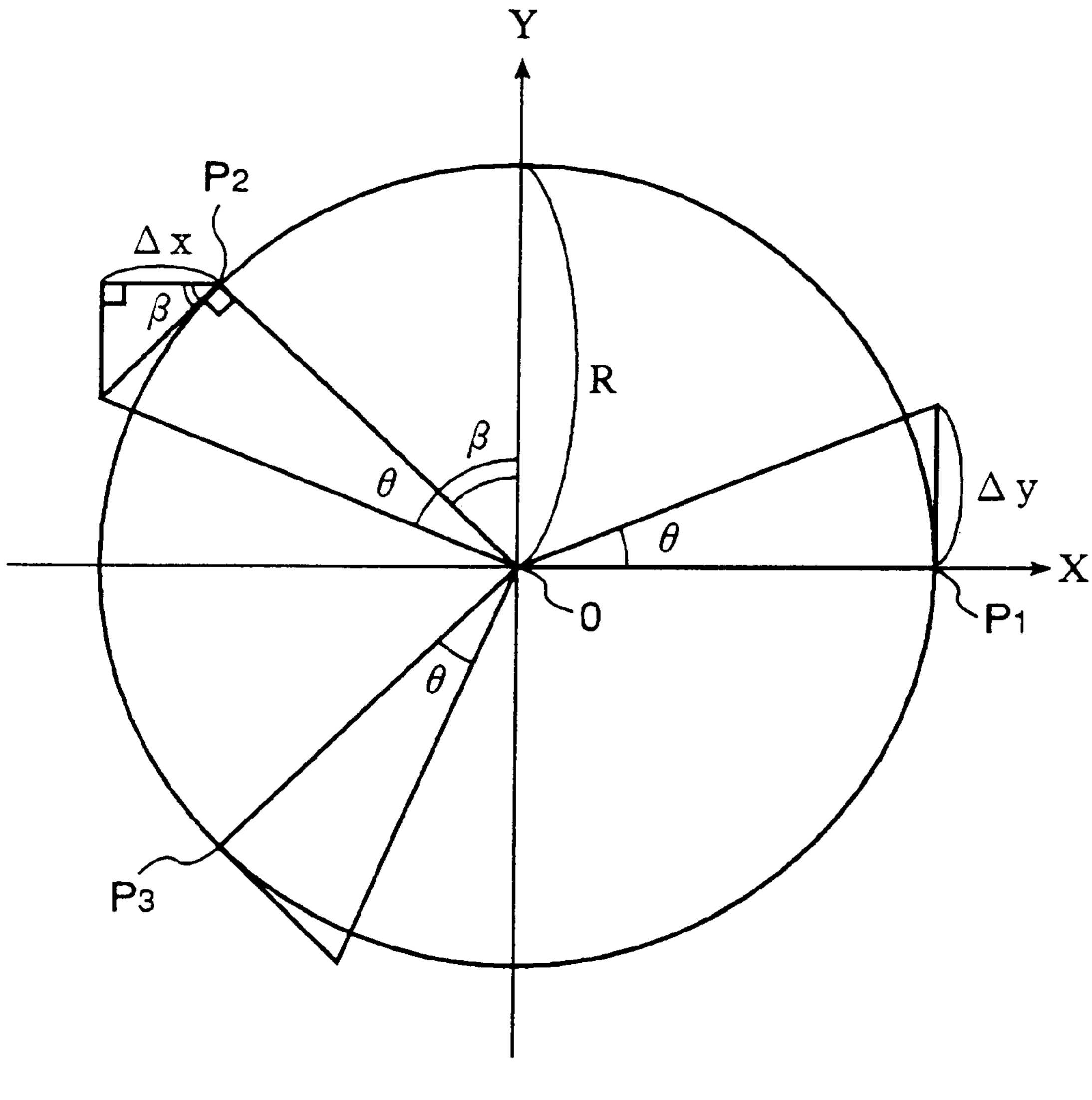


Fig 17

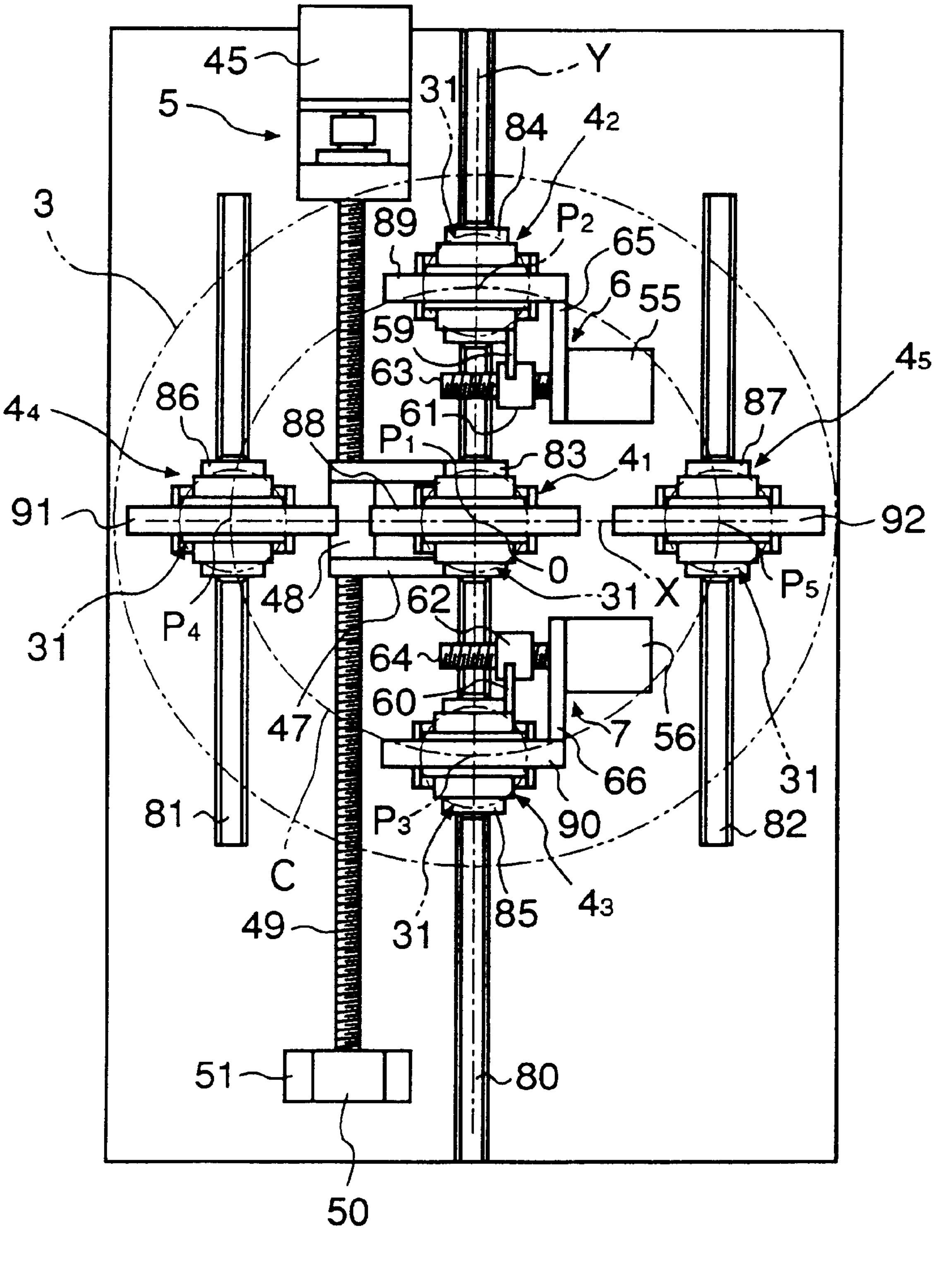

45
5
Y
31
84
4_2
3
89
P_2
65
6
55
59
63
4_5
4_4
86
61
87
88
P_1
83
4_1
91
92
0
48
31
X
P_5
P_4
62
31
64
60
47
7
56
66
31
81
P_3
90
82
C
31
85
4_3
49
51
80
50

Fig 18

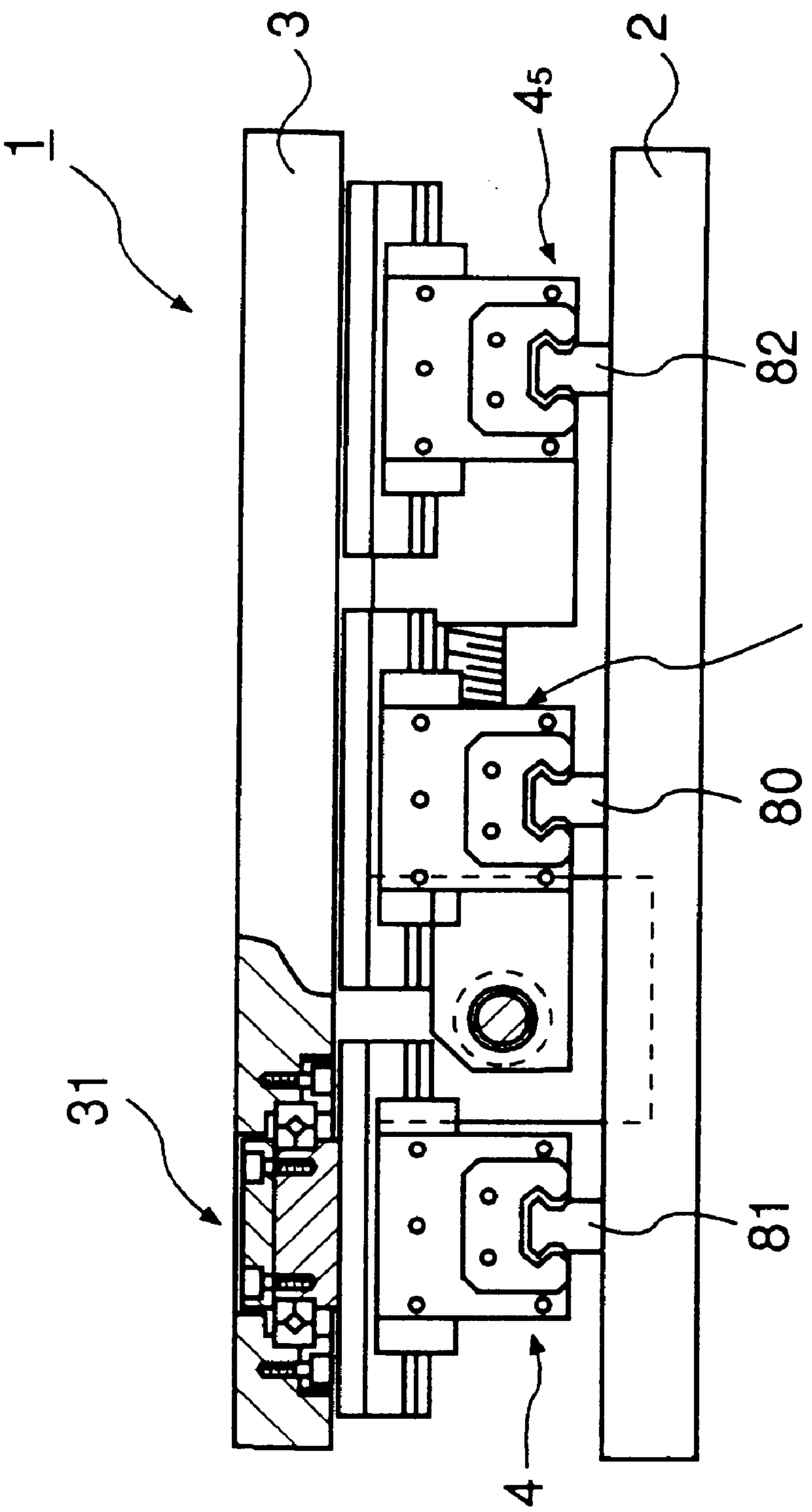


Fig 19

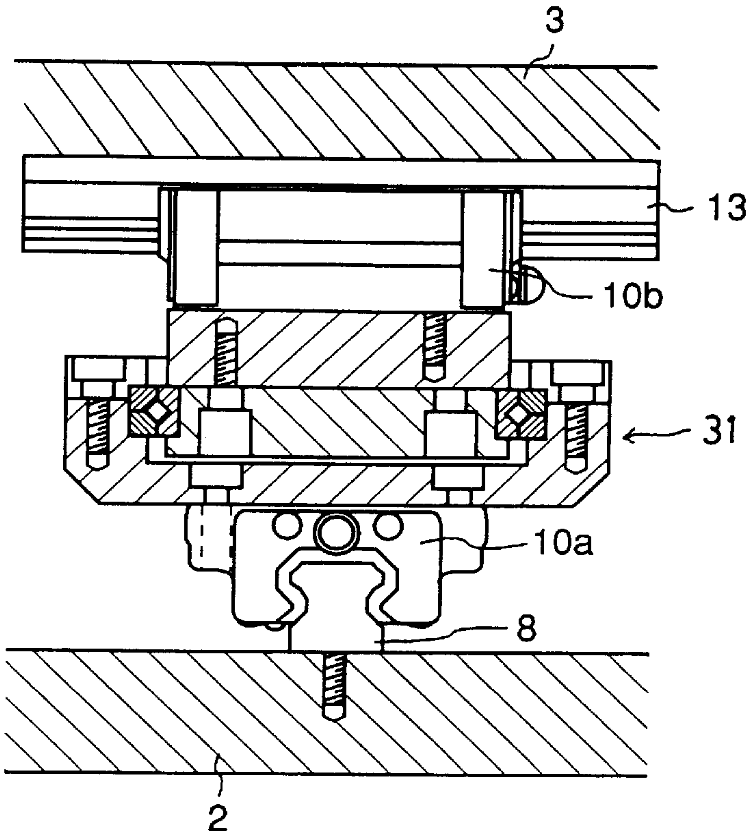
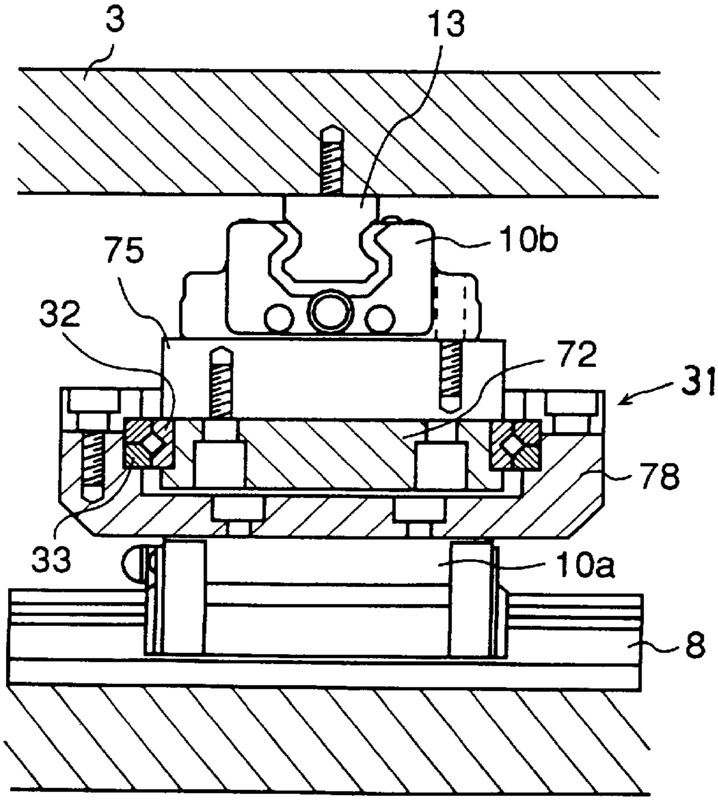


Fig 20



MOVABLE TABLE UNIT

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a movable table unit for use in a precision printing machine, a precision processing machine, a precision manufacturing machine or the like, and more specifically to a movable table unit which is mounted movably relative to a table base plate along two axes intersecting each other and rotatably relative to an axis perpendicular to a plane formed by the two axes.

2. Description of the Related Art

As a movable table unit for use in the aforementioned precision printing machine, a precision processing machine, a precision manufacturing machine or the like, so-called XY table in which a movable table is mounted movably relative to a table base plate along two axes intersecting each other has been often used.

Conventionally, as a movable table unit for use in the precision printing machine, the precision processing machine, the precision manufacturing machine or the like, so-called XY table in which a movable table is mounted movably along two axes intersecting each other with respect to a table base plate has been often used. In this XY table, a work placed on the movable table is moved along two axes, X and Y axes independently. In the precision printing machine or the like, not only an operation for moving a printing work placed on the movable table along the two axes, but also an operation for rotating it around an axis perpendicular to a plane formed by the two axes are required depending on the case.

Therefore, as the movable table for use in the precision printing machine or the like, an apparatus called "XYθ table" has been used, in which the movable table is not only mounted movably along the two axes intersecting each other with respect to the table base plate but also rotatably around an axis perpendicular to a plane formed by the two axes.

The technology relating to this XYθ table has been already disclosed in, for example, Unexamined Published Japanese Patent Application No.HEI8-99243, Unexamined Published Japanese Patent Application No.HEI1-240246, Unexamined Published Japanese Patent Application No.HEI1-242989, Unexamined Published Japanese Patent Application No.HEI4-210347, Unexamined Published Japanese Patent Application No.HEI8-211173, Unexamined Published Japanese Patent Application No.HEI8-252733, Unexamined Published Japanese Patent Application No.HEI9-42405, Unexamined Published Japanese Patent Application No.HEI9-155666, Unexamined Published Japanese Patent Application No.HEI9-216138, Unexamined Published Japanese Utility Model Application No.2515316, Unexamined Published Japanese Patent Application No.HEI4-354637, Unexamined Published Japanese Patent Application No.HEI6-31563, Unexamined Published Japanese Patent Application No.HEI7-219636, Unexamined Published Japanese Patent Application No.HEI5-77125, Unexamined Published Japanese Patent Application No.HEI4-2435, Unexamined Published Japanese Patent Application No.HEI3-56895, Unexamined Published Japanese Patent Application No.HEI2-202031, Unexamined Published Japanese Patent Application No.SHO62-282294 and the like.

The XYθ tables will be explained about a typical example thereof. In the longitudinally/laterally moving rotation table unit according to Unexamined Published Japanese Patent Application No.HEI8-99243, a movable table is supported on a base movably in all directions through three XY linear guide systems and a driving force is applied to moving blocks possessed by these XY linear guide systems through an independent ball screw unit. A upper rail possessed by each XY linear guide system is fixed to a bottom surface of the movable table. Upper and lower blocks possessed by the XY linear guide system are connected to each other with pins and bearing such that they are freely rotatable.

In the movable table according to Unexamined Published Japanese Utility Model No.2515316, the movable table is supported freely movably in all directions through a thrust bearing on a base. Three driving units are mounted in directions perpendicular to each other and output shafts of these driving units are connected to the movable table through a joint.

However, the above described conventional arts have the following problems. That is, in case of the longitudinally/laterally moving rotation table unit according to the Unexamined Published Japanese Patent Application No.HEI8-99243, a movable table is supported freely movably in all directions through three XY linear guide systems on the base and a driving force is applied to each of moving blocks possessed by these XY linear guide systems through an independent ball screw unit. Therefore, to rotate the movable table at a position other than an original point or move the movable table in parallel after it is rotated by a predetermined angle, the three XY linear guide systems have to be moved by different amounts mutually relating to one another, so that the table motion control becomes complicated. Also, in case of the longitudinally/laterally moving rotation table unit according to Unexamined Published Japanese Patent Application No.HEI8-99243, there is another problem, because the rotation center of the movable table is deviated due to motions thereof in the XY directions; it is difficult to carry out such a processing as printing or the like on a work placed on the movable table by rotating the movable table while moving it linearly along an axis after the movable table is positioned in the XY plane. Additionally, in case of the longitudinally/laterally moving rotation table unit according to the aforementioned Unexamined Published Japanese Patent Application No.HEI8-99243, the movable table is supported freely movably in all directions through three XY linear guide systems. Thus, further problem is that when a work is mounted or dismounted on/from the movable table, the movable table cannot be moved largely along a single axis even if it is requested.

On the other hand, in case of the movable table according to the aforementioned Unexamined Published Japanese Utility Model Application No.2515316, the movable table is supported movably in all directions through a thrust bearing on the base and three driving units intersecting each other are mounted on the base. Then, output shafts of the driving units are connected to the movable table through a joint. To rotate the movable table at a position other than an original point or move the movable table in parallel after it is rotated by a predetermined angle, the three driving units have to be moved by different amounts mutually relating to one another, so that the table motion control becomes complicated. Further, this invention has a problem that the rotation center of the movable table is deviated because of motions thereof in the XY directions and further has a problem that the movable table cannot be largely moved along an axis.

OBJECT AND SUMMARY OF THE INVENTION

Accordingly, the present invention has been made to solve the above described problems, and therefore, it is an object of the invention to provide a movable table unit capable of carrying out an operation for rotating a movable table at a position other than an original point and an operation for moving it in parallel after rotating by a predetermined angle by a simple control, capable of moving the rotation center linearly along two axes easily, and further moving the movable table largely along a single axis.

To achieve the above object, the present invention provides a movable table unit comprising: a table base plate; a movable table supported movably on the table base plate; a plurality of moving members joined to a bottom surface of the movable table; a plurality of two-axis guiding systems for guiding each of the moving members along two axes intersecting with each other on the table base plate and for guiding it largely along an axis; rotation systems for supporting the movable table or moving members rotatably relative to each of the two-axis guiding systems; and a plurality of driving means for moving each of the moving members selectively along any one of the two axial directions so as to provide the movable table with a linear motion along the two axes and for providing the movable table with a rotation motion around an axis perpendicular to the table base plate.

According to the above technological means, a plurality of the moving members are joined to a bottom surface of the movable table and each of these moving members is guided freely movably along two axes intersecting each other on the table base plate by the two-axis guiding system. Thus, by moving each of the moving members selectively along any one of the two axes by the driving means, the movable table can be moved linearly along each axis.

By combining the plural moving members to be moved by the driving means or selecting a direction of the motion thereof, a rotation moment force is applied to the movable table so as to provide the table with a rotation motion around an axis perpendicular to the table base plate.

Further, because the two-axis guiding system for guiding the moving member on the table base plate is so constructed that the moving member is guided largely along an axis, when a work to be placed on the moving table is mounted or dismounted, the movable table can be moved largely along an axis.

According to the present invention, an operation for rotating the movable table at a position other than an original point or an operation for moving the movable table in parallel after it is rotated by a predetermined angle can be carried out by a simple control, and an operation for moving the rotation center linearly along an axis can be carried out easily. Additionally, a movable table unit capable of moving the movable table largely along an axis can be provided.

According to the present invention, as the two-axis guiding system, for example, a system in which the movable member is guided movably along the X axis and Y axis which are perpendicular to each other, is used. However, the two axes guided by the two-axis guiding system are not restricted to the X-axis and Y-axis directions which are perpendicular to each other, but any two axes are permitted as long as they cross each other at a predetermined angle.

This two-axis guiding system, for example, comprises a track rail formed in a linear shape and a moving block formed to have a substantially C-shaped cross section and mounted movably to the track rail through a plurality of rolling bodies. That is, by stacking two two-axis guiding systems such that the track rails thereof intersect each other, the movable table can be guided in two directions which are perpendicular to each other. This is the same as the known

XY table. Further, it is permissible to employ a linear motion guide system which comprises a wide track rail formed in channel shape and a moving block mounted movably within a channel of the track rail through a plurality of rolling bodies.

Any rotation system may be used as long as the movable table or the moving member joined thereto is supported rotatably relative to each two-axis guiding system. For example, it is permissible to provide the rotation system between the movable table and moving member or it is also permissible to incorporate the rotation system in the two-axis guiding system for guiding the moving member.

However, in case where the rotation system is provided between the movable table and moving member, a force for driving the movable table is transmitted directly through the rotation system. Therefore, the driving force can be transmitted in a substantially parallel direction to a gravity center of the movable table. When the movable table is driven, unbalanced moment load is never applied to the rolling bodies or the like incorporated in the rotation system, so that the movable table can be moved smoothly.

Any two-axis guiding system may be used as long as it is capable of receiving a load in the lateral direction. Not only other type of linear bearing using the rolling guide but also the sliding bearing can be used.

Further, the driving means is constituted of, for example, a screw feeding (ball screw or the like) mechanism and the nut portion meshing with the feeding screw shaft is provided in the two-axis guiding system or moving member. If the driving means is constituted of a screw feeding mechanism, a position in the direction of the screw shaft is determined when the screw shaft is stopped. This driving means is not restricted to the screw feeding mechanism, but for example, an actuator (e.g., made by ORIENTARU MOTOR Co.) in which a shaft reciprocates linearly can be used. Meanwhile, although the driving means is mounted on the table base plate which is a fixed side, it may be also mounted to the movable table which is a movable side.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view showing a first embodiment of a movable table of the present invention;

FIG. **2** is a partially broken-away side view showing the movable table unit according to the first embodiment;

FIG. **3** is a front sectional view showing the two-axis guiding system;

FIG. **4** is a side sectional view showing the two-axis guiding system;

FIG. **5** is a perspective view showing the two-axis guiding system;

FIG. **6** is a front view showing a cross section of a first concave portion of the two-axis guiding system;

FIG. **7** is a sectional view showing arrangement of balls in the first concave portion of the two-axis guiding system;

FIG. **8** is a front view showing a cross section of a second concave portion of the two-axis guiding system;

FIG. **9** is a sectional view showing arrangement of balls in the second concave portion of the two-axis guiding system;

FIG. **10** is a partially broken-away perspective view showing a rotation system;

FIG. **11** is a sectional view of major portions showing a mounting condition of the rotation system;

FIG. **12** is a plan view showing a case in which the movable table according to the first embodiment has been moved in the Y-axis direction;

FIG. **13** is a plan view showing a case in which the movable table according to the first embodiment has been moved in the X-axis direction;

FIG. **14** is a plan view showing a case in which the movable table according to the first embodiment has been rotated;

FIG. **15** is an explanatory view showing forces to be applied to the movable table according to the first embodiment;

FIG. **16** is an explanatory view showing a rotation angle of the movable table according to the first embodiment of the present invention;

FIG. **17** is a plan view showing a second embodiment of the movable table of the present invention;

FIG. **18** is a partially broken-away side view showing the movable table according to the second embodiment;

FIG. **19** is a front sectional view showing the two-axis guiding system according to the fourth embodiment of the movable table unit of the present invention; and

FIG. **20** is a side sectional view showing the two-axis guiding system according to the fourth embodiment of the movable table of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, a movable table unit of the present invention will be described in detail with reference to the accompanying drawings.

Embodiment 1

FIGS. **1** and **2** are construction diagrams showing a first embodiment of the movable table unit of the present invention.

As shown in FIGS. **1** and **2**, the movable table unit **1** of the first embodiment comprises a table base plate **2**, a movable table **3**, moving members **13**, **14**, **15** joined to a bottom face of this movable table, three two-axis guiding systems $\mathbf{4}_1$, $\mathbf{4}_2$, $\mathbf{4}_3$ for guiding movably these moving members **13**, **14**, **15** along both X and Y axes perpendicular to each other and guiding them largely movably along the Y axis, a rotation system **31** for joining the aforementioned movable table **3** to the moving members **13**, **14**, **15** freely rotatably, a first driving means **5** for driving the moving member **13** guided by the first two-axis guiding system $\mathbf{4}_1$ along the Y-axis, and two secondary driving means **6**, **7** for driving the moving members **14**, **15** guided by the second and third two-axis guiding systems $\mathbf{4}_2$, $\mathbf{4}_3$ independently along the X-axis.

As shown in FIGS. **1** and **2**, the aforementioned table base plate **2** is formed in the shape of a flat rectangular plate and the movable table **3** is formed in the shape of a disk having a slightly smaller diameter than the width of the table base plate **2**. Three two-axis guiding systems $\mathbf{4}_1$, $\mathbf{4}_2$, $\mathbf{4}_3$ are disposed at each predetermined position on the table base plate **2**. As shown in FIG. **1**, in an initial state before the driving is started, the positions P_1, P_2, P_3 of rotation shafts of the first, second and third two-axis guiding systems $\mathbf{4}_1$, $\mathbf{4}_2$, $\mathbf{4}_3$ for supporting the movable table **3** rotatably are disposed so as to be located on a single circle C formed around an original position **0**. The first, second and third two-axis guiding systems $\mathbf{4}_1$, $\mathbf{4}_2$, $\mathbf{4}_3$ are joined to the movable table **3** freely rotatably under a positional relation shown in FIG. **1**. That is, the first two-axis guiding system $\mathbf{4}_1$ is joined to the movable table **3** at the position P_1 intersecting the circle C on the X-axis with respect to the rotation center O of the movable table **3**, and the other second and third two-axis guiding systems $\mathbf{4}_2$, $\mathbf{4}_3$ are joined to the movable table **3** at the positions P_2, P_3 on the circle C which are symmetrical relative to the X axis.

As shown in FIG. **1**, the track rail **8** in the Y-axis direction for the first two-axis guiding system $\mathbf{4}_1$ is installed near an end in the width direction (X-axis direction) of the table base plate **2** such that it spans an entire length of the table base plate **2** along the length direction (Y-axis direction) thereof. Of the aforementioned three two-axis guiding systems, the second and third two-axis guiding systems $\mathbf{4}_2$, $\mathbf{4}_3$ use the track rail **9** in the Y-axis direction commonly, and the track rail **9** in the Y-axis direction is installed near the other end in the width direction of the table base plate **2** so that it spans an entire length of the table base plate **2** along the length direction thereof and it is parallel to the track rail **8** of the first two-axis guiding system $\mathbf{4}_1$.

The three two-axis guiding systems $\mathbf{4}_1$, $\mathbf{4}_2$, $\mathbf{4}_3$ are constructed in the same way, comprising the track rails **8**, **9** in the Y-axis direction with a long span installed on the table base plate **2**, moving blocks **10**, **11**, **12** mounted to the track rails **8**, **9** in the Y-axis direction freely movably through a plurality of balls as rolling bodies, and short X-axis direction track rails **13**, **14**, **15** mounted freely movably in a direction perpendicular to the track rails **8**, **9** through a plurality of balls as rolling bodies to the moving blocks **10**, **11**, **12**. These short track rails **13**, **14**, **15** are joined to the moving table as a moving member.

Further, a structure of the two-axis guiding systems $\mathbf{4}_1$, $\mathbf{4}_2$, $\mathbf{4}_3$ will be described in detail. As shown in FIGS. **3**, **4**, the two-axis guiding systems $\mathbf{4}_1$, $\mathbf{4}_2$, $\mathbf{4}_3$ is a linear guiding system comprising the track rails **8**, **9** in the Y-axis direction, the moving blocks **10**, **11**, **12** and the track rails **13**, **14**, **15** in the X-axis direction for guiding the movable table **3** freely movably along two axes (XY axes) intersecting each other and supporting the movable table **3** freely rotatably. As shown in FIG. **3**, a guiding portion **16** is formed on a upper portion of the track rails **8**, **9** in the Y-axis direction such that it is protruded in a trapezoidal shape to both the sides thereof. Two ball rolling grooves **18** in which a plurality of balls **17** as rolling bodies roll are formed on corner portions located up and down of the right and left guide portions **16**, totaling four ball rolling grooves. As shown in FIG. **3**, a first concave portion **19** having a C-shaped cross section in which each of the track rails **8**, **9** in the Y-axis direction is inserted, is provided in a bottom face of the moving blocks **10**, **11**, **12** and as shown in FIG. **4**, a second concave portion **20** having a C-shaped cross section in which each of the track rails **13**, **14**, **15** in the X-axis direction is inserted, is provided in a top face of the moving blocks **10**, **11**, **12** such that the second concave portion **20** intersects the first concave portion **19**. Further, as shown in FIG. **6**, four ball rolling grooves **21** are provided in right and left inner faces of the first concave portion **19** of the moving blocks **10**, **11**, **12** opposing the right and left side faces of the track rails **8**, **9** in the Y-axis direction such that they are located at positions corresponding to the right and left ball rolling grooves of the track rails **8**, **9** in the Y-axis direction.

As shown in FIGS. **5**, **6**, four ball escaping paths **22** are provided corresponding to the four ball rolling grooves **21** of the first concave portion **19** in the lower portion of the moving blocks **10**, **11**, **12** such that they are in parallel to each other. In the lower portion of the moving blocks **10**, **11**, **12**, as shown in FIG. **7**, side lids **24** containing four direction changing paths **23** for connecting the ball rolling grooves **21** of the moving blocks **10**, **11**, **12** with the ball escaping paths **22** on both ends are provided on both end portions in the length direction of the first concave portion **19**.

The contact directions of the four rows of the balls **17** interposed between the track rails **8**, **9** in the Y-axis direction and the first concave portion **19** are inclined at a predetermined angle α with respect to a horizontal line H passing through the center of the upper and lower ball rows, such that they are symmetrical thereto, as shown in FIG. **6**. In this embodiment, an outward opening contact structure is applied, in which the contact angle line L connecting the center of each ball **17** and a contact point thereof with the ball rolling groove **21** is closed in an inward direction of the first concave portion **19** and opened in an outward direction which is opposite to the first rolling groove **21**. Consequently, an appropriate preliminary pressure is applied to the balls **17**. Of course, an inward opening contact structure which is opened in an inward direction of the first concave portion **19** may be utilized.

On the other hand, as shown in FIGS. **5**, **8**, two ball rolling grooves **26** in which balls **25** roll are provided on each of the right and left sides of the track rails **13**, **14**, **15** in the X-axis direction and totally four ball rolling grooves **26** are provided. Four ball rolling grooves **27** corresponding to the ball rolling grooves **26** of the track rails **13**, **14**, **15** in the X-axis direction are provided on the right and left inner faces of the second concave portion **20** of the moving blocks **10**, **11**, **12** opposing the right and left side faces of the track rails **13**, **14**, **15** in the X-axis direction.

Further, in the upper end portion of the moving blocks **10**, **11**, **12**, four ball escaping paths **28** corresponding to the four ball rolling grooves **27** of the second concave portion **20** are provided in parallel to each other. As shown in FIG. **9**, side lids **30** containing four direction changing paths **29** for connecting both ends of each ball rolling grooves **27** of the moving blocks **10**, **11**, **12** and both ends of the ball escaping paths **28** are provided on both end portions of the second concave portion **20** of the moving blocks **10**, **11**, **12**.

Further, as shown in FIG. **8**, contact directions of four rows of the balls **25** interposed between the track rails **13**, **14**, **15** in the X-axis direction and the second concave portion **20** are inclined at a predetermined angle α with respect to the horizontal line H passing through the center of the ball rolling grooves **26** of the upper and lower rows, such that they are symmetrical thereto. In this embodiment, outward opening contact structure is employed, in which a contact angle line L connecting the center of the ball **25** with a contact point of the ball rolling groove **26** is closed in an inward direction of the second concave portion **20** and opened in an outward direction of the second concave portion **20**. Of course, inward opening contact structure which is opened in an inward direction of the second concave portion **20** may be utilized. An appropriate preliminary pressure is applied to the balls **25**.

A rotation system **31** for supporting the movable table **3** freely rotatably with respect to the track rails **13**, **14**, **15** in the X-axis direction of the three two-axis guiding systems 4_1, 4_2, 4_3 will be described in detail.

As shown in FIGS. **3**, **4**, **10**, **11**, the rotation system **31** contains inner track ring **32** and outer track ring **33**, which are formed in a circular shape. These inner and outer track rings **32**, **33** are disposed concentrically such that they engage each other. In this embodiment, the track ring fixed to the track rails **13**, **14**, **15** in the X-axis direction is the inner track ring **32** and the track ring fixed to the movable table **3** is the outer track ring **33**. A plurality of rollers **34** as rolling bodies are disposed between both the track rings **32** and **33**.

As shown in FIGS. **3**, **4**, the aforementioned inner track ring **32** is joined to the linear track rails **13**, **14**, **15** in the X-axis direction through a joint member **70**. This joint member **70** comprises a first joint plate **71** to which the track rails **13**, **14**, **15** in the X-axis direction are fixed and a disc-shaped second joint plate **72** to which the inner track ring **32** is fixed, and the first joint plate **71** and the second joint plate **72** are fixed to each other with a bolt **73**. A step concave portion **74** is provided on an outer periphery of the second joint plate **72** and the inner track ring **32** is mounted on this step concave portion **74** from upward. A pressing member **75** is fixed to a top end face of the step concave portion **74** by screwing a bolt, so that the inner track ring **32** is fixed in a condition in which it is nipped from up and down between the pressing member **75** and a step portion **74*a*** located at the root of the step concave portion **74**.

On the other hand, the movable table **3** to which the outer track rail **33** is to be fixed includes a circular opening portion **76**, in which the pressing member **75** of the inner track ring **32** can be inserted from up and a circular step concave portion **77** is provided on a lower edge of the internal periphery of the opening portion **76**. The outer track ring **33** is mounted on this step concave portion **77**. Further, a pressing member **78** for pressing the outer track ring **33** is fixed to an opening edge of the step concave portion **77** by tightening a bolt **73**, so that the outer track ring **33** is held between this pressing member **78** and the step portion **77*a*** of the step concave portion **77** in a condition in which it is nipped from up and down.

As shown in FIG. **11**, a first track groove **37** constituted of upper and lower roller rolling surfaces **35**, **36** which are opened outward in the radius direction at a substantially 90° is formed on an outer peripheral face of the inner track ring **32**. On the other hand, a second track groove **40** constituted of two upper and lower roller rolling surfaces **38**, **39** which are opened inward in the radius direction at an angle of substantially 90° opposing the first track groove **37** is formed on an inner peripheral face of the outer track ring **33**.

As shown in FIG. **10**, a part of the rollers **34** interposed between the first track groove **37** and the second track groove **40** are interposed between a upper roller rolling face **35** of the first track groove **37** and a lower roller rolling face **36** of the second track groove **40** such that they are freely rotatable. The remaining rollers **34** are interposed between a lower roller rolling face **36** of the first track groove **37** and a upper roller rolling face **38** of the second track groove **40** such that they are freely rotatable.

The rollers **34** interposed between the upper roller rolling surface **35** of the first track groove **37** and the lower roller rolling surface **39** of the second track groove **40** such that they are freely rotatable, and the rollers **34** interposed between the lower roller rolling face **36** of the first track groove **37** and the upper roller rolling face **38** of the second track groove **40** such that they are freely rotatable, are so constructed in so-called "cross rotor type", in which both of the rollers **34** are arranged such that they intersect each other alternately. As shown in FIG. **10**, a spacer retainer **41** is interposed between the rollers **34**.

As for the arrangement of the rollers **34**, the rollers **34** may be arranged not such that their rotating axes intersect each other alternately, but such that their rotating axes change their directions every two or three rollers. The rollers **34** may be arranged in various ways. A plurality of the rollers **34** interposed between the inner track ring **32** and outer track ring **33** are supplied with a preliminary pressure. As for application of the preliminary pressure, according to this embodiment, as shown in FIG. **11**, the inner track ring **32** is divided to the upper and lower portions **32*a***, **32*b***, and a gap is formed between the upper and lower portions **32*a*** and **32*b*** of the inner track ring **32** in a condition that the upper and lower roller rolling faces **35**, **36** are in a free contact with the roller **34**, and then the upper and lower portions **32*a***, **32*b*** are tightened vertically until the gap therebetween is eliminated, thereby compressing each roller **34** by a predetermined amount to apply the preliminary pressure thereto.

As other structure for applying the preliminary pressure to the rollers **34**, it is permissible to provide a circumference of the outer track ring **33** with a slit (not shown), so that when the outer track ring **33** is mounted on the step concave portion **42** of the movable table **3**, the slit in the outer track ring **33** is narrowed to reduce the diameter thereof, thereby pressing the rollers **34** from the right and left sides to apply the preliminary pressure.

By constructing the rotation system **31** with a structure in which the rollers **34** are interposed between the inner track ring **32** and outer track ring **33**, it is possible to obtain a supporting structure having a high stiffness against a load from every direction including a load for compressing in the rotation axis direction, a load for pulling in the rotation axis direction, a load to be applied in a direction perpendicular to the rotation axis, a moment load for inclining the rotation axis and the like. Therefore, a light, highly stiff supporting structure can be obtained.

The movable table unit **1** according to the first embodiment, as shown in FIG. **1**, comprises a first driving means **5** for driving the moving block **10** of the first two-axis guiding system $\mathbf{4}_1$ along the Y axis having a large moving amount, and the second driving means **6**, **7** for driving the track rails **14**, **15** of the second and third two-axis guiding systems $\mathbf{4}_2$, $\mathbf{4}_3$ independently along the X axis.

As shown in FIGS. **1**, **2**, the first driving means **5** comprises a driving motor **45** such as a servo motor, stepping motor or the like and a feeding screw mechanism **46** for converting a rotating motion of the driving motor **45** to a linear motion. The aforementioned feeding screw mechanism **46** comprises a nut **48** joined to the moving block **10** of the first two-axis guiding system $\mathbf{4}_1$ through two brackets **47**, a long screw shaft **49** meshing with this nut **48**, double row angular contact type bearing **50** for supporting each end of this screw shaft **49** freely rotatably and a bearing support **51** for supporting this bearing **50**. The aforementioned driving motor **45** is fixed to an end portion in the length direction of the table base plate **2** through a bracket **52** and a motor shaft **53** is joined to a shaft end of the screw shaft **49** through a joint member **54**. The long screw shaft **49** of the feeding screw mechanism **46** is disposed in parallel near an end in the width direction of the table base plate **2** and along the track rail **8** in the Y-axis direction of the first two-axis guiding system $\mathbf{4}_1$.

The second driving means **6**, **7** are constructed in the same way, and as shown in FIGS. **1**, **2**, comprise a driving motor **55**, **56** such as a servo motor, stepping motor and the like, and a feeding screw mechanism **57**, **58** for converting a rotating motion of the driving motor **55**, **56** to linear motion. The aforementioned feeding screw mechanisms **57**, **58** each comprise a nut **61**, **62** joined to the moving block **11**, **12** of the second, third two-axis guiding system $\mathbf{4}_2$, $\mathbf{4}_3$ through a bracket **59**, **60** and a short screw shaft **63**, **64** which meshes with the nut **61**, **62**. The driving motors **55**, **56** are fixed to the track rails **14**, **15** in the X-axis direction of the second, third two-axis guiding system $\mathbf{4}_2$, $\mathbf{4}_3$ through brackets **65**, **66** and the short screw shafts **63**, **64** are directly connected to a motor shaft (not shown). In the aforementioned two second driving means **6**, **7**, the driving motors **55**, **56**, screw shafts **63**, **64** and the like are disposed symmetrically relative to the X axis in FIG. **1**.

In the movable table unit according to the first embodiment having the above described structure, turning the movable table at a position other than the original point, moving the movable table in parallel after turning it at a predetermined angle and the like can be carried out by a simple control, and further moving the rotation center linearly along the two axes can be carried out easily, and additionally moving the movable table largely along an axis can be carried out.

That is, in the movable table unit **1** according to the first embodiment, the movable table **3** is stopped at a position shown in FIG. **1** in an initial state before the movable table **3** is moved. For example, in case where the movable table **3** is moved in parallel to the Y axis from this state without changing the posture of the movable table **3**, the driving motor **45** of the first driving means **5** for driving the moving block **10** of the first two-axis guiding system $\mathbf{4}_1$ along the Y axis is driven in a predetermined direction so as to rotate the long screw shaft **49** joined to the motor shaft **53** of the driving motor **45**. Then, because the nut **48** meshing with the screw shaft **49** is fed in the Y-axis direction with a rotation of the screw shaft **49**, the moving block **10** of the first two-axis guiding system $\mathbf{4}_1$ fixed to the nut **48** meshing with the screw shaft **49** through a bracket **47** is also moved along the Y axis as shown in FIG. **12**. Consequently, the movable table **3** joined to the moving block **10** of the first two-axis guiding system $\mathbf{4}_1$ is moved at a predetermined distance y along the Y axis together with the track rail **13** of the first two-axis guiding system $\mathbf{4}_1$.

In case where the movable table **3** is moved in parallel to the X axis, the driving motors **55**, **56** of the second driving means **6**, **7** for driving the track rails **14**, **15** in the X-axis direction of the second, third two-axis guiding systems $\mathbf{4}_2$, $\mathbf{4}_3$ are driven in the same rotation direction so as to rotate the screw shafts **63**, **64** joined to motor shafts (not shown) of the driving motors **55**, **56** in the same direction. Then, because the nuts **61**, **62** meshing with the screw shafts **63**, **64** are joined to the moving blocks **11**, **12** of the second and third two-axis guiding systems $\mathbf{4}_2$, $\mathbf{4}_3$ which do not move along the X axis, through the brackets **59**, **60**, the screw shafts **63**, **64** meshing with the nuts **61**, **62** are moved in the same direction along the X axis with rotations thereof as shown in FIG. **13**. Thus, the driving motors **55**, **56** joined to the screw shafts **63**, **64** are moved in the same direction along the X axis (for example, leftward direction of FIG. **13**) with the screw shafts **63**, **64**. As a result, the movable table **3** joined to the track rails **14**, **15** in the X-axis direction freely rotatably through the rotation system **31** is moved by a predetermined amount along the X axis, together with the track rails **14**, **15** in the X-axis direction of the second, third two-axis guiding systems $\mathbf{4}_2$, $\mathbf{4}_3$ joined to the driving motors **55**, **56** through the brackets **65**, **66**.

In case where the movable table **3** is turned with respect to a rotating axis **0** perpendicular to a plane formed by the X and Y axes, the driving motors **55**, **56** of the second driving means **6**, **7** for driving the track rails **14**, **15** in the X-axis direction of the second, third two-axis guiding systems $\mathbf{4}_2$, $\mathbf{4}_3$ are driven in opposite directions to each other, so as to rotate the screw shafts **63**, **64** connected to motor shafts (not shown) of the driving motors **55**, **56** in opposite directions to each other. If the movable table **3** is rotated in a counterclockwise direction, as shown in FIG. **14**, the track rail **14** in the X-axis direction of the second two-axis guiding system $\mathbf{4}_2$ is moved leftward in the Figure, while the track rail **15** in the X-axis direction of the third two-axis guiding system $\mathbf{4}_3$ is moved rightward in the same Figure. On the other hand, in case where the movable table **3** is turned in a clockwise direction, the track rail **14** in the X-axis direction of the second two-axis guiding system $\mathbf{4}_2$ is moved rightward in FIG. **14**, while the track rail **15** in the X-axis direction of the third two-axis guiding system 4_3 is moved leftward in the same Figure. In case where the movable table **3** is turned in a counterclockwise direction, the moving block **10** of the first two-axis guiding system 4_1 is moved upward as viewed in FIG. **14** by a predetermined amount, while the movable table **3** is turned in a clockwise direction, the moving block **10** of the first two-axis guiding system 4_1 is moved downward as viewed in FIG. **14** by a predetermined amount.

Because the nuts **61, 62** meshing with the screw shafts **63, 64** of the second driving means **6, 7** are joined to the moving blocks **11, 12** of the second, third two-axis guiding systems 4_2, 4_3 which are not moved in the X-axis direction through the brackets **59, 60**, the screw shafts **63, 64** meshing with the nuts **61, 62** are moved in opposite directions to each other along the X axis with rotations thereof. Therefore, the driving motors **55, 56** joined to the screw shafts **63, 64** are moved by the same amount in opposite directions to each other along the X axis as shown in FIG. **14**. Consequently, the track rails **14, 15** in the X-axis direction of the second, third two-axis guiding systems 4_2, 4_3 joined to the driving motors **55, 56** through the brackets **65, 66** are also moved in opposite directions to each other along the X axis by the same amounts $-\Delta x$, $+\Delta x$.

The screw shaft **49** is driven by the driving motor **45** of the first driving means **5** so that the nut **48** meshing with the screw shaft **49** is moved by a predetermined amount in the Y-axis direction with a rotation of the screw shaft **49**. Therefore, the moving block **10** of the first two-axis guiding system 4_1 fixed to the nut **48** meshing with the screw shaft **49** through the bracket **47** is moved by a predetermined amount $+\Delta y$ along the Y axis.

As described above, according to the first and second driving means **5, 6, 7**, the moving block **10** of the first two-axis guiding system 4_1 is moved by a predetermined amount $+\Delta y$ along the Y axis and at the same time, the track rails **14, 15** in the X-axis direction of the second, third two-axis guiding systems 4_2, 4_3 are moved in opposite directions to each other by the same amounts $-\Delta x$, $+\Delta x$ along the X axis. Then, in the movable table **3** guided by the first-third two-axis guiding systems 4_1, 4_2, 4_3 freely movably along the two axes, X axis and Y axis and supported freely rotatably, as shown in FIGS. **14, 15**, a point P_2 supported by the second two-axis guiding system 4_2 is moved leftward in FIG. **14** by the second driving means **6**, a point P_3 supported by the third two-axis guiding system 4_3 is moved rightward by the second driving means **7** and a point P_1 supported by the first two-axis guiding system 4_1 is moved upward with respect to FIG. **14** by the first driving means **5**. As a result, forces F_1, F_2, F_3 are applied to the points P_1, P_2, P_3 supported rotatably of the movable table **3** by the first and second driving means **5, 6, 7**, as shown in FIG. **15**. Components of force $F\theta_1$, $F\theta_2$, $F\theta_3$ in the circumferential direction of the forces F_1, F_2, F_3 serve for rotation moments for rotating the movable table **3** so that the movable table **3** is rotated in the counterclockwise direction of FIG. **15**.

To rotate the movable table **3** at an angle θ, as shown in FIG. **16**, the track rail **13** of the first two-axis guiding system 4_1 is moved by a predetermined amount $+\Delta y = R\tan\theta$ along the Y axis by the first driving means **57** and the track rails **14, 15** in the X-axis direction of the second and third two-axis guiding systems 4_2, 4_3 are moved by the same amounts $-\Delta x = -R\tan\theta\cdot\cos\beta$, $+\Delta x = +R\tan\theta\cdot\cos\beta$ respectively, in opposite directions to each other along the X axis. Where R is a radius from the rotation center O of the movable table **3** to the points P_1, P_2, P_3 for supporting the movable table **3** freely rotatably and β is an angle formed by a line connecting the rotation axis O with the point P_2 before the movable table **3** is rotated, with respect to the Y axis.

Further, the movable table **3** may be rotated not only around the rotation axis O but also around an arbitrary rotation axis at a desired rotation radius as shown by an arrow R in FIG. **14**. That is, to rotate the movable table **3** around an arbitrary rotation axis at a desired rotation radius, the first two-axis guiding system 4_1 is moved by a predetermined amount Δy along the Y axis by the first driving means **5**, and simultaneously the second and third two-axis guiding systems 4_2, 4_3 are moved by different predetermined amounts $+\Delta x$, $-\Delta x'$ respectively, in opposite directions along the X axis by the second driving means **6, 7**. Consequently, the movable table **3** is rotated at a rotation radius determined depending on the moving amounts $+\Delta x$, $-\Delta x'$, Δy of the first-third two-axis guiding systems 4_1, 4_2, 4_3 around a desired rotation axis. Because the moving amounts $+\Delta x$, $-\Delta x'$, Δy of the first-third two-axis guiding systems 4_1, 4_2, 4_3 are determined geometrically, if a relational expression is memorized in a control unit preliminarily, the amounts $+\Delta x$, $-\Delta\Delta x'$, Δy and rotation amounts of the respective rotation motors are calculated by specifying a rotation center and rotation angle, so as to control the first and second driving means **5, 6, 7**. A change of positions in which the two-axis guiding systems 4_1, 4_2, 4_3 supports the movable table **3** freely rotatably, accompanied by a motion of the first-third two-axis guiding systems 4_1, 4_2, 4_3 is absorbed by free motions of the track rail **13** in the X-axis direction and the moving blocks **11, 12** of the two-axis guiding systems 4_1, 4_2, 4_3.

In the movable table unit **1**, if the movable table **3** is moved in an arbitrary direction on the XY plane and simultaneously rotated in the direction θ around the rotation axis O, a motion for moving the movable table **3** in the X-axis direction, a motion for moving the movable table **3** in the Y-axis direction and a motion for rotation the movable table **3** along the direction θ are combined in an arbitrary way. However, by carrying out these three motions independently of each other, the control for moving the movable table **3** to a predetermined position and at a predetermined angle can be carried out more easily.

That is, in case where in the movable table unit **1**, the movable table **3** is moved in an arbitrary direction on the XY plane and further rotated in the direction θ around the rotation axis O, the movable table **3** is moved at a desired amount along the Y axis by driving the first driving means **5**, and then by driving the second driving means **5, 6** in the same direction, the movable table **3** is moved at a desired amount along the X axis. After that, by driving the second driving means **5, 6** in opposite directions to each other and simultaneously driving the first driving means **5**, the movable table **3** is rotated at a desired angle in the direction θ around the rotation axis O. That is, the motion controls in the X axis, Y axis and direction θ can be carried out independently of each other, so that the motion control of themovable table **3** can be further facilitated.

As described above, in the movable table unit **1** of the first embodiment, an operation for rotating the movable table **3** at a position other than the original point or an operation for rotating it at a predetermined angle and then moving it in parallel can be carried out by a simple control. In the movable table unit **1**, by driving only the first driving means **5**, the movable table **3** can be moved linearly in the Y axis easily and further by driving only the second driving means **6** in the same direction, the movable table **3** can be moved linearly in the X-axis direction. Further, because the track rail **8** in the Y-axis direction of the first two-axis guiding system 4_1 to be driven by the first driving means **5** is formed in a long length, the movable table can be moved largely along an axis.

Even if yawing occurs in the movable table unit **1** according to the first embodiment when the movable table **3** is moved along the Y axis by the first driving means **5**, by driving the second driving means **6**, **7** which are driving means for the X axis and direction θ, the yawing can be corrected so as to be able to move the movable table **3** to a predetermined position always with an appropriate posture.

Although in the movable table unit **1** according to the first embodiment, a case in which the movable table **3** is formed in a circular shape has been described, the movable table **3** may be so constructed that a center portion thereof is bored in a circular shape, because the three two-axis guiding systems are disposed on a circle around a rotation axis, thereby realizing a pass-through work and reduction of weight.

Although, in the first embodiment, the feeding screw mounted to the table base plate and the nut portions mounted to the moving block of the first two-axis guiding system are used as driving means, it is permissible to fix the feeding screw on the moving table and fix the nut portions on the moving block of the first two-axis guiding system.

Although in the first embodiment, a case in which the first and second driving means are provided independently for the first-third two-axis guiding systems has been described, the present invention is not restricted to this example, but it is permissible to provide the moving blocks or the like of the first and second driving means with the nut portions integrally and dispose the feeding screw inside the moving blocks or the like integrally. In this case, because the first and second driving means can be integrated with the first-third two-axis guiding systems, the size of this unit can be further reduced.

Second Embodiment

FIGS. **17**, **18** show a second embodiment of the present invention and the same reference numerals are attached to the same components as the first embodiment. According to the second embodiment, five two-axis guiding systems are provided. A two-axis guiding system provided with the first driving means is disposed in the center of rotation of the moving table and two two-axis guiding systems provided with the second driving means are disposed concentrically with the rotation center of the moving table and on a diameter along the Y axis.

That is, in the movable table unit **1** according to the second embodiment, as shown in FIG. **17**, five two-axis guiding systems 4_1, 4_2, 4_3, 4_4, 4_5 are disposed on each predetermined position on the table base plate **2**. As for these five two-axis guiding systems 4_1, 4_2, 4_3, 4_4, 4_5, as shown in FIG. **17**, the position P_1 in which the first two-axis guiding system 4_1 supports the movable table **3** freely rotatably is disposed so as to be located in the center O of a circle C in an initial state before the driving is started, and the positions P_2, P_3, P_4, P_5 in which the second-fifth two-axis guiding systems 4_2, 4_3, 4_4, 4_5, support the movable table **3** freely rotatably are disposed so as to be located on the same circle C around the rotation center O. The second and third two-axis guiding systems 4_2, 4_3 are disposed on the circle C formed with respect to the rotation axis O around which the movable table **3** rotates and at positions different by 180° on the Y axis. The fourth and fifth two-axis guiding systems 4_4, 4_5 are disposed on the circle C concentric with the rotation center of the movable table **3** and at positions different by 180° on the X axis.

Of the aforementioned five two-axis guiding systems, the first-third two-axis guiding systems 4_1, 4_2, 4_3 use a track rail **80** in the Y-axis direction in common and this track rail **80** in the Y-axis direction is mounted so as to span an entire length (Y-axis direction) of the table base plate **2**, in the center with respect to the width direction (X-axis direction) of the table base plate **2**. In the fourth two-axis guiding system 4_4, the track rail **81** in the Y-axis direction is mounted near an end in the width direction of the table base plate **2** in such a condition that it is shorter than the track rail **80** of the first two-axis guiding system 4_1 and parallel thereto. Further, in the fifth two-axis guiding system 4_5, the track rail **82** in the Y-axis direction is mounted near the other end in the width direction of the table base plate **2** and along the length direction of the table base plate **2** in such a condition that it is shorter than the track rail **80** of the first two-axis guiding system 4_1 and parallel thereto.

The five two-axis guiding systems 4_1, 4_2, 4_3, 4_4, 4_5 are constructed in the same way, comprising the track rails **80**, **81**, **82** in the Y-axis direction mounted on the table base plate **2** as described above, moving blocks **83**, **84**, **85**, **86**, **87** mounted to the track rails **80**, **81**, **82** movably in the Y-axis direction through a plurality of the balls as rolling bodies, and shorter track rails **88**, **89**, **90**, **91**, **92** in the X-axis direction mounted on the moving blocks **83**, **84**, **85**, **86**, **87** through a plurality of the balls as the rolling bodies in a direction perpendicular to the aforementioned track rails **80**, **81**, **82**.

The two-axis guiding systems 4_1, 4_2, 4_3, 4_4, 4_5 are constructed in the same manner as the first embodiment, and comprise the track rails **80**, **81**, **82** in the Y-axis direction, moving blocks **83**, **84**, **85**, **86**, **87** and track rails **88**, **89**, **90**, **91**, **92** in the X-axis direction. They are linear guiding systems for guiding the movable table **3** movably along two axes (XY axes) which are perpendicular to each other and supporting the movable table **3** rotatably. The track rails **88**, **89**, **90**, **91**, **92** in the X-axis direction of the two-axis guiding systems 4_1, 4_2, 4_3, 4_4, 4_5 support the movable table **3** rotatably through the rotation systems **31**.

The movable table unit **1** according to the second embodiment comprises the first driving means **5** for driving the track rail **88** of the first two-axis guiding system 4_1 along the Y axis ensuring a large traveling amount and two second driving means **6**, **7** for driving the track rails **89**, **90** of the second and third two-axis guiding system 4_2, 4_3 independently along the X axis.

As shown in FIGS. **17**, **18**, the first and second driving means **5**, **6**, **7** comprise driving motors **45**, **55**, **56** and feeding screw mechanisms **46**, **57**, **58** for converting rotation of the driving motors **45**, **55**, **56** to linear motion like the first embodiment. Meanwhile, the fourth and fifth two-axis guiding systems 4_4, 4_5 have no driving means.

In the movable table unit according to the second embodiment having such a structure, operations for rotating the movable table at a position other than the original point and moving it in parallel after rotating at a predetermined angle can be carried out by a simple control. Also, an operation for moving the rotation center linearly along two axes can be carried out and further, the movable table can be moved largely along a single axis.

That is, in the movable table unit **1** according to the second embodiment, the movable table **3** is stopped at a position shown in FIG. **17** for example, in an initial state before the movable table **3** is moved. For example, in case where the movable table **3** is moved in parallel along the Y axis without changing the posture thereof, the driving motor **45** of the first driving means **5** for driving the moving block

84 of the first two-axis guiding system 4_1 along the Y-axis is driven in a predetermined direction so as to rotate the long screw shaft **49** joined to the motor shaft **53** of the driving motor **45**. Then, the nut **48** meshing with this screw shaft **49** is moved in the Y-axis direction with rotations of the screw shaft **49**, so that the moving block **10** of the first two-axis guiding system 4_1 fixed to the nut **48** meshing with the screw shaft **49** through the brackets **47** is also moved in the Y-axis direction. As a result, the movable table **3** joined to the moving block **10** of the first two-axis guiding system 4_1 is moved by only a predetermined amount y along the Y axis with the moving block **10** of the first two-axis guiding system 4_1.

Next, in case where the movable table **3** is moved in parallel along the X axis, as shown in FIG. **17**, by driving the driving motors **55**, **56** of the second driving means **6**, **7** for driving the track rails **89**, **90** in the X-axis direction of the second and third two-axis guiding systems 4_2, 4_3, along the X axis, in the same direction, the screw shafts **63**, **64** joined to motor shafts (not shown) of the driving motors **55**, **56** are rotated. Then, because the nuts **61**, **62** meshing with the screw shafts **63**, **64** are joined to the moving blocks **84**, **85** of the second and third two-axis guiding systems 4_2, 4_3 which are not moved in the X-axis direction, through the brackets **59**, **60**, conversely the screw shafts **63**, **64** meshing with the nuts **61**, **62** are moved in the same direction along the X axis with rotations thereof. Consequently, the driving motors **55**, **56** joined to the screw shafts **63**, **64** are also moved in the same direction along the X axis with the screw shafts **63**, **64**. As a result, the movable table **3** joined to the track rails **89**, **90** in the X-axis direction rotatably through the rotation systems **31** is moved by only a predetermined amount x in the same direction along the X axis, together with the track rails **89**, **90** in the X-axis direction of the second and third two-axis guiding systems 4_2, 4_3 joined to the driving motors **55**, **56** through the brackets **65**, **66**.

Further, in case where the movable table **3** is rotated around a rotation axis perpendicular to a plane formed by the X and Y axes, by driving the driving motors **55**, **56** of the second driving means **6**, **7** for driving the track rails **89**, **90** in the X-axis direction of the second and third two-axis guiding systems 4_2, 4_3 in opposite directions to each other, the screw shafts **63**, **64** joined to motor shafts (not shown) of the driving motors **55**, **56** are rotated in opposite directions to each other.

Because the nuts **61**, **62** meshing with the screw shafts **63**, **64** of the second driving means **6**, **7** are joined to the moving blocks **84**, **85** of the second and third two-axis guiding systems 4_2, 4_3 which are not moved in the X-axis direction through the brackets **59**, **60**, conversely, the screw shafts **63**, **64** meshing with the nuts **61**, **62** are moved in opposite directions to each other along the X axis with rotations thereof. Thus, the driving motors **55**, **56** joined to the screw shafts **63**, **64** are moved in opposite directions to each other along the X axis together with the screw shafts **63**, **64**. As a result, the movable table **3** joined to the track rails **89**, **90** in the X-axis direction rotatably through the rotation systems **31** is moved by only a predetermined amount x in opposite directions along the X axis, together with the track rails **89**, **90** in the X-axis direction of the second and third two-axis guiding systems 4_2, 4_3 joined to the driving motors **55**, **56** through the brackets **65**, **66**.

As described above, the movable table **3** is guided movably along the two axes, X and Y axes and supported rotatably by the five two-axis guiding systems 4_1, 4_2, 4_3, 4_4, 4_5. For example, the point P_2 supported by the second two-axis guiding system 4_2 is moved leftward in FIG. **11** by the second driving means **6** and the point P_3 supported by the third two-axis guiding system 4_3 is moved leftward in FIG. **11** by the third driving means **7**. Because the second and third two-axis guiding systems 4_2, 4_3 are disposed on the circle C formed relative to the rotation axis O around which the movable table **3** is rotated and at positions different by 180° on the Y axis. Therefore, forces applied to the points P_2, P_3 in which the second and third two-axis guiding systems 4_2, 4_3 support the movable table **3** rotatably become rotation moment forces for directly rotating the movable table **3**. Thus, in the movable table **3** mentioned above, rotation moment forces for rotating the movable table **3** are applied to the points P_2, P_3 supported rotatably, by the second driving means **6**, **7** as shown in FIG. **17**. As a result, the movable table **3** is rotated in a counterclockwise direction in FIG. **17**.

In case where the movable table **3** is moved in an arbitrary direction on the XY plane and simultaneously rotated in the direction θ around the rotation axis O in the movable table unit **1**, an operation for moving the movable table **3** in the X-axis direction, an operation for moving the movable table **3** in the Y-axis direction and an operation for rotating the movable table **3** in the direction θ may be combined.

That is, in case where the movable table **3** is moved in an arbitrary direction on the XY plane and simultaneously rotated in the direction θ around the rotation axis O in the movable table unit **1**, first of all, the first driving means **5** is driven so as to move the movable table **3** in the Y-axis direction, then second driving means **5**, **6** are driven in the same direction so as to move the movable table **3** in the X-axis direction and after that, the second driving means **6**, **7** are driven in opposite directions to each other so as to rotate the movable table **3** by a predetermined amount around the rotation axis O. As a result, the motion control in the X-axis direction, Y-axis direction and in the direction θ can be carried out independently thereby facilitating the motion control of the movable table **3**.

As described above, in the movable table unit **1** according to the second embodiment, an operation for rotating the movable table **3** at a position other than the original point and an operation for moving it in parallel after rotating at a predetermined angle can be carried out by a simple control. Further, in the movable table unit **1**, by driving only the first driving means **5**, the movable table **3** can be moved linearly in the Y-axis direction easily. By driving the second driving means **6**, **7** in the same direction, the movable table **3** can be moved linearly in the X-axis direction easily. Further, because the track rail **80** in the Y-axis direction of the first two-axis guiding system 4_1 driven by the first driving means **5** is formed in a long length, the movable table **3** can be moved largely along a single axis.

In the second embodiment, when rotating the movable table **3**, only two second driving means **6**,**7** have to be driven and it is not necessary to drive the first driving means **5** in addition to the two second driving means **6**, **7** unlike the first embodiment. Thus, the rotation of the movable table **3** can be carried out further easily.

Further, according to the second embodiment, as plural two-axis guiding systems, the fourth and fifth two-axis guiding systems are disposed on the right and left sides of the first-third two-axis guiding systems. Thus, the movable table can be supported across an entire width thereof and the motion of the movable table can be further stabilized. This is particularly effective for use of a wide table or increasing the load capacity or the like.

Although the second embodiment has been described about a case in which as plural two-axis guiding systems, the fourth and fifth two-axis guiding systems are disposed on the right and left sides of the first-third two-axis guiding systems, the present is not restricted to this example, but it is possible to eliminate the fourth and fifth two-axis guiding systems by using a wide track rail in the Y-axis direction for the first-third two-axis guiding systems or narrowing the width of the movable table.

Because the structure and operation are the same as the first embodiment, a description thereof is omitted.

Third Embodiment

FIGS. **19**, **20** show a third embodiment of the present invention and the same reference numerals are attached to the same components as the first embodiment. Although this third embodiment is the same as the first embodiment in the structures of the first track rail, moving block and the second track rail, the rotation system is not provided between the movable table and two-axis guiding system, and therefore this point is different from the first embodiment.

That is, the movable table unit **1** of the third embodiment comprises first moving block **10***a* and second moving block **10***b*, which are upper and lower divisions of the two-axis guiding system **4**. The aforementioned rotation system **31** is disposed between the first moving block **10***a* and second moving block **10***b*. The other structure and operation are the same as the first embodiment, and therefore a description thereof is omitted.

What is claimed is:

1. A movable table unit comprising:

a table base plate;

a movable table supported movably on said table base plate;

a first track rail installed on the table base plate along an Y axial direction;

a plurality of rotating and two-axis guiding systems guided by the first track rail, for guiding the movable table along a different direction from the Y axial direction and supporting the movable table rotatably;

a first driving means fixed to the table base plate for driving at least one of the rotating and two-axis guiding systems along the Y axial direction; and

a plurality of second driving means fixed to the rotating and two-axis guiding systems for driving the movable table independently along the different direction from the Y axial direction,

wherein each of the rotating and two-axis guiding systems comprises a moving block guided by the first track rail, a second track rail guided by the moving block along an X axial direction and a rotation system for supporting the movable table rotatably relative to the moving block, and

wherein the rotation system is arranged between the movable table and the second track rail.

2. A movable table unit as claimed in claim **1**, wherein a rotation center of each of the rotating and two-axis guiding systems are disposed on a rotation center of the movable table.

3. A movable table unit as claimed in claim **1**, wherein the plurality of rotating and two-axis guiding systems are guided by the same first track rail.

4. A movable table unit as claimed in claim **1**, wherein the first track rail is substantially fixed on a full length of the table base plate.

5. A movable table unit as claimed in claim **1**, wherein the second track rails of the guiding systems are arranged parallel to each other.

* * * * *

US006155718A

United States Patent [19]

Takamatsu et al.

[11] **Patent Number: 6,155,718**

[45] **Date of Patent: Dec. 5, 2000**

[54] **SLIDE GUIDE AND ITS ROLLER CHAIN WITH ENDS**

[75] Inventors: **Hiroshi Takamatsu; Hiroaki Mochizuki; Tomozumi Murata**, all of Tokyo, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **09/051,256**

[22] PCT Filed: **Jun. 23, 1997**

[86] PCT No.: **PCT/JP97/02154**

§ 371 Date: **Apr. 14, 2000**

§ 102(e) Date: **Apr. 14, 2000**

[87] PCT Pub. No.: **WO97/49931**

PCT Pub. Date: **Dec. 31, 1997**

[30] **Foreign Application Priority Data**

Jun. 27, 1996 [JP] Japan 8-167985

[51] **Int. Cl.**[7] **F16C 33/56**

[52] **U.S. Cl.** **384/45**; 384/51

[58] **Field of Search** 384/45, 49, 51

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,947,605	9/1999	Shirai	384/45
5,988,883	11/1999	Takamatu et al.	384/45

FOREIGN PATENT DOCUMENTS

5-52217	3/1993	Japan .
5-126149	5/1993	Japan .
5-196036	8/1993	Japan .
5-196037	8/1993	Japan .
6-56181	7/1994	Japan .
7-317762	12/1995	Japan .

Primary Examiner—Thomas R. Hannon

Attorney, Agent, or Firm—Arent Fox Kitner Plotkin & Kahn, PLLC

[57] **ABSTRACT**

This invention relates to a sliding guide apparatus for, for example, a linear guiding apparatus, curved guiding apparatus, swiveling bearing or the like for infinite sliding motion, and more particularly to a sliding guide apparatus wherein an end-present rolling element chain for supporting a linear motion or rotary motion is inserted in a full track. The sliding guide apparatus comprises a track rail having a rolling path for rolling elements extending in the length direction of the sliding guide apparatus, a moving body which contains a loaded rolling path facing the aforementioned rolling path and an unloaded rolling path which circulates the rolling elements from one end to the other end of the loaded rolling path and moves along the aforementioned track rail, and a plurality of rolling elements which roll between the moving body and track rail while being loaded with a load and circulate in a full track composed of the loaded rolling path and unloaded rolling path of the aforementioned moving body. The rolling elements are disposed in line at predetermined intervals in a single or plurality of flexible connecting belts such that they can roll freely and incorporated in the full track of the sliding member together with the connecting belts. The connecting belts circulate with the balls in the full track of the sliding member while both end portions thereof are opposed to each other.

4 Claims, 4 Drawing Sheets

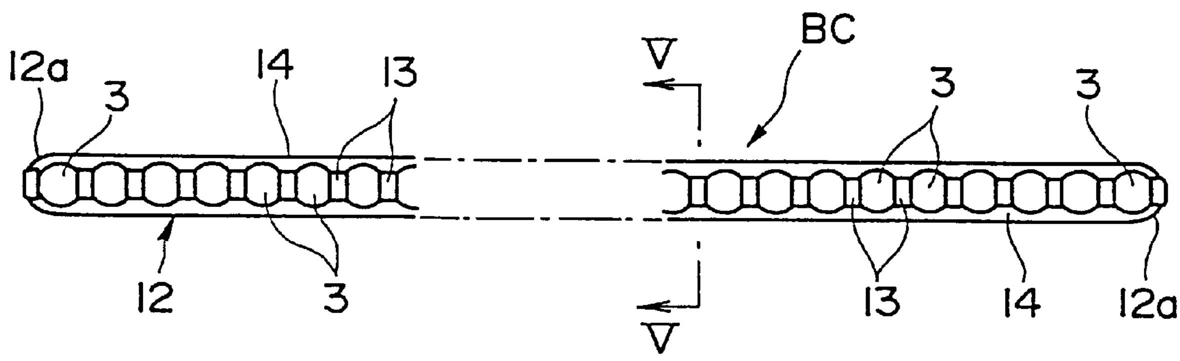


Fig. 1

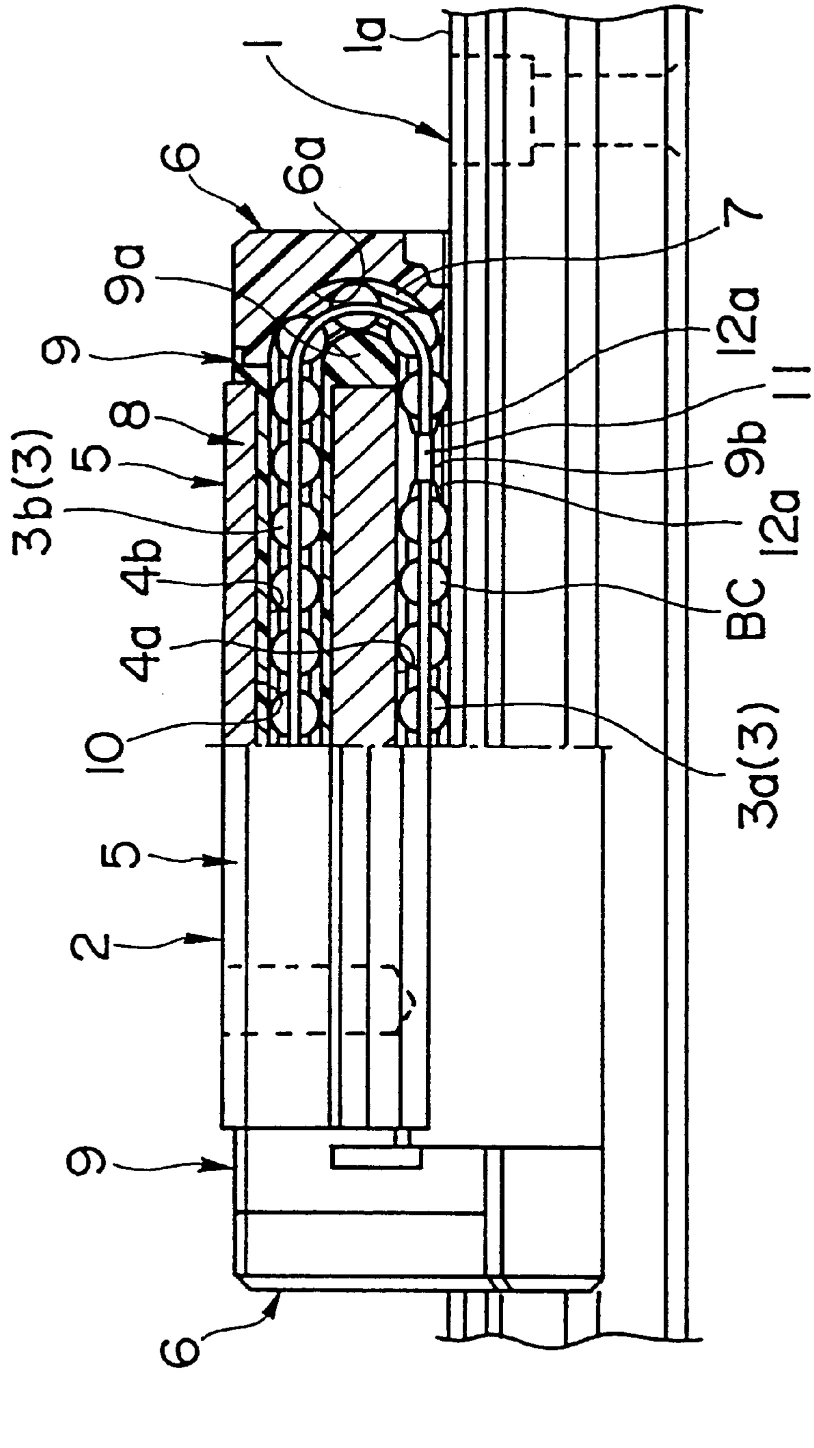


Fig. 2

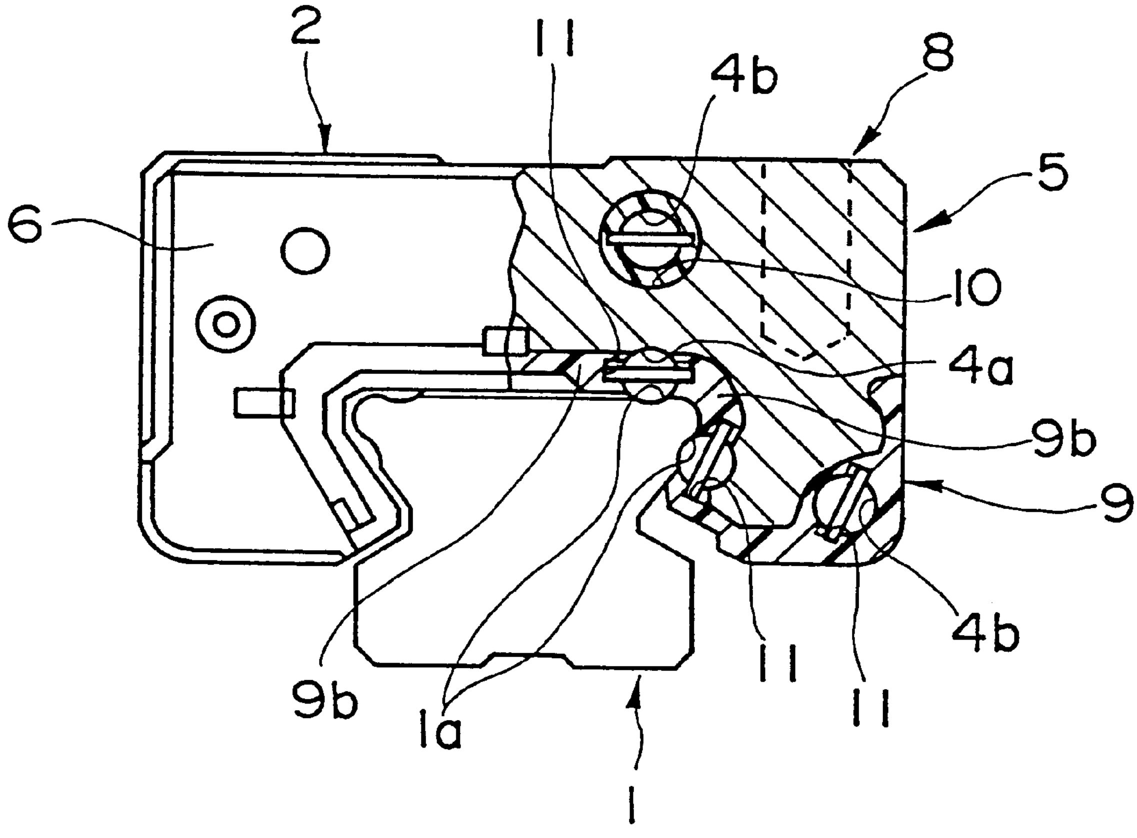


Fig. 3

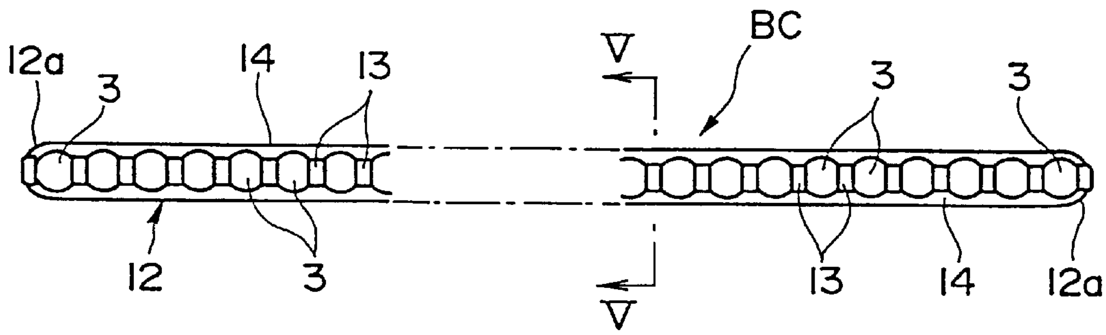


Fig. 4

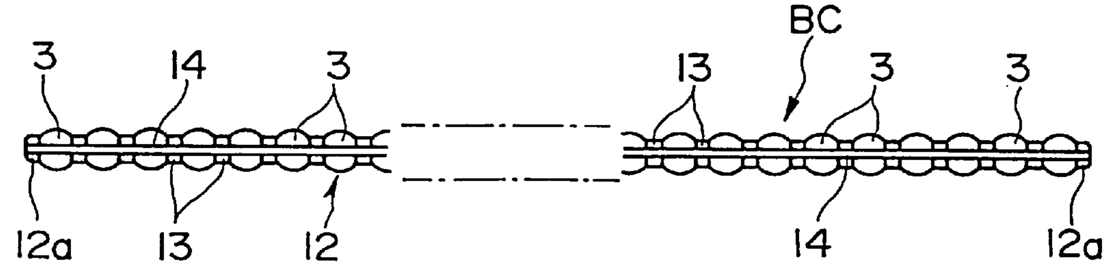


Fig. 5

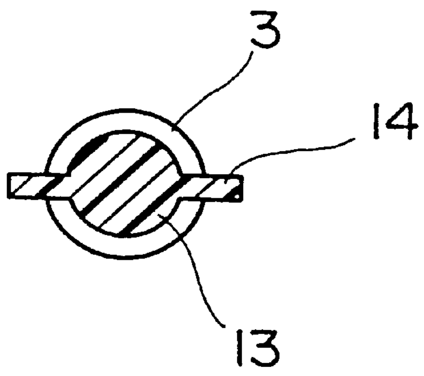
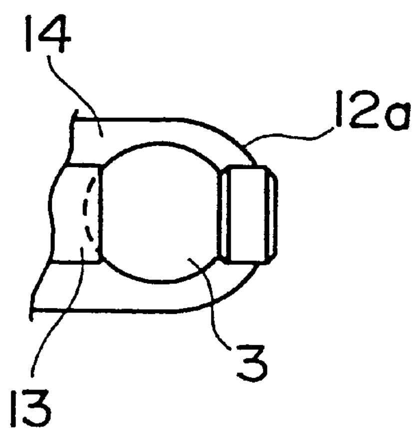


Fig. 6



SLIDE GUIDE AND ITS ROLLER CHAIN WITH ENDS

FIELD OF THE INVENTION

This invention relates to a sliding guide apparatus for, for example, a linear guiding apparatus, curved guiding apparatus, swiveling bearing or the like for infinite sliding motion, and more particularly to a sliding guide apparatus wherein an end-present rolling element chain for supporting a linear motion or rotary motion is inserted in a full track.

BACKGROUND ART

In various sliding guide apparatuses containing bearing, by using rolling motion of rolling elements such as balls or rollers interposed between a track rail and a moving body, relative linear motion or rotary motion between the track rail and moving body is enabled. To (1) prevent the rolling elements from falling out of the moving body when the moving body is separated from the track rail, (2) reduce frictional resistance by avoiding relative contact between respective rolling elements, and (3) arrange the rolling elements at predetermined positions so as to secure a smooth motion or the like, generally a plurality of the rolling elements are incorporated between the track rail and moving body while being held by rolling element retainer or rolling element cage made of metallic thin plate or synthetic resin.

However, in a sliding guide apparatus using a conventional rolling element retainer, this rolling element retainer is incorporated in the moving body and then the rolling elements are incorporated in a rolling path formed for the rolling elements. Then, the moving body is installed on the track rail. Particularly if this sliding guide apparatus contains a full track of the rolling elements, assembly work for this sliding guide apparatus using the rolling element retainer requires experienced skill, so that automation thereof is difficult.

In the sliding guide apparatus using the conventional rolling element cage, the rolling element cage has a plurality of pockets such that respective rolling elements are rotatably held in these pockets. Thus, assembly work for incorporating the plurality of the rolling elements into the sliding guide apparatus is easy. However, because it is necessary to incorporate the plurality of the rolling elements in the respective pockets of the rolling element cage and hold them so that they do not slip out, it takes time and labor to produce this rolling element cage itself.

Therefore, to solve such problem, various ball chains which are produced by injection molding of resin with balls being disposed as inner ring on a substantially flat plane in a mold so that they are incorporated without an end in a full track of a moving body have been proposed (Japanese Examined Patent Publication No. Hei 6-56181, Japanese Unexamined Patent Application No. Hei 5-52217, Japanese Unexamined Patent Application No. Hei 5-126149, Japanese Unexamined Patent Application No. Hei 5-196036, Japanese Unexamined Patent Application No. Hei 5-196037).

In this conventional ball chain, after the ball chain is incorporated in a full track of a moving body, both end portions thereof are connected to each other so as to form an endless ball chain. However, this connecting work is very troublesome.

In such a sliding guide apparatus, following so-called ball selective engagement method has been applied to support four directional loads including radial, reverse radial and

right/left direction loads between the moving body and track rail, and further improve accuracy of reciprocation of the moving body relative to the track rail and stiffness thereof. That is, pre-pressure is applied to each ball of the ball chain interposed between the moving body and track rail or this pre-pressure may be sometimes adjusted. To apply the pre-pressure and adjust it, as a general easy method, a ball having a slightly larger size than a dimension of a gap between the loaded rolling path of the moving body and a rolling path of the track rail is selected and engaged. At this time, its sliding resistance and stiffness are measured so as to determine the size of a ball for use.

However, in the sliding guide apparatus using the aforementioned conventional ball chain, when this ball selective engagement is carried out, if the ball chain first incorporated in the moving body and connected endlessly has not achieved a desired sliding resistance and stiffness due to its ball diameter, this endless connection of the ball chain must be released so as to create ends thereof and that ball chain having the ends must be removed from the moving body. Then, another ball chain having ends and a different ball diameter is incorporated in the moving body and connected endlessly. Whether or not this incorporated ball chain has achieved its desired sliding resistance and stiffness is investigated. Until the ball diameter of the ball chain incorporated in the moving body achieved its desired sliding resistance and stiffness, the same procedure must be repeated. As a result, the ball selective engagement method which is essentially a simple method for application of pre-pressure and adjustment thereof, conversely becomes a very complicated method.

DISCLOSURE OF THE INVENTION

The present invention has been proposed in viewpoints of this problem. It therefore is an object thereof to provide a sliding guide apparatus and an end-present rolling element chain thereof, which are easy to handle without slip-out of the rolling elements and incorporate in a full track of the sliding guide apparatus while automation of such procedures is also easy, and wherein not only the ball selective engagement method for application of pre-pressure and adjustment thereof can be applied without making its operation complicated, but also the operation of the ball selective engagement method is further made easy to facilitate handling of the rolling elements so that they do not slip out.

According to the present invention, there is provided a sliding guide apparatus containing a track rail, a moving body which moves along the track rail and a plurality of rolling elements which roll between the moving body and track rail while being loaded with a load, the track rail having a rolling path on which the rolling elements roll, the moving body comprising a main unit having a loaded rolling path in which loaded rolling elements roll facing the rolling path of the track rail and an unloaded rolling path in which unloaded rolling elements roll, and a pair of lid portions which are mounted on front and rear ends in advancement direction and in which direction changing paths for the rolling elements for connecting the loaded rolling path and the unloaded rolling path are formed, the loaded rolling path and unloaded rolling path of the moving body, direction changing path and rolling path of the track rail facing the loaded rolling path of the moving body forming full tracks for the rolling elements, the plurality of rolling elements being connected by flexible resin connecting body having interposed portions which are interposed between the respective rolling elements and connecting portions for connecting the respective interposed portions so as to hold the plurality of the rolling elements in arranged condition such that they can roll, and further having both end portions, the plurality of rolling elements being further composed in the form of a single or plural end-present rolling element chains which are built into the full track.

Further according to the present invention, there is provided an end-present rolling element chain comprising a plurality of rolling elements and a resin connecting body having interposed portions which are interposed between the rolling elements and connecting portions for connecting the respective interposed portions so as to hold the plurality of rolling elements in arranged condition such that the rolling elements can roll, the resin connecting body having chamfered guiding portions for guiding both end portions of the resin connecting body.

According to the present invention, the track rail of the sliding guide apparatus has rolling paths for the rolling elements in its axial direction. The shape of this rolling path is not restricted to any particular one, but for example if the rolling element is a ball, this may be circular arc groove or gothic arc groove. Further, the number of the rolling grooves can be arbitrarily determined depending on the number of the full tracks formed on the moving body. For example, it is permissible to form one track on single side or two tracks on single side.

The moving body forming the sliding guide apparatus comprises a main unit having a loaded rolling path in which loaded rolling elements roll facing the rolling path of the track rail and an unloaded rolling path in which unloaded rolling elements roll, and a pair of lid portions which are mounted on front and rear ends in advancement direction and in which direction changing paths for the rolling elements for connecting the loaded rolling path and the unloaded rolling path are formed. The shape and structure thereof, the number of the incorporated full tracks, performance, function and the like are not restricted to any particular ones. For example, a type in which a single full track is provided on single side, a type in which two tracks are provided on single side, a type in which loads in four directions are supported, a type in which one side supports downward load while the other side supports upward load, a type in which a bearing lace having a loaded rolling path is provided, and the like are available.

Preferably, the main unit of this moving body is composed of a bearing race having at least a loaded rolling path and a resin forming portion which is formed on this bearing race in mold. Further preferably, it is permissible to form guiding grooves for guiding a resin connecting body of the end-present rolling element chain in an unloaded area (that is, an unloaded rolling path formed in the resin forming portion of the main unit and direction changing path formed by a pair of lid portions made of synthetic resin) of the full track formed in this moving body. Further, it is permissible to form a ball holding portion made of synthetic resin on both sides of the loaded rolling path of the bearing race as a part of the resin forming portion and a guiding groove for guiding the resin connecting portion of the end-present rolling element chain over an entire range of the full track including this ball holding portion.

Further according to the present invention, the end-present rolling element chain comprises a plurality of rolling elements and a resin connecting body having interposed portions which are interposed between the respective rolling elements and connecting portions for connecting the respective interposed portions so as to hold the plurality of the rolling elements in arranged condition such that they can roll. Preferably, chamfered guiding portions for guiding both end portions of the resin connecting body are formed at the both end portions of the resin connecting body. Consequently, when the end-present rolling element chain is moved in the full track, particularly when the both end portions of the end-present rolling element chain invade into the direction changing guiding hole or escapes from this direction changing guiding hole, the both end portions are guided so as to move the chain smoothly. As for the chamfered guiding portions formed on both ends of the resin connecting body, a radius of curvature, shape and the like thereof are determined and designed taking into account a radius of curvature and the like of the direction changing path in the full track of the sliding guide apparatus.

Although the length of the end-present rolling element chain is determined taking into account a length of the full track of the sliding guide apparatus in which the chain is used, if the sliding guide apparatus is so large that the length of the full track is very long, it is permissible to divide this full track to plural sections, that is, 2 or 3 sections, thereby making it possible to reduce the size of forming molds. In this case, it is recommended to form the chamfered guiding portions on both end portions of each resin connecting body of a divided end-present rolling element chain.

Here, as a rolling element for use in such an end-present rolling element chain, concretely balls or rollers are available. As a rolling element for use in a sliding guide apparatus requiring a smooth sliding property, the ball is preferred. As a rolling element for use in a sliding guide apparatus in which a relatively heavy load is applied, the roller is preferred.

Further, as a method for producing the end-present rolling element chain of the present invention, a method for forming a resin connecting body holding a plurality of the rolling elements by injection molding with the plurality of the rolling elements disposed as inner rings, is available. For the injection molding with the plurality of the rolling elements disposed as inner rings, so-called insert moldings disclosed in the aforementioned Japanese Examined Patent Publication No. Hei 6-56181, Japanese Unexamined Patent Application No. Hei 5-52217, Japanese Unexamined Patent Application No. Hei 5-126149, Japanese Unexamined Patent Application No. Hei 5-196036, Japanese Unexamined Patent Application No. Hei 5-196037, are applicable.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a partially sectional side view of a linear sliding guide apparatus according to an embodiment of the present invention;

FIG. **2** is a partially sectional front view of FIG. **1**;

FIG. **3** is a plan view of an end-present rolling element chain for use in the linear sliding guide apparatus of FIG. **1**;

FIG. **4** is a front view of FIG. **3**;

FIG. **5** is a sectional view taken along the lines V—V of FIG. **1**; and

FIG. **6** is a partially enlarged plan view showing an enlargement of an end portion of the end-present rolling element chain shown in FIG. **3**.

BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, the embodiment of a linear sliding guide apparatus shown in the accompanying drawing will be described in detail.

FIGS. **1** and **2** show a linear sliding guide apparatus according to an embodiment of the present invention. This linear sliding guide apparatus basically is formed of end-present rolling element chain BC comprising a track rail **1**, a sliding base (moving body) **2** moving along this track rail **1** and a plurality of balls (rolling elements) **3** rolling between the sliding base **2** and track rail **1** while being loaded with a load.

According to this embodiment, the aforementioned track rail **1** has four rolling grooves (rolling paths) **1***a*, two grooves being provided on each side of right and left shoulders, such that the balls **3** roll in the rolling grooves **1***a*.

The aforementioned sliding base **2** comprises a main unit **5** having a loaded ball rolling groove (loaded rolling path) **4***a* in which load applied balls (loaded balls) **3***a* roll facing the rolling groove la of the track rail **1** and an unloaded ball guiding hole (unloaded rolling path) **4***b* in which no-load applied balls (unloaded balls) **3***b* roll, and a pair of lid portions **6** which are mounted on front and rear ends in advancement direction and in which direction changing holes (direction changing paths) **7** for the balls **3** for connecting the loaded ball rolling groove **4***a* and the unloaded ball guiding hole **4***b* are formed. Full track for the ball **3** is formed by the loaded ball rolling groove **4***a* and unloaded ball guiding hole **4***b* in the aforementioned sliding base **2**, direction changing hole **7** formed in the respective lid portions **6** and the rolling groove la of the track rail **1** facing the loaded ball rolling groove **4***a* in the sliding base **2**.

According to this embodiment, the main unit **5** of the aforementioned sliding base **2** comprises a metallic bearing race **8** having the loaded ball rolling groove **4***a* and through hole **10**, and a resin forming portion **9** which is insert-formed on the bearing race **8** in a mold and has a direction changing guide portion **9***a*, which forms the direction changing guide hole **7** together with the unloaded ball guiding hole **4***b* and the direction changing guiding groove **6***a* formed inside the respective lid portions **6**, and a ball holding portion **9***b* formed along the loaded ball rolling groove **4***a* of the bearing race **8**. A guiding groove **11** is formed in the unloaded ball guiding hole **4***b* and ball holding portion **9***b* of the resin forming portion **9** and direction changing guiding groove **6***a* of the respective lid portions **6** such that it extends endlessly along the formed full track, and guides the end-present rolling element chain BC incorporated in the full track so as to smooth a circulation of this end-present rolling element chain BC.

As shown in FIGS. **3** through **6**, the end-present rolling element chain BC is formed of flexible resin connecting body **12** which has a plurality of balls **3**, interposed portions **13** which are interposed between the balls **3** and connecting portions **14** for connecting the respective interposed portions **13** so as to hold the plurality of the balls **3** in arranged condition such that they can roll and has both end portions, and chamfered guiding portions **12***a* for guiding both end portions of this resin connecting body **12** are formed on the both portions of this resin connecting body **12**. Consequently, when the end-present rolling element chain BC is moved in the full track, particularly when the both end portions of the end-present rolling element chain BC invade into the direction changing guiding hole **7** or escapes from this direction changing guiding hole **7**, the both end portions are guided so as to move the chain BC smoothly.

When this end-present rolling element chain BC is incorporated in the full track of the sliding guide apparatus, the connection portions **14** composing the resin connecting body **12** of this end-present rolling element chain BC are engaged with the guiding grooves **11** formed in the aforementioned sliding base **2** so that the posture of the end-present rolling element chain BC is controlled during circulation thereof in the full track so as to secure a smooth rolling of the balls **3**. The chamfered guiding portions **12***a* formed on the both end portions of the resin connecting body **12** guide the front end portion of the end-present rolling element chain BC so as to achieve smooth circulation of the end-present rolling element chain BC.

INDUSTRIAL APPLICABILITY

As described above, according to the sliding guide apparatus and end-present rolling element chain of the present invention, the rolling elements are free of slip-out, easy to use and easy to be incorporated in the full track of the sliding guide apparatus. Further, automation of that work is possible. A ball selective engagement method for application of the pre-pressure and adjustment thereof can be applied without damaging its easy property thereof, and rather its operability thereof can be further improved.

What is claimed is:

1. A sliding guide apparatus containing a track rail, a moving body which moves along said track rail and a plurality of rolling elements which roll between said moving body and track rail while being loaded with a load, said track rail having a rolling path on which said rolling elements roll, said moving body comprising a main unit having a loaded rolling path in which loaded rolling elements roll facing the rolling path of said track rail and an unloaded rolling path in which unloaded rolling elements roll, and a pair of lid portions which are mounted on front and rear ends in advancement direction and in which direction changing paths for said rolling elements for connecting the loaded rolling path and the unloaded rolling path are formed, said loaded rolling path and unloaded rolling path of said moving body, direction changing path and rolling path of said track rail facing said loaded rolling path of said moving body forming full tracks for said rolling elements, said plurality of rolling elements being connected by flexible resin connecting body having interposed portions which are interposed between the respective rolling elements and connecting portions for connecting the respective interposed portions so as to hold said plurality of the rolling elements in arranged condition such that they can roll, and further having both end portions, said plurality of rolling elements being further composed in the form of a single or plural end-present rolling element chains which are built into said full track.

2. A sliding guide apparatus according to claim **1** wherein the main unit of said moving body comprises a bearing race having at least the loaded rolling path and a resin forming portion formed on said bearing race in mold.

3. A sliding guide apparatus according to claim **1** or **2** wherein said end-present rolling chain contains chamfered guiding portions which are provided on both ends of the resin connecting body and guide a circulation of said end-present rolling chain in said full-track.

4. An end-present rolling element chain comprising a plurality of rolling elements and a resin connecting body having interposed portions which are interposed between the rolling elements and connecting portions for connecting the respective interposed portions so as to hold said plurality of rolling elements in arranged condition such that said rolling elements can roll, said resin connecting body having chamfered guiding portions for guiding both end portions of said resin connecting body.

* * * * *

US006155717A

United States Patent [19]

Michioka et al.

[11] **Patent Number: 6,155,717**

[45] **Date of Patent: Dec. 5, 2000**

[54] **LINEAR MOVEMENT DEVICE AND LUBRICANT SUPPLYING DEVICE USED THEREFOR**

[75] Inventors: **Hidekazu Michioka**; **Mitsuaki Honma**, both of Tokyo, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **09/091,354**

[22] PCT Filed: **Nov. 10, 1997**

[86] PCT No.: **PCT/JP97/04088**

§ 371 Date: **Jun. 18, 1998**

§ 102(e) Date: **Jun. 18, 1998**

[87] PCT Pub. No.: **WO98/21493**

PCT Pub. Date: **May 22, 1998**

[30] **Foreign Application Priority Data**

Nov. 11, 1996 [JP] Japan 8-314250

[51] **Int. Cl.**^{7} **F16C 29/06**; F16C 33/66

[52] **U.S. Cl.** **384/15**; 384/13; 384/16; 384/45; 74/89.15

[58] **Field of Search** .... 384/13, 15, 16, 384/43, 44, 45; 74/89.15, 459, 424.8 R

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,399,023	3/1995	Winkelmann et al.	384/15 X
5,492,413	2/1996	Tsukada	384/15
5,547,285	8/1996	Hutzel et al.	384/15
5,678,927	10/1997	Yabe et al.	384/15
5,694,811	12/1997	Tsukada	384/13 X
5,749,266	5/1998	Tsukada	74/89.15 X

FOREIGN PATENT DOCUMENTS

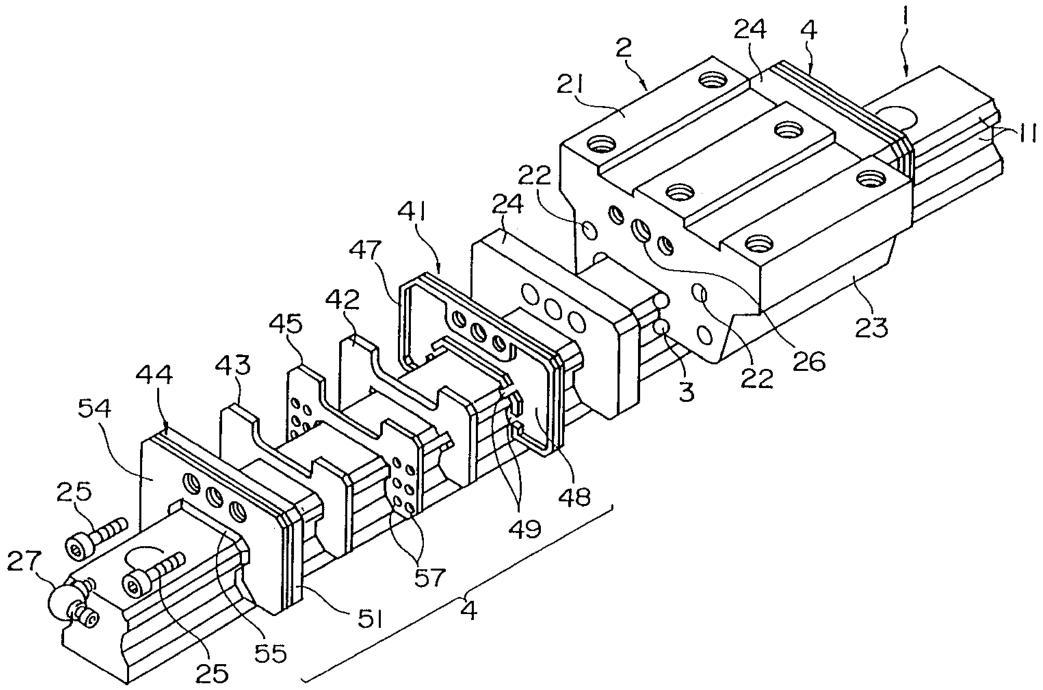
61-99143	6/1986	Japan .
5-71443	9/1993	Japan .
6-307442	11/1994	Japan .
7-23824	5/1995	Japan .
8-247144	9/1996	Japan .
9-025933	1/1997	Japan .
9-152095	6/1997	Japan .

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Nikaido, Marmelstein, Murray & Oram LLP

[57] **ABSTRACT**

The present invention relates to a linear movement device, for example, a linear guide device, a ball screw, a ball spline or the like in which a track shaft and a slide member is engaged movably relative to each other via a rolling element of a ball, a roller or the like, in details, to an improvement of a linear movement device having a lubricant supplying member coating a lubricant on a face of the track shaft. The linear movement device is constituted by a track shaft where a rolling face of a rolling element is formed, a slide member engaged with the track shaft via the rolling element and moved relative to the track shaft and a lubricant supplying member mounted to the slide member and coating a lubricant on a surface of the track shaft in accordance with the relative movement and further, the lubricant supplying member includes a lubricant coater brought into contact with the track shaft for coating the lubricant on the track shaft, a lubricant absorber installed contiguous to the lubricant coater for supplying the lubricant to the lubricant coater while absorbing the lubricant and holding the lubricant and oil amount controlling means for controlling an amount of the lubricant supplied from the lubricant absorber to the lubricant coater.

10 Claims, 17 Drawing Sheets



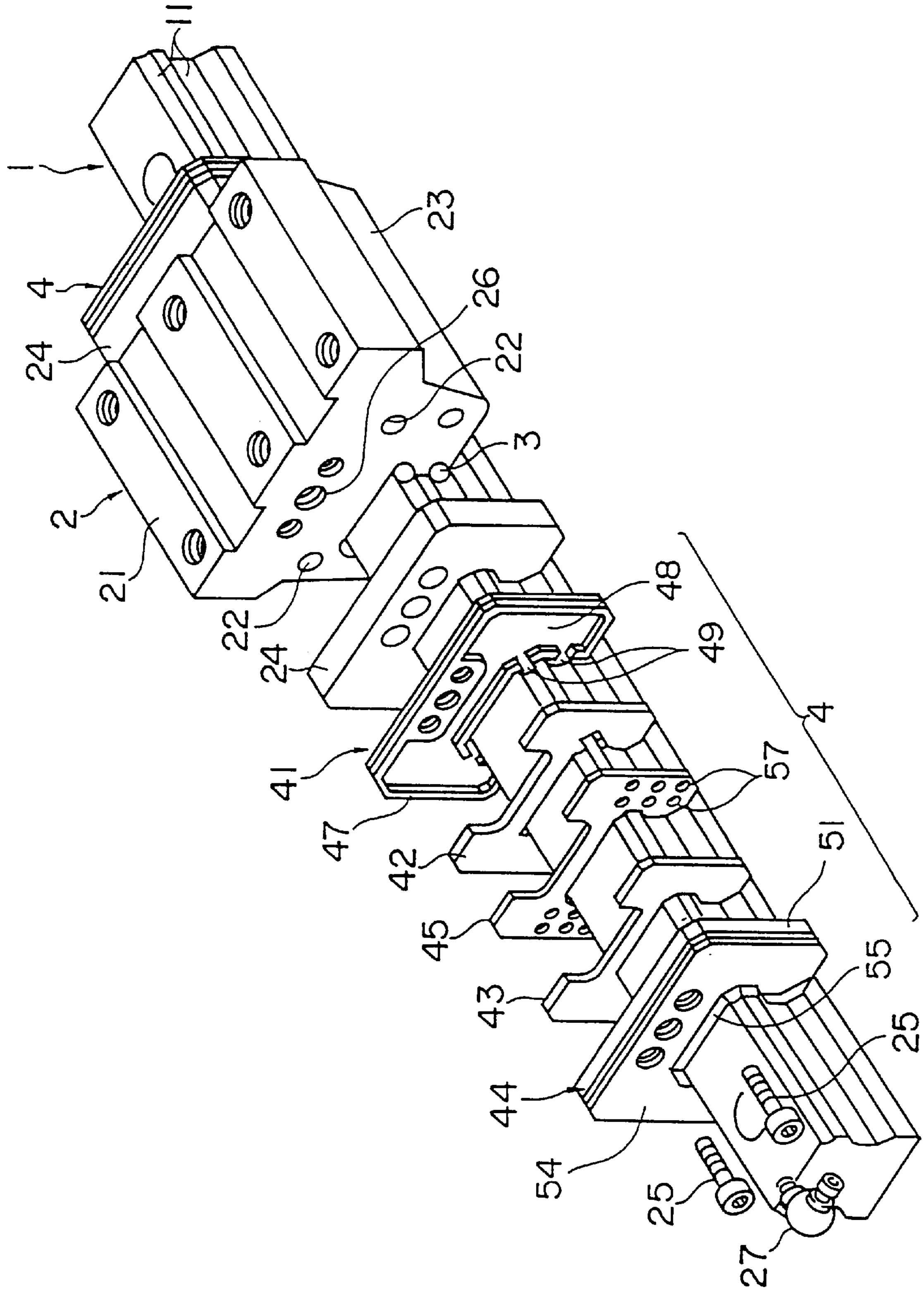

1
11
2
21
22
22
23
24
24
26
3
4
4
41
42
43
44
45
47
48
49
51
54
55
57
25
25
27

FIG.1

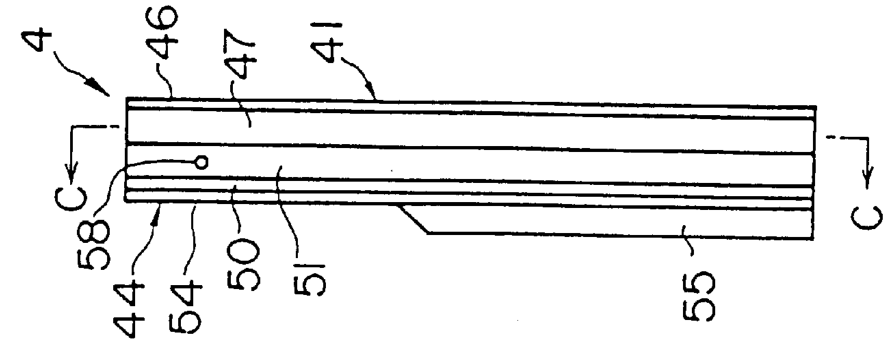

4
46
47
41
C
58
44
54
50
51
55
C

FIG.2(b)

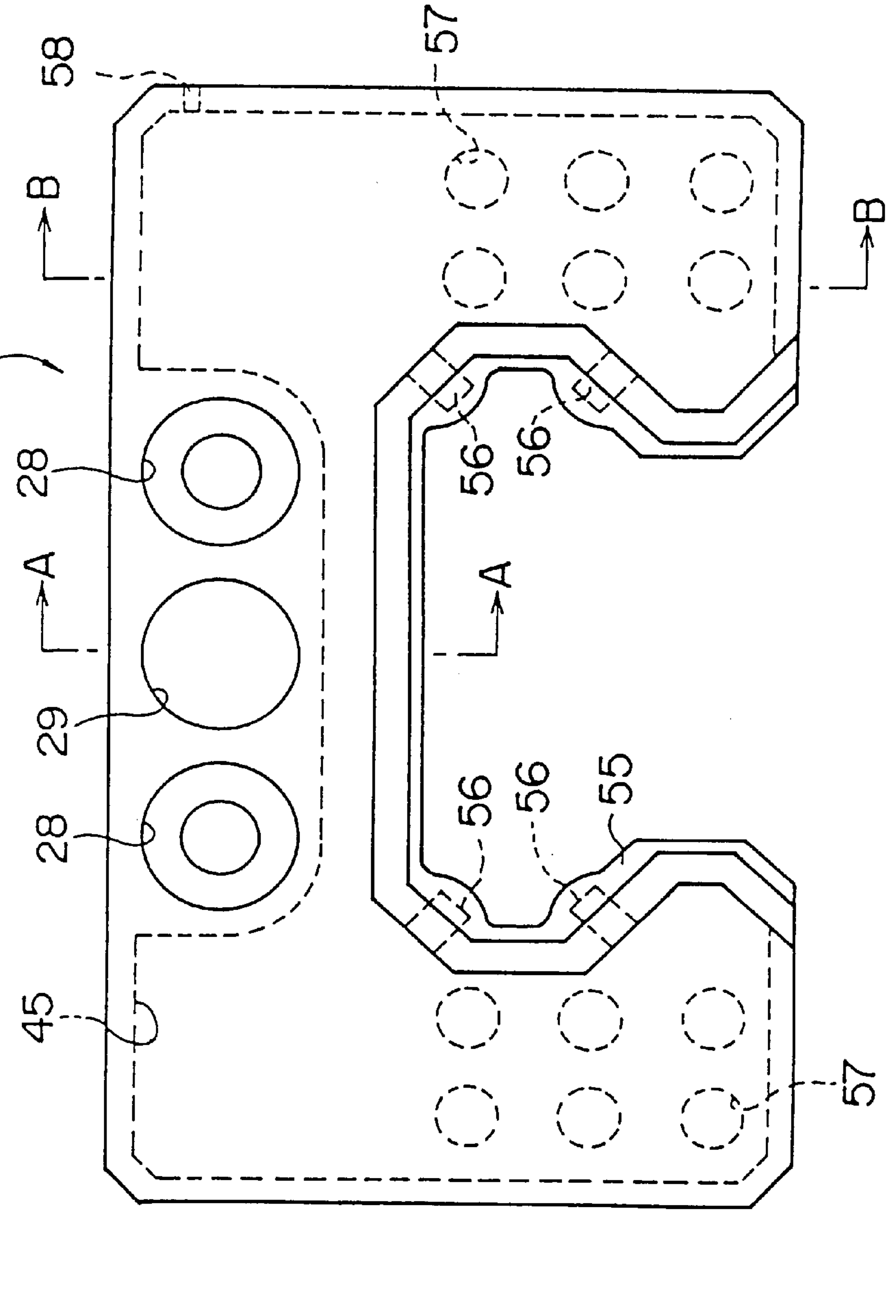

58
57
B
B
4
28
56
56
A
A
29
28
56
56
55
45
57

FIG.2(a)

FIG. 3(a)

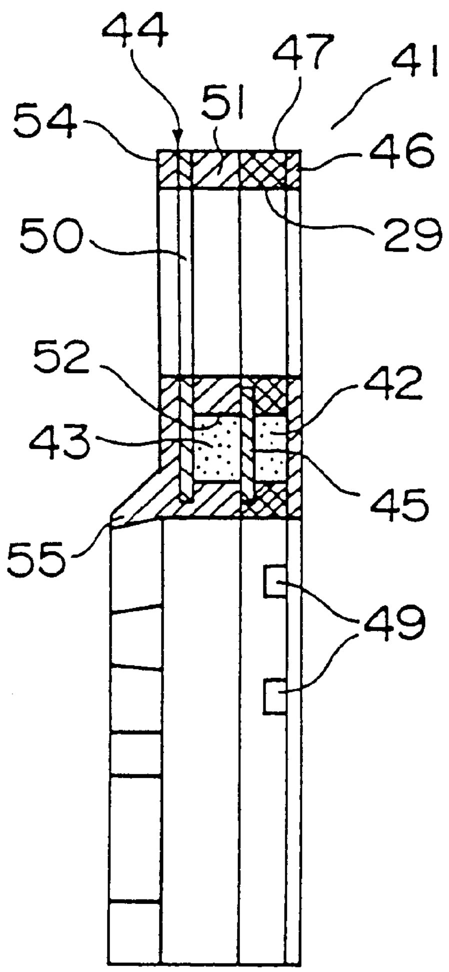
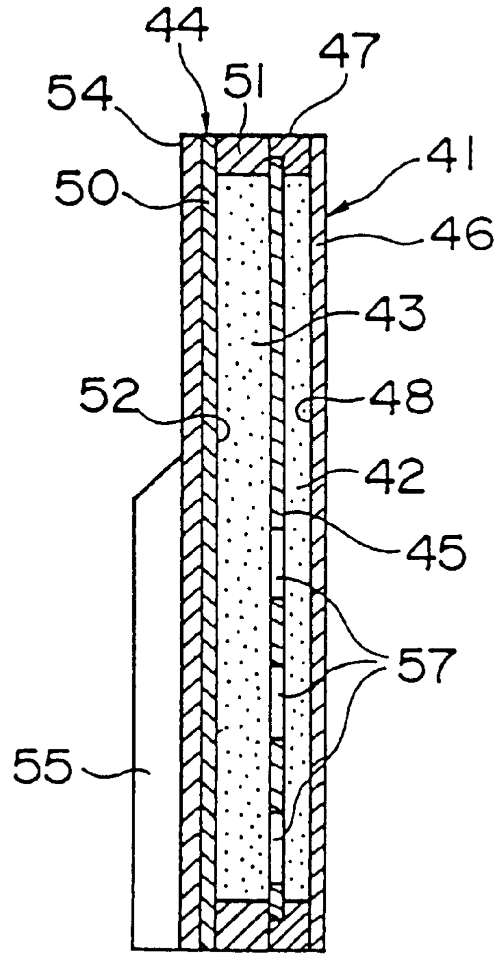
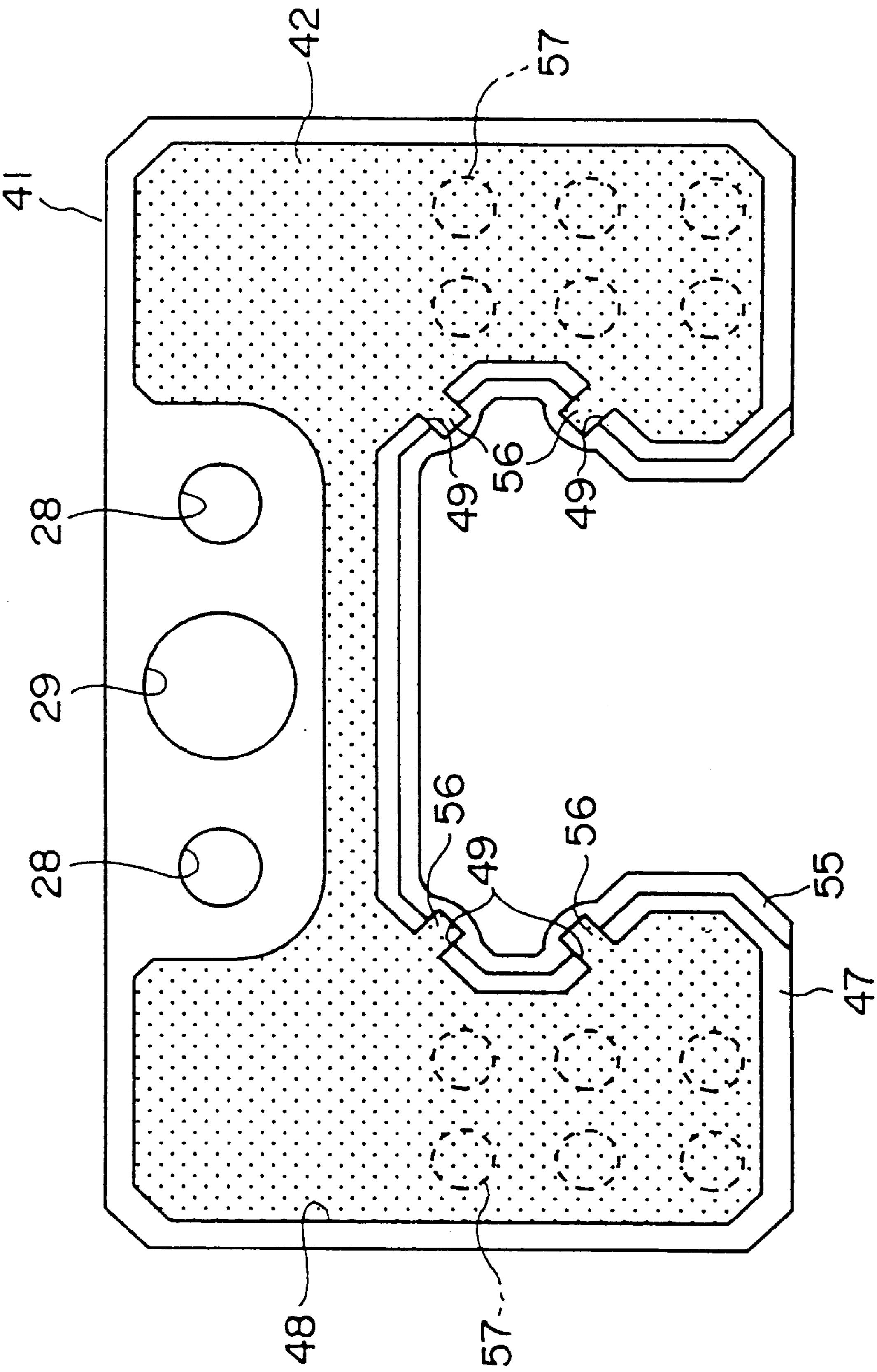
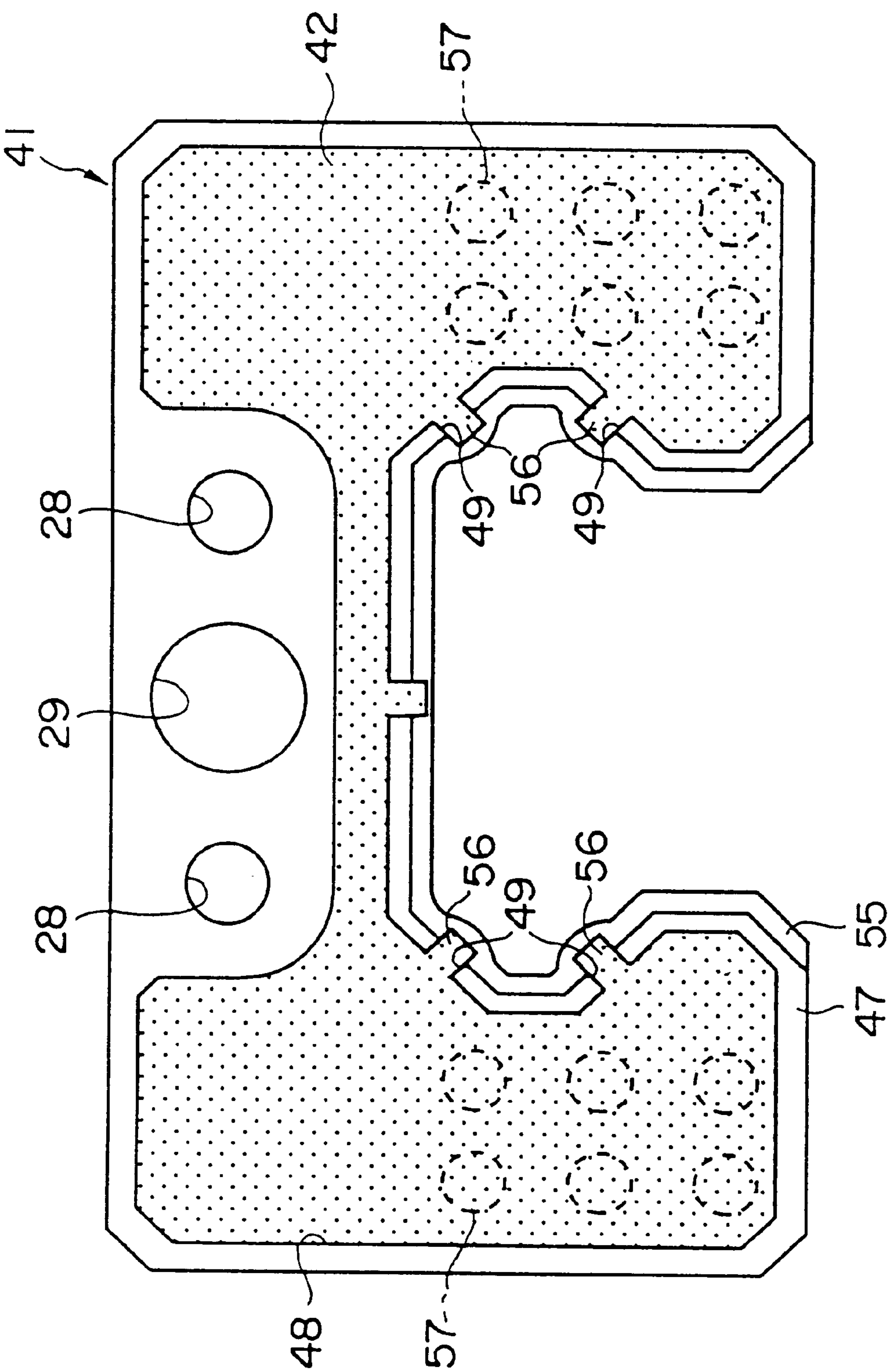

44
47
41
51
54
46
50
29
52
42
43
45
55
49

FIG. 3(b)


44
47
51
54
41
50
46
43
52
48
42
45
57
55

F I G. 4





F I G. 5

FIG. 6(b)

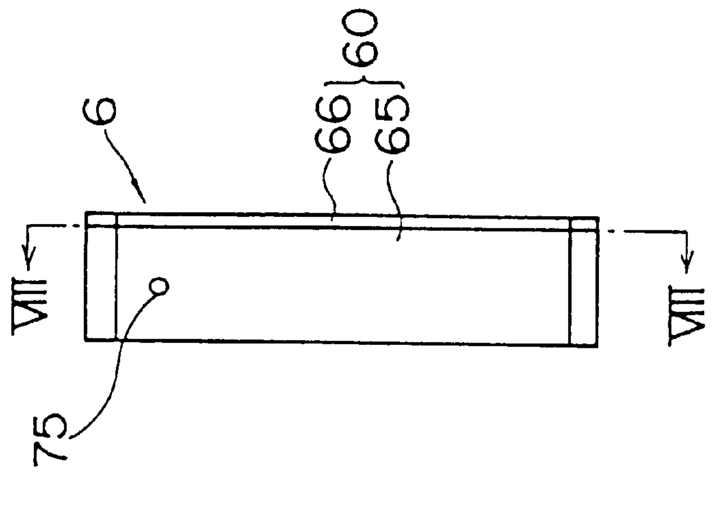
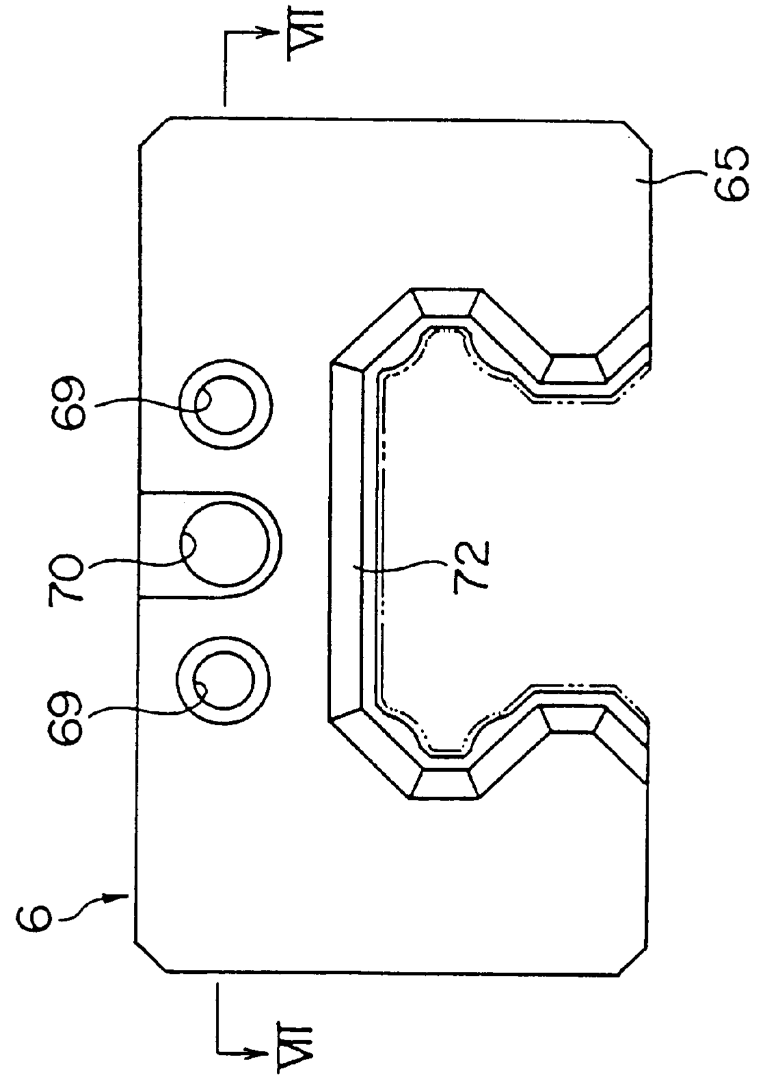
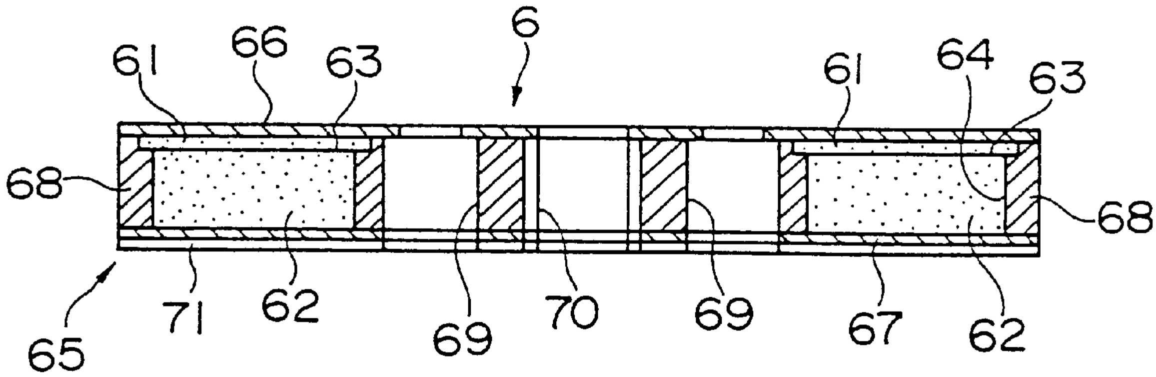


FIG. 6(a)



F I G. 7


6
61
66
63
61
64
63
68
68
65
71
62
69
70
69
67
62

F I G. 8

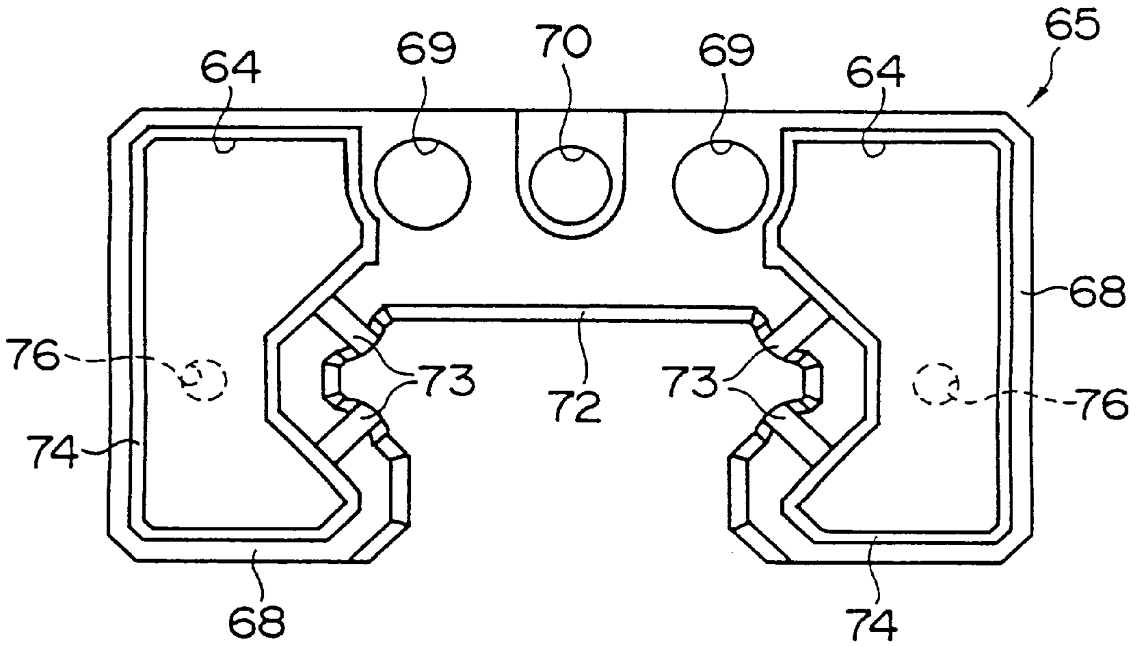

64
69
70
69
64
65
68
76
73
72
73
76
74
68
74

FIG.9

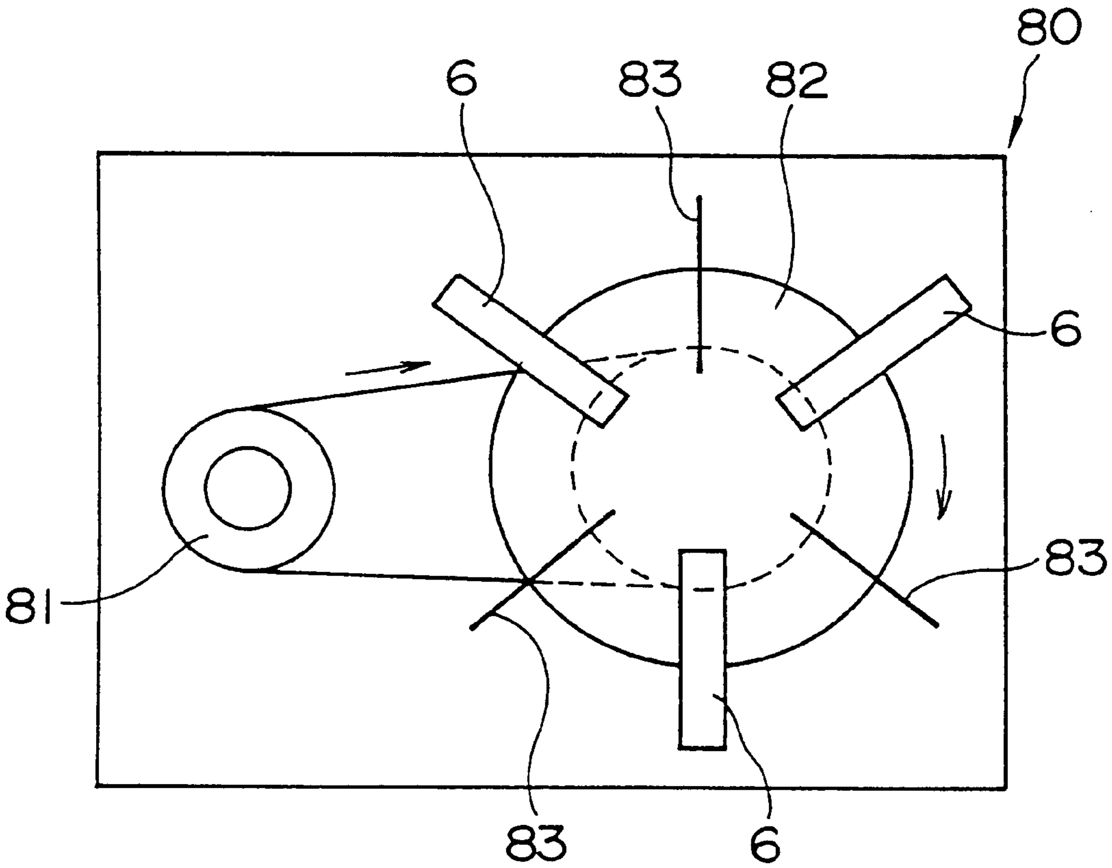


FIG. 10(a)

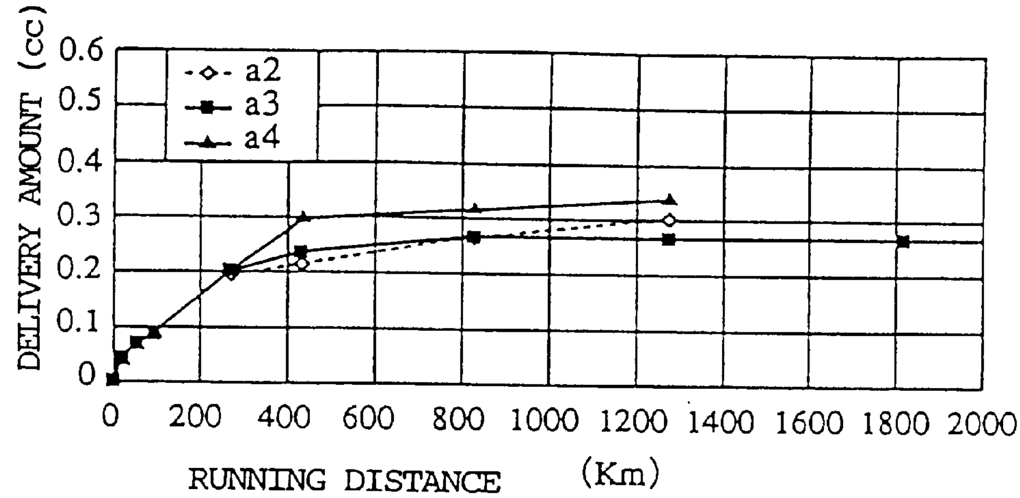


FIG. 10(b)

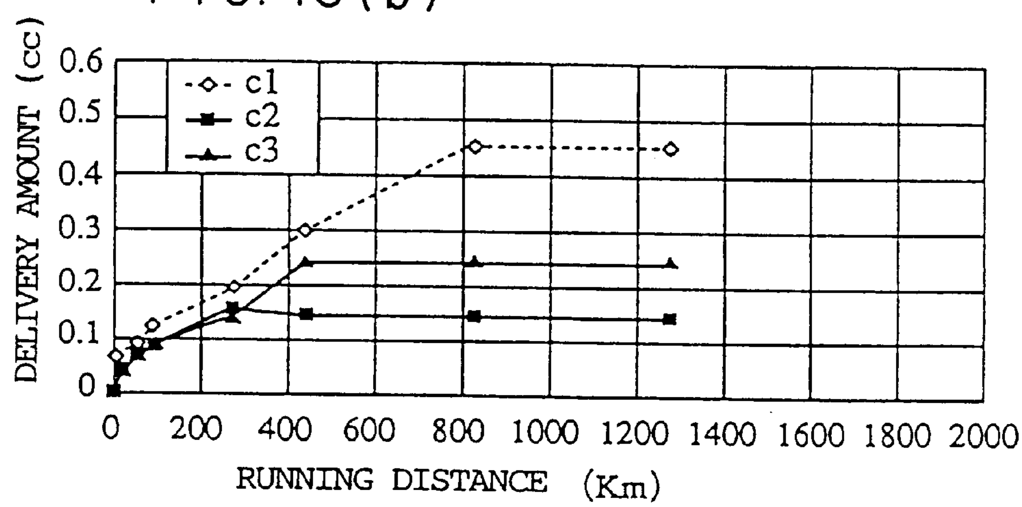


FIG. 10(c)

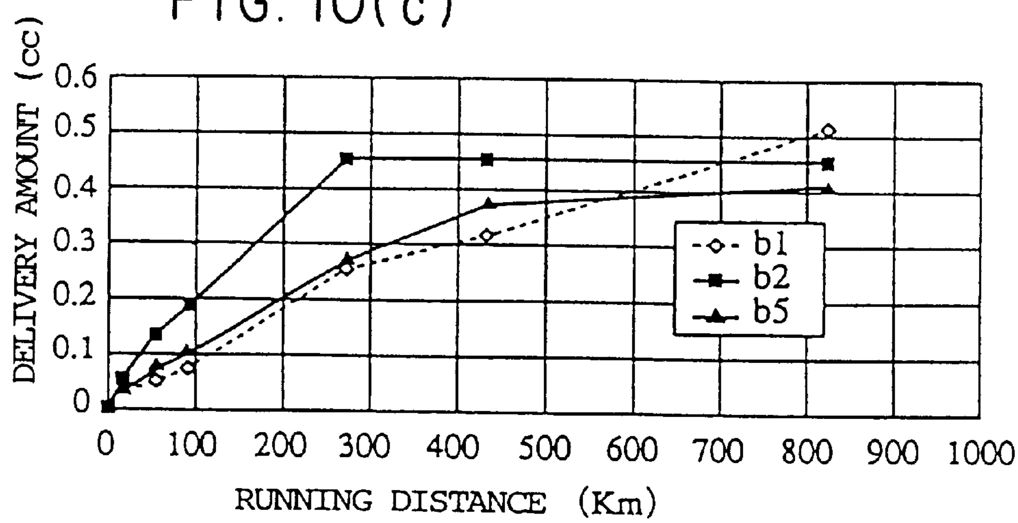
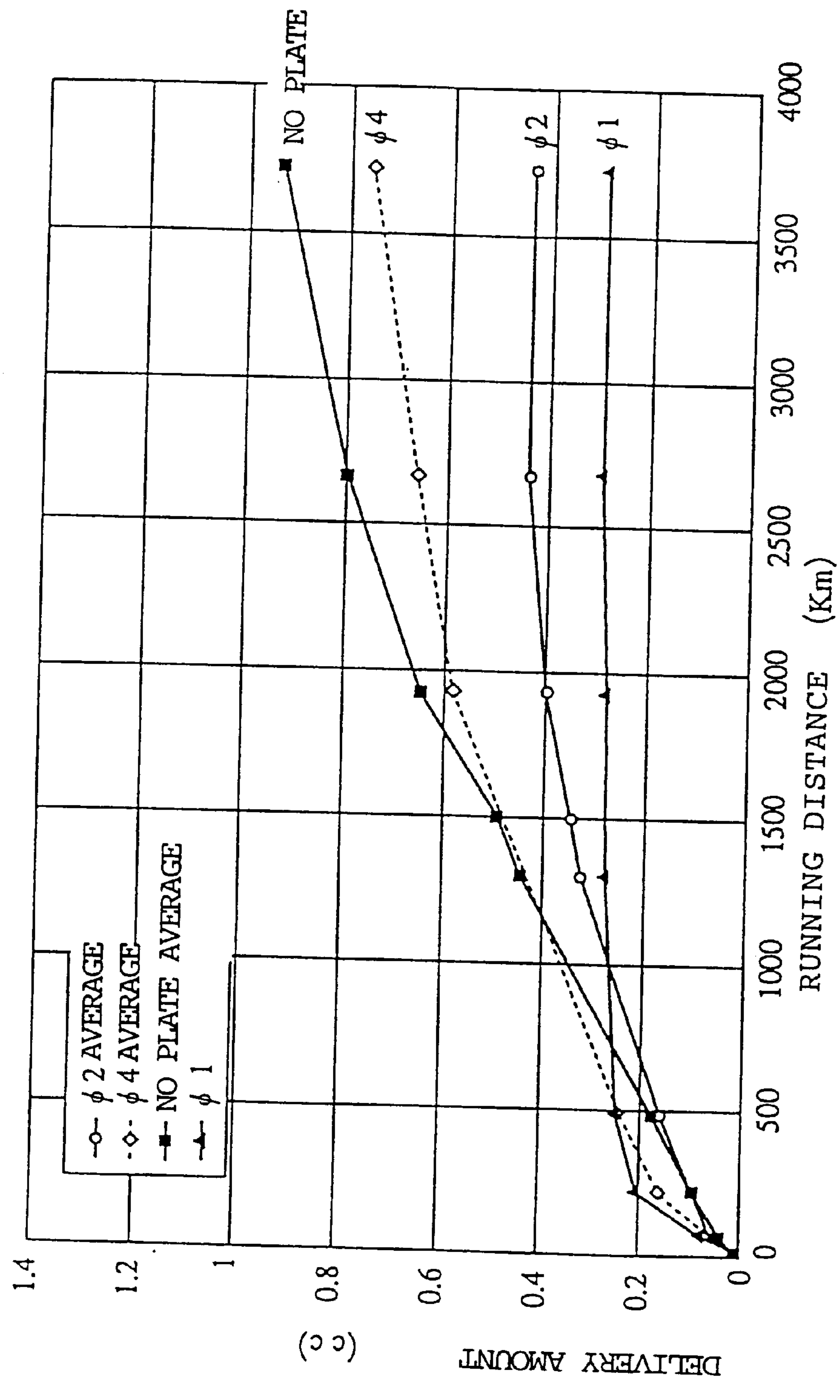
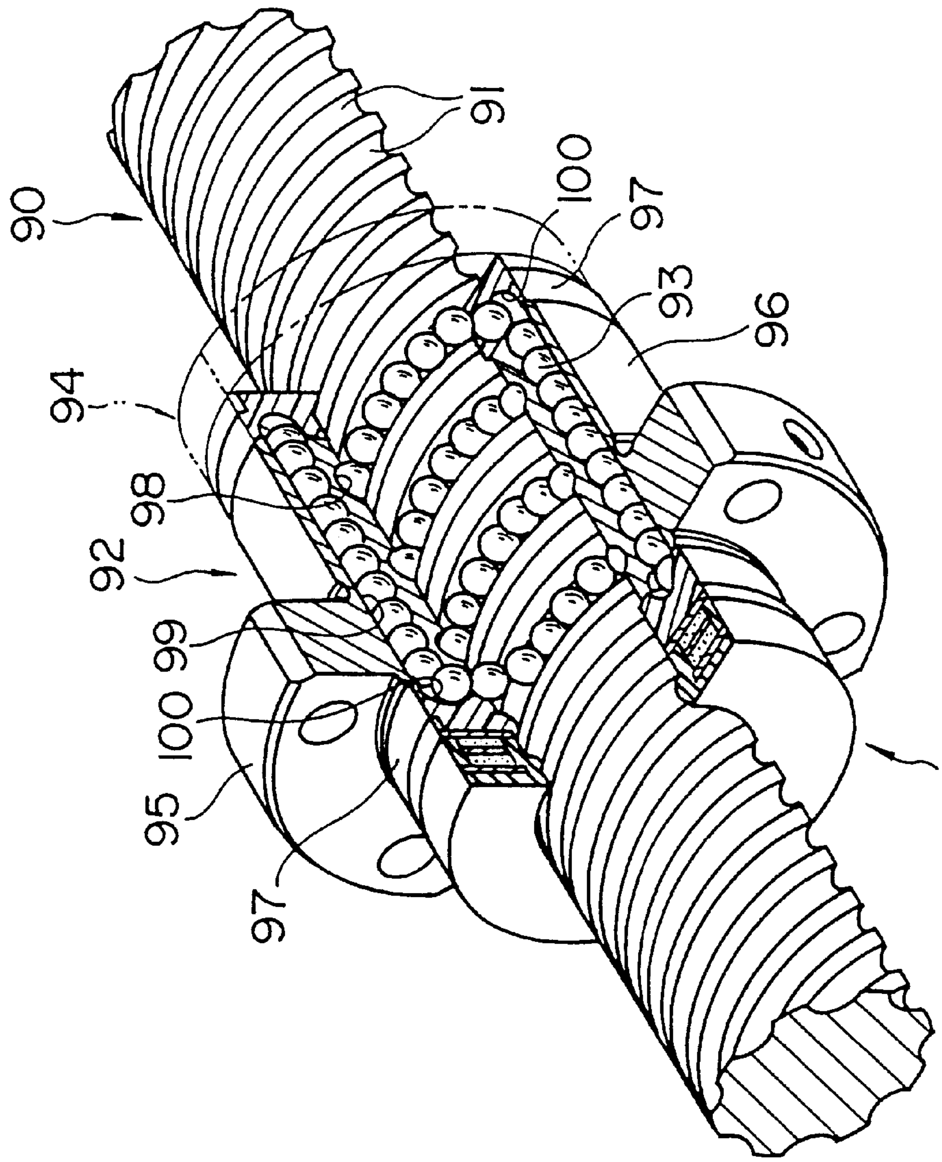


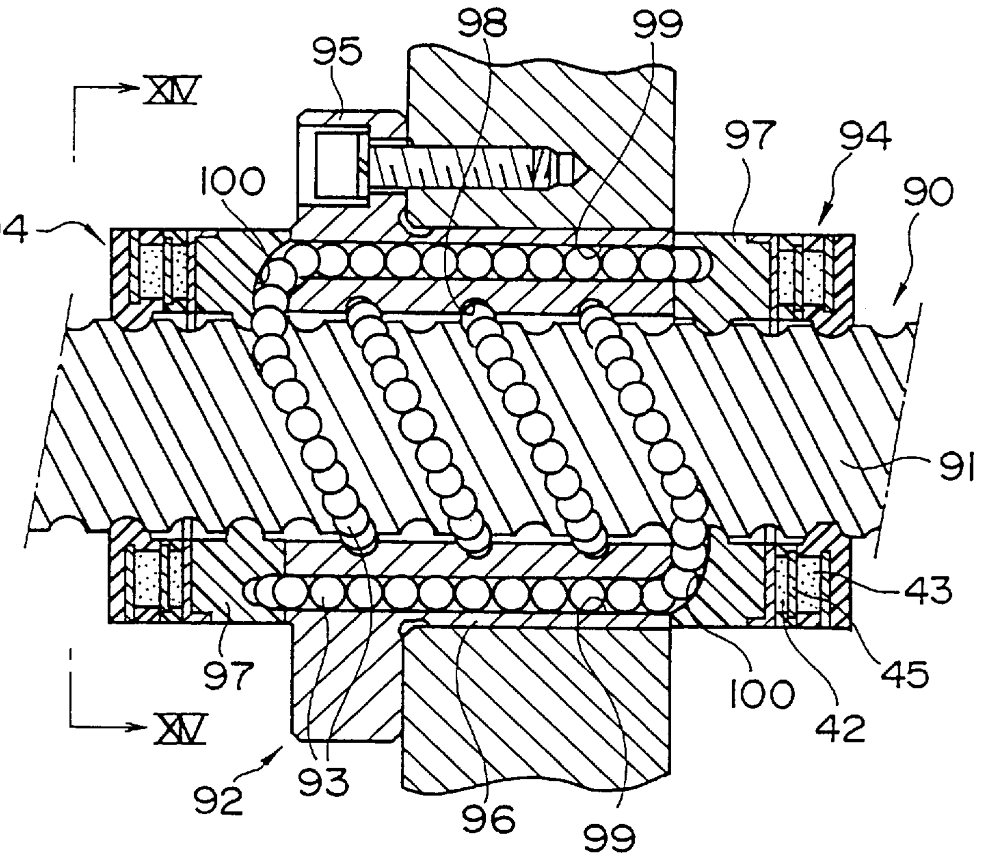
FIG. 11


φ 2 AVERAGE
φ 4 AVERAGE
NO PLATE AVERAGE
φ 1
NO PLATE
φ 4
φ 2
φ 1
DELIVERY AMOUNT (c c)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
RUNNING DISTANCE (Km)
0
500
1000
1500
2000
2500
3000
3500
4000

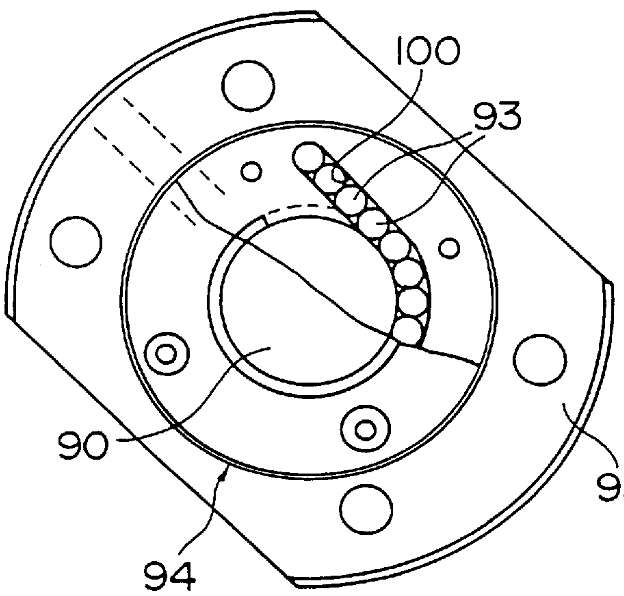
F I G .12



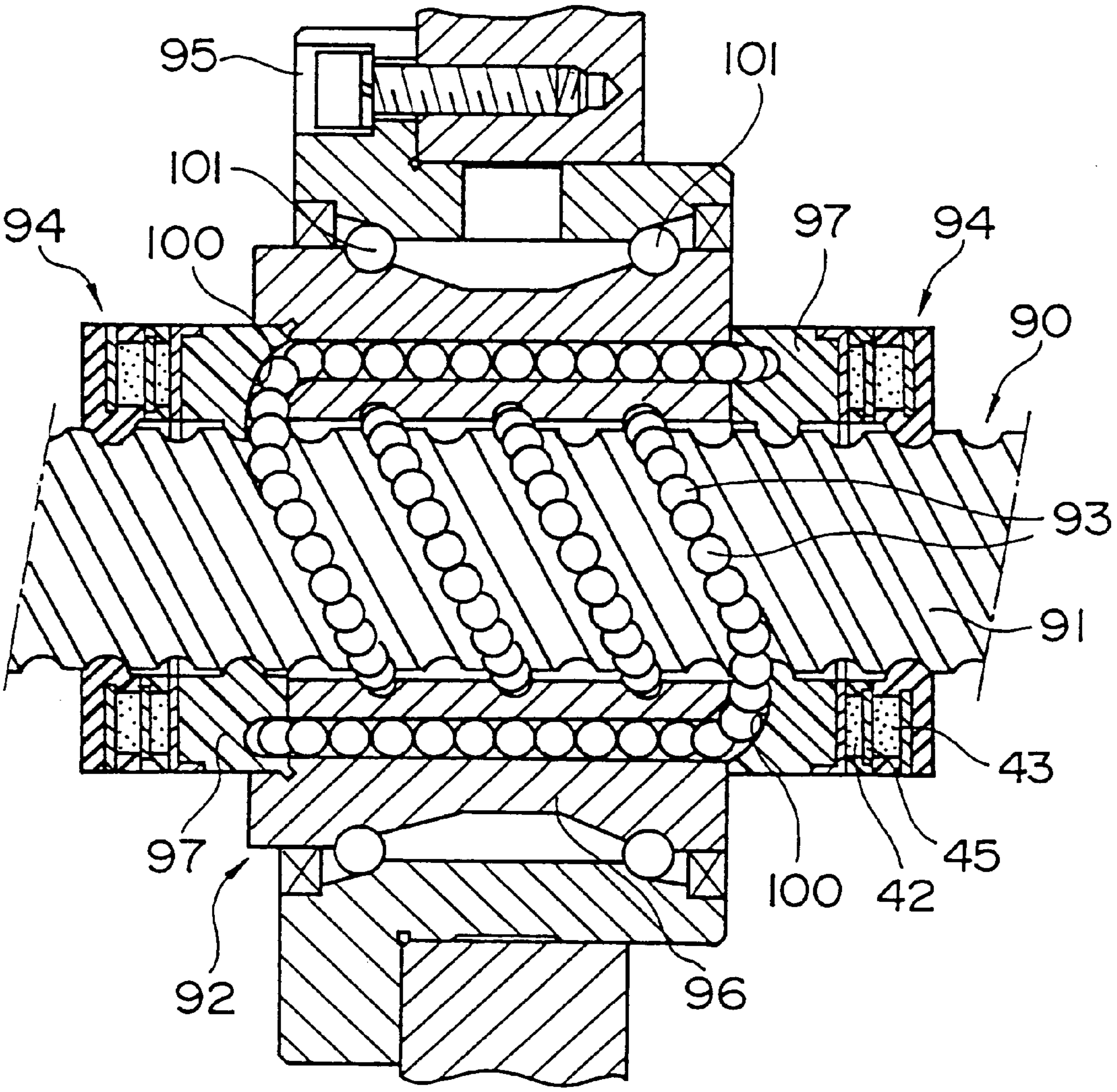
F I G. 13


95
98
99
XIV
100
97
94
90
94
91
43
45
42
100
97
XIV
92
93
96
99

F I G. 14


100
93
90
95
94

F I G. 15



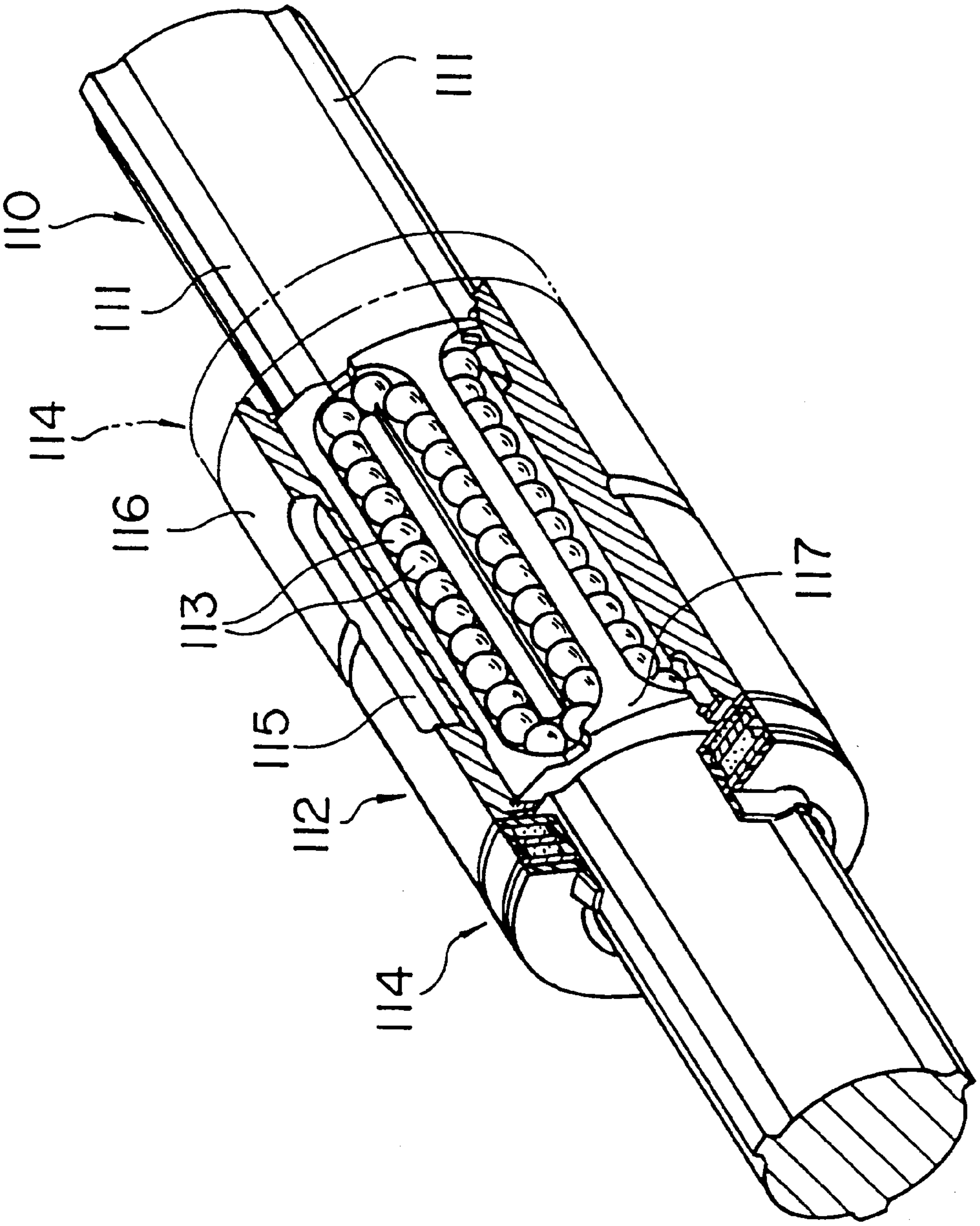
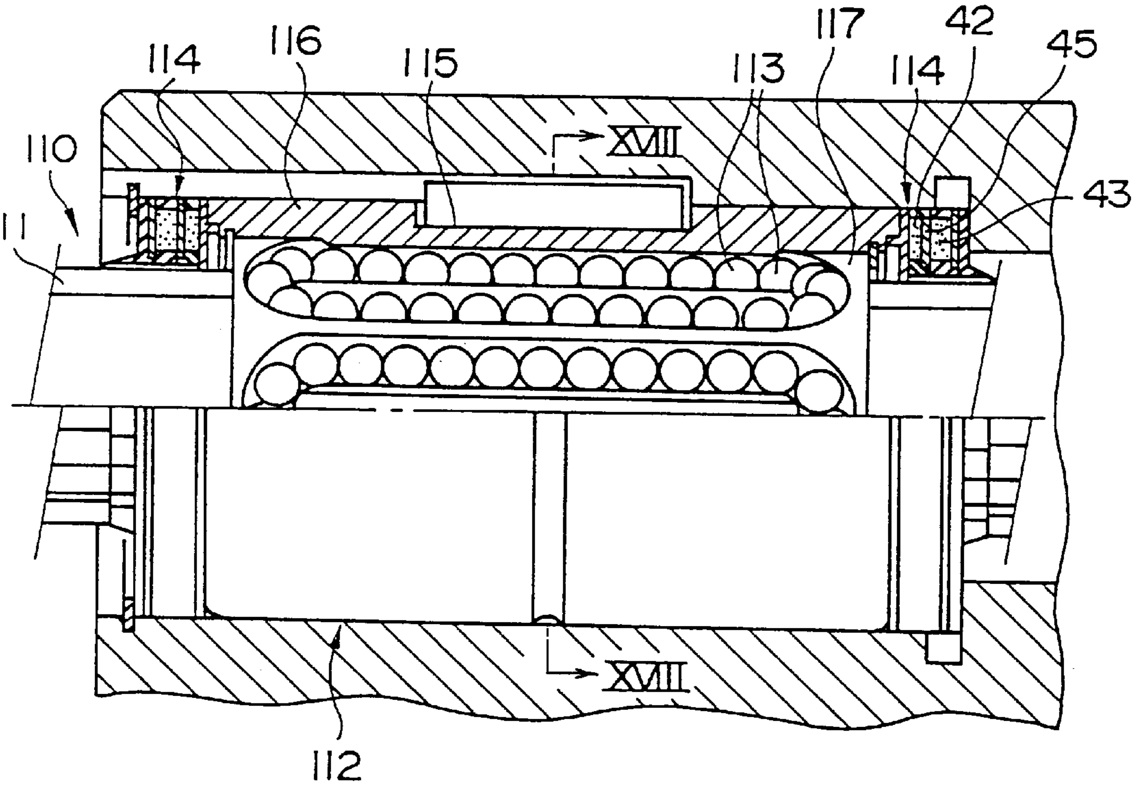
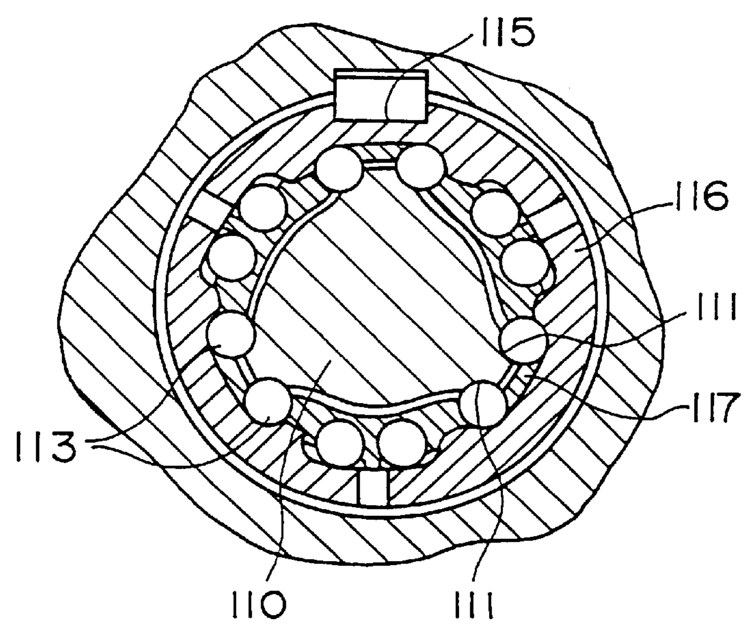


FIG. 16

F I G. 17

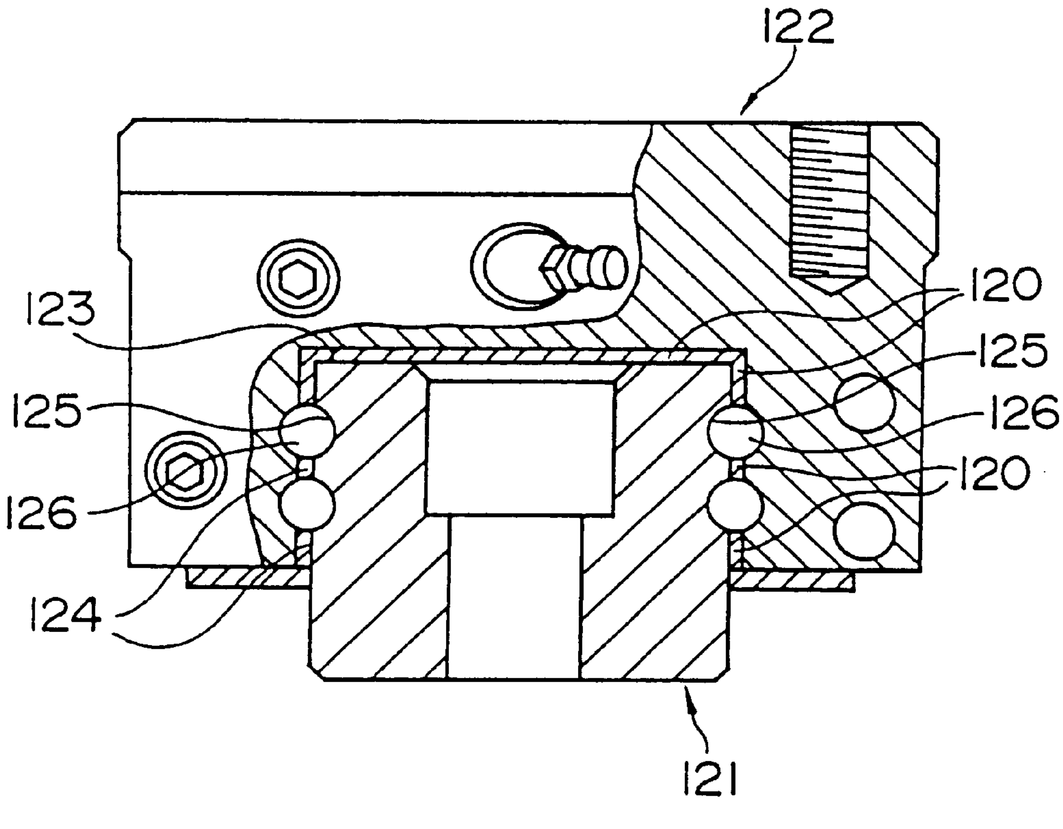

114
116
115
113
117
42
45
114
110
111
XVIII
43
XVIII
112

F I G. 18

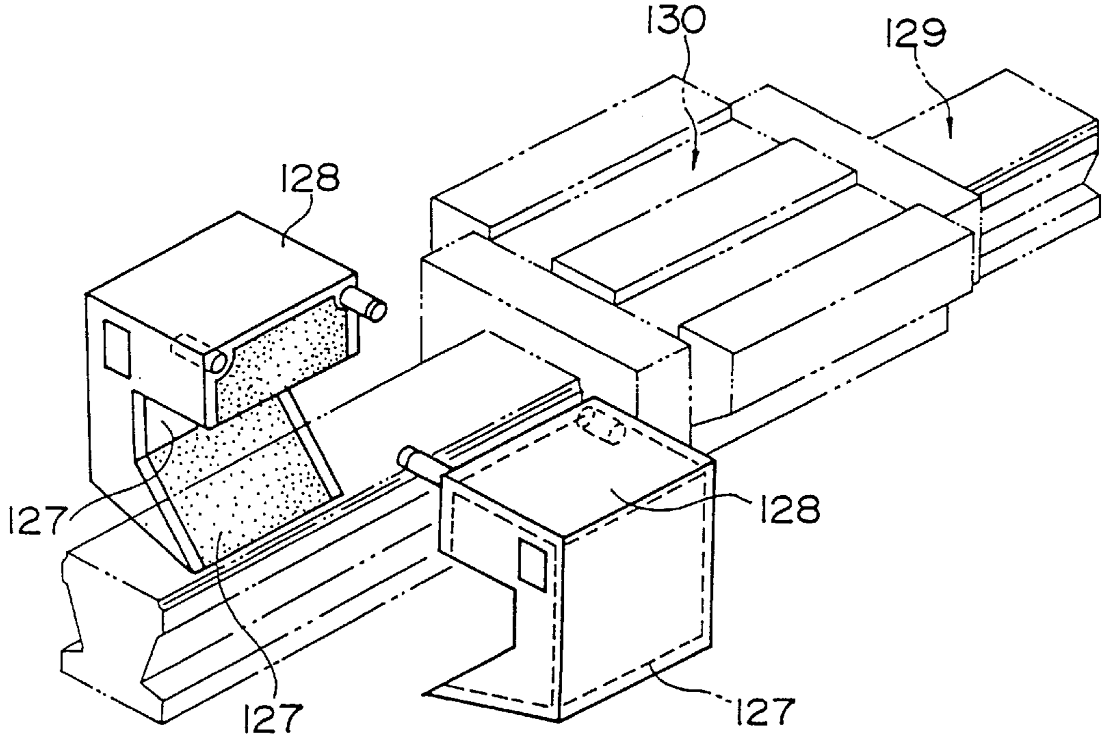

115
116
111
117
113
110
111

F I G. 19

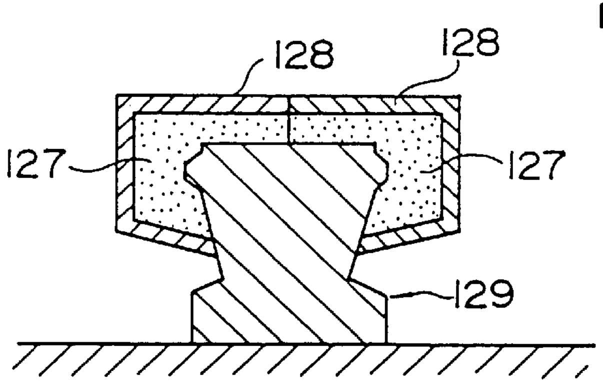
PRIOR ART



F I G. 20(a)
PRIOR ART



F I G. 20(b)
PRIOR ART



LINEAR MOVEMENT DEVICE AND LUBRICANT SUPPLYING DEVICE USED THEREFOR

TECHNICAL FIELD

The present invention relates to a linear movement device in which a track shaft and a slide member are engaged movably relative to each other via rolling elements of balls, rollers or the like as in, for example, a linear guide device, a ball screw, a ball spline or the like, in details, to an improvement of a linear movement device having a lubricant supplying device for coating a lubricant on a surface of the track shaft.

BACKGROUND ART

Conventionally, there has been known, as this kind of a linear movement device, a linear guide device used in a linear guide portion of a machine tool, a transferring device or the like for guiding a movable body of a table or the like on a fixed unit of a bed, a saddle or the like, a ball screw used along with the linear guide device for providing stroke of linear movement in accordance with a rotational amount of a motor to the movable body or the like.

The former linear guide device is constituted by a track rail (track shaft) arranged above the fixed unit and where a rolling groove of balls is formed in the longitudinal direction and a sliding base (slide member) having a load rolling groove opposed to the rolling groove of the track rail via a number of rolls and where an infinite circulation path of balls rolling on the load rolling groove is formed and is constituted such that the sliding base supporting the movable body is linearly moved continuously along the track rail in accordance with infinite circulation of the balls. Further, in contrast thereto, there is a case where it is constituted such that the track rail is moved relative to the fixed sliding base.

Meanwhile, the latter ball screw is constituted by a screw shaft (track shaft) where a ball rolling groove in a spiral shape is formed by a predetermined lead and a nut member (slide member) having a load rolling groove opposed to the ball rolling groove via a number of balls and where an infinite circulation path of the balls rolling on the load rolling groove is formed and is constituted such that the balls are circulated in the infinite circulation path in correspondence with relative rotational movement between the screw shaft and the nut member by which the nut member and the screw shaft are moved in the shaft direction relative to each other.

Meanwhile, in using such a linear movement device, the balls or the above-described rolling grooves and so on need to pertinently lubricate in accordance with conditions of use in view of restraining wear of the balls per se, wear of the rolling groove of the track rail or the screw shaft on which the balls roll or wear of the load rolling groove of the sliding base or the nut member and maintaining high precision movement of the slide member over a long period of time.

Conventionally, there has been known a linear guide device disclosed in Japanese Unexamined Utility Model Publication No. JP-A-7-23824 as a linear movement device having a device for supplying lubricant to balls, rolling grooves and so forth. According to the linear guide device, as shown in FIG. **19**, polymer members **120** impregnating a lubricant are provided on an inner face of a sliding base **122** opposed to a track rail **121**, the lubricant gradually oozing out from the polymer members **120** is coated on an upper face **123** and side faces **124** in accordance with reciprocating movement of the sliding base **122** by which the lubricant is supplied to rolling grooves **125** and balls **126**.

Further, there has been known other lubricant supplying device for lubricating a track shaft of a linear movement device disclosed in Japanese Unexamined Patent Publication No. JP-A-6-307442. According to the lubricant supplying device, as shown in FIG. **20**, pads **127** impregnating a lubricant are incorporated into cover frames **128** by which the pads **127** at inside thereof are brought into contact with a track rail **129** and the cover frames **128** are mounted at a front portion and a rear portion of a sliding base **130** in the movement direction such that the pads **127** are brought into sliding contact with the track rail **129** in accordance with the movement of the sliding base **130**. Accordingly, when the sliding base **130** is reciprocated along the track rail **129**, the lubricant oozed out from the pads **127** is coated on the surface of the track rail **129** and the lubricant is similarly supplied to rolling grooves or balls.

However, according to these lubricant supplying devices, the polymer member or the pad mounted to the sliding base is provided with both of a function as a coater for coating the lubricant on the track rail and a function as an absorber for holding the lubricant per se, a material which is optimum as the former of the coater is not necessarily a material which is optimum as the latter of the absorber and accordingly, it is difficult to stably supply the lubricant to the track rail over a long period of time.

That is, at an initial stage of start of use, the polymer member or the pad is sufficiently impregnated with the lubricant and accordingly, an amount of the lubricant excessive for lubricating the ball rolling grooves or the balls is coated on the track rail, whereas with an increase in an accumulated running distance of the sliding base in respect of the track rail, the amount of coating the lubricant to the track rail is significantly reduced and it is difficult to coat a necessary minimum amount of the lubricant for lubricating the ball rolling grooves and the balls stably on the track rail over a long period of time.

Meanwhile, although in order to coat a sufficient amount of the lubricant on the track rail over a long period of time, the polymer member or the pad may be magnified and a large amount of the lubricant may be held thereby, even when such a measure is adopted, the above-described problem in which the amount of supplying the lubricant is significantly changed in accordance with accumulation of the running distance of the sliding base cannot be resolved, or there also poses a problem in which the sliding base mounted with the polymer member or the pad is magnified and downsizing of a linear movement device cannot be achieved.

DISCLOSURE OF THE INVENTION

The present invention has been carried out in view of such a problem and it is an object of the present invention to provide a linear movement device capable of coating lubricant of an amount which is necessary minimum in lubricating a rolling groove of a rolling element or a rolling element stably over a long period of time and capable of achieving to downsize a slide member. Further, it is other object of the present invention to provide a lubricant supplying device preferable in a linear movement device such as a linear guide device, a ball screw device or the like.

In order to achieve the above-described object, there is provided a linear movement device including a track shaft where a rolling face of a rolling element is formed, a slide member engaged with the track shaft via the rolling element and moved relative to the track shaft and a lubricant supplying member mounted to the slide member and coating a lubricant on a surface of the track shaft in accordance with the relative movement as a premise wherein the lubricant supplying member includes a lubricant coater brought into contact with the track shaft for coating the lubricant on the track shaft, a lubricant absorber installed contiguous to the lubricant coater for supplying the lubricant to the lubricant coater while absorbing the lubricant and holding the lubricant and oil amount controlling means for controlling an amount of the lubricant supplied from the lubricant absorber to the lubricant coater.

According to such a technical means, coating of the lubricant on the track shaft is carried out by the lubricant supplying member mounted to the slide member, the lubricant supplying member includes the lubricant coater and the lubricant absorber and a function of coating the lubricant to the track shaft and a function of holding the lubricant are allotted to the lubricant coater and the lubricant absorber. Therefore, the lubricant of an amount in correspondence with an amount of supply from the lubricant absorber to the lubricant coater, is coated on the track shaft in this linear movement device.

Further, the lubricant supplying member is provided with the oil amount controlling means for controlling the amount of the lubricant supplied from the lubricant absorber to the lubricant coater and accordingly, the amount of supplying the lubricant from the former to the latter does not change significantly with elapse of time and a stable amount of the lubricant can always be impregnated to the lubricant coater.

In this way, according to the linear movement device of the present invention, even when an accumulated running distance of the slide member in respect of the track shaft is increased with elapse of time, the lubricant coater supplied with the lubricant from the lubricant absorber, impregnates always the stable amount of the lubricant and a constant amount of the lubricant can always be coated from the lubricant coater onto the track shaft.

In this case, while a material capable of coating the lubricant impregnated to the lubricant coater onto the track shaft with no stagnation, for example, felt made of polyester mixed with sheep wool, sintered resin or the like is preferable for the lubricant coater, a material capable of absorbing and holding a large amount of the lubricant, for example, felt made of polyester, sintered resin or the like is preferable for the lubricant absorber.

Further, in mounting the lubricant supplying member onto the slide member, the lubricant coater and the lubricant absorber may be directly mounted onto the slide member in an exposed state or the lubricant coater and the lubricant absorber may be incorporated in a casing and a casing may be mounted onto the slide member. For example, when the lubricant coater and the lubricant absorber are fabricated by sintered resin, they can be molded into desired shapes comparatively easily and can be fixed directly to the slide member by screwing.

Further, in incorporating the lubricant coater and the lubricant absorber in the casing, these may be incorporated separate casings respectively and two casings may be connected to constitute the lubricant supplying member.

Further, the oil amount controlling means may be of any constitution so far as the amount of supplying the lubricant from the lubricant absorber to the lubricant coater is restricted. For example, by using respectively different materials for forming the lubricant absorber and the lubricant coater, the movement of the lubricant from the former to the latter can be restricted to some degree and the lubricant which is held in the lubricant absorber in a large amount can be supplied to the lubricant coater by a constant amount.

As other oil amount controlling means, an oil amount adjusting film for permeating the lubricant may be installed between the lubricant absorber and the lubricant coater and only the lubricant which has permeated the oil amount adjusting film may be supplied from the lubricant absorber to the lubricant coater. As such an oil amount adjusting film, for example, paper through which the lubricant is permeable may be used and laminating operation may be performed by polyethylene or the like on the surface of the paper to adjust an area through which the lubricant permeate. According to such a constitution, by selecting material, thickness or the like of the oil amount adjusting film, an amount of the lubricant supplied from the lubricant absorber to the lubricant coater per unit time can be controlled and the amount of the lubricant coated from the lubricant coater onto the track shaft can be stabilized over a long period of time.

However, although in providing the oil amount adjusting film between the lubricant absorber and the lubricant coater, an intermediary between a peripheral edge of the oil amount adjusting film and the casing needs to hermetically seal completely by a caulking compound or the like to prevent the lubricant from leaking from the intermediary, the operation of hermetically sealing the surrounding is not easy since the oil amount adjusting film is as soft as paper or the like. Accordingly, from such a view point, it is preferable to constitute the oil amount controlling means by a thin stainless steel sheet or the like separating the lubricant absorber and the lubricant coater and open a supply hole for supplying the lubricant in the oil amount adjusting plate.

Further, according to the oil amount adjusting plate, by adjusting an inner diameter or a number of the supply holes opened in the plate, the amount of the lubricant supplied from the lubricant absorber to the lubricant coater per unit time can be controlled and the amount of the lubricant coated onto the track shaft by the lubricant coater can be adjusted.

Meanwhile, in view of the inherent object of lubricating the rolling face of the rolling element or the rolling element per se, the lubricant coater needs not to coat the lubricant on all the peripheral faces of the track shaft and the lubricant may be coated only on the rolling faces of the rolling elements.

Further, according to this kind of a linear movement device, it is general to hermetically seal a clearance between the track shaft and the slide member by mounting a seal member onto the slide member in order to prevent dust or the like adhered to the track shaft from entering the clearance between the track shaft and the slide member. According to the linear movement device of the present invention, although a seal member may be provided separately from the lubricant supplying member and the seal member may be mounted to the slide member or the lubricant supplying member, according to such a constitution, a number of parts mounted to the slide member is increased and assembling operation thereof is complicated. Hence, in order to construct a more simple constitution, it is preferable to install a seal grip portion which is brought into close contact with the surface of the track shaft at the casing of the lubricant supplying member such that the lubricant supplying member is provided with also a function as a seal member.

Further, when the seal grip portion is provided with the casing of the lubricant supplying member, it is preferable that the casing is formed by a soft elastic body of rubber of the like and the seal grip portion and the casing are integrally molded by injection molding or the like. In addition thereto, when the casing of the lubricant supplying member is formed by a soft elastic body, by piercing an injection needle into the casing, the lubricant can also be replenished easily to the lubricant absorber in the casing.

Incidentally, the linear movement device according to the present invention is a concept including not only the linear guide device mentioned above and the ball screw, but also a ball spline in which a nut member in a cylindrical shape is fitted to a spline shaft where ball rolling grooves are formed along the axial direction.

Meanwhile, according to another aspect of the present invention, there is provided a lubricant supplying device mounted to a slide member engaged with a track shaft via a rolling element for coating a lubricant to the track shaft in accordance with a relative movement between the slide member and the track shaft wherein the lubricant supplying device includes a lubricant coater brought into contact with the track shaft for coating the lubricant to the track shaft, a lubricant absorber installed contiguous to the lubricant coater for supplying the lubricant to the lubricant coater while absorbing the lubricant and holding the lubricant and oil amount controlling means for controlling an amount of the lubricant supplied from the lubricant absorber to the lubricant coater.

Further, also in the lubricant supplying device, the lubricant coater and the lubricant absorber may be mounted directly to the slide member in an exposed state, or the lubricant coater and the lubricant absorber may be incorporated in a casing and the casing may be mounted to the slide member.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a disassembled perspective view showing a first embodiment in which the present invention is applied to a linear guide device.

FIGS. **2**(*a*) and **2**(*b*) are a front view and a side view showing a lubricant supplying member according to the first embodiment.

FIG. **3**(*a*) is a sectional view taken along a line A—A of FIG. 2 and FIG. **3**(*b*) is a sectional view taken along a line B—B of FIG. **2**.

FIG. **4** is a sectional view taken along a line C—C of FIG. **2**.

FIG. **5** is a sectional view showing an example in which the lubricant supplying member according to the first embodiment is modified such that a lubricant can be coated also on an upper face of a track rail.

FIGS. **6**(*a*) and **6**(*b*) illustrate a front view and a side view showing a second embodiment of a lubricant supplying member.

FIG. **7** is a sectional view taken along a line VII—VII of FIG. **6**.

FIG. **8** is a sectional view taken along a line VIII—VIII of FIG. **6**.

FIG. **9** is a plane view showing an outline of a tester for testing function of the lubricant supplying member according to the second embodiment.

FIGS. **10**(*a*)–**10**(*c*) are graphs showing a result of testing differences in delivery amounts of a lubricant coated on a track rail when a number of supply holes perforated in an oil amount adjusting plate is changed.

FIG. **11** illustrates graphs showing a result of testing a difference in delivery amounts of a lubricant coated on a track rail when an inner diameter of a supply hole perforated in an oil amount adjusting plate is changed.

FIG. **12** is a partially cut perspective view showing an embodiment in which the present invention is applied to a ball screw.

FIG. **13** is a sectional view showing a state of using the ball screw shown in FIG. **12**.

FIG. **14** is a view viewing the ball screw from a line XIV—XIV in FIG. **13**.

FIG. **15** is a longitudinal sectional view showing other embodiment in which the present invention is applied to a ball screw.

FIG. **16** is a partially cut perspective view showing an embodiment in which the present invention is applied to a ball spline.

FIG. **17** is a sectional view showing a state of using the ball spline shown in FIG. **16**.

FIG. **18** is a sectional view taken along a line XVIII—XVIII of FIG. **17**.

FIG. **19** is a partially cut sectional view showing an example of a conventional linear movement device.

FIGS. **20**(*a*) and **20**(*b*) are a disassembled perspective view and a sectional view showing other example of a conventional linear movement device.

Explanations of Notations

1—Track rail (track shaft), **2**—Sliding base (sliding member), **3**—Ball (rolling element), **4**—Lubricant supplying member, **41**—First casing (casing), **42**—Lubricant coater, **43**—Lubricant absorber, **44**—Second casing (casing), **45**—Oil amount adjusting plate (oil amount controlling means)

BEST MODE FOR CARRYING OUT THE INVENTION

A detailed explanation will be given of a linear movement device according to the present invention in reference to the attached drawings as follows.

FIG. **1** is a disassembled perspective view showing a first embodiment in which the present invention is applied to a linear guide device. The linear guide device according to the embodiment is constituted by a track rail (track shaft) **1** where rolling faces **11** for balls are formed along the longitudinal direction, a sliding base (sliding member) **2** fitted to the track rail via a number of balls **3** which are rolling elements and installed with infinite circulation paths of the balls at inside thereof and a pair of lubricant supplying members **4** for coating a lubricant on the surface of the track rail **1** in accordance with movement of the sliding base **2** which are mounted at both front and rear end faces in the direction of moving the sliding base **2** and is constituted such that the sliding base **2** is reciprocated on the track rail **1** in accordance with circulation of the balls **3**.

Further, the sliding base **2** is constituted by a block main body **23** substantially in a saddle-like shape having a face **21** for attaching a machine device of a table or the like and having ball return holes **22** for circulating the balls **3** and a pair of end plates **24** fixed to the both front and rear faces of the block main body **23**. The end plates **24** are formed with direction change paths (not illustrated) for scooping up the balls **3** from the ball rolling faces **11** of the track rail **1** and transferring the balls to the ball return holes **22** of the block main body **23** and on the other hand, transferring the balls **3** from the ball return holes **22** to the ball rolling faces **11** and by fixing the end plates **24** to the block main body **23** by using attaching bolts **25**, infinite circulation paths of the balls **3** are formed in the sliding base **2**.

Further, oil supply ports **26** for supplying a lubricant to the infinite circulation paths are installed to the block main body **23** and the oil supply ports are mounted with supply nipples **27** via the lubricant supplying members **4** and the end plates **24**.

Meanwhile, the lubricant supplying member **4** is constituted by a first casing **41** which is brought into contact with the end plate **24**, a lubricant coater **42** which is incorporated in the first casing **41** and is brought into contact with the track rail **1** for coating the lubricant to the track rail **1**, a lubricant absorber **43** which absorbs and holds the lubricant and supplies the lubricant to the lubricant coater **42**, a second casing **44** for incorporating the lubricant absorber **43**, and an oil amount adjusting plate (oil amount controlling means) **45** for separating the lubricant coater **42** and the lubricant absorber **43** when the first casing **41** and the second casing **44** are bonded with each other.

As shown in FIG. **2** through FIG. **4**, the first casing **41** is projected with a strip-like projection **47** along a contour of a steel plate for constituting a base plate **46** and a recess portion **48** surrounded by the strip-like projection **47** constitutes a space for incorporating the lubricant coater **42**. Further, openings **49** are formed in the strip-like projection **47** at positions opposed to the rolling faces **11** of the track rail **1** and portions of the lubricant coater **42** are projected from the openings **49**. Here, the strip-like projection **47** is molded by a rubber material which is a soft elastic body and is bonded to the base plate **46** by vulcanization bonding. The recess portion **48** is formed to evade through holes **28** and **29** for the attaching bolts **25** and the supply nipple **27** and a substantially H-like shape is constituted as a whole as shown in FIG. **4**.

Further, the second casing **43** is also projected with a strip-like projection **51** along the contour of a steel plate constituting a base plate **50** and a recess portion **52** surrounded by the strip-like projection **51** constitutes a space for incorporating the lubricant absorber **43**. The strip-like projection **51** is also molded by a rubber material which is a soft elastic body and is projected from a face of the substrate **50** on the side of the first casing **41** to be brought into contact with the strip-like projection **47** of the first casing **41**. Further, a face of the substrate **50** on the opposite side is covered with a protective layer **54** comprising a rubber member and the protective layer **54** is projected with a seal lip portion **55** that is brought into close contact with the side faces and the upper face of the track rail **1**. Further, the recess portion **52** of the second casing **43** is formed also to evade the through holes **28** and **29** for the attaching bolts **25** and the supply nipple **27** and a substantially H-like shape is constituted as a whole.

Further, the lubricant coater **42** is molded in a substantially H-like shape the same as that of the recess portion **48** of the first casing **41** and projection pieces **56** which are brought into contact with the rolling faces **11** of the track rail **1** are projected in conformity with positions of the openings **49** formed in the strip-like projection **47**. An entangled body of fiber having a material which is liable to cause movement of the lubricant by capillary phenomenon, that is, felt or the like having a low percentage of void, is suitable for the lubricant coater **42** such that the impregnated lubricant can be coated on the track rail **1** with no stagnation and in this embodiment, sheep wool felt having a percentage of void of 54% is used.

Further, the lubricant absorber **43** is molded in a substantially H-like shape the same as that of the recess portion **52** of the second casing **44** and an entangled body of fiber such as felt or the like having a high percentage of void is suitable therefor such that a large amount of the lubricant can be absorbed and held. In this embodiment, sheep wool felt mixed with rayon having a percentage of void of 81% is used.

Meanwhile, the oil amount adjusting plate **45** is constituted to be sandwiched between the lubricant coater **42** and the lubricant absorber **43** to separate them when the strip-like projection **47** of the first casing **41** and the strip-like projection **51** of the second casing **44** are bonded together and in this embodiment, a thin stainless steel sheet having a thickness of 0.1 through 0.2 mm is used. Further, the oil amount adjusting plate **45** is opened with a plurality of supply holes **57** and is constituted such that the lubricant impregnated in the lubricant absorber **43** is moved to the lubricant coater **42** via the supply holes **57**. Further, in order to prevent the lubricant from leaking from the lubricant absorber **43** to the lubricant coater **42** via the peripheral edge of the oil amount adjusting plate **45**, a stepped portion is formed in the strip-like projection **47** of the first casing **41** for fitting the peripheral edge of the oil amount adjusting plate **45** and when the strip-like projection **47** of the first casing **41** and the strip-like projection **51** of the second casing **44** are bonded together, the peripheral edge of the oil amount adjusting plate **45** is sealed by being sandwiched by the strip-like projections **47** and **51**.

Further, in order to smoothly supply the lubricant from the lubricant absorber **43** to the lubricant coater **42**, as shown in FIG. **2**, a vent hole **58** is opened in the strip-like projection **51** of the second casing **44** by which pressures in the first casing **41** and the second casing **44** are maintained always at the atmospheric pressure. Accordingly, the movement of the lubricant from the lubricant absorber **43** to the lubricant coater **42** is mainly dependent upon the capillary phenomenon of the lubricant at inside of the entangled bodies of fiber. However, the lubricant disposed upward from the supply holes **57** of the oil amount adjusting plate **45** in the lubricant impregnated in the lubricant absorber **43**, is moved to the side of the lubricant coater **42** also by gravity.

According to the lubricant supplying member **4** constituted as mentioned above, firstly, the lubricant is previously impregnated sufficiently to the lubricant coater **42** and the lubricant absorber **43**, thereafter, the lubricant coater **42** is incorporated into the first casing **41**, the lubricant absorber **43** is incorporated to the second casing **44** and the both casings **41** and **44** are bonded together by vulcanization bonding to sandwich the oil amount adjusting plate **45**. Thereby, integration of the lubricant supplying member **4** in which the lubricant absorber **43** and the lubricant coater **42** are incorporated is completed. Further, the lubricant supplying members **4** are mounted to both of the front and the rear end faces of the sliding base **2** by the attaching bolts **25**.

In a state where the lubricant supplying members **4** are attached to the sliding base **2**, the projection pieces **56** of the lubricant coater **42** projected from the first casing **41** are brought into press contact with the ball rolling faces **11** of the track rail **1** and when the sliding base **2** is moved on the track rail **1**, the lubricant is coated from the projection pieces **56** to the ball rolling faces **11**. Further, the seal lip portions **55** projected from the second casing **44** is brought into sliding contact with the upper face and the side faces of the track rail **1** and prevent dust adhered to the track rail **1** from invading a clearance between the track rail **1** and the sliding base **2**.

When the lubricant is coated from the projection pieces **56** of the lubricant coater **42** onto the track rail **1** in this way, the lubricant impregnated in the lubricant coater **42** is moved to the projection pieces **56** by the capillary phenomenon. Meanwhile, a large amount of the lubricant is held in the lubricant absorber **43** and therefore, when the lubricant impregnated to the lubricant coater **42** is gradually reduced, the lubricant impregnated in the lubricant absorber **43** is supplied to the lubricant coater **42** via the supply holes **57** of the oil amount adjusting plate **45** similarly by the capillary phenomenon.

In this way, a substantially constant amount of the lubricant is always impregnated in the lubricant coater **42** and stabilization of amount of the lubricant coated from the lubricant coater **42** onto the track rail **1** can be achieved. Further, the amount of the lubricant coated from the lubricant coater **42** onto the track rail **1** can arbitrarily be adjusted by changing a contact area between the projection pieces **56** and the ball rolling faces **11** of the track rail **1** or changing the percentage of void of the fiber entangled body constituting the lubricant coater **42**.

Meanwhile, according to the embodiment, the amount of the lubricant coated from the lubricant coater **42** onto the ball rolling faces **11** of the track rail **1** can be adjusted by changing the number or the inner diameter of the supply holes **57** opened in the oil amount adjusting plate **45**. The reason is that when the inner diameter or the number of the supply holes **57** opened in the oil amount adjusting plate **45** is changed, the contact area in respect with the lubricant absorber **43** and the lubricant coater **42** is changed and therefore, the amount of the lubricant supplied from the lubricant absorber **43** to the lubricant coater **42** per unit time is changed and the amount of the lubricant impregnated in the lubricant coater **42** is increased or decreased. Accordingly, in the linear movement device of the embodiment, an amount of the lubricant optimum to object of use can be coated onto the track rail **1** by adjusting the inner diameter and/or the number of the supply holes **57** opened in the oil amount adjusting plate **45** in accordance with different use or the like.

Further, in the case where a time period of use has elapsed to some degree and almost all of the lubricant impregnated in the lubricant absorber **43** has been consumed, the lubricant needs to replenish from outside to the lubricant absorber **43** and in such a case, the lubricant can be supplied to the lubricant absorber **43** in the second casing **44** via the vent hole **58** installed to the second casing **44**. Further, the strip-like projection **51** of the second casing **44** is molded by rubber material and therefore, by piercing an injection needle directly to the strip-like projection **51**, the lubricant can also be replenished easily to the lubricant absorber **43**.

Further, according to the lubricant supplying member **4** of the embodiment, the lubricant coater **42** is constituted to coat the lubricant only to ball rolling grooves **11** of the track rail **1**, however, in such a constitution, the lubricant is difficult to adhere onto the upper face of the track rail **1** and therefore, when the sliding base **2** is moved on the track rail **1** at high speed, there is a concern that the seal lip portions **55** which are brought into abrasive contact with the track rail **1** may be destructed. Therefore, from such a point of view, as shown in FIG. **5**, it is preferable to form the projection piece **56** of the lubricant coater **42** also at a position in correspondence with the upper face of the track rail **1** and to coat the lubricant from the projection piece **56** onto the upper face of the track rail **1**.

FIG. **6** through FIG. **8** show a second embodiment of a lubricant supplying member.

A lubricant supplying member **6** of the second embodiment is constituted by a casing **60** which is mounted to the end plate **24** of the sliding base **2**, a lubricant coater **61** and a lubricant absorber **62** both incorporated in the casing **60**, and an oil amount adjusting plate (oil amount controlling means) **63** which separates the lubricant coater **61** from the lubricant absorber **62**.

The casing **60** is constituted by a casing main body **65** having a recess portion **64** for constituting a space for accommodating the lubricant absorber **62** and the lubricant coater **61** and a lid base plate **66** for hermetically closing the recess portion **64** of the casing main body **65** and when the casing **60** is mounted to the end plate **24** of the sliding base **2**, the lid base plate **66** is brought into contact with the end plate **24**.

FIG. **8** shows the casing main body **65**. According to the casing main body **65**, a side wall **68** made of rubber is erected along the contour of a steel plate constituting a base plate **67** and the recess portion **64** surrounded by the side wall **68** constitutes a space for accommodating the lubricant coater **61** and the lubricant absorber **62**. The recess portion **64** is formed to evade through holes **69** and **70** for the attaching bolts **25** and the supply nipple **27** and two of the recess portions **64** in correspondence with both of the left and right side faces of the track rail **1** are installed independently from each other and the lubricant coater **61** and the lubricant absorber **62** for lubricating the left side face of the track rail **1** and those for lubricating the right side face are incorporated in the two recess portions **64** independently from each other. Further, a face of the base plate **67** on the side opposed to the side wall **68** is covered by a protective layer **71** comprising rubber material and as shown in FIG. **6**, the seal lip portion **72** which is brought into close contact with the side faces and the upper face of the track rail **1** is projected from the protective layer **71**.

Meanwhile, the side wall **68** is formed with recess grooves **73** at positions opposed to the rolling faces **11** of the track rail **1** and portions of the lubricant coater **61** incorporated in the recess portion **64** are projected from the recess grooves **73**. Further, a stepped portion **74** is formed at the side wall **68** along the inner peripheral edge of the recess portion **64** and the oil amount adjusting plate **63** is fitted to the stepped portion **74** by which the lubricant coater **61** and the lubricant absorber **62** are separated from each other. Further, a vent hole **75** is formed in the side wall **68** also in this embodiment and smooth movement of the lubricant from the lubricant absorber **62** to the lubricant coater **61** is achieved.

Similar to the first embodiment, the oil amount adjusting plate **63** is formed by a thin stainless steel sheet and only a single hole of a supply hole **76** for supplying the lubricant impregnated to the lubricant absorber **62** to the lubricant coater **61** is opened. Although the shape of the supply hole **76** is circular in this embodiment, other shape may be adopted. The positions of opening the supply holes **76** are disposed at positions designated by broken lines in FIG. **8** and positions constituting substantially even distances to two streaks of the ball rolling faces **11** to which the lubricant is supplied from the respective lubricant coaters **61**.

Further, according to the lubricant supplying member **6** constituted in this way, firstly, the side walls **68** and the protective layer **71** are bonded to the base plate **67** by vulcanization bonding to thereby fabricate the casing main body **65**, the lubricant absorber **62** impregnating with the lubricant is incorporated in the recess portion **64** of the casing main body **65** and thereafter, the oil amount adjusting plates **63** are fitted to the stepped portions **74** of the side walls **68** of the casing main body **65** to cover the lubricant absorbers **62**. Next, the lubricant coaters **61** are made to overlap the oil amount adjusting plates **63** and finally, the lid base plate **66** is bonded to the side walls **68** of the casing main body **65** by vulcanization bonding. In this way, the lubricant supplying member **6** incorporating the lubricant coater **61** and the lubricant absorber **62** at inside thereof is completed.

The lubricant supplying member **6** of the second embodiment constituted in this way is mounted to both of the front and rear end faces of the sliding base **2** of the linear guide device similar to the supplying member **4** of the first embodiment and the lubricant is coated from the lubricant coaters **61** onto the ball rolling faces **11** of the track rail **1** in accordance with movement of the sliding base **2**.

In order to confirm whether the lubricant can stably be coated on the ball rolling faces **11** of the track rail **1** by the lubricant supplying member **6** of the second embodiment, the inventors have measured an amount of the lubricant actually delivered from the lubricant supplying member **6** by using a tester **80** shown in FIG. **9**. According to the tester, a rotating circular disk **82** rotated by a motor **81** is assumed to represent the track rail **1**, three pieces of the lubricant supplying members **6** are arranged at the surrounding of the rotating circular disk **82** and the lubricant is coated from the lubricant coaters **61** of the lubricant supplying members **6** onto the rotating circular disk **82**. In this case, a speed of moving the rotating circular disk **82** relative to the lubricant supplying member **6** is set to 300 m/min. Further, in view of maintaining the viscosity of the lubricant constant, temperature of each of the lubricant supplying members **6** is monitored by a thermocouple and temperature of the lubricant occluded in the lubricant supplying member **6** is maintained at 25° C. Further, scrapers **83** are arranged among the lubricant supplying members **6** contiguous to each other such that coating condition of the lubricant on the rotating circular disk **82** is always made uniform and the lubricant coated from the lubricant supplying members **6** onto the rotating circular disk **82** is scraped off.

According to the test, the delivery amount of the lubricant from the lubricant supplying member **6** is calculated as follows. First, the weight of the lubricant supplying member **6** before supplying the lubricant is measured by an electronic balance, thereafter, the lubricant is injected into the lubricant absorber **62** incorporated in the lubricant supplying member **6** and the weight of the lubricant supplying member **6** is measured again by the electronic balance. Thereby, the weight of the supplied lubricant is grasped. Next, the lubricant supplying members **6** are set to the tester, the lubricant supplying members **6** are made to run by a predetermined distance by rotating the rotating circular disk **82** and thereafter, the weight of the lubricant supplying member **6** is measured by the electronic balance by which a total amount of the lubricant delivered during the rotation of the rotating circular disk **82** is calculated.

First, the applicant has carried out a test of confirming the delivery amount of the lubricant in respect of each of cases where the number of the supply hole having a diameter of 1 mm is 1, where it is 3 and where it is 6 in order to confirm whether the delivery amount of the lubricant in respect of the ball rolling face **11** of the track rail **1** differs in accordance with the number of the supply holes **76** opened in the oil amount adjusting plate **63**. Further, the test has been carried out by preparing 3 of test pieces in respect of each of the numbers of the supply holes **76**. FIG. **10**(*a*) shows a result when the number of supply hole is 1, FIG. **10**(*b*) shows that in the case of 2 of the supply holes and FIG. **10**(*c*) shows a case of 3 of the supply holes.

As is apparent from these graphs, it is confirmed that even in cases of different numbers of the supply holes **76** opened in the oil amount adjusting plate **63**, after running a certain degree of distance, the inclinations of the graphs are reduced, and an extremely small amount of the lubricant is stably supplied from the lubricant supplying member **6** to the rotating circular disk **82**. However, it has been found that although when the number of the supply hole **76** opened in the oil amount adjusting plate **63** is 1, substantially the same amount of the lubricant is delivered in each of the three test pieces, when the number of the supply holes **76** is plural, there is a tendency in which a dispersion in the delivery amount of the lubricant is significant in respect of the three test pieces and when the test piece is changed, the delivery amount of the lubricant differs significantly. Therefore, it is preferable in view of achieving stabilization of the amount of coating the lubricant onto the track rail **1** for each of the lubricant supplying members **6** to set the number of the supply hole **76** opened in the oil amount adjusting plate **63** to 1 for each of the lubricant coater **61**.

Next, the applicant has carried out a test of confirming the delivery amount of the lubricant in respect of 4 kinds of cases where the inner diameter of the supply hole **76** is 1 mm, where it is 2 mm, where it is 4 mm and further, where the oil amount adjusting plate **63** is not installed in order to confirm whether the delivery amount of the lubricant in respect of the ball rolling face **11** of the track rail **1** differs in accordance with a change in the inner diameter of the supply hole **76** opened in the oil amount adjusting plate **63**. Further, the test has been carried out by preparing three test pieces for each of the inner diameters of the supply hole **76**. A result thereof is shown in FIG. **11**.

As is apparent from these graphs, it has been found that the larger the inner diameter of the supply hole **76** opened in the oil amount adjusting plate **63**, the larger the inclination of the graph and the more increased is the lubricant coated from the lubricant supplying member **6** onto the rotating circular disk **82**. The reason seems to be that the larger the inner diameter of the supply hole **76**, the more increased is the contact area between the lubricant coater **61** and the lubricant absorber **62**, the amount of the lubricant moving from the lubricant absorber **62** to the lubricant coater **61** is increased and more lubricant is impregnated by the lubricant coater **61**.

Accordingly, it is preferable in view of stably coating a small amount of lubricant to the ball rolling face **11** of the track rail **1** over a long period of time to determine that the number of the supply hole **76** opened in the oil amount adjusting plate **63** is set to 1 for each of the lubricant coaters **61** and determine the inner diameter in accordance with the amount of lubricant which is necessitated in accordance with use of a bearing for linear sliding or the like.

Further, when the inventors has measured the delivery amount of lubricant by changing the attitude of the lubricant supplying member **6** in respect to the rotating circular disk **82**, even in the case where the number and the inner diameter of the supply hole opened in the oil amount adjusting plate **63** remains the same, the amount of lubricant delivered from the respective lubricant supplying member **6** onto the rotating circular disk **12** has differed. The reason seems to be that when the attitude of using the lubricant supplying member **6** is changed, the amount of lubricant disposed upward from the supply hole **76** of the oil amount adjusting plate **63** in the lubricant impregnated to the lubricant absorber **62** is changed and the amount of the lubricant moving from the lubricant absorber **62** to the lubricant coater **61** is changed by influence of gravity.

Accordingly, it is preferable that the supply hole **76** is opened in the oil amount adjusting plate **63** in coincidence with the gravity center of the lubricant absorber **62** and according to such a constitution, regardless of the attitude of using the lubricant supplying member **6**, the amount of lubricant moving from the lubricant absorber **62** to the lubricant coater **61** by influence of gravity can be made substantially constant.

FIG. **12** through FIG. **14** show an embodiment where the present invention is applied to a ball screw.

In the drawings, notation **90** designates a screw shaft (track shaft) on which a ball rolling groove **91** in a spiral shape is formed with a predetermined lead, notation **92** designates a nut member (slide member) having infinite tracks for circulating balls **93** and screwed to the screw shaft **90** via the balls **93**, and notation **94** designates lubricant supplying members mounted to both of front and rear end faces of the nut member **92**. Further, the lubricant coater **42**, the lubricant absorber **43** and the oil amount adjusting plate (oil amount controlling means) **45** provided to the lubricant supplying member **94** are the same as those in the first embodiment mentioned above and accordingly, the same reference notations are attached thereto in the drawings and an explanation thereof will be omitted.

Here, the nut member **92** is constituted by a nut main body **96** made of steel projected with a flange portion **95** for fixing the nut member **92** and a pair of lids **97** made of synthetic resin fixed on both of the front and rear end faces of the nut main body **96**.

While a load rolling groove **98** in a spiral shape opposed to the ball rolling groove **91** of the screw shaft **90** is formed on the inner diameter side, a ball return hole **99** in parallel with the screw shaft **90** is perforated. Further, the lid **97** is formed with direction change paths **100** for guiding the balls **93** which have finished rolling on the load rolling groove **98** of the nut main body **96** to ends on one side of the ball return holes **99** and on the other hand, guiding the balls **93** from ends on the other side of the ball return hole **99** to the load rolling groove **98** and the infinite tracks of the balls **93** are completed by fixing the lids **97** to the nut main body **96**.

Further, although the lubricant supplying member **94** is formed in a ring-like shape in compliance with the shape of the nut member **92**, the point where the lubricant coater, the oil amount adjusting plate and the lubricant absorber are incorporated in the casing is similar to that in the lubricant supplying members **4** and **6** mounted to the above-described linear guiding device and a detailed explanation thereof will be omitted here.

Further, according to the ball screw device of the embodiment constituted as mentioned above, when the screw shaft **90** and the nut member **92** are rotated relative to each other, the balls **93** roll on the load rolling groove **98** of the nut member **92** and the ball rolling groove **91** of the screw shaft **90** and the nut member **92** is moved in the axial direction of the screw shaft **90** while revoluting around the screw shaft **90**. In this case, the lubricant is coated from the lubricant supplying member **94** onto the ball rolling groove **91** of the screw shaft **90** in accordance with the movement of the nut member **92** and lubrication of the ball rolling groove **91** and the balls **93** rolling thereon is carried out similar to the above-described embodiments.

Further, the ball screw shown in FIG. **12** through FIG. **14** is of a type where the nut member **92** is fixed to a machine device of a table or the like by the flange portion **95** and which is used by rotating the screw shaft **90** by a motor, the ball screw to which the present invention is applicable is not limited thereto but, for example, as shown in FIG. **15**, it may be of a type in which the nut member **92** is supported rotatably by a fixed unit of a table of the like via a pair of angular contact bearings **101** and which is used by rotating it in respect of the nut member **92** by a motor (not illustrated).

Next, FIG. **16** through FIG. **18** show an embodiment in which the present invention is applied to a ball spline.

In the drawings, notation **110** designates a spline shaft (track shaft) where ball rolling grooves **111** are formed along the axial direction, notation **112** designates a nut member (slide member) having infinite tracks for circulating balls **113** and fitted to the spline shaft **110** via the balls **113** and notation **114** designates lubricant supplying members mounted to both of front and rear end faces of nut member **112**.

In this case, the nut member **112** is constituted by a nut main body **116** made of steel where a key groove **115** for fixing the nut member **112** is formed on the outer peripheral face and ball retainers **117** made of synthetic resin for forming the infinite circulation paths of the balls **113** by being fitted to the inner diameter of the nut main body **116**. Further, although the lubricant supplying member **114** is formed in a ring-like shape in compliance with the shape of the nut member **112**, the point where the lubricant coater, the oil amount adjusting plate and the lubricant absorber are incorporated in the casing is the same as that of the lubricant supplying members **4** and **6** mounted to a bearing for linear sliding and a detailed explanation thereof will be omitted here.

Further, according to the ball spline of the embodiment constituted as described above, when the nut member **112** is moved along the spline shaft **110**, the lubricant is coated from the lubricant supplying members **114** mounted to the nut member **112** onto the ball rolling grooves **111** of the spline shaft **110** and lubrication of the ball rolling grooves **111** and the balls **113** rolling thereon is carried out similar to the above-described embodiments.

INDUSTRIAL APPLICABILITY

As has been explained, according to the linear movement device of the present invention, the lubricant supplying member is provided with the lubricant coater for coating lubricant to the track shaft and the lubricant absorber for supplying the lubricant to the lubricant coater and is further provided with the oil amount controlling means for controlling the amount of the lubricant supplied from the lubricant absorber to the lubricant coater and accordingly, even when the accumulated running distance of the guide member in respect of the track shaft is increased in accordance with elapse of time, a stable amount of the lubricant is always impregnated to the lubricant coater supplied with the lubricant from the lubricant absorber, a constant amount of the lubricant is always coated from the lubricant coater onto the track shaft and accordingly, an amount of the lubricant which is a necessary minimum in lubricating the rolling face of the rolling element or the rolling element can be coated on the track shaft stably over a long period of time.

Further, the necessary minimum amount of the lubricant can stably be coated and therefore, the face of the track shaft for rolling the rolling element can be lubricated by a small amount of the lubricant over a long period of time and the lubricant absorber can be downsized by that amount and a compact linear movement device can be designed.

What is claimed is:

1. A linear movement device comprising a track shaft where a rolling face of a rolling element is formed, a slide member engaged with the track shaft via the rolling element and moved relative to the track shaft and a lubricant supplying member mounted to the slide member and coating a lubricant on a surface of the track shaft in accordance with the relative movement:

wherein the lubricant supplying member comprises a lubricant coater brought into contact with the track shaft for coating the lubricant on the track shaft, a lubricant absorber installed contiguous to the lubricant coater for supplying the lubricant to the lubricant coater while absorbing the lubricant and holding the lubricant and oil amount controlling means for controlling an amount of the lubricant supplied from the lubricant absorber to the lubricant coater.

2. The linear movement device according to claim **1**, wherein the lubricant supplying member comprises a casing mounted to the sliding member and the lubricant coater and the lubricant absorber are incorporated in the casing.

3. The linear movement device according to claim **2**, wherein the casing comprises a seal lip portion brought into close contact with the surface of the track shaft.

4. The linear movement device according to claim **2** or claim **3**, wherein the casing is formed by a soft elastic body.

5. The linear movement device according to claim **1** or **2**, wherein the oil amount controlling means is constituted by changing a material of the lubricant absorber from a material of the lubricant coater.

6. The linear movement device according to claim **1** or **2**, wherein the oil amount controlling means is an oil amount adjusting film which separates the lubricant absorber from the lubricant coater and permeates the lubricant from a side of the lubricant absorber to a side of the lubricant coater.

7. The linear movement device according to claim **1** or claim **2**, wherein the supply amount controlling means is an oil amount adjusting film which separates the lubricant absorber from the lubricant coater and in which a supply hole of the lubricant is opened.

8. The linear movement device according to claim **7**, wherein an inner diameter and/or a number of the supply holes opened in the oil amount adjusting plate is adjusted in accordance with an amount of lubricant to be coated on the track shaft.

9. A lubricant supplying device mounted to a slide member engaged with a track shaft via a rolling element for coating a lubricant to the track shaft in accordance with a relative movement between the slide member and the track shaft:

wherein the lubricant supplying device comprises a lubricant coater brought into contact with the track shaft for coating the lubricant to the track shaft, a lubricant absorber installed contiguous to the lubricant coater for supplying the lubricant to the lubricant coater while absorbing the lubricant and holding the lubricant and oil amount controlling means for controlling an amount of the lubricant supplied from the lubricant absorber to the lubricant coater.

10. The lubricant supplying device according to claim **9**, wherein the lubricant coater and the lubricant absorber are incorporated in a casing and mounted to the slide member via the casing.

* * * * *

US006155716A

United States Patent [19]

[11] **Patent Number: 6,155,716**

[45] **Date of Patent: Dec. 5, 2000**

Okamura et al.

[54] **GUIDE APPARATUS FOR BIAXIAL SHIFTING MOTION AND UNIAXIAL TURNING MOTION**

[75] Inventors: **Satoru Okamura**; **Yoichi Fukasawa**, both of Tokyo-to, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo-to, Japan

[21] Appl. No.: **09/245,880**

[22] Filed: **Feb. 8, 1999**

[30] **Foreign Application Priority Data**

Feb. 26, 1998 [JP] Japan 10-062230

[51] **Int. Cl.**[7] **F16C 17/00**; F16C 29/00; F16C 31/00

[52] **U.S. Cl.** **384/7**; 384/48

[58] **Field of Search** 384/7, 45, 48, 384/55, 50, 51, 52, 44

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,118,101	10/1978	Teramachi	384/7
5,249,867	10/1993	Iida	384/45
5,290,106	3/1994	Ichida	384/45
5,391,003	2/1995	Ooya	384/44

Primary Examiner—Charles A Marmor
Assistant Examiner—Tisha D. Waddell
Attorney, Agent, or Firm—Young & Thompson

[57] **ABSTRACT**

A guide apparatus for biaxial shifting motion and uniaxial turning motion comprises a biaxial shifting guide mechanism and a pivot supporting mechanism. The biaxial shifting motion guide mechanism supports a second member so as to be movable relative to a first member in a constant posture state along biaxial lines intersecting at right angles with each other. The pivot supporting mechanism is disposed on the biaxial shifting motion guide mechanism at an opposite side of the first member and pivotably supports the second member.

8 Claims, 11 Drawing Sheets

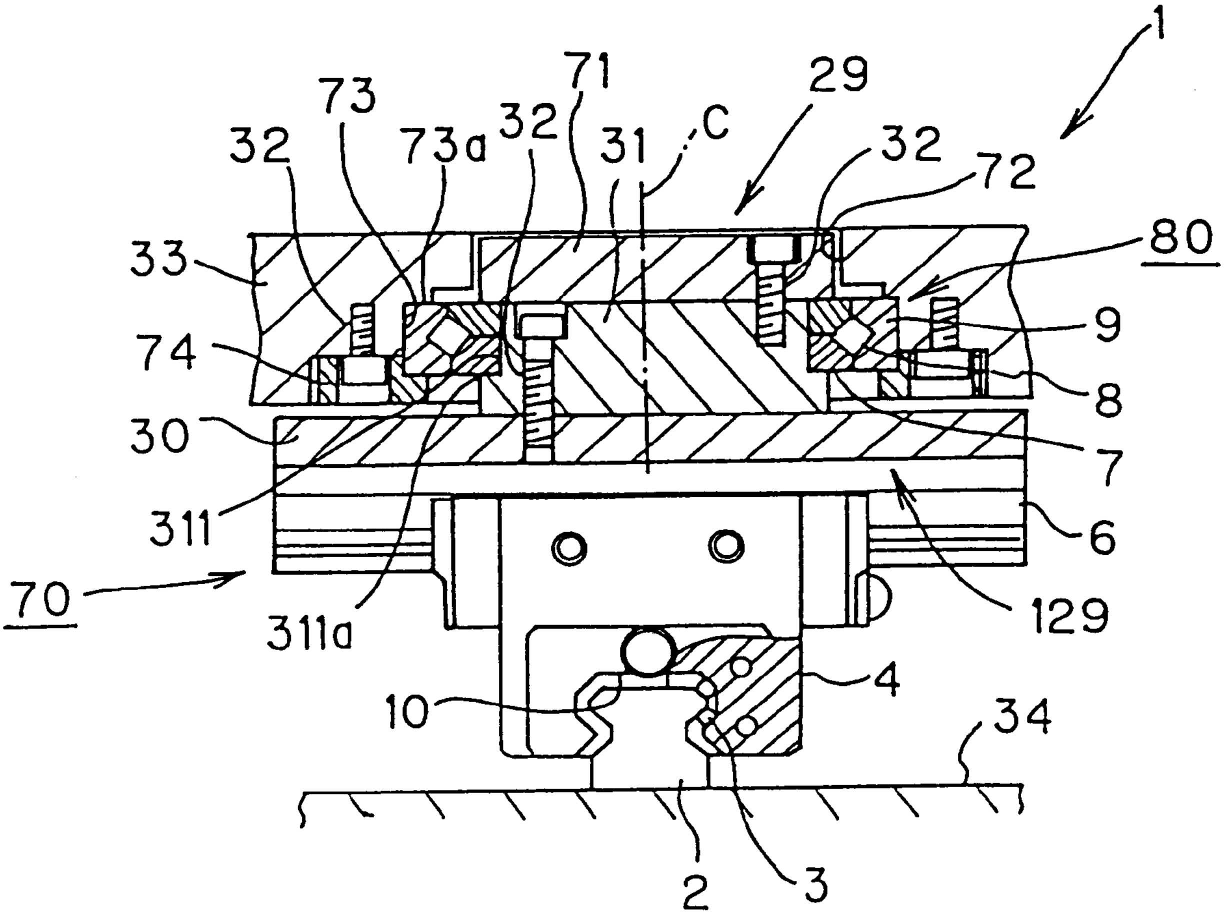


FIG. 1(a)

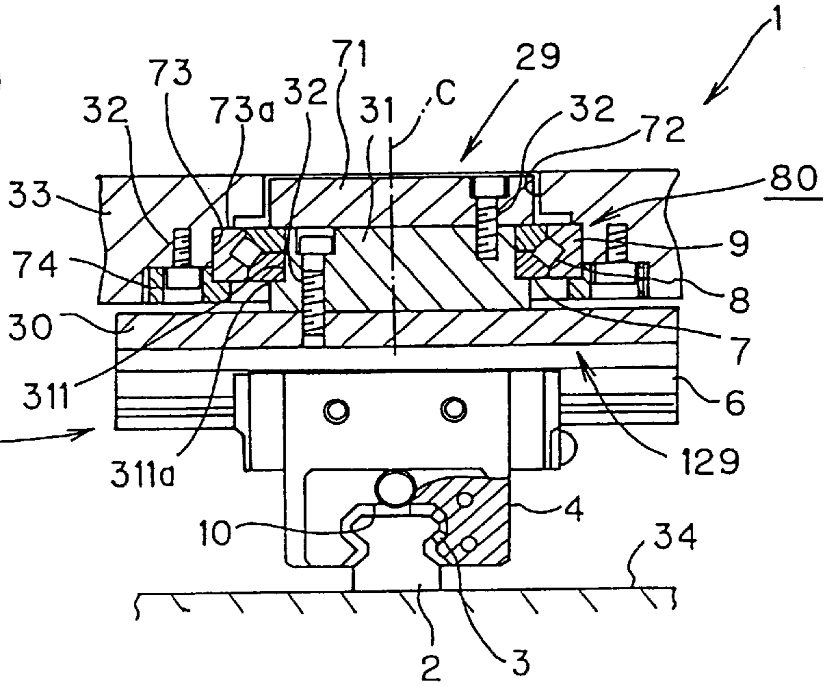

1
29
71
73
73a
32
31
C
32
72
32
33
80
9
74
8
30
7
311
6
70
129
311a
4
10
34
2
3

FIG. 1(b)

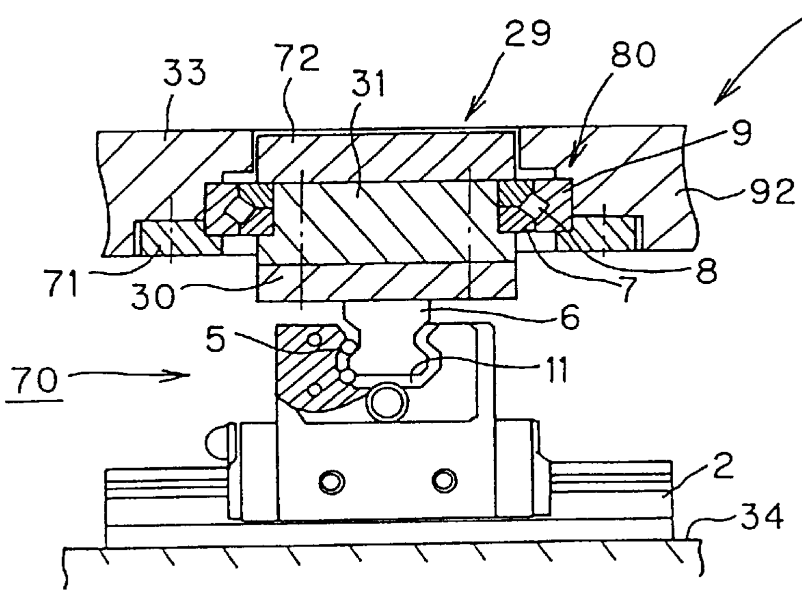

1
29
33
72
31
80
9
92
71
30
7
8
6
5
11
70
2
34

FIG. 2(a)

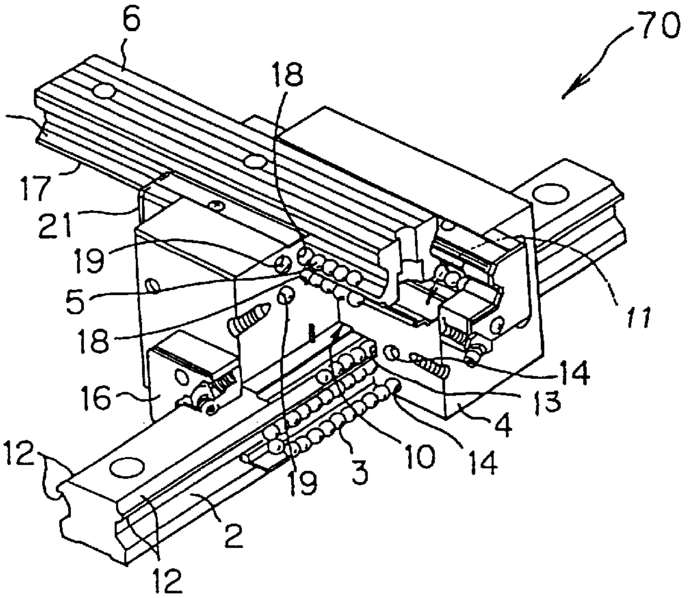


FIG. 2(b)

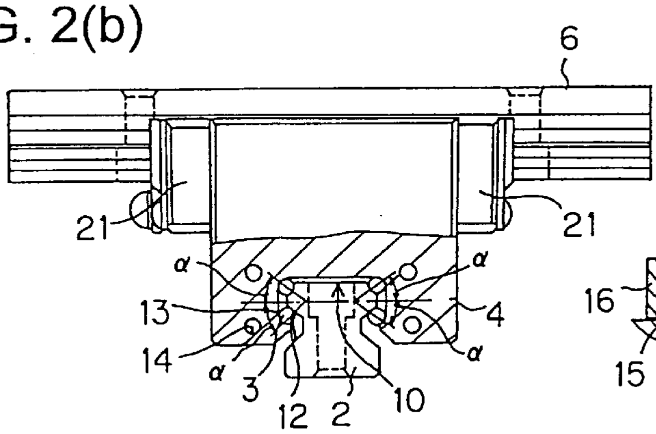


FIG. 2(c)

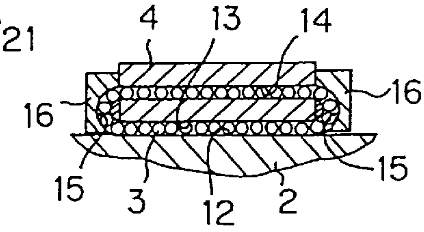


FIG. 2(e)

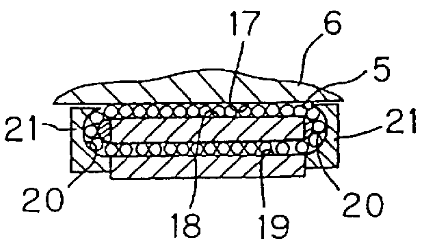


FIG. 2(d)

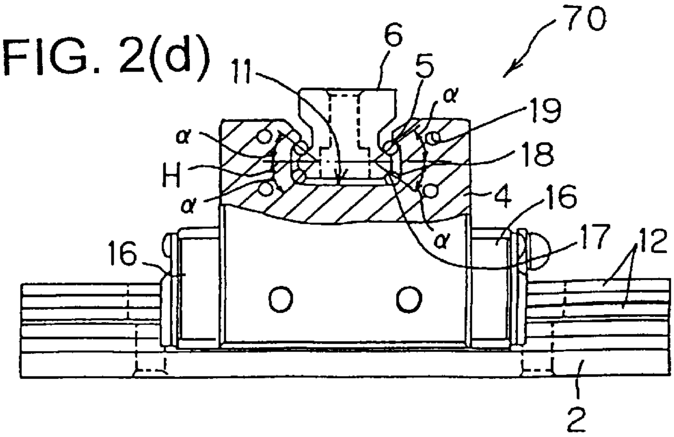


FIG. 3(a)

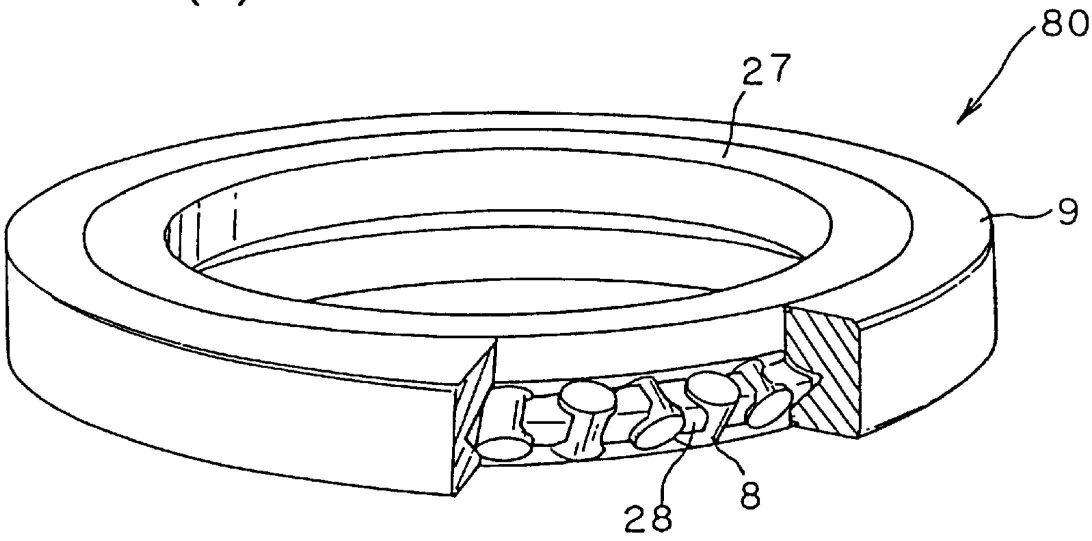

80
27
9
28
8

FIG. 3(b)

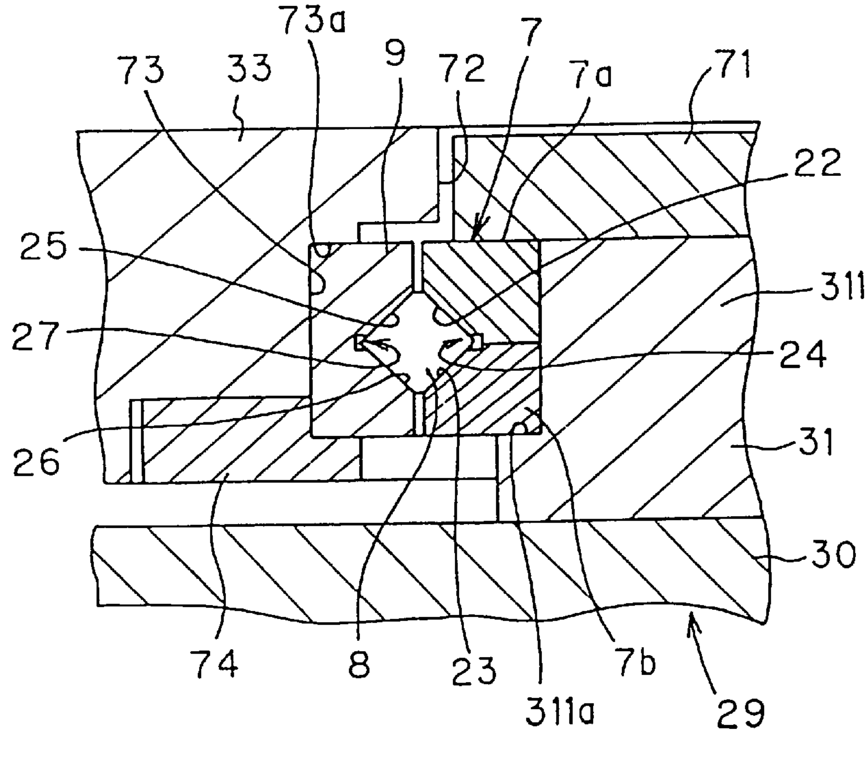

73a
9
7
73
33
72
7a
71
22
25
311
27
24
26
31
30
74
8
23
311a
7b
29

FIG. 4(b)

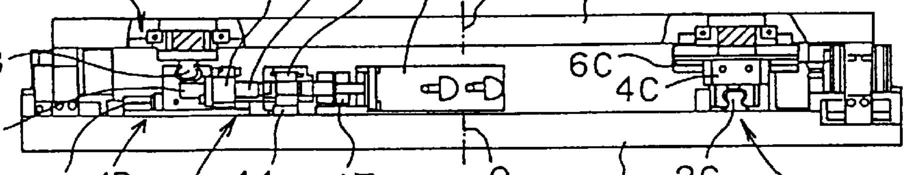

80
42
41
38
43
Co
33
6B
6C
4C
4B
2B
1B
39
44
47
0
34
2C
1C

FIG. 4(a)

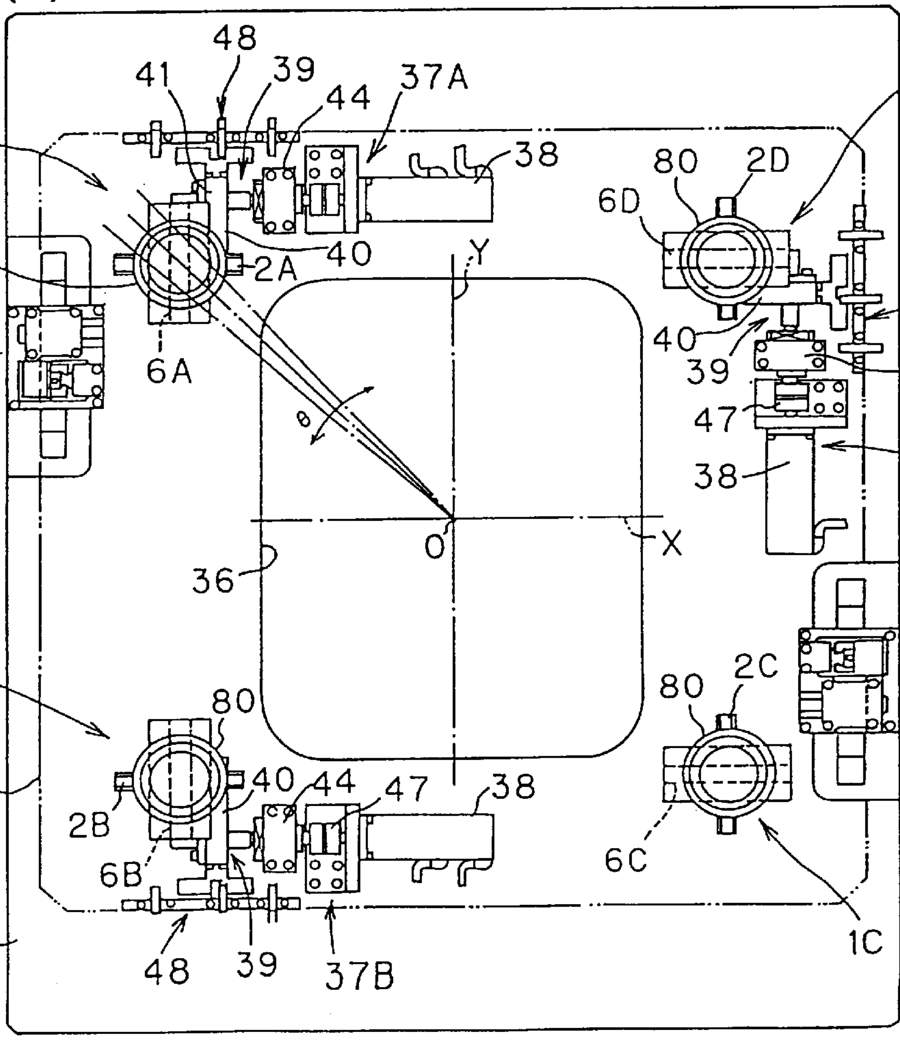

48
41
39
44
37A
1D
1A
38
80
2D
6D
80
2A
40
Y
48
49
6A
40
39
44
47
37D
38
0
X
36
1B
80
2C
80
33
2B
40
44
47
38
6B
6C
1C
34
48
39
37B

FIG. 5

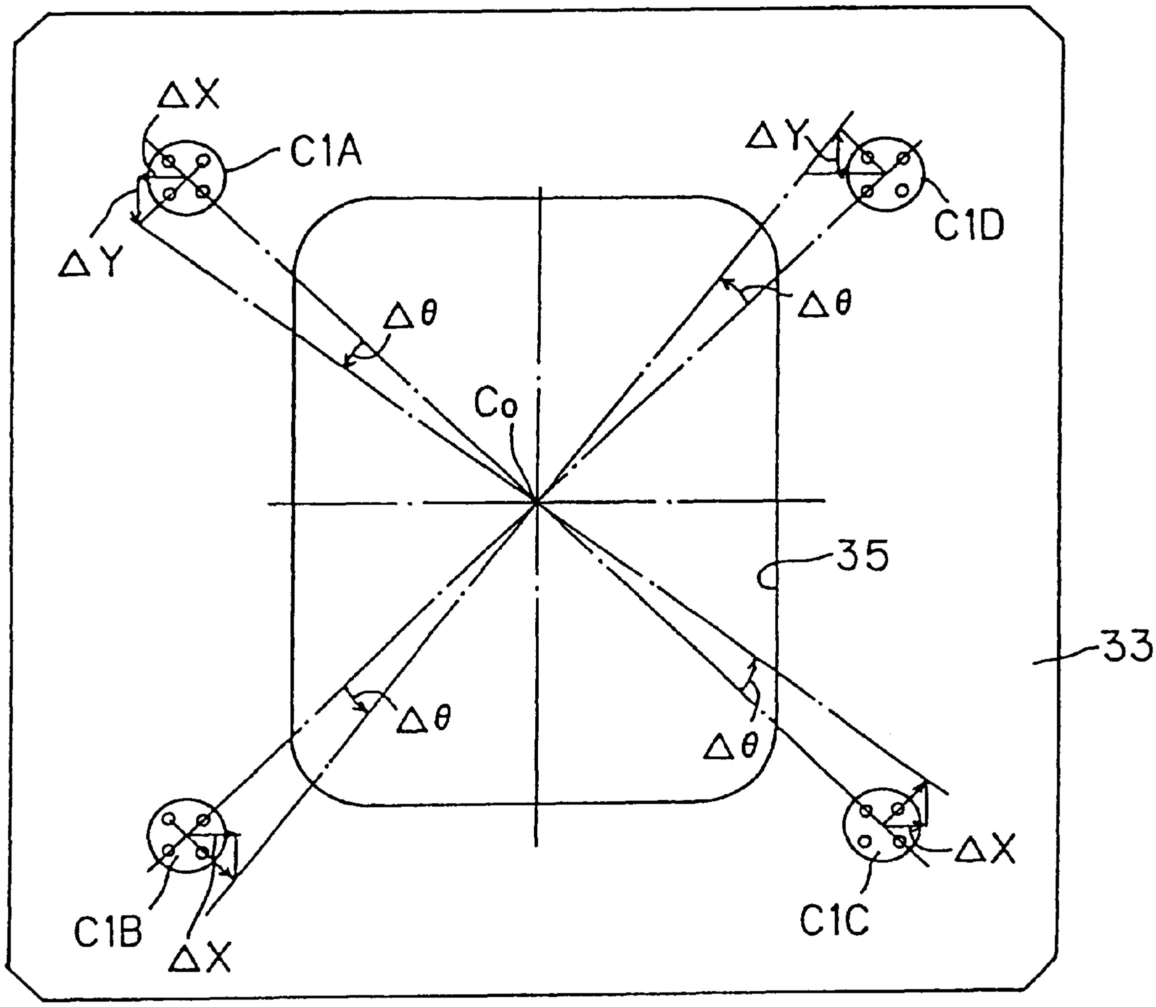


FIG. 6(a)

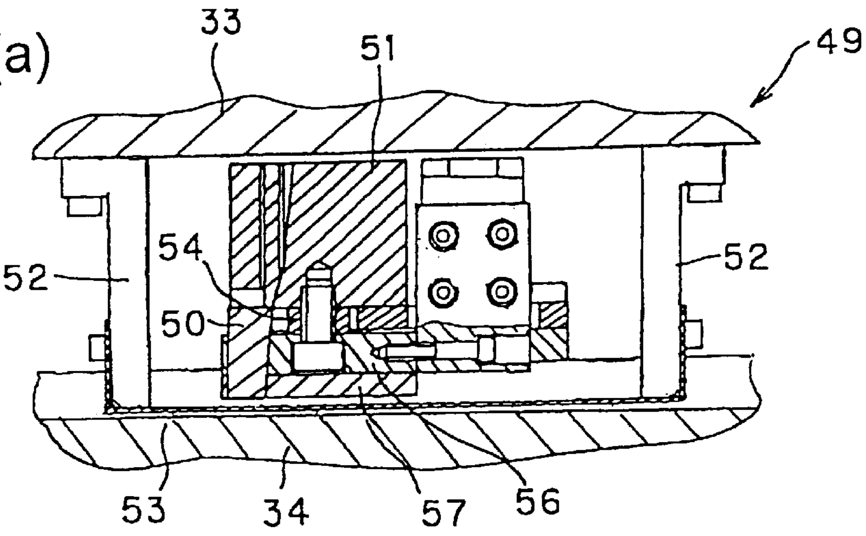


FIG. 6(b)

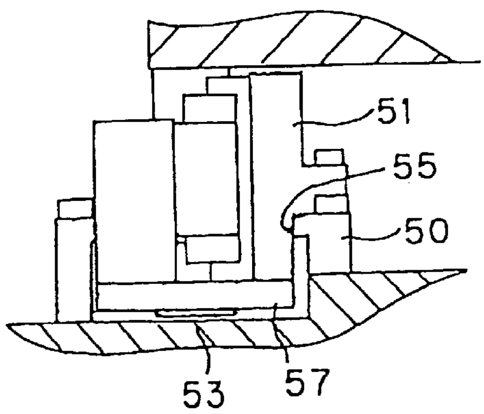


FIG. 6(c)

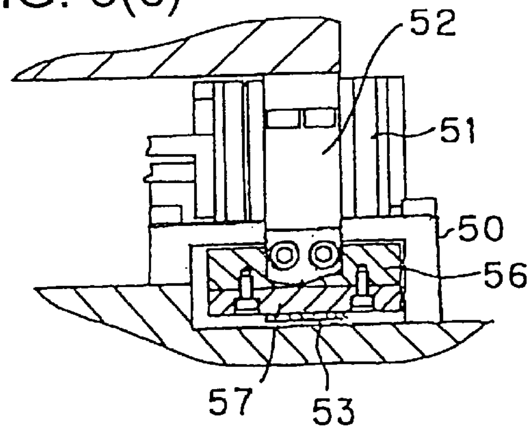


FIG. 6(d)

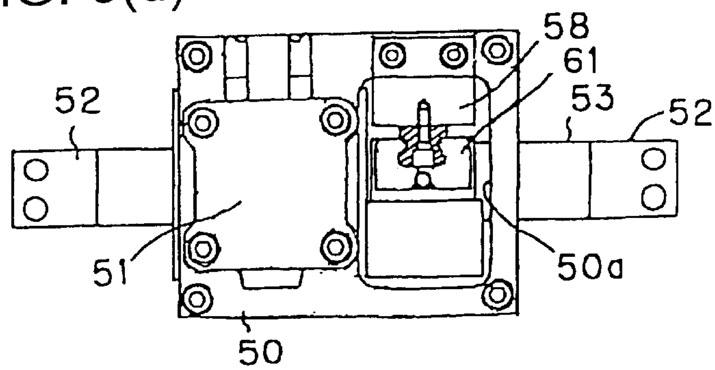


FIG. 7(a)

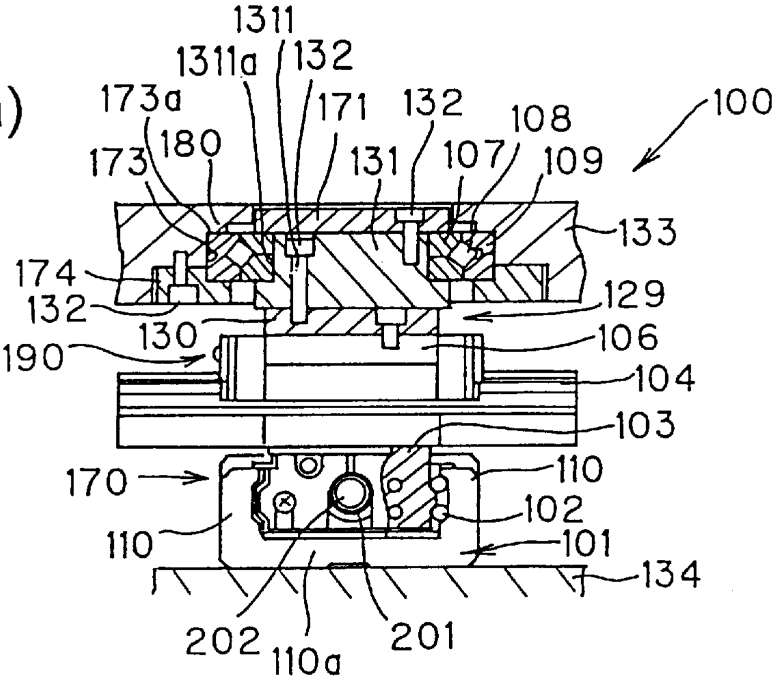

1311
1311a
132
173a
171
132
108
100
180
173
131
107
109
133
174
132
129
130
106
190
104
103
170
110
102
110
101
134
202
110a
201

FIG. 7(b)

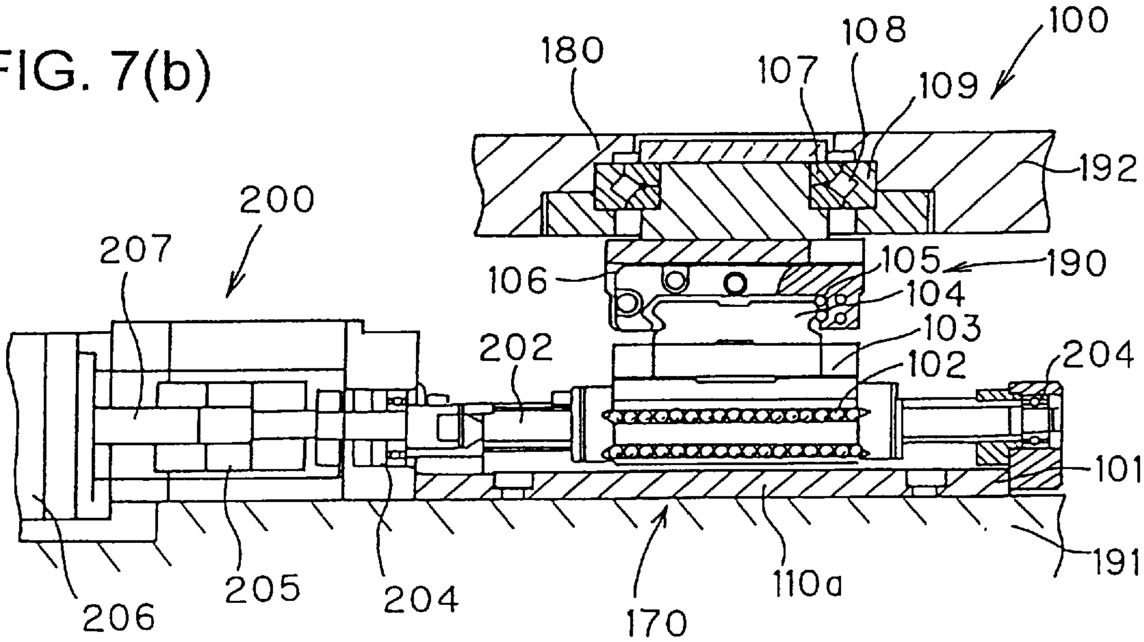

180
108
100
107
109
192
200
207
105
190
106
104
103
202
102
204
101
191
206
205
204
170
110a

FIG. 8(a)

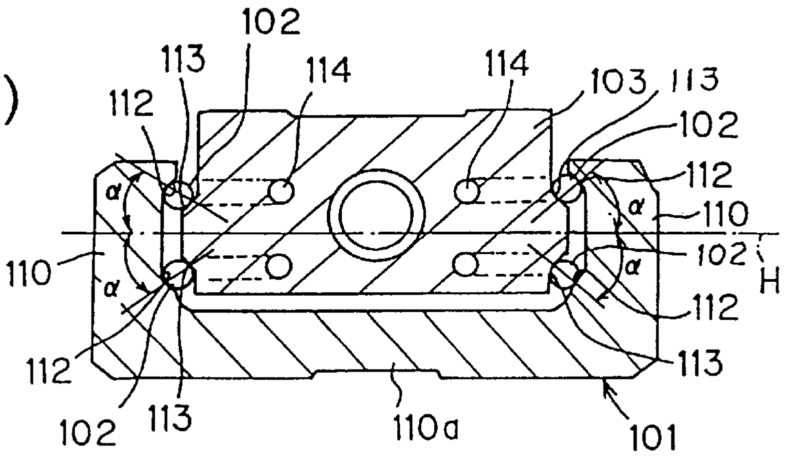


FIG. 8(b)

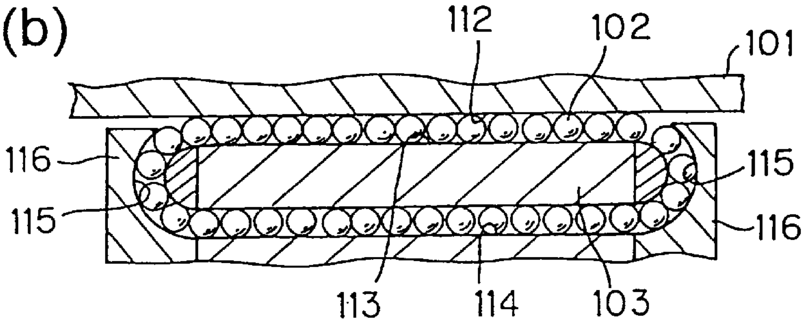


FIG. 8(c)

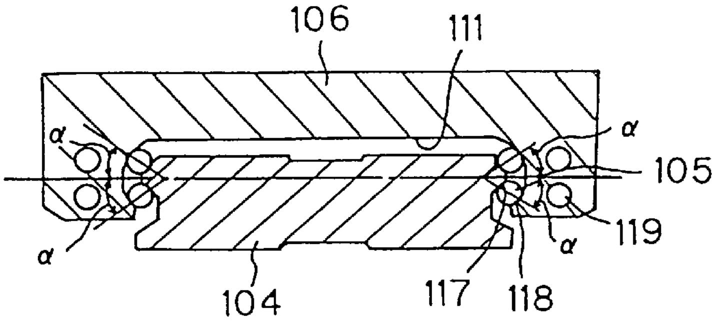


FIG. 8(d)

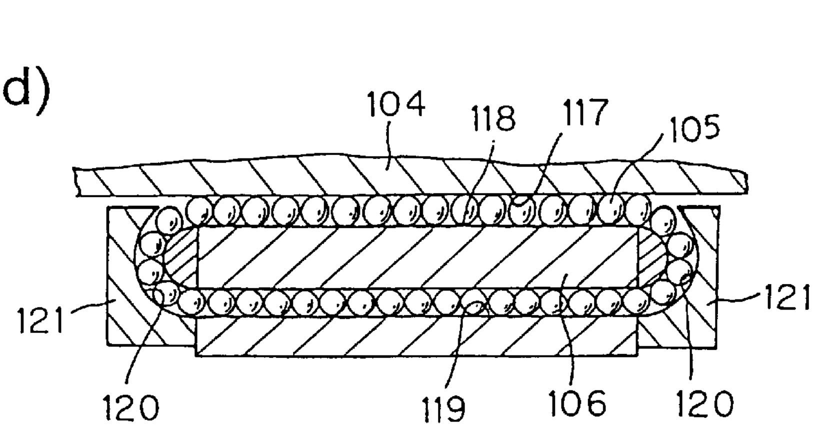


FIG. 9(a)

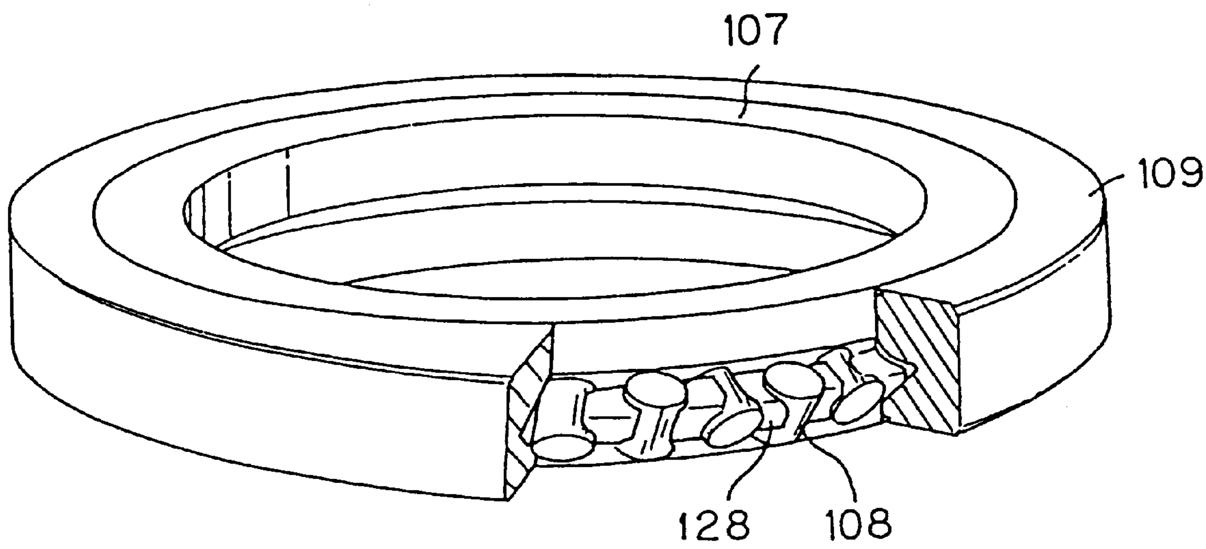


FIG. 9(b)

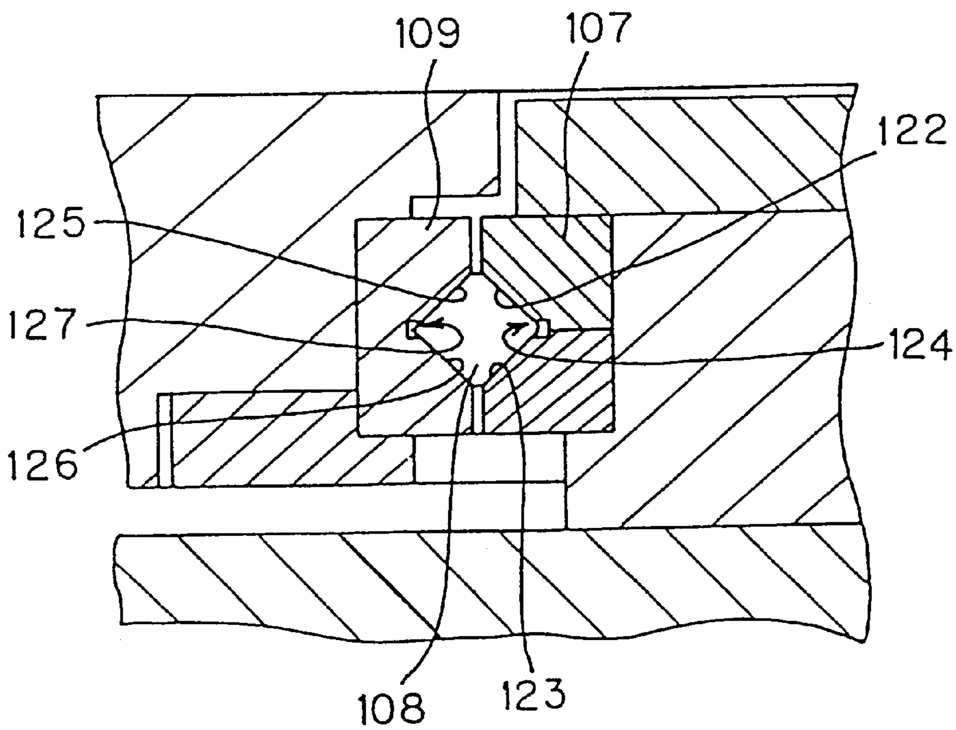


FIG. 10(a)

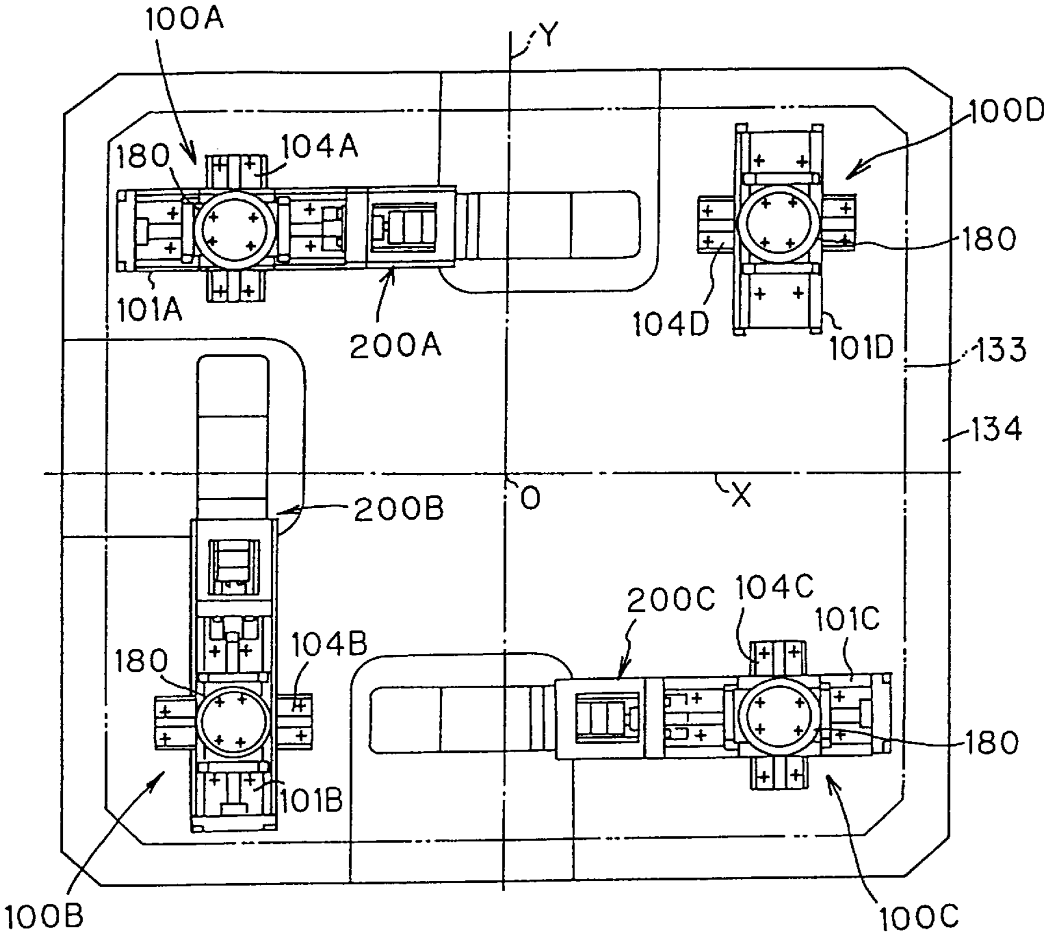


FIG. 10(b)

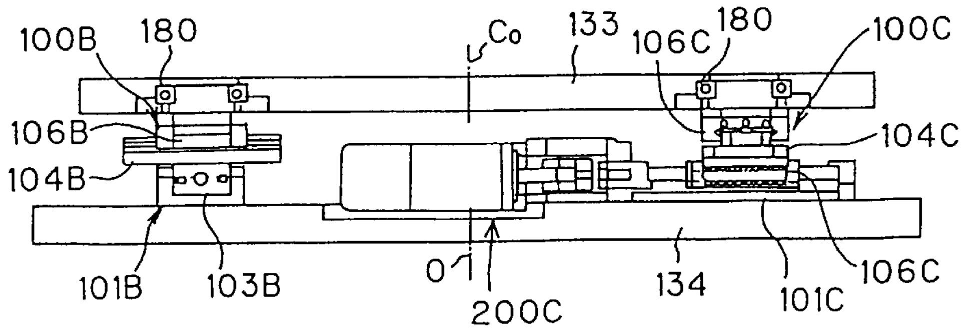
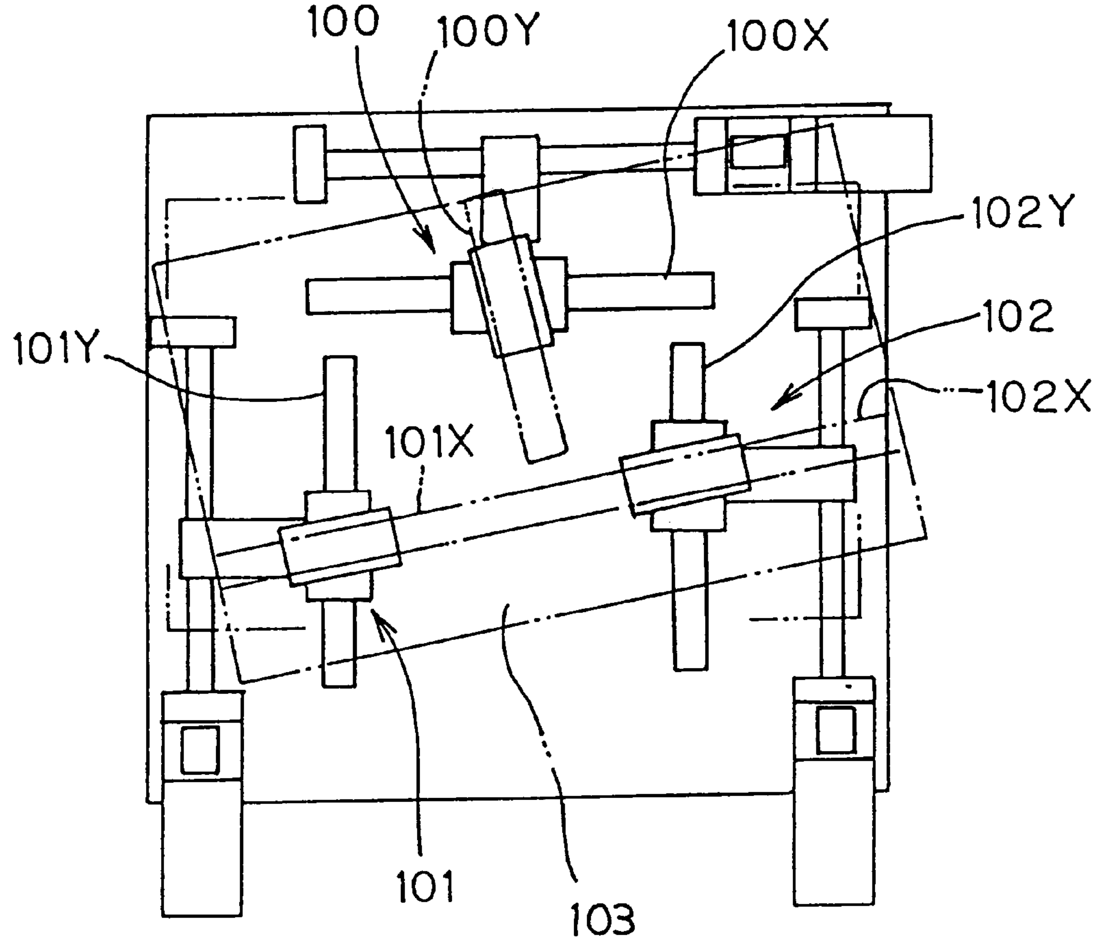


FIG. 11



GUIDE APPARATUS FOR BIAXIAL SHIFTING MOTION AND UNIAXIAL TURNING MOTION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a guide apparatus for biaxial shifting motion and uniaxial turning motion.

2. Description of the Related Art

There has already been known a guide apparatus for biaxial shifting motion and uniaxial turning motion disclosed for example in Japanese Patent Provisional Publication No. H8-99243.

In the above-mentioned guide apparatus, a linear motion guide apparatus composed of a guide rail and a movable block is combined with the other linear motion guide apparatus having the same structure so that the movable block of the former is pivotably connected through a pivot supporting mechanism to the movable block of the latter. The guide rail of the former linear motion guide apparatus is fixed to a base and the guide rail of the latter liner motion guide apparatus is fixed to a table. A plurality of guide apparatus each having such a structure are used to form a table for biaxial shifting motion and uniaxial turning motion.

The above-described conventional guide apparatus for biaxial shifting motion and uniaxial turning motion however has the following problems.

In the conventional guide apparatus, two guide rails defining biaxial directions respectively turn on the plane defined by the biaxial lines. As a result, there is difficulty in control of turning motion at a point other than the origin of the coordinate axes and of shifting motion in longitudinal and lateral directions (i.e., X and Y directions) after the turn by a prescribed turning angle. When a table **103** turns as shown in FIG. **11** at the origin of the coordinate axes with the use of three sets of guide apparatus for biaxial shifting motion and uniaxial turning motion **100**, **101**, **102**, movable guide rails **100**Y, **101**X, **102**X of the guide apparatus **100**, **101**, **102** incline relative to stationary guide rails **100**X, **101**Y, **102**Y. A translation operation of the table **103** from the above-mentioned condition requires a parallel movement of each of the movable guide rails **100**Y, **101**X, **102**X as well as a proper maintenance of the inclined angle of the movable guide rails **100**Y, **101**X, **102**X relative to the stationary guide rails **100**OX, **101**Y, **102**Y, thus leading to an extremely complex control.

It is actually difficult to dispose the pivot supporting mechanism between the movable blocks of the linear motion guide apparatus. More specifically, when the pivot supporting mechanism having outer and inner rings is disposed between the movable blocks, the outer ring is for example secured to one of the movable blocks and the inner ring is secured to the other of them. Accordingly, it is necessary to form a hole on the one movable block, into which the outer ring can be fitted, to form a projection on the other movable block, which can be fitted into the inner surface of the inner ring, and to provide a means for preventing the pivot supporting mechanism from coming out, thus requiring a complex structure.

There is also required a proper squareness of the bottom surface of each of the guide rails secured to the base and the table, respectively, relative to the pivot axis of each of the pivot supporting mechanisms. The squareness is determined for example by the fitting surfaces of the outer ring and the portion of the one movable block, which forms the hole as

well as the fitting surfaces of the inner ring and the projection formed on the other movable block, as described above. Combination of a working error in diametrical length of the hole formed on the one movable block with an improper squareness of the inner peripheral surface of the portion of the one movable block, which forms the hole, combination of a working error in diametrical length of the outer periphery of the projection formed on the other movable block with an improper squareness of the outer peripheral surface of the projection, and combination of working errors in an outer diametrical length of the outer ring and an inner diametrical length of the inner ring are complicated and there cannot be obtained a proper squareness of the bottom surface of the guide rail relative to the pivot axis of the pivot supporting mechanism.

An improper squareness causes a wavy movement of the table when the table turns, thus making it impossible to carry out a positional determination with high precision. A conceivable method of disposing a guide mechanism between the movable blocks in order to obtain a proper squareness leads to a complicated structure.

A plurality of holes for bolts for fixing the guide rails to the table are required to be formed thereon. In this case, it is necessary to apply a precise working to the table to form the hole with a prescribed proper pitch.

When force is applied to the table at a position apart from the pivot axis of the guide apparatus for biaxial shifting motion and uniaxial turning motion, a moment load having a function of inclining the pivot axis is applied to the pivot supporting mechanism. The moment load is applied through the guide rail to the pivot supporting mechanism so that the moment load is amplified by an amount corresponding to the length of the guide rail. Accordingly, a large displacement occurs at the pivot axis and the inclination angle of the table increases, thus leading to a poor positional determination.

SUMMARY OF THE INVENTION

An object of the present invention, which was made in order to solve the above-described problems, is therefore to provide a guide apparatus for biaxial shifting motion and uniaxial turning motion, which permits an easy operation control and an easy installation in a table and a proper guide and support of the table with high precision.

In order to attain the aforementioned object, a guide apparatus for biaxial shifting motion and uniaxial turning motion comprises a biaxial shifting motion guide mechanism for supporting a second member so as to be movable relative to a first member in a constant posture state along biaxial lines intersecting at right angles with each other; and a pivot supporting mechanism disposed on said biaxial shifting motion guide mechanism at an opposite side of said first member, for pivotably supporting said second member.

In the present invention, even when the second member is moved in parallel to a prescribed position and then is turned there, the biaxial lines in the biaxial shifting motion guide mechanism are invariable, thus making it possible to make an easy determination of an amount of displacement in each of the biaxial directions, which corresponds to the turning motion of the second member.

The biaxial lines in the biaxial shifting motion guide mechanism are invariable as mentioned above even after the turning motion of the second member, it is very easy to control of the parallel movement of the second member along the biaxial directions.

In the present invention, the pivot supporting mechanism may comprise a first ring and a second ring. The first ring is secured to the biaxial shifting motion guide mechanism and has a central axis, which is substantially identical with a line intersecting at right angles a plane defined by the biaxial lines. The second ring is coupled through a plurality of rolling members with the first ring so as to be rotatable relative thereto and is connected to the second member.

The biaxial shifting motion guide mechanism may comprise a first guide rail secured to the first member, a movable block connected through a plurality of rolling members to the first guide rail so as to be movable and a second guide rail connected through a plurality of rolling members to the movable block so as to be movable in a direction intersecting the first guide rail. The pivot supporting mechanism may comprise a first ring and a second ring. The first ring is secured to the second guide rail and the second ring is coupled through a plurality of rolling members with the first ring so as to be rotatable relative thereto and is secured to the second member.

In such an embodiment of the present invention, the first ring is secured to the second guide rail and the second ring is secured to the second member. Accordingly, the securing of the first ring to the second rail suffices, leading to an easy installation working.

The first guide rail and the second guide rail are connected to the single movable block, and parallelism between the bottom surfaces of the pair of guide rails can therefore be obtained by an easy machining process of the single movable block.

As a result, when there is obtained only a proper squareness of the pivot axis of the first ring relative to the second guide rail, a proper squareness of the bottom surface of the first guide rail relative to the pivot axis can automatically be obtained, and the parts of the guide apparatus can very easily be assembled under a precise positional determination condition.

Formation of only a hole, into which the second ring is to be fitted, on a table as the second member suffices, thus leading to an easy working process on the table. When force is applied to the table at a position apart from the pivot axis of the guide apparatus for biaxial shifting motion and uniaxial turning motion, a moment load having a function of inclining the pivot axis is applied to the pivot supporting mechanism. The moment load is however applied through the second ring to the pivot axis and a merely small displacement occurs at the pivot axis.

The apparatus of the present invention may further comprise a linear actuator secured to any one of the first member and the second member. The linear actuator is operatively connected to the movable block.

In such an embodiment of the present invention, pushing the movable block by means of the above-mentioned linear actuator permits relative movement of the movable block between the first member and the second member.

According to such an operative connection of the linear actuator with the movable block, it is unnecessary to form any specific connecting portions for the linear actuator on the first and second members.

It is preferable to use a screw feeding mechanism as the linear actuator. In this case, the movable block preferably has a nut portion, to which a feed screw of the above-mentioned screw feeding mechanism is screwed.

When the screw feeding mechanism is used, the non-turning condition of the feed screw permits to make a positional determination of the movable block in the axial direction of the feed screw.

It is preferable to provide the apparatus of the present invention with the following features:

(1) the first recess portion, into which the first guide rail is to be inserted slidably is formed on one side of the movable block;

(2) there are provided four roller running grooves so that the two roller running grooves of them are respectively formed on the upper and lower portions of each of the right and left-hand longitudinal side surfaces of the first guide rail, there are provided four roller running counter-grooves, which face the four roller running grooves, respectively, so that the two roller running counter-grooves of them are respectively formed on the upper and lower portions of each of the right and left-hand inner surfaces of the first recess portion, there are formed four rolling member returning passages on the movable block so as to be in parallel with the above-mentioned four roller running grooves, and there is provided on each of the longitudinal opposite ends of the movable block a side cover having direction changing passages for connecting the four roller running grooves with the four rolling member returning passages;

(3) in each of the right and left-hand longitudinal side surfaces of the first guide rail, a line connecting the contact points of the rolling member with the upper roller running groove and the upper roller running counter-groove facing thereon and the other line connecting the contact points of the rolling member with the lower roller running groove and the lower roller running counter-groove facing thereon symmetrically incline relative to a horizontal line locating between the upper two trains of rolling members and the lower two trains of rolling members;

(4) the second recess portion, into which the second guide rail is to be inserted slidably is formed on the other side of the movable block;

(5) there are provided four roller running grooves so that the two roller running grooves of them are respectively formed on the upper and lower portions of each of the right and left-hand longitudinal side surfaces of the second guide rail, and there are provided four roller running counter-grooves, which face the four roller running grooves, respectively, so that the two roller running counter-grooves of them are respectively formed on the upper and lower portions of each of the right and left-hand inner surfaces of the second recess portion, there are formed four rolling member returning passages on the movable block so as to be in parallel with the above-mentioned four roller running grooves, and there is provided on each of the longitudinal opposite ends of the movable block a side cover having direction changing passages for connecting the four roller running grooves with the four rolling member returning passages; and

(6) in each of the right and left-hand longitudinal side surfaces of the second guide rail, a line connecting the contact points of the rolling member with the upper roller running groove and the upper roller running counter-groove facing thereon and the other line connecting the contact points of the rolling member with the lower roller running groove and the lower roller running counter-groove facing thereon symmetrically incline relative to a horizontal line locating between the upper two trains of rolling members and the lower two trains of rolling members.

According to such a structure in which the four trains of rolling members are disposed between the first recess portion of the movable block and the first guide rail and the similar four trains of rolling members are also disposed between the second recess portion of the movable block and the second guide rail, and in each of the right and left-hand longitudinal side surfaces of each of the first and second guide rails, the line connecting the contact points of the rolling member with the upper roller running groove and the upper roller running counter-groove facing thereon and the other line connecting the contact points of the rolling member with the lower roller running groove and the lower roller running counter-groove facing thereon symmetrically incline relative to the horizontal line locating between the upper two trains of rolling members and the lower two trains of rolling members, there can be obtained a supporting structure having a high rigidity against loads applied from any direction, such as compressive load in the axial direction of the pivot axis, tensile load in the axial direction of the pivot axis, load acting in a direction perpendicular to the pivot axis, moment load having a function of inclining the pivot axis and the like.

In the present invention, the biaxial shifting motion guide mechanism may comprise a first guide rail secured to the first member, a first movable block connected through a plurality of rolling members to the first guide rail so as to be movable, a second guide rail secured to the first movable block so as to intersect the first guide rail and a second movable block movably connected through a plurality of rolling members to the second guide rail; and the pivot supporting mechanism may comprise a first ring and a second ring. The first ring is secured to the second movable block and the second ring is coupled through a plurality of rolling members with the first ring so as to be rotatable relative thereto and is secured to the second member.

Also in such an embodiment of the present invention, the first ring is secured to the second guide rail and the second ring is secured to the second member. Accordingly, the securing of the first ring to the second rail suffices, leading to an easy installation working.

In the above-mentioned embodiment, the second guide rail is secured to the first movable block and the second movable block is slidably connected to the second guide rail. As a result, when there is obtained only a proper squareness in the contact surfaces of the first movable block and the second guide rail, which are secured to each other, and in the contact surfaces of the second movable block and the first guide rail, a proper squareness of the bottom surface of the first guide rail relative to the pivot axis can automatically be obtained, and the parts of the guide apparatus can very easily be assembled under a precise positional determination condition.

Formation of only a hole, into which the second ring is to be fitted, on a table as the second member suffices, thus leading to an easy working process on the table. When force is applied to the table at a position apart from the pivot axis of the guide apparatus for biaxial shifting motion and uniaxial turning motion, a moment load having a function of inclining the pivot axis is applied to the pivot supporting mechanism. The moment load is however applied through the second ring to the pivot axis and a merely small displacement occurs at the pivot axis.

In the present invention, the first guide rail may have a pair of supporting walls, between which the first movable block is held through the rolling members.

According to such a structure in which the first movable block is held between the pair of supporting walls of the first guide rail, stability can be improved.

It is preferable to dispose a linear actuator for moving the first movable block relative to the first guide rail, between the first guide rail and the first movable block.

When the linear actuator is disposed between the first guide rail and the first movable block as mentioned above, and the linear actuator is located in the central portion of the first movable block, the distance between the portion of the first movable block, to which force for moving the first movable block is imparted, and each of the trains of the rolling members located between the first guide rail and the first movable block can be decreased, with the result that moment load caused by the rolling resistance of the trains of the rolling members and the driving force for moving the first movable block does not have any adverse effects.

The above-mentioned linear actuator is preferably composed of a screw shaft, which is disposed so as to be in parallel with the supporting walls of the first guide rail and is screwed into a screw hole formed on the first movable block; a bearing member for rotatably supporting the screw shaft; and a driving mechanism for rotating the screw shaft.

According to such a structure, it is unnecessary to provide any specific linear driving mechanism between the base and the table.

It is also preferable to provide the apparatus of the present invention with the following features:

(1) there are provided four roller running grooves so that the two roller running grooves of them are respectively formed on the upper and lower portions of each of the right and left-hand supporting walls of the first guide rail, there are provided four roller running counter-grooves, which face the four roller running grooves, respectively, so that the two roller running counter-grooves of them are respectively formed on the upper and lower portions of each of the right and left-hand side surfaces of the first guide rail, there are formed four rolling member returning passages on the first movable block so as to be in parallel with the above-mentioned four roller running grooves, and there is provided on each of the longitudinal opposite ends of the movable block a side cover having direction changing passages for connecting the four roller running grooves with the four rolling member returning passages;

(2) the second recess portion, into which the second guide rail is to be inserted slidably is formed on the second movable block; and

(3) there are provided four roller running grooves so that the two roller running grooves of them are respectively formed on the upper and lower portions of each of the right and left-hand longitudinal side surfaces of the second guide rail, and there are provided four roller running counter-grooves, which face the four roller running grooves, respectively, so that the two roller running counter-grooves of them are respectively formed on the upper and lower portions of each of the right and left-hand inner surfaces of the second recess portion of the second movable block, there are formed four rolling member returning passages on the second movable block so as to be in parallel with the above-mentioned four roller running grooves, and there is provided on each of the longitudinal opposite ends of the second movable block a side cover having direction changing passages for connecting the four roller running grooves with the four rolling member returning passages.

When the four trains of rolling members are disposed between the first movable block and the supporting walls of the first guide rail and the similar four trains of rolling members are also disposed between the second guide rail and the inner side surfaces of the recess portion of the second movable block, and a line connecting the contact points of the rolling member with the upper roller running groove and the upper roller running counter-groove facing thereon and the other line connecting the contact points of the rolling member with the lower roller running groove and the lower roller running counter-groove facing thereon symmetrically incline relative to a horizontal line locating between the upper two trains of rolling members and the lower two trains of rolling members, then there can be obtained a supporting structure having a high rigidity against loads applied from any direction, such as compressive load in the axial direction of the pivot axis, tensile load in the axial direction of the pivot axis, load acting in a direction perpendicular to the pivot axis, moment load having a function of inclining the pivot axis and the like.

In the present invention, the second ring may be coupled through rollers as the rolling members with an outer periphery of the first ring; the first ring may have on an outer peripheral surface thereof a first groove, which opens outward in a radius direction of the first ring, the first groove is composed of an upper roller-running surface and a lower roller-running surface intersecting the upper roller-running surface substantially at right angles; the second ring may have on an inner peripheral surface thereof a second groove, which opens inward in a radius direction of the second ring so as to face the first groove, the second groove is composed of an upper roller-running surface and a lower roller-running surface intersecting the upper roller-running surface substantially at right angles; and a part of the rollers disposed between the first groove and the second groove may be rollable between the upper roller-running surface of the first ring and the lower roller-running surface of the second ring, and a remaining part of the rollers may be rollable between the lower roller-running surface of the first ring and the upper roller-running surface of the second ring.

According to such a structure in which the rollers are disposed between the first ring and the second ring, there can be obtained a supporting structure, which is composed of a pair of rings, i.e., the first ring and the second ring, and has a high rigidity against loads applied from any direction, such as compressive load in the axial direction of the pivot axis, tensile load in the axial direction of the pivot axis, load acting in a direction perpendicular to the pivot axis, moment load having a function of inclining the pivot axis and the like. As a result, there can be obtained the supporting structure, which is lightweight and has a high rigidity. In addition, such a supporting structure can be provided in a large-size.

Each of the above-mentioned part of the rollers disposed so as to be rollable between the upper roller-running surface of the first groove and the lower roller-running surface of the second groove, and each of the remaining part of the rollers disposed so as to be rollable between the lower roller-running surface of the first groove and the upper roller-running surface of the second groove may be arranged alternately.

It is preferable to provide a pre-load imparting means for imparting pre-load to the rollers disposed between the first groove and the second groove. The supporting structure having a further high rigidity can be obtained by imparting such pre-load to the rollers.

An apparatus for biaxial shifting motion and uniaxial turning motion of the present invention comprise (1) a base, (2) a table, (3) a biaxial shifting motion guide mechanism for supporting the table so as to be movable relative to the base in a constant posture state along biaxial lines intersecting at right angles with each other and (4) a pivot supporting mechanism disposed on the biaxial shifting motion guide mechanism at an opposite side of the base, for pivotably supporting the table.

In an embodiment of the above-described apparatus of the present invention, the biaxial shifting motion guide mechanism may comprise a first guide rail secured to the base, a movable block connected through a plurality of rolling members to the first guide rail so as to be movable and a second guide rail connected through a plurality of rolling members to the movable block so as to be movable in a direction intersecting the first guide rail, and the pivot supporting mechanism may comprise a first ring and a second ring. The first ring is secured to the second guide rail and the second ring is coupled through a plurality of rolling members with the first ring so as to be rotatable relative thereto and is secured to the table.

In the other embodiment of the above-mentioned apparatus of the present invention, the biaxial shifting motion guide mechanism may comprise a first guide rail secured to the base, a first movable block connected through a plurality of rolling members to the first guide rail so as to be movable, a second guide rail secured to the first movable block so as to intersect the first guide rail and a second movable block movably connected through a plurality of rolling members to the second guide rail, and the pivot supporting mechanism may comprise a first ring and a second ring. The first ring is secured to the second movable block and the second ring is coupled through a plurality of rolling members with the first ring so as to be rotatable relative thereto and is secured to the table.

In the above described embodiments of the present invention, the first guide rail of the biaxial shifting motion guide mechanism is secured to the base and the second ring of the pivot supporting mechanism is secured to the table. However, the second ring of the pivot supporting mechanism may be secured to the base and the first guide rail of the biaxial shifting motion guide mechanism may be secured to the table.

As the biaxial shifting motion guide mechanism, there may be used a plurality of biaxial shifting motion guide mechanisms disposed between the base and the table.

The plurality of biaxial shifting motion guide mechanisms can be disposed in any place. In case that the table having a rectangular shape is supported, the biaxial shifting motion guide mechanisms respectively disposed at the four corners of the table permit to prevent the four corners of the table from being deformed. There is available a structure in which a large vacancy is formed at the central portion of the table, and as a result, a working process of passing something through the vacancy can be carried out. Such a structure leads to decrease in weight of the apparatus.

A braking mechanism for maintaining the stationary condition of the table relative to the base may be provided between the table and the base. The braking mechanism may comprise a brake pad provided so as to be capable of coming into contact with any one of the table and the base or separating therefrom, a linear guide mechanism secured to the other of the table and the base, for guiding and supporting the brake pad, and a pressure mechanism for moving the brake pad toward the above-mentioned one of the table and the base and pressing the same against the above-mentioned one of them.

According to such a structure in which the brake pad is guided and supported by the linear guide mechanism, load given to the brake pad through the table can be born by means of the linear guide mechanism and is not applied to the pressure mechanism. Even when the pressure mechanism has no sufficient rigidity in the transverse direction, there occurs no variation in shifting position of the table, which may be caused by the deformation of the pressure mechanism.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**(*a*) is a plan view having a partially sectioned portion, illustrating a guide apparatus for biaxial shifting motion and uniaxial turning motion of the first embodiment of the present invention, and FIG. **1**(*b*) is a side view having a partially sectioned portion, illustrating the guide apparatus as shown in FIG. **1**(*a*);

FIG. **2**(*a*) is a perspective view having a partially sectioned portion, illustrating the guide apparatus as shown in FIGS. **1**(*a*) and **1**(*b*), FIG. **2**(*b*) is a view illustrating a biaxial shifting motion guide mechanism of the guide apparatus as shown in FIG. **2**(*a*), which has the lower half sectioned portion thereof, FIG. **2**(*c*) is a sectional view illustrating the structure of a ball circulation passage of the guide apparatus as shown in FIG. **2**(*b*), FIG. **2**(*d*) is a view illustrating an X-Y guide mechanism of the guide apparatus as shown in FIG. **2**(*a*), which has the upper half sectioned portion thereof, and FIG. **2**(*e*) is a sectional view illustrating the structure of a ball circulation passage of the guide apparatus as shown in FIG. **2**(*d*);

FIG. **3**(*a*) is a perspective view having a partially sectioned portion, illustrating a pivot supporting mechanism of the guide apparatus as shown in FIGS. **1**(*a*) and **1**(*b*), and FIG. **3**(*b*) is a partial sectional view of the pivot supporting mechanism as shown in FIG. **3**(*a*);

FIG. **4**(*a*) is a plan view illustrating a table type working apparatus provided with the guide apparatus for biaxial shifting motion and uniaxial turning motion as shown in FIGS. **1**(*a*) and **1**(*b*), in which plan view a table is shown in two-dot chain lines, and FIG. **4**(*b*) is a front view illustrating the table type working apparatus as shown in FIG. **4**(*a*);

FIG. **5** is a plan view illustrating the table as shown in FIG. **4**(*a*);

FIG. **6** is a view illustrating a braking mechanism of the table type working apparatus as shown in FIGS. **4**(*a*) and **4**(*b*);

FIG. **7**(*a*) is a front view having a partially sectioned portion, illustrating a guide apparatus for biaxial shifting motion and uniaxial turning motion of the second embodiment of the present invention, and FIG. **7**(*b*) is a side view having a partially sectioned portion, illustrating the guide apparatus as shown in FIG. **7**(*a*);

FIG. **8**(*a*) is a sectional view illustrating the first guide rail and the first movable block as shown in FIGS. **7**(*a*) and **7**(*b*), FIG. **8**(*b*) is a sectional view illustrating a ball circulation passage as shown in FIG. **8**(*a*), FIG. **8**(*c*) is a sectional view illustrating the second guide rail and the second movable block as shown in FIGS. **7**(*a*) and **7**(*b*), and FIG. **8**(*d*) is a sectional view illustrating a ball circulation passage as shown in FIG. **8**(*c*);

FIG. **9**(*a*) is a perspective view having a partially sectioned portion, illustrating a pivot supporting mechanism of the guide apparatus as shown in FIGS. **7**(*a*) and **7**(*b*), and FIG. **9**(*b*) is a partial sectional view of the pivot supporting mechanism as shown in FIG. **9**(*a*);

FIG. **10**(*a*) is a plan view illustrating a table type working apparatus provided with the guide apparatus for biaxial shifting motion and uniaxial turning motion as shown in FIGS. **7**(*a*) and **7**(*b*), in which plan view a table is shown in two-dot chain lines, and FIG. **10**(*b*) is a front view illustrating the table type working apparatus as shown in FIG. **10**(*a*); and

FIG. **11** descriptive view illustrating the operation of a conventional table type working apparatus provided with a conventional guide apparatus for biaxial shifting motion and uniaxial turning motion.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now, embodiments of a guide apparatus for biaxial shifting motion and uniaxial turning motion of the present invention will be described in detail below with reference to the accompanying drawings.

FIGS. **1**(*a*) to **3**(*b*) illustrate a guide apparatus **1** for biaxial motion and uniaxial turning motion of the first embodiment of the present invention.

In the first embodiment, the guide apparatus **1** is composed of a biaxial shifting motion guide mechanism **70** designed as an integral body and of a pivot supporting mechanism **80** combined with the biaxial shifting motion guide mechanism **70**.

More specifically, the biaxial shifting motion guide mechanism **70** is composed of a first guide rail **2** secured to a base **34** designed as the first member, a movable block **4** connected through balls **3** designed as a plurality of rolling members to the first guide rail **2** so as to be movable and a second guide rail **6** connected through balls **5** designed as a plurality of rolling members to the movable block **4** so as to be movable in a direction intersecting the first guide rail **2**.

The pivot supporting mechanism **80** is composed of a first ring **7** and a second ring **9**. The first ring **7** is secured to the second guide rail **6**. The second ring **9** is coupled through rollers **8** designed as a plurality of rolling members with the first ring **7** so as to be rotatable relative thereto. A table **33** designed as the second member is secured to the above-mentioned second ring **9**.

The first ring **7** designed as an inner ring and the above-mentioned second guide rail **6** having a linear shape are connected with each other through a coupling portion **29**.

The coupling portion **29** is provided with a first coupling plate **30** having a rectangular shape and a second coupling plate **31** having a disc-shape. The second guide rail **6** is secured to the first coupling plate **30**. The first ring **7** is secured to the second coupling plate **31**. The first coupling plate **30** and the second coupling plate **31** are connected to each other by means of a fastening member **32** such as a bolt and the like. The second coupling plate **31** has on its periphery a projection portion **311**. The first ring **7** designed as the inner ring is fitted to the projection portion **311** from the upper side. A supporting member **71** is tightly secured to the upper surface of the projection portion **311** by means of the fastening member **32** such as a bolt and the like. The first ring **7** is designed to be held between the supporting member **71** and a shoulder portion **311***a*, which is located at the lower portion of the projection portion **311** so as to maintain the stationary condition of the first ring **7**.

The table **33** to which the second ring **9** is to be secured has an opening **72** having a circular shape. The above-mentioned supporting member **71** of the first ring **7** is designed to be able to be inserted in the opening **72** from the upper side. A recess portion **73** is formed on the lower peripheral surface of the opening **72** of the table **33**. The second ring **72** is fitted to the recess portion **73**. A supporting member **74** for holding the second ring **9** is tightly secured to the peripheral edge of the recess portion **73** by means of the fastening member **32** such as a bolt and the like. The second ring **9** is designed to be held between the supporting member **74** and the peripheral edge **73***a* of the recess portion **73** so as to maintain the stationary condition of the second ring **9**.

A detailed description of the biaxial shifting motion guide mechanism **70** will be given below. The first guide rail **2**, the movable block **4** and the second guide rail **6** compose, as shown in FIG. **2**(*a*), a biaxial linear guide mechanism in which guiding directions cross each other at right angles. The movable block **4** has on its lower surface a first recess portion **10** having an inverse U-shaped cross section, in which the first guide rail **2** is to be inserted slidably. The movable block **4** has on its upper surface, i.e., the opposite surface to the first recess portion **10**, a second recess portion **11** in which the second guide rail **6** is to be inserted slidably.

The first guide rail **2** is provided with four ball running grooves **12** so that the two ball running grooves **12** are formed on each of the right and left-hand surfaces of the first guide rail **2**. On the other hand, the movable block **4** is provided with four ball running counter-grooves **13** so that the two ball running counter-grooves **13** are formed on each of the right and left-hand inner surfaces defining the first recess portion **10** of the movable block **4**, which face the right and left-hand surfaces of the first guide rail **2**. Accordingly, the four ball running grooves **12** of the first guide rail **2** face the four ball running counter-grooves **13** of the movable block **4**, respectively.

The movable block **4** has four ball return passages **14**, which are formed in parallel with each other on the lower half portion of the movable block **4**. The four ball return passages **14** correspond to the four ball running counter-grooves **13** formed in the first recess portion **10** of the movable block **4**, respectively. A side plate **16** is secured to each of the opposite end portions of the lower half portion of the movable block **4**, which has the first recess portion **10**. Each of the side plates **16** has four direction changing passages **15** for connecting the four ball running grooves **13** and the four ball return passages **14** of the movable block **4**.

In each of the right and left-hand longitudinal side surfaces of the first guide rail **2**, a line connecting the contact points of the ball **3** with the upper roller running groove **12** and the upper roller running counter-groove **13** facing thereon and the other line connecting the contact: points of the ball **3** with the lower roller running groove **12** and the lower roller running counter-groove **13** facing thereon symmetrically incline at a prescribed angle a relative to a horizontal line locating between the upper two trains of balls **3** and the lower two trains of balls **3**. In this embodiment, there is adopted a structure in which the line connecting the contact points of the ball **3** with the upper roller running groove **12** and the upper roller running counter-groove **13** facing thereon and the other line connecting the contact points of the ball **3** with the lower roller running groove **12** and the lower roller running counter-groove **13** facing thereon are close to each other at the inside of the first recess portion **10**, on the one hand, and are apart from each other at the outside of the first: recess portion **10**, on the other hand. Pre-load is given to the balls **3**. In the modification, there may of course be adopted a structure in which the line connecting the contact points of the ball **3** with the upper roller running groove **12** and the upper roller running counter-groove **13** facing thereon and the other line connecting the contact points of the ball **3** with the lower roller running groove **12** and the lower roller running counter-groove **13** facing thereon are apart from each other at the inside of the first recess portion **10**.

The second guide rail **6** is also provided with four ball running grooves **17** so that the two ball running grooves **17** are formed on each of the right and left-hand surfaces of the second guide rail **6**. On the other hand, the movable block **4** is provided with four ball running counter-grooves **18** so that the two ball running counter-grooves **18** are formed on each of the right and left-hand inner surfaces defining the second recess portion **11** of the movable block **4**, which face the right and left-hand surfaces of the second guide rail **6**. Accordingly, the four ball running grooves **17** of the second guide rail **6** face the four ball running counter-grooves **18** of the movable block **4**, respectively.

Further, the movable block **4** has four ball return passages **19**, which are formed in parallel with each other on the upper half portion of the movable block **4**. The four ball return passages **19** correspond to the four ball running counter-grooves **18** formed in the second recess portion **11** of the movable block **4**, respectively. A side plate **21** is secured to each of the opposite end portions of the upper half portion of the movable block **4**, which has the second recess portion **11**. Each of the side plates **21** has four direction changing passages **20** for connecting the four ball running grooves **18** and the four ball return passages **19** of the movable block **4**.

In each of the right and left-hand longitudinal side surfaces of the second guide rail **6**, a line connecting the contact points of the ball **5** with the upper roller running groove **17** and the upper roller running counter-groove **18** facing thereon and the other line connecting the contact points of the ball **5** with the lower roller running groove **17** and the lower roller running counter-groove **18** facing thereon symmetrically incline at a prescribed angle a relative to a horizontal line locating between the upper two trains of balls **5** and the lower two trains of balls **5**. In this embodiment, there is adopted a structure in which the line connecting the contact points of the ball **5** with the upper roller running groove **17** and the upper roller running counter-groove **18** facing thereon and the other line connecting the contact points of the ball **5** with the lower roller running groove **17** and the lower roller running counter-groove **18** facing thereon are close to each other at the inside of the second recess portion **11**, on the one hand, and are apart from each other at the outside of the second recess portion **11**, on the other hand. In the modification, there may of course be adopted a structure in which the line connecting the contact points of the ball **5** with the upper roller running groove **17** and the upper roller running counter-groove **18** facing thereon and the other line connecting the contact points of the ball **5** with the lower roller running groove **17** and the lower roller running counter-groove **18** facing thereon are apart from each other at the inside of the second recess portion **11**. Pre-load is given to the balls **5**.

Then, a detailed description of the pivot supporting mechanism **80** will be given below. As shown in FIGS. **3**(*a*) and **3**(*b*), the first and second rings **7**, **9** are designed as inner and outer rings, which are arranged concentrically with each other, respectively. In this embodiment, the first ring **7** secured to the second guide rail **6** is used as the inner ring, and the second ring **9** is used as the outer ring. Rollers **8** are used as the rolling members in this embodiment.

The first ring **7** designed as the inner ring has on its outer peripheral surface a first groove **24**, which opens outward in a radius direction of the first ring **7**. The first groove **24** is composed of an upper roller-running surface **22** and a lower roller-running surface **23** intersecting the upper roller-running surface **22** substantially at right angles. The second ring **9** has on its inner peripheral surface a second groove **27**, which opens inward in a radius direction of the second ring **9** so as to face the first groove **24**. The second groove **27** is composed of an upper roller-running surface **25** and a lower roller-running surface **26** intersecting the upper roller-running surface **25** substantially at right angles.

A part of the rollers **8** disposed between the first groove **24** and the second groove **27** is rollable between the upper roller-running surface **22** of the first groove **24** and the lower roller-running surface **26** of the second groove **27**. A remaining part of the rollers **8** is rollable between the lower roller-running surface **23** of the first groove **24** and the upper roller-running surface **25** of the second groove **27**.

There is especially adopted a so-called "cross-roller type" structure in which each of the part of the rollers **8** disposed so as to be rollable between the upper roller-running surface **22** of the first groove **24** and the lower roller-running surface **26** of the second groove **27**, and each of the remaining part of the rollers **8** disposed so as to be rollable between the lower roller-running surface **23** of the first groove **24** and the upper roller-running surface **25** of the second groove **27** are arranged alternately. A spacing retainer **28** is disposed between the adjacent two rollers **8**.

In this embodiment, there is adopted a structure in which every other roller **8** has the same oriented central axis, which is perpendicular to an oriented axis of the other roller **8**. There may be adopted a modified structure in which every two or three roller **8** has the same oriented central axis, which is perpendicular to an oriented axis of the other roller **8**. Arrangement of the rollers **8** may optionally be modified in this manner.

Pre-load is given to the rollers **8** disposed between the first ring **7** and the second ring **9**.

In this embodiment, the first ring **7** is divided into upper and lower half portions. When a gap is formed between the upper and lower half portions of the first ring **7**, the rollers **8** can be brought into contact freely with the upper roller-running surface **22** and the lower roller-running surface **23** of the first groove **24**. When the upper half portion of the first ring **7** is pressed against the lower half portion thereof so as to form no gap between them, each of the rollers **8** is pressed under a prescribed pressure, thus imparting pre-load to the rollers **8**.

With respect to such a pre-load imparting mechanism, there may be used the second ring **9**, which has a slit so that the second ring **9** can change its shape from a C-shape under a released condition into a circular shape under a restricted condition. When the second ring **9** having such a structure is fitted to the recess portion **73** of the table **33**, the both ends of the second ring **9**, which define the slit are brought into contact with each other so as to decrease the diameter of the second ring **9**, thus imparting pre-load to the rollers **8**.

According to such a structure, in which the rollers **8** are disposed between the first ring **7** and the second ring **9**, there can be obtained a supporting structure, which is composed of the first ring **7** and the second ring **8**, and has a high rigidity against loads applied from any direction, such as compressive load in the axial direction of the pivot axis C, tensile load in the axial direction of the pivot axis C, load acting in a direction perpendicular to the pivot axis C, moment load having a function of inclining the pivot axis C and the like. As a result, there can be obtained the supporting structure, which is lightweight and has a high rigidity.

FIGS. **4**(*a*) and **4**(*b*) and FIG. **5** illustrate a table type working apparatus provided with the guide apparatus **1** for biaxial shifting motion and uniaxial turning motion of the first embodiment of the present invention.

In the above-mentioned table type working apparatus, a table **33** is supported through four guide apparatus **1A**, **1B**, **1C**, **1D** for biaxial shifting motion and uniaxial turning motion on a base **34** so as to be able to shift in biaxial directions intersecting at right angles with each other and to turn around a pivot axis Co located at the central portion of the table **33**. The table **33** has an opening **35** formed at the central portion thereof. The base **34** has an opening **36** formed at the central portion thereof. The four guide apparatus **1A**, **1B**, **1C**, **1D** for biaxial shifting motion and uniaxial turning motion are disposed on the four corners so as to surround the openings **35**, **36** and to maintain the condition that a first line connecting the centers of the guide apparatus **1A**, **1C** intersects a second line connecting the centers of the guide apparatus **1B**, **1D** at right angles. In case that the table **33** having a square shape is supported, arrangement of the four guide apparatus **1A**, **1B**, **1C**, **1D** at the four corners of the table **33** permits to prevent the four corners of the table **33** from being deformed. There is available a structure in which a large vacancy is formed at the central portion of the table **33**, and as a result, a working process of passing something through the vacancy can be carried out. Such a structure leads to decrease in weight of the apparatus.

Here, the pivot axis Co, which locates at the central portion of the table **33** does not always coincide with the central axis O of the base **34**. More specifically, the table **33** can be shifted in the biaxial directions relative to the base **34**. When the center of the t able **33** i s shifted to a place other than the central axis O of the base **34**, the pivot axis Co of the table **33** does not coincide with the central axis O of the base **34**. The table **33** can be turned around the pivot axis Co at any position to which the table **33** can be shifted.

The four guide apparatus **1A**, **1B**, **1C**, **1D** for biaxial shifting motion and uniaxial turning motion are arranged so that the first line connecting the centers of the guide apparatus **1A**, **1C** intersects the second line connecting the centers of the guide apparatus **1B**, **1D** at right angles at the central axis O of the base **34**. Accordingly, the guide apparatus **1A**, **1C** are located symmetrically relative to the second line and the guide apparatus **1B**, **1D** are also located symmetrically relative to the first line . Assumptions that one axis of the biaxial directions mentioned above is an X-axis in the lateral direction in FIG. **4**(*a*) and the other axis of them is a Y-axis in the longitudinal direction in the same figure, cause the description given below to be simplified. With respect to the two guide apparatus **1A**, **1B**, which are disposed at the left-hand side of the Y-axis so as to be symmetrical relative to the X-axis, each of the first guide rails **2A**, **2B** secured to the base **34** is arranged in parallel with the X-axis, and each of the second guide rails **6A**, **6B** is arranged in parallel with the Y-axis.

With respect to the two guide apparatus **1C**, **1D**, which are disposed at the right-hand side of the Y-axis so as to be symmetrical relative to the X-axis, each of the first guide rails **2C**, **2D** secured to the base **34** is arranged in parallel with the Y-axis, and each of the second guide rails **6C**, **6D** is arranged in parallel with the X-axis.

Linear drive mechanisms **37A**, **37B**, **37D**, which perform a linear expansion or contraction action, are operatively connected to three guide apparatus **1A**, **1B**, **1D** of the above-described four guide apparatus **1A**, **1B**, **1C**, **1D**.

More specifically, the linear drive mechanisms **37A**, **37B**, which perform the linear action along the X-axis are respectively connected to the two guide apparatus **1A**, **1B**, which are disposed at the left-hand side of the Y-axis. The linear drive mechanism **37D**, which performs the linear action along the Y-axis is connected to the guide apparatus **1D**, which is disposed at the right-hand side of the Y-axis and the upper side of the X-axis. The guide apparatus **1C**, which is disposed at the right-hand side of the Y-axis and the lower side of the X-axis, is designed to make a following motion.

The linear drive mechanisms **37A**, **37B**, **37D** cause the movable blocks **4A**, **4B**, **4D** of the guide apparatus **1A**, **1B**, 1D to move relative to the base **34**. The linear drive mechanisms **37**A, **37**B, **37**D have the respective first end portions secured to the base **34** and the respective second end portions operatively connected to the respective movable blocks **4**A, **4**B, **4**D of the guide apparatus **1**A, **1**B, **1**D. The movable blocks **4**A, **4**B, **4**D are movable relative to the base **34**, and the guide apparatus **1**A, **1**B, **1**D are movable in the directions of the X-axis and the Y-axis along the first guide rail **2**A, **2**B, **2**D secured to the base **34**.

There may of course be adopted a modified structure in which the respective first end portions of the linear drive mechanisms **37**A, **37**B, **37**D are secured to the table **33** so that the movable blocks **4**A, **4**B, **4**D are movable relative to the table **33**. In this case, the linear drive mechanisms **37**A, **37**B, **37**D are designed to be movable in the directions parallel with the second guide rails **6**A, **6**B, **6**D secured to the table **33**.

All the linear drive mechanisms **37**A, **37**B, **37**D have the same structure and are composed of a motor **38** and a screw feeding mechanism **39** for converting the rotational motion of the motor **38** into the linear motion. The screw feeding mechanism **39** is composed of a nut **41** connected through a bracket **40** to the movable block **4**A, **4**B, **4**D, a screw shaft **42** engaged in the nut **41**, a bearing **43** of the plural trains-angular contact type for rotatably supporting the screw shaft **42**, and a bearing support member **44** for supporting the bearing **43**. The motor **38** is secured through a bracket **45** on the base **34**. The motor shaft **46** is connected through a coupling member **47** to the end of the screw shaft **42**.

The above-mentioned linear drive mechanisms **37**A, **3713**, **37**D may be connected between the base **34** and the table **33** so as to have no relation to the guide apparatus **1**A, **1**B, **1**D.

Detecting mechanisms **48** for detecting a feeding amount are provided in the vicinity of the linear drive mechanisms **37**A, **37**B, **37**D.

The two linear drive mechanisms **37**A, **37**B, which perform a linear motion in the X direction, are caused to be driven in synchronization with each other by the same amount of operation in order to shift the table **33** for example in the X direction. As a result, the movable blocks **4**A, **4**B of the two guide apparatus **1**A, **1**B shift in the X direction relative to the first guide rail **2**A, **2**B. The second guide rails **6**C, **6**D of the two guide apparatus **1**C, **1**D disposed at the right-hand side of the Y-axis accordingly shift in the X direction relative to the movable blocks **4**C, **4**D.

Drive of the linear drive mechanism **37**D, which performs a liner motion in the Y direction, is carried out in order to shift the table **33** in the Y direction. As a result, the second guide rails **6**A, **6**B shift in the Y direction relative to the movable blocks **4**A, **4**B of the two guide apparatus **1**A, **1**B disposed at the left-hand side of the Y-axis. The movable blocks **4**C, **4**D of the two guide apparatus **1**C, **1**D disposed at the right-hand side of the Y-axis accordingly shift in the Y direction relative to the first guide rails **2**C, **2**D.

The combination of the synchronous drive of the two linear drive mechanisms **37**A, **37**B performing the linear motion in the X direction with the drive of the single linear drive mechanism **37**D performing the linear motion in the Y direction permits the table **33** to be shifted in a constant posture state in the X and Y directions. The pivot axis Co of the table **33** simultaneously shifts in the X and Y directions.

The linear drive mechanism **37**A performing the linear motion in the X direction is caused to be driven by a feeding amount of $+\Delta X$, the linear drive mechanism **37**B performing the linear motion in the X direction is caused to be driven in the opposite direction to the driving direction of the linear drive mechanism **37**A by a feeding amount of $-\Delta X$, and the linear drive mechanism **37**D performing the linear motion in the Y direction is caused to be driven by a feeding amount of ΔY, in order to turn the table **33** around the pivot axis Co as shown in FIG. **5**. As a result, the table **33** turns around the pivot axis Co by a prescribed angle of $\Delta\theta$. The relationship among ΔX, ΔY and $\Delta\theta$ can geometrically be obtained and expressed by a formula. When the formula is previously stored in a controlling apparatus, the designation of a turning angle of the table **33** causes values of ΔX and ΔY as well as a value of turning number of each of the motors **38** to be calculated automatically so that the linear drive mechanisms **37**A, **37**B, **37**D can be controlled on the basis of the thus calculated values.

Linear motors may be used to perform the direct drive in replacement of the screw feeding mechanism **39** as the linear drive mechanisms **37**A, **37**B, **37**D. There may be used fluid-pressure type actuators instead, which utilizes hydraulic pressure such as oil pressure, or gas pressure such as air pressure.

The braking mechanism **49** designed as a braking means for maintaining the stationary condition of the table **33** relative to the base **34** is provided on each of two places between the table **33** and the base **34**.

As shown in FIGS. **6**(*a*) to **6**(*d*), the braking mechanism **49** is provided with a cylinder **51**, which is designed as a pressure mechanism secured to the base **34** through a cylinder-bracket **50** and utilizes the fluid pressure such as hydraulic pressure, i.e., oil pressure, etc., gas pressure, i.e., air pressure, etc., or the like, and a brake plate **53** secured to the table **33** through brake-brackets **52**. The both ends of the brake plate **53** are fixed to the brake-brackets **52** through two fastening members such as bolts placed horizontally. As is clear from FIG. **6**(*d*), the cylinder **51** is arranged above the brake plate **53**.

The cylinder **51** is a gas-pressure type cylinder such as an air cylinder, which is fixed to the cylinder-bracket **50** by means of a fastening member such as a bolt. The cylinder-bracket **50** has a hole **55** in which a piston rod **54** extending downward from the cylinder **51** is to be inserted. A pad-bracket **56** is fixed to the forward end of the piston rod **54** passing through the above-mentioned hole **55**, by means of fastening members such as bolts. A brake pad **57** is secured to the lower surface of the pad-bracket **56** by means of fastening members such as bolts so as to press the brake plate **53**.

The cylinder-bracket **50** has a long hole **50***a* in which a portion of a rail-bracket **58** is inserted. The rail-bracket **58** is secured to the cylinder-bracket **50** by means of fastening members such as bolts placed vertically. A guide rail **60** of a linear motion guide mechanism **59** is secured to the rail-bracket **58** by means of two fastening members such as bolts placed horizontally. A block-bracket **62** is secured to a movable block **61** of the linear motion guide mechanism **59** by means of fastening members such as bolts. The linear motion guide mechanism **59** has a structure in which the movable block **61** is movably connected to the guide rail **60** through rolling members.

The block-bracket **62** is fixed to the pad-bracket **56** by means of two fastening members such as bolts placed horizontally, in a space covered with the cylinder-bracket **50**. Accordingly, the upward or downward movement of the piston rod **54** of the cylinder **51** causes the movable block **61** of the linear motion guide mechanism **59** to move in the same direction.

The above-described braking mechanism **49** operates as follows.

When the piston rod **54** of the cylinder **51** is moved downward, the brake plate **53** is pressed down by means of the brake pad **57** secured to the forward end of the piston rod **54**. The thus pressed brake plate **53**, which is extremely thin, is deformed so as to be pressed against the base **34**.

The brake plate **53** has a rectangular shape, whose long side is extremely longer than the short side thereof, and the brake-bracket **52** has a sufficient rigidity. There is almost no adverse influence on the upper surface of the table **33**.

The cylinder **51** has a low rigidity against load acting in the lateral direction. A high rigidity can be ensured by means of the block-bracket **62** secured to the linear motion guide mechanism **59** in the vicinity of the cylinder **51** and by means of the pad-bracket **56** secured to the forward end of the piston rod **54** of the cylinder **51**.

A linear actuator utilizing an electromagnetic force caused by a solenoid may be used in replacement of the above-described fluid-p-pressure type cylinder as the braking mechanism.

Any kind of mechanism having a function of bearing load in the lateral direction may be used as the linear motion guide mechanism **59**. As the linear motion guide mechanism **59**, there may be used a slide bearing as well as a linear bearing utilizing the guiding function of rolling members.

FIGS. **7**(*a*) and **7**(*b*) illustrate a guide apparatus **100** for biaxial motion and uniaxial turning motion of the second embodiment of the present invention.

The guide apparatus **100** for biaxial motion and uniaxial turning motion is composed of a first linear motion guide mechanism **170** acting in the single axial direction, a second linear motion guide mechanism **190**, which is disposed above the first linear motion guide mechanism **170** and connected thereto so that the guide direction of the second linear motion guide mechanism **190** intersects the guide direction of the first linear motion guide mechanism **170** at right angles, and a pivot supporting mechanism **180**, which is disposed above the second linear motion guide mechanism **190** and connected thereto.

More specifically, the first linear motion guide mechanism **170** is composed of a first guide rail **101** and a first movable block **103**, which is movably connected to the first guide rail **101** through balls **102** designed as a plurality of rolling members.

The second linear motion guide mechanism **190** is composed of a second guide rail **104** secured to the first movable block **103** of the first linear motion guide mechanism **170** so as to intersect the first guide rail **101**, and of a second movable block **106**, which is connected to the second guide rail **104** through balls **105** designed as a plurality of rolling members so as to be movable along the second guide rail **104**.

The pivot supporting mechanism **180** is composed of a first ring **107** secured to the second movable block **106** of the second linear motion guide mechanism **190**, and of a second ring **109** coupled with the first ring **107** through rollers **108** designed as a plurality of rolling members so as to be turnable relative to the first ring **107**.

The first ring **107** designed as the inner ring is connected to the above-mentioned second movable block **106** through a coupling portion **129**.

The coupling portion **129** is provided with a first coupling plate **130** having a rectangular shape and a second coupling plate **131** having a disc-shape. The second movable block **106** is secured to the first coupling plate **130**. The first ring **107** is secured to the second coupling plate **131**. The first coupling plate **130** and the second coupling plate **131** are connected to each other by means of a fastening member **132** such as a bolt and the like. The second coupling plate **131** has on its periphery a projection portion **1311**. The first ring **107** designed as the inner ring is fitted to the projection portion **1311** from the upper side. A supporting member **171** is tightly secured to the upper surface of the projection portion **1311** by means of the fastening member **132** such as a bolt and the like. The first ring **107** is designed to be held between the supporting member **171** and a shoulder portion **1311***a*, which is located at the lower portion of the projection portion **1311** so as to maintain the stationary condition of the first ring **107**.

The table **133** to which the second ring **109** is to be secured has an opening **172** having a circular shape. The above-mentioned supporting member **171** of the first ring **107** is designed to be able to be inserted in the opening **172** from the upper side. A recess portion **173** is formed on the lower peripheral surface of the opening **172** of the table **133**. The second ring **172** is fitted to the recess portion **173**. A supporting member **174** for holding the second ring **109** is tightly secured to the peripheral edge of the recess portion **173** by means of the fastening member **132** such as a bolt and the like. The second ring **109** is designed to be held between the supporting member **174** and the peripheral edge **173**a of the recess portion **173** so as to maintain the stationary condition of the second ring **L09**.

A detailed description of the first linear motion guide mechanism **170** will be given below.

As shown in FIGS. **8**(*a*) and **8**(*b*), the first guide rail **101** is designed as an integral formed body, which is composed of a pair of supporting wall portions **110, 110**, between which the first movable block **103** is held and supported, and of a bottom wall portion **110***a* for connecting the supporting wall portions **110, 110**. The first guide rail **101** is provided with four ball running grooves **112** so that the two ball running grooves **112** are formed on each of the inner surfaces of the supporting wall portions **110, 110**. On the other hand, the first movable block **103** is provided with four ball running counter-grooves **113** so that the two ball running counter-grooves **113** are formed on each of the right and left-hand outer surfaces of the first movable block **103**. Accordingly, the four ball running grooves **112** of the first guide rail **101** face the four ball running counter-grooves **113** of the first movable block **103**, respectively.

The first movable block **103** has four ball return passages **114**, which are formed in parallel with each other. The four ball return passages **114** correspond to the four ball running counter-grooves **113**, respectively. A side plate **116** is secured to each of the opposite end portions of the first movable block **103**. Each of the side plates **116** has four direction changing passages **115** for connecting the four ball running grooves **113** and the four ball return passages **114**.

In each of the inner surfaces of the supporting wall portions **110, 110** of the first guide rail **101**, a line connecting the contact points of the ball **102** with the upper roller running groove **112** and the upper roller running counter-groove **113** facing thereon and the other line connecting the contact points of the ball **102** with the lower roller running groove **112** and the lower roller running counter-groove **113** facing thereon symmetrically incline at a prescribed angle α relative to a horizontal line locating between the upper two trains of balls **102** and the lower two trains of balls **102**. In this embodiment, there is adopted a structure in which the line connecting the contact points of the ball **102** with the upper roller running groove **112** and the upper roller running counter-groove **113** facing thereon and the other line connecting the contact points of the ball **102** with the lower roller running groove **112** and the lower roller running counter-groove **113** facing thereon are close to each other at the inside of the supporting wall portions **110**, **110**, on the one hand, and are apart from each other at the outside of the supporting wall portions **110**, **110**, on the other hand.

When the first linear motion guide mechanism **170** is coupled with a linear motion drive mechanism **200**, there can be obtained a guide apparatus for biaxial shifting motion and uniaxial turning motion, provided with a driving mechanism.

More specifically, the first movable block **103** has in its central portion a screw hole **201**, which extends in parallel with the lower roller running counter-grooves **113**. A screw shaft **202** is engaged in the screw hole **201**. It is preferable to dispose balls between the screw hole **201** and the screw shaft **202** so as to be rollable, to form a ball screw mechanism.

The both end portions of the screw shaft **202** are rotatably supported through bearings **204** on bearing supports **203** fixed to the first guide rail **101**. The one end of the screw shaft **202** is connected through a coupling member **205** to an output shaft **207** of a motor **206** fixed to the first guide rail **101**.

A detailed description of the second linear motion guide mechanism **190** will be given below.

As shown in FIGS. **8**(*c*) and **8**(*d*), the second movable block **106** has on its lower surface a second recess portion **111** in which the second guide rail **104** secured on the first movable block **103** is movably inserted.

The second guide rail **104** is also provided with four ball running grooves **117** so that the two ball running grooves **117** are formed on each of the right and left-hand side surfaces of the second guide rail **104**. On the other hand, the second movable block **106** is provided with four ball running counter-grooves **118** so that the two ball running counter-grooves **118** are formed on each of the right and left-hand inner surfaces of the second recess portion **1 1 1** of the second movable block **106**. Accordingly, the four ball running grooves **117** of the second guide rail **104** face the four ball running counter-grooves **118** of the second movable block **106**, respectively.

The second movable block **106** has four ball return passages **119**, which are formed in parallel with each other. The four ball return passages **119** correspond to the four ball running counter-grooves **118** of the second recess portion **111**, respectively. A side plate **121** is secured to each of the opposite end portions of the second movable block **106**. Each of the side plates **121** has four direction changing passages **120** for connecting the four ball running counter-grooves **118** and the four ball return passages **119**.

In each of the right and left-hand longitudinal side surfaces of the second guide rail **104**, a line connecting the contact points of the ball **105** with the upper roller running groove **117** and the upper roller running counter-groove **118** facing thereon and the other line connecting the contact points of the ball **105** with the lower roller running groove **117** and the lower roller running counter-groove **118** facing thereon symmetrically incline at a prescribed angle α relative to a horizontal line locating between the upper two trains of balls **105** and the lower two trains of balls **105**. In this embodiment, there is adopted a structure in which the line connecting the contact points of the ball **105** with the upper roller running groove **117** and the upper roller running counter-groove **118** facing thereon and the other line connecting the contact points of the ball **105** with the lower roller running groove **117** and the lower roller running counter-groove **118** facing thereon are close to each other at the inside of the second recess portion **111**, on the one hand, and are apart from each other at the outside of the second recess portion **111**, on the other hand.

A detailed description of the pivot supporting mechanism **180** will be given below.

As shown in FIGS. **9**(*a*) and **9**(*b*), the first and second rings **107**, **109** are designed as inner and outer rings, which are arranged concentrically with each other, respectively. In this embodiment, the first ring **107** secured to the second guide rail **104** is used as the inner ring, and the second ring **109** is used as the outer ring. Rollers **108** are used as the rolling members in this embodiment.

The first ring **107** designed as the inner ring is connected to the above-mentioned second movable block **106** through a coupling portion **129**.

The first ring **107** designed as the inner ring has on its outer peripheral surface a first groove **124**, which opens outward in a radius direction of the first ring **107**. The first groove **124** is composed of an upper roller-running surface **122** and a lower roller-running surface **123** intersecting the upper roller-running surface **122** substantially at right angles. The second ring **109** has on its inner peripheral surface a second groove **127**, which opens inward in a radius direction of the second ring **109** so as to face the first groove **124**. The second groove **127** is composed of an upper roller-running surface **125** and a lower roller-running surface **126** intersecting the upper roller-running surface **125** substantially at right angles.

A part of the rollers **108** disposed between the first groove **124** and the second groove **127** is rollable between the upper roller-running surface **122** of the first groove **124** and the lower roller-running surface **126** of the second groove **127**. A remaining part of the rollers **108** is rollable between the lower roller-running surface **123** of the first groove **124** and the upper roller-running surface **125** of the second groove **127**.

There is especially adopted a so-called "cross-roller type" structure in which each of the part of the rollers **108** disposed so as to be rollable between the upper roller-running surface **122** of the first groove **124** and the lower roller-running surface **126** of the second groove **127**, and each of the remaining part of the rollers **108** disposed so as to be rollable between the lower roller-running surface **123** of the first groove **124** and the upper roller-running surface **125** of the second groove **127** are arranged alternately. A spacing retainer **128** is disposed between the adjacent two rollers **108**.

In this embodiment, there is adopted a structure in which every other roller **108** has the same oriented central axis, which is perpendicular to an oriented axis of the other roller **108**. There may be adopted a modified structure in which every two or three roller **108** has the same oriented central axis, which is perpendicular to an oriented axis of the other roller **108**. Arrangement of the rollers **8** may optionally be modified in this manner.

Pre-load is given to the rollers **8** disposed between the first ring **107** and the second ring **109**.

In this embodiment, the first ring **107** is divided into upper and lower half portions. When a gap is formed between the upper and lower half portions of the first ring **107**, the rollers **108** can be brought into contact freely with the upper roller-running surface **122** and the lower roller-running surface **123** of the first groove **124**. When the upper half portion of the first ring **107** is pressed against the lower half portion thereof so as to form no gap between them, each of the rollers **108** is pressed under a prescribed pressure, thus imparting pre-load to the rollers **108**.

With respect to such a pre-load imparting mechanism, there may be used the second ring **109**, which has a slit so that the second ring **109** can change its shape from a C-shape under a released condition into a circular shape under a restricted condition. When the second ring **109** having such a structure is fitted to the recess portion **173** of the table **133**, the both ends of the second ring **109**, which define the slit are brought into contact with each other so as to decrease the diameter of the second ring **109**, thus imparting pre-load to the rollers **108**.

According to such a structure, in which the rollers **108** are disposed between the first ring **107** and the second ring **109**, there can be obtained a supporting structure, which is composed of the first ring **107** and the second ring **108**, and has a high rigidity against loads applied from any direction, such as compressive load in the axial direction of the pivot axis C, tensile load in the axial direction of the pivot axis C, load acting in a direction perpendicular to the pivot axis C, moment load having a function of inclining the pivot axis C and the like. As a result, there can be obtained the supporting structure, which is lightweight and has a high rigidity.

FIGS. **10**(*a*) and **10**(*b*) illustrate a table type working apparatus provided with the guide apparatus **100** for biaxial shifting motion and uniaxial turning motion of the second embodiment of the present invention.

In the above-mentioned table type working apparatus, a table **133** is supported through four guide apparatus **100**A, **100**B, **100**C, **100**D for biaxial shifting motion and uniaxial turning motion on a base **134** so as to be able to shift in biaxial directions intersecting at right angles with each other and to turn around a pivot axis Co located at the central portion of the table **133**.

Here, the pivot axis Co, which locates at the central portion of the table **133** does not always coincide with the central axis O of the base **134**. More specifically, the table **133** can be shifted in the biaxial directions relative to the base **134**. When the center of the table **133** is shifted to a place other than the central axis O of the base **134**, the pivot axis Co of the table **133** does not coincide with the central axis O of the base **134**. The table **133** can be turned around the pivot axis Co at any position to which the table **133** can be shifted.

The four guide apparatus **100**A, **100**B, **100**C, **100**D for biaxial shifting motion and uniaxial turning motion are arranged so that the first line connecting the centers of the guide apparatus **100**A **100**C intersects the second line connecting the center s of the guide apparatus **100**B, **100**D at right angles at the central axis O of the base **134**. Accordingly, the guide apparatus 1A, 1C are located symmetrically relative to the central axis O of the base **134** and the guide apparatus 1B, 1D are e also located symmetrically relative to the above-mentioned central axis O.

Assumptions that one axis of the biaxial directions mentioned above is an X-axis in the lateral direction in FIG. **10**(*a*) and the other axis of them is a Y-axis in the longitudinal direction in the same figure, cause the description given below to be simplified. With respect to the guide apparatus **100**A, which is disposed at the left-hand side of the Y-axis as well as at the upper side of the X-axis and the guide apparatus **100**C, which is disposed at the right-hand side of the Y-axis as well as at the lower s side of the X-axis, each of the first guide rails **101**A, **101**C secured to the base **134** is a arranged in parallel with the X-axis , and each of the second guide rails **104**A, **104**B is arranged in parallel with the Y-axis.

With respect to the guide apparatus **100**B, which is disposed at the left-hand side of the Y-axis a s well as at the lower side of the X-axis and the guide apparatus **100**D, which is disposed at the right-hand side of the Y-axis as well as at the upper side of the X-axis, each of the first guide rails **110**B, **101**D secured to the base **134** is arranged in parallel with the Y-axis, and each of the second guide rails **104**B, **104**D is arranged in parallel with the X-axis.

Linear drive mechanisms **200**A, **200**B, **200**C, which perform a linear expansion or contraction action, are operatively connected to three guide apparatus **100**A, **100**B, **100**C of the above-described four guide apparatus **100**A, **100**B, **100**C, **100**D.

The two linear drive mechanisms **200**A, **200**C, which perform a linear motion in the X direction, are caused to be driven in synchronization with each other by the same amount of operation in order to shift the table **133** for example in the X direction. As a result, the second movable blocks **106**B, **106**D of the guide apparatus **100**B, **100**D shift in the X direction along the second guide rails **104**B, **104**D.

Drive of the linear drive mechanism **200**B, which performs a linear motion in the Y direction, is carried out in order to shift the table **133** in the Y direction. As a result, the second movable blocks **106**A, **106**C of the guide apparatus **100**A, **100**C shift in the Y direction along the second guide rails **104**A, **104**C.

The combination of the synchronous drive of the two linear drive mechanisms **200**A, **200**C performing the linear motion in the X direction with the drive of the single linear drive mechanism **200**B performing the linear motion in the Y direction permits the table **133** to be shifted in a constant posture state in the X and Y directions. The pivot axis Co of the table **133** simultaneously shifts in the X and Y directions.

The linear drive mechanism **200**A performing the linear motion in the X direction is caused to be driven by a feeding amount of $+\Delta X$, the linear drive mechanism **200**B performing the linear motion in the X direction is caused to be driven in the opposite direction to the driving direction of the linear drive mechanism **200**A by a feeding amount of $-\Delta X$, and the linear drive mechanism **200**B performing the linear motion in the Y direction is caused to be driven by a feeding amount of ΔY, in order to turn the table **133** around the pivot axis Co. As a result, the table **133** turns around the pivot axis Co by a prescribed angle of $\Delta\theta$. The relationship among ΔX, ΔY and $\Delta\theta$ can geometrically be obtained and expressed by a formula. When the formula is previously stored in a controlling apparatus, the designation of a turning angle of the table **33** causes values of ΔX and ΔY as well as a value of turning number of each of the motors to be calculated automatically so that the linear drive mechanisms **200**A, **200**B, **200**C can be controlled on the basis of the thus calculated values.

Linear motors may be used to perform the direct drive in replacement of the screw feeding mechanism **39** as the linear drive mechanisms **200**A, **200**B, **200**D. There may be used fluid-pressure type actuators instead, which utilizes hydraulic pressure such as oil pressure, or gas pressure such as air pressure.

Needless to say, there may be provided the same braking mechanism as in the first embodiment of the present invention, for maintaining the stationary condition of the table **133** relative to the base **134**. The description of the braking mechanism will be omitted.

In the biaxial shifting motion guide mechanism of the guide apparatus according to the first embodiment of the present invention, the movable block has on its opposite surfaces the first and second recess portions, respectively, extending directions of which intersect with each other at right angles, and the first and second guide rails are inserted through the rolling members in the first and second recess portions, respectively, so as to perform a linear motion. In the biaxial shifting motion guide mechanism of the guide apparatus according to the second embodiment of the present invention, the first movable block is supported through the rolling members between the right and left-hand supporting walls of the first guide rail so as to perform a linear motion, the second guide rail is secured to the above-mentioned first movable block so that the extending directions of the first and second guide rails intersect with each other at right angles, and the second movable block is connected through the rolling members to the second guide rail so as to perform a linear motion. The structure of the biaxial shifting motion guide mechanism is not limited only to that of these embodiments. More specifically, there may be adopted any kind of structure, which permits to support the second member so as to be movable relative to the first member in a constant posture state along the biaxial lines intersecting at right angles with each other.

According to the present invention as described in detail, the second member can be supported so as to be movable relative to the first member in the constant posture state along the biaxial directions intersecting at right angles with each other. Even when the second member is moved in parallel to a prescribed position and then is turned there, the biaxial lines in the biaxial shifting motion guide mechanism are invariable, thus making it possible to make an easy determination of an amount of displacement in each of the biaxial directions, which corresponds to the turning motion of the second member.

The biaxial lines in the biaxial shifting motion guide mechanism are invariable as mentioned above even after the turning motion of the second member, it is very easy to control of the parallel movement: of the second member along the biaxial directions.

When there is adopted a structure in which the first ring is secured to the second guide rail and the second ring is secured to the second member, the securing of the first ring to the second rail suffices, leading to an easy installation working.

When there is adopted a structure in which the first guide rail and the second guide rail are connected to the single movable block, parallelism between the bottom surfaces of the pair of guide rails can therefore be obtained by an easy machining process of the single movable block. As a result, when there is obtained only a proper squareness of the pivot axis of the first ring relative to the second guide rail, a proper squareness of the bottom surface of the first guide rail relative to the pivot axis can automatically be obtained, and the parts of the guide apparatus can very easily be assembled under a precise positional determination condition.

Formation of only a hole, into which the second ring is to be fitted, on a table as the second member suffices, thus leading to an easy working process on the table. When force is applied to the table at a position apart from the pivot axis of the guide apparatus for biaxial shifting motion and uniaxial turning motion, a moment load having a function of inclining the pivot axis is applied to the pivot supporting mechanism. The moment load is however applied through the second ring to the pivot axis and a merely small displacement occurs at the pivot axis.

When there is adopted a structure in which a linear actuator secured to any one of the first member and the second member is operatively connected to the movable block, relative movement of the movable block between the first member and the second member is permitted by pushing the movable block by means of the above-mentioned linear actuator and it is unnecessary to form any specific connecting portions for the linear actuator on the first and second members.

In case that there is adopted a structure in which the second guide rail is secured to the first movable block and the second movable block is slidably connected to the second guide rail, when there is obtained only a proper squareness in the contact surfaces of the first movable block and the second guide rail, which are secured to each other, and in the contact surfaces of the second movable block and the first guide rail, a proper squareness of the bottom surface of the first guide rail relative to the pivot axis can automatically be obtained, and the parts of the guide apparatus can very easily be assembled under a precise positional determination condition.

When there is adopted a structure in which the first guide rail has a pair of supporting walls, between which the first movable block is held through the rolling members, stability can be improved.

When the linear actuator is disposed between the first guide rail and the first movable block, and the linear actuator is located in the central portion of the first movable block, the distance between the portion of the first movable block, to which force for moving the first movable block is imparted, and each of the trains of the rolling members located between the first guide rail and the first movable block can be decreased, with the result that moment load caused by the rolling resistance of the trains of the rolling members and the driving force for moving the first movable block does not have any adverse effects.

When there is adopted a structure in which the rollers are disposed between the first ring and the second ring, there can be obtained a supporting structure, which is composed of a pair of rings, i.e., the first ring and the second ring, and has a high rigidity against loads applied from any direction, such as compressive load in the axial direction of the pivot axis, tensile load in the axial direction of the pivot axis, load acting in a direction perpendicular to the pivot axis, moment load having a function of inclining the pivot axis and the like. As a result, there can be obtained the supporting structure, which is lightweight and has a high rigidity. In addition, such a supporting structure can be provided in a large-size.

When there is adopted a structure in which the table is supported by means of a plurality of biaxial shifting motion guide mechanisms, the plurality of biaxial shifting motion guide mechanisms can be disposed in any place. In case that the table having a rectangular shape is supported, the biaxial shifting motion guide mechanisms respectively disposed at the four corners of the table permit to prevent the four corners of the table from being deformed. There is available a structure in which a large vacancy is formed at the central portion of the table, and as a result, a working process of passing something through the vacancy can be carried out. Such a structure leads to decrease in weight of the apparatus.

What is claimed is:

1. A guide apparatus for biaxial shifting motion and uniaxial turning motion, which comprises:

a biaxial shifting motion guide mechanism for supporting a second member so as to be movable relative to a first member in a constant posture state along biaxial lines intersecting at right angles with each other; and

a pivot supporting mechanism disposed on said biaxial shifting motion guide mechanism at an opposite side of said first member, for pivotably supporting said second member, wherein:

said biaxial shifting motion guide mechanism comprises a first guide rail secured to said first member, a movable block connected through a plurality of rolling members to said first guide rail so as to be movable and a second guide rail connected through a plurality of rolling members to said movable block so as to be movable in a direction intersecting said first guide rail; and

said pivot supporting mechanism comprises a first ring and a second ring, said first ring being secured to said second guide rail and said second ring being coupled through a plurality of rolling members with said first ring so as to be rotatable relative thereto and being secured to said second member.

2. The apparatus as claimed in claim **1**, further comprises:

a linear actuator secured to any one of said first member and said second member, said linear actuator being operatively connected to said movable block.

3. A guide apparatus for biaxial shifting motion and uniaxial turning motion, which comprises:

a biaxial shifting motion guide mechanism for supporting a second member so as to be movable relative to a first member in a constant posture state along biaxial lines intersecting at right angles with each other; and

a pivot supporting mechanism disposed on said biaxial shifting motion guide mechanism at an opposite side of said first member, for pivotably supporting said second member, wherein:

said biaxial shifting motion guide mechanism comprises a first guide rail secured to said first member, a first movable block connected through a plurality of rolling members to said first guide rail so as to be movable, a second guide rail secured to said first movable block so as to intersect said first guide rail and a second movable block movably connected through a plurality of rolling members to said second guide rail; and

said pivot supporting mechanism comprises a first ring and a second ring, said first ring being secured to said second movable block and said second ring being coupled through a plurality of rolling members with said first ring so as to be rotatable relative thereto and being secured to said second member.

4. The apparatus as claimed in claim **3**, wherein:

said first guide rail has a pair of supporting walls, between which said first movable block is held through said rolling members.

5. The apparatus as claimed in claim **3**, further comprises:

a linear actuator is disposed between said first guide rail arid said first movable block, for causing said first movable block to move.

6. The apparatus as claimed in claim **4**, further comprises:

a linear actuator is disposed between said first guide rail and said first movable block, for causing said first movable block to move.

7. An apparatus for biaxial shifting motion and unaxial turning motion, which comprises:

a base;

a table;

a biaxial shifting motion guide mechanism for supporting said table so as to be movable relative to said base in a constant posture state along biaxial lines intersecting at right angles with each other; and

a pivot supporting mechanism disposed on said biaxial shifting motion guide mechanism at an opposite side of said base, for pivotably supporting said table, wherein:

said biaxial shifting motion guide mechanism comprises a first guild rail secured to said base, a movable block connected through a plurality of rolling members to said first guide rail so as to be movable and a second guide rail connected through a plurality of rolling members to said movable block so as to be movable in a direction intersecting said first guide rail; and

said pivot supporting mechanism comprises a first ring and a second ring, said first ring being secured to said second guide rail and said second ring being coupled through a plurality of rolling members with said first ring so as to be rotatable relative thereto and being secured to said table.

8. An apparatus for biaxial shifting motion and uniaxial turning motion, which comprises:

a base;

a table;

a biaxial shifting motion guide mechanism for supporting said table so as to be movable relative to said base in a constant posture state along biaxial lines intersecting at right angles with each other; and

a pivot supporting mechanism disposed on said biaxial shifting motion guide mechanism at an opposite side of said base, for pivotably supporting said table, wherein:

said biaxial shifting motion guide mechanism comprises a first guide rail secured to said base, a first movable block connected through a plurality of rolling members to said first guide rail so as to be movable, a second guide rail secured to said first movable block so as to intersect said first guide rail and a second movable block movably connected through a plurality of rolling members to said second guide rail; and

said pivot supporting mechanism comprises a first ring and a second ring, said first ring being secured to said second movable block and said second ring being coupled through a plurality of rolling members with said first ring so as to be rotatable relative thereto and being secured to said table.

* * * * *

US006152602A

United States Patent [19]

Honma et al.

[11] **Patent Number: 6,152,602**

[45] **Date of Patent: Nov. 28, 2000**

[54] **BALL SPLINE UNIT AND METHOD OF FORMING OUTER CYLINDER OF BALL SPLINE UNIT**

[75] Inventors: **Mitsuaki Honma**; **Tomozumi Murata**, both of Tokyo, Japan

[73] Assignee: **THK Co. Ltd.**, Tokyo, Japan

[21] Appl. No.: **09/230,541**

[22] PCT Filed: **May 30, 1997**

[86] PCT No.: **PCT/JP97/01853**

§ 371 Date: **Jan. 28, 1999**

§ 102(e) Date: **Jan. 28, 1999**

[87] PCT Pub. No.: **WO98/54474**

PCT Pub. Date: **Dec. 3, 1998**

[51] **Int. Cl.**[7] **F16C 29/06**

[52] **U.S. Cl.** **384/45**

[58] **Field of Search** 384/45, 43, 44; 464/168

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,128,279 12/1978 Ernst et al. .
5,755,516 5/1998 Teramachi et al. .
5,947,605 9/1999 Shirai 384/45

FOREIGN PATENT DOCUMENTS

0 743 465 A1 11/1996 European Pat. Off. .
44-11482 5/1969 Japan .
55-97518 7/1980 Japan .
7-317762 12/1995 Japan .
8296641 11/1996 Japan .
WO95/32366 11/1995 WIPO .

Primary Examiner—Lenard A. Footland
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

An object of the present invention is to provide a ball spline unit enabling the balls to smoothly circulate without increasing a size of the ball spline unit, and enabling to be integrally molded by accurately setting a position of a resin portion to be formed to an outer cylinder. To achieve the object, the present invention is characterized in that at least one of the unloaded ball passage, retainer portions and ball direction changing passage inner peripheral portions is integrally molded with the outer cylinder in accordance with an insert molding method in which the outer cylinder is positioned within a molding die with reference to the loaded ball rolling grooves.

6 Claims, 9 Drawing Sheets

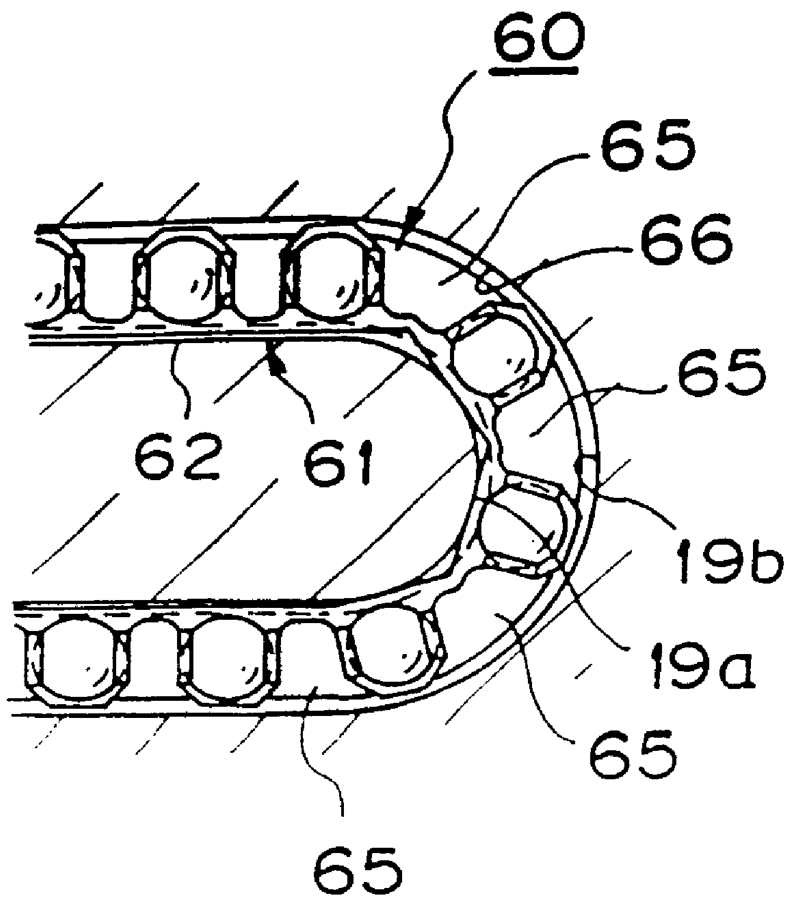


FIG. 1

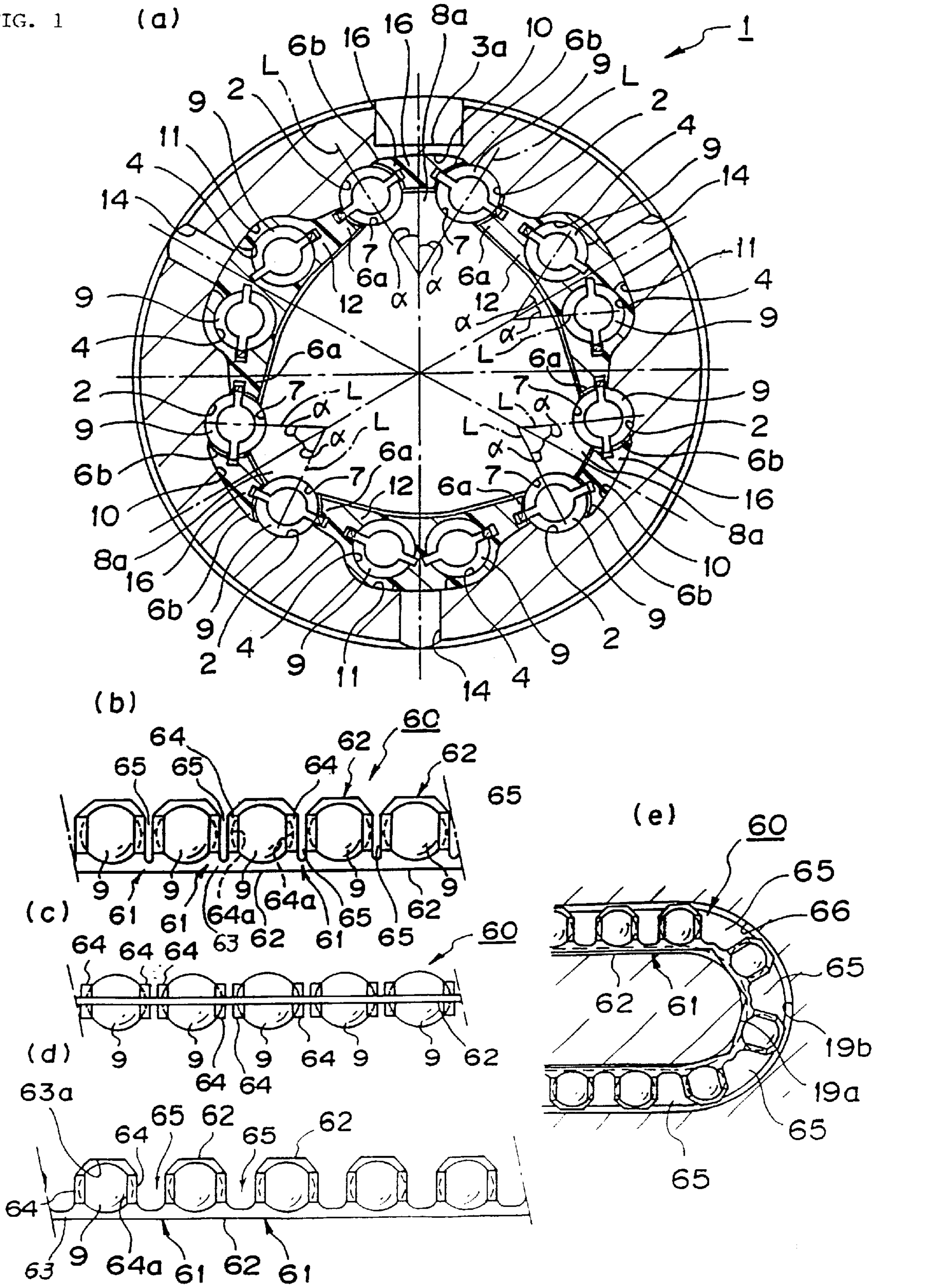
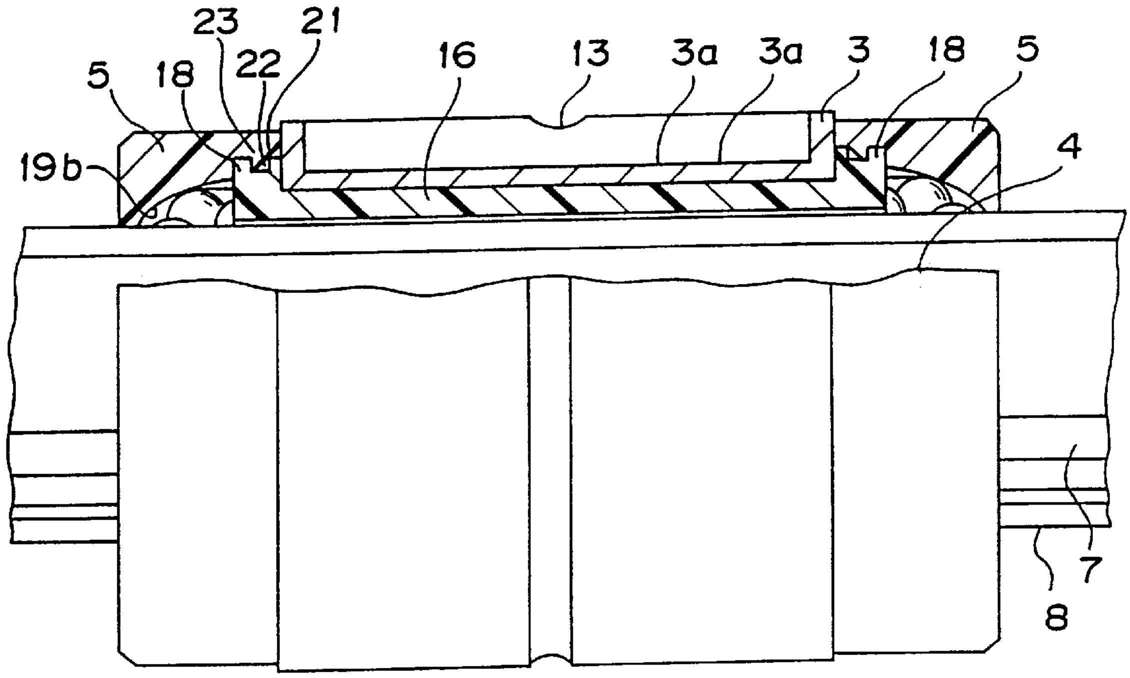


FIG. 2

(a)


23
21
22
5
18
16
13
3a
3a
3
18
5
19b
4
7
8

(b)

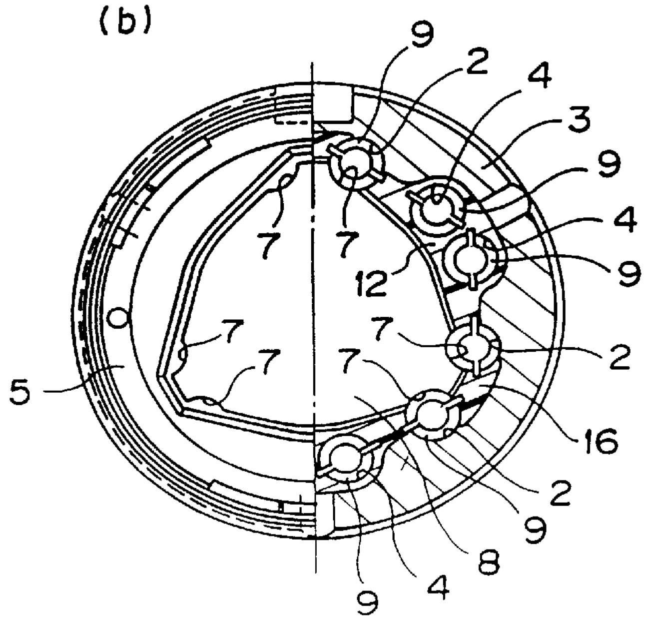

9
2
4
3
9
4
7
7
12
9
7
7
2
7
7
5
16
2
9
8
4
9

FIG. 3

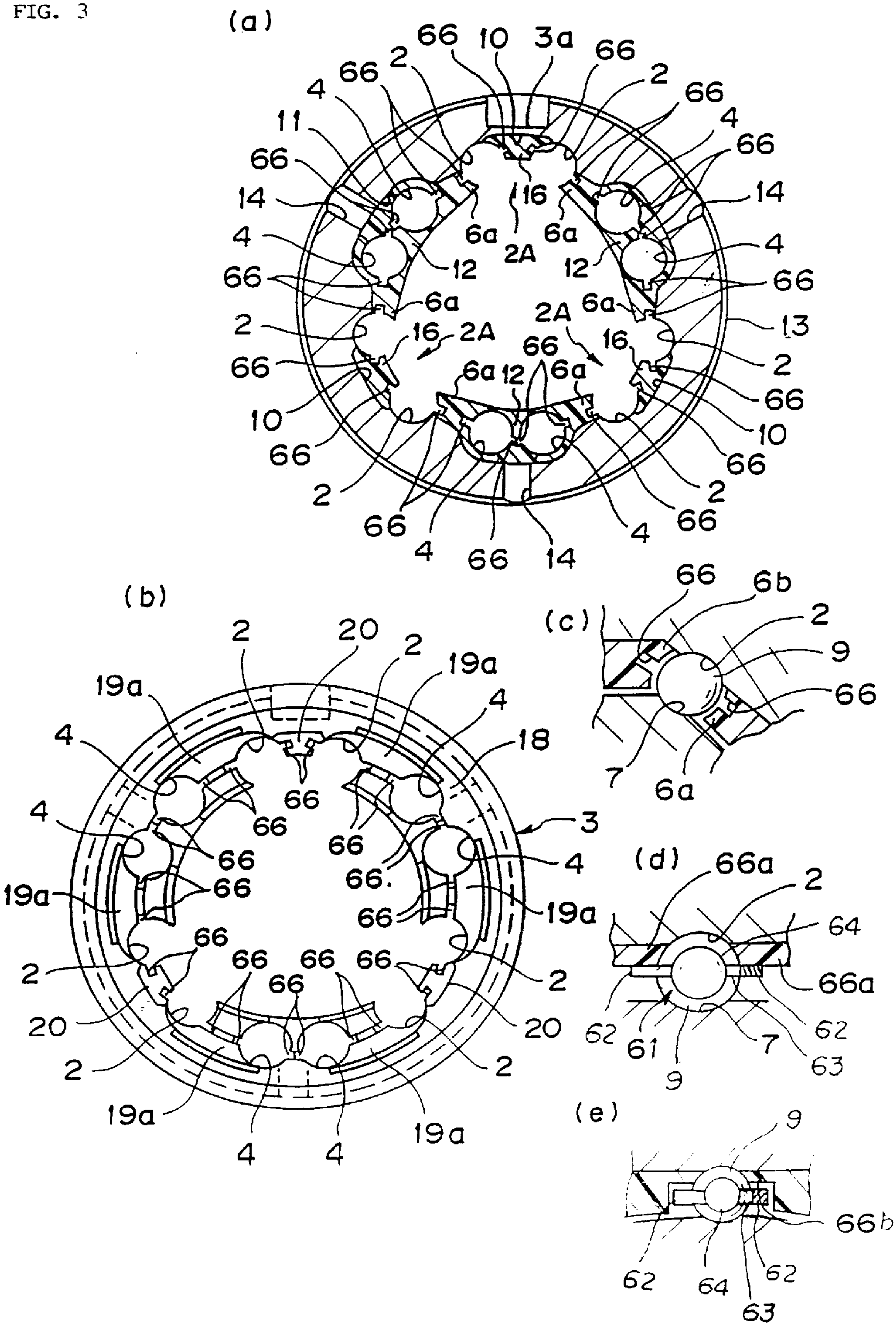
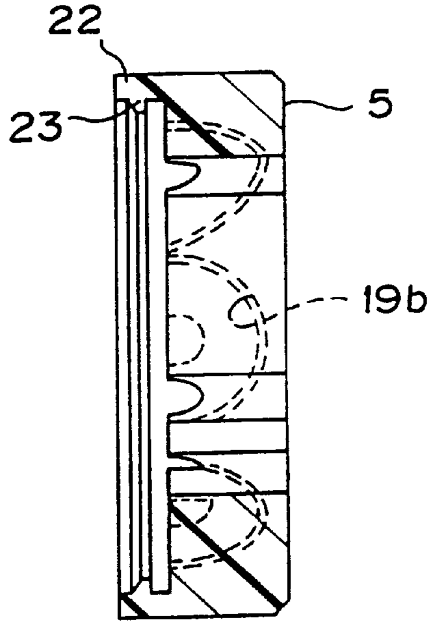
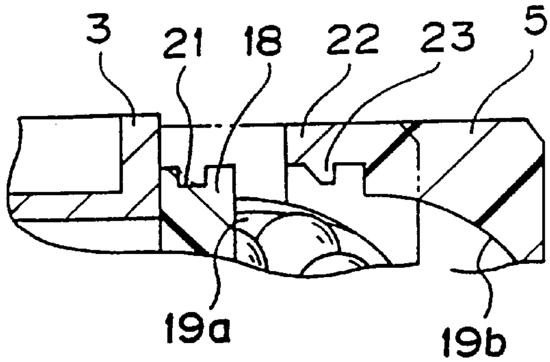

(a)
66
10
3a
2
4
11
14
16
6a
2A
12
13
(b)
20
19a
18
3
(c)
6b
9
7
(d)
66a
64
62
61
63
(e)
66b

FIG. 4

(a)



(b)



(c)

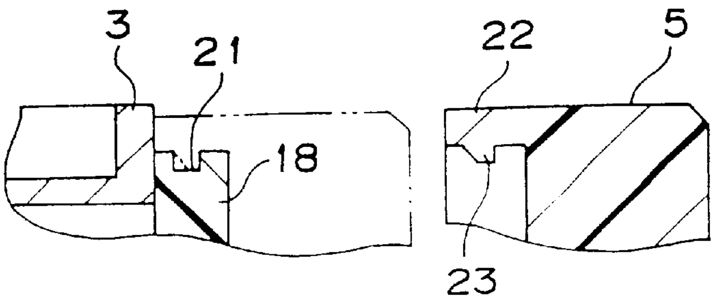
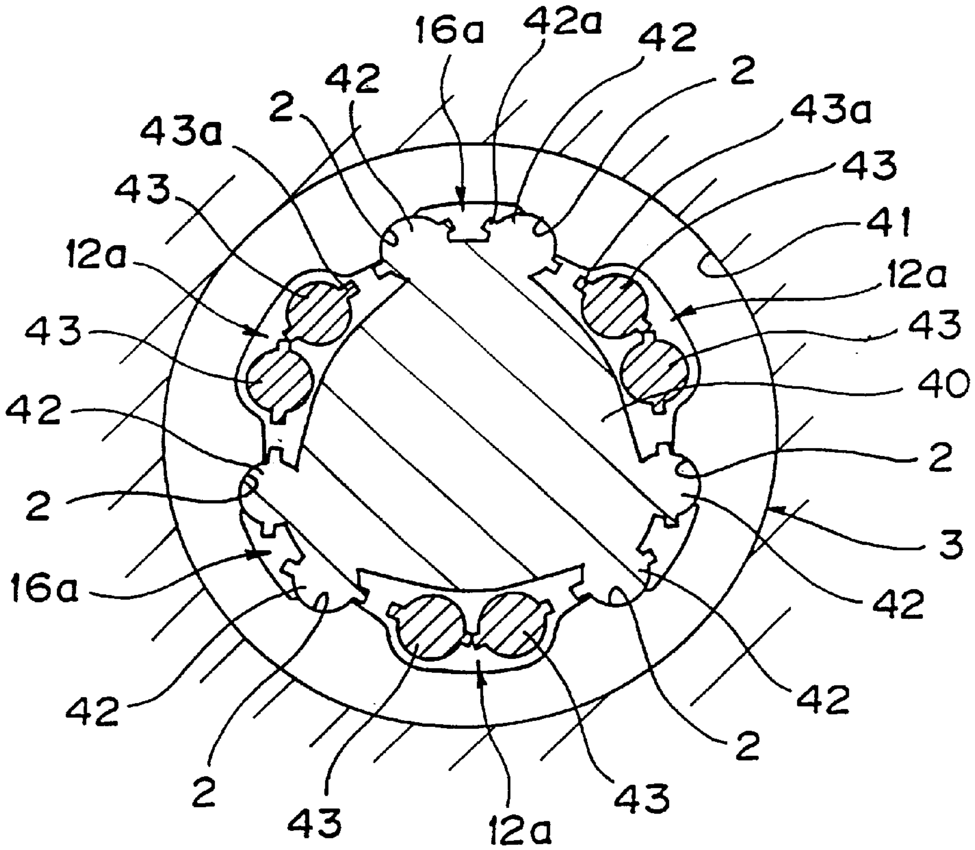


FIG. 5

(a)


16a
42a
42
2
43a
43
41
12a
43
40
2
3
42
42
2
12a
43
43
2
42
16a
2
42
43
12a
43a
2
42

(b)

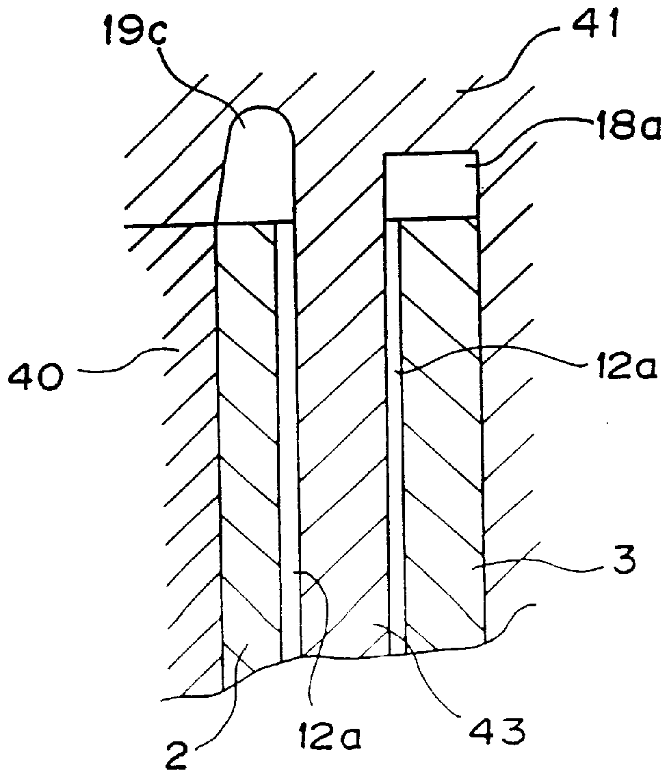

19c
41
18a
40
12a
3
2
12a
43

FIG. 6

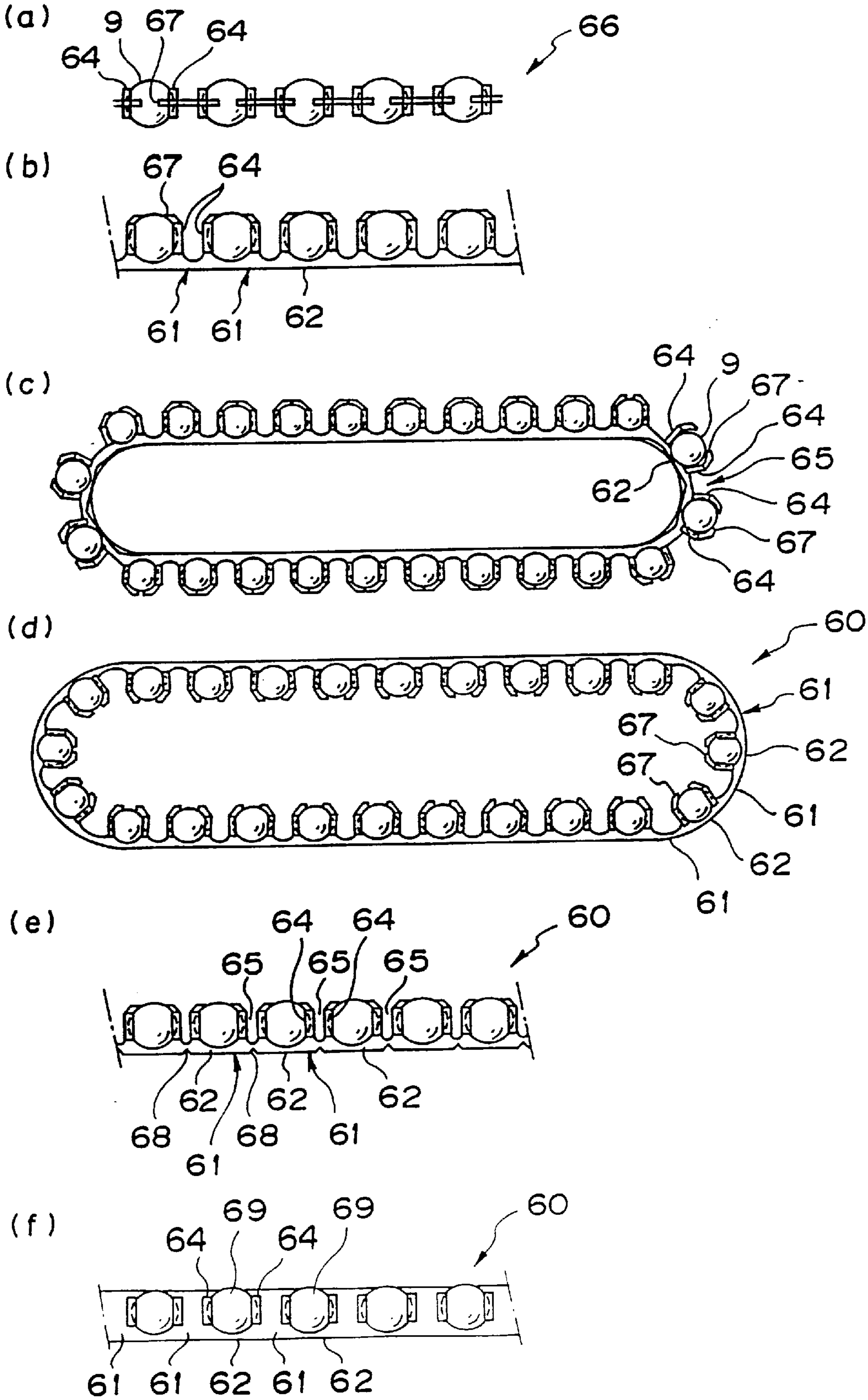

(a)
9
67
64
64
66
(b)
67
64
61
61
62
(c)
64
9
67
64
65
62
64
67
64
(d)
60
61
67
62
67
61
62
61
(e)
64
64
60
65
65
65
62
62
62
68
61
68
61
(f)
69
69
60
64
64
61
61
62
61
62

FIG. 7

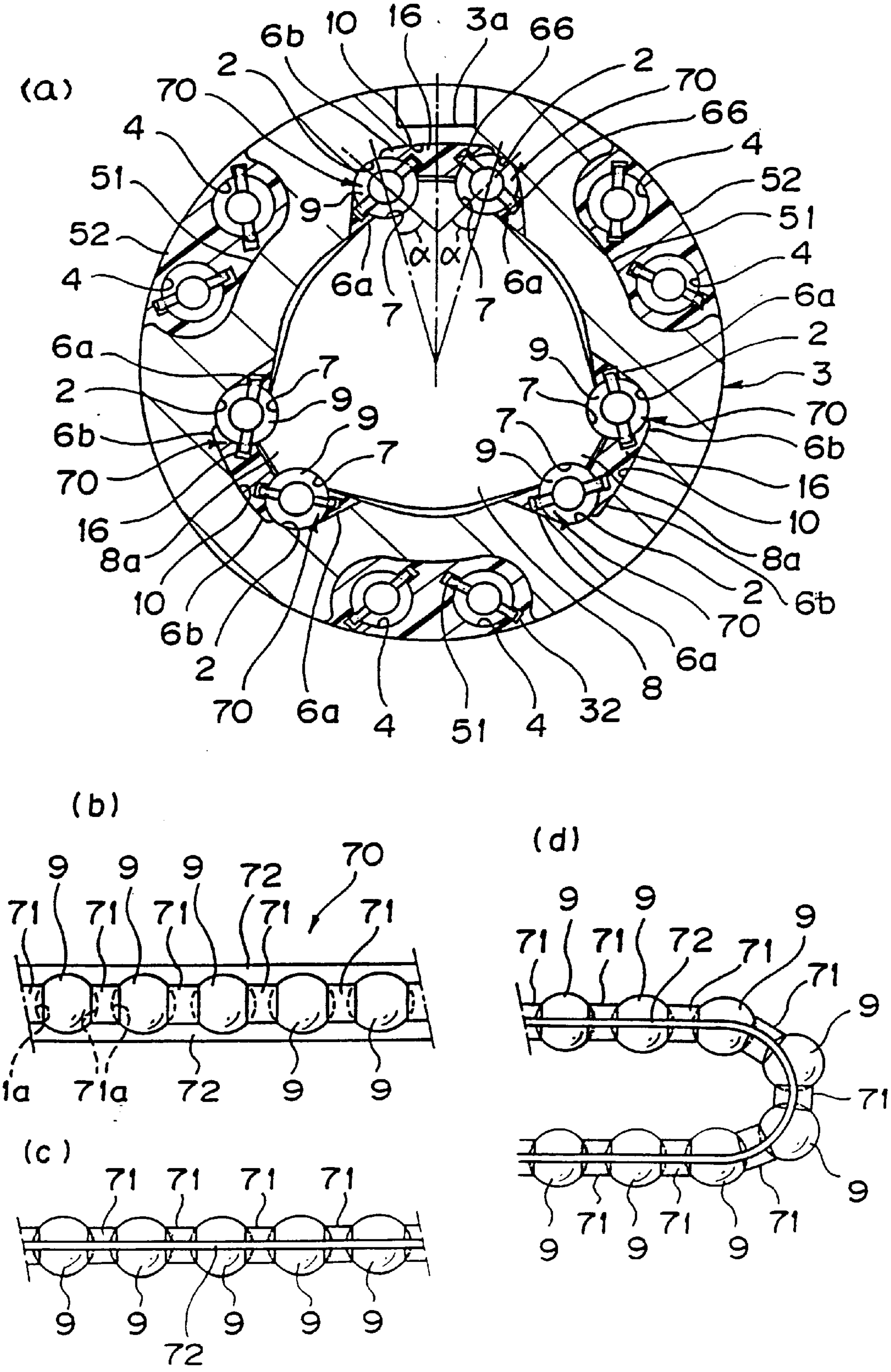


FIG. 8

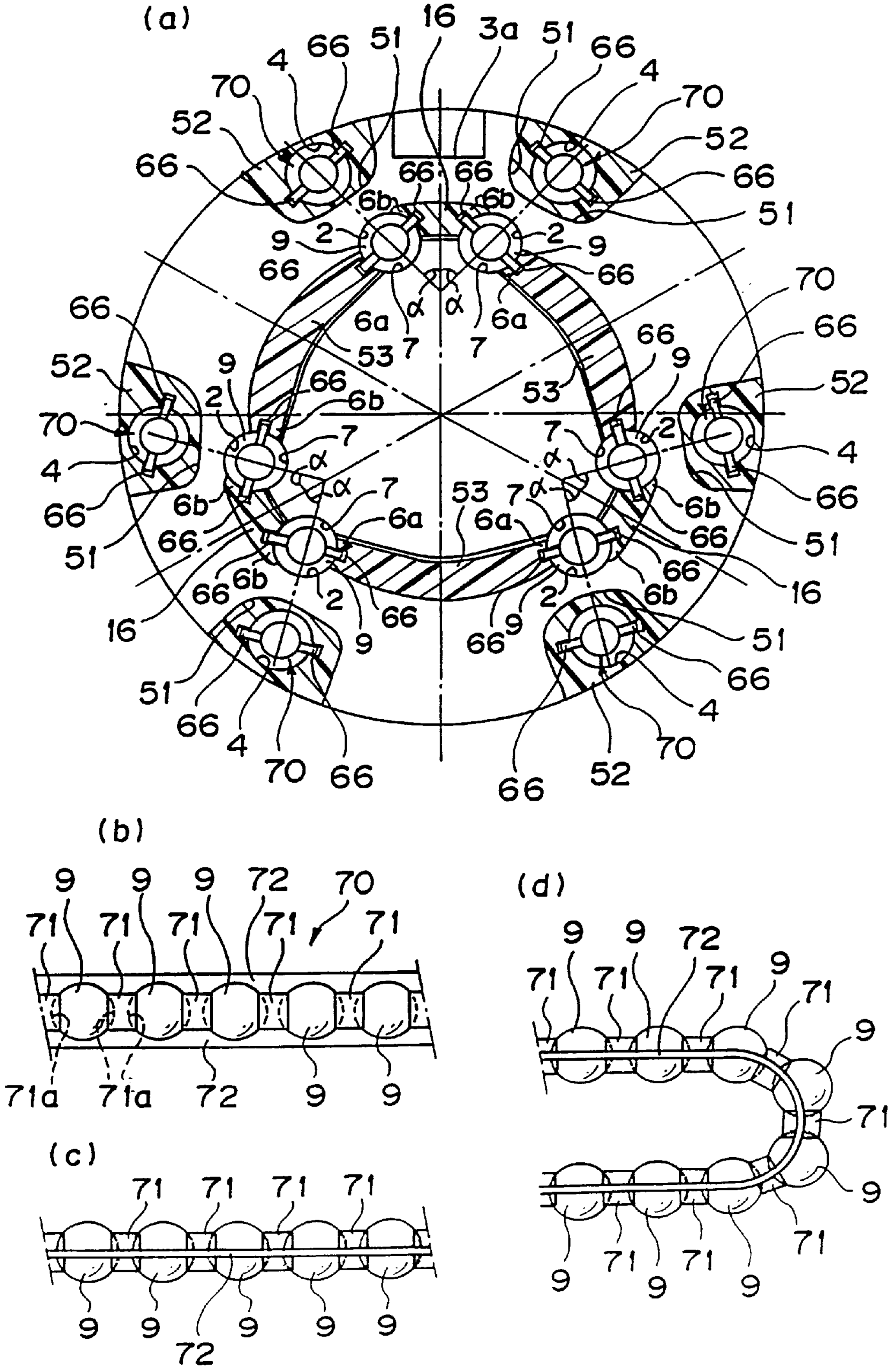
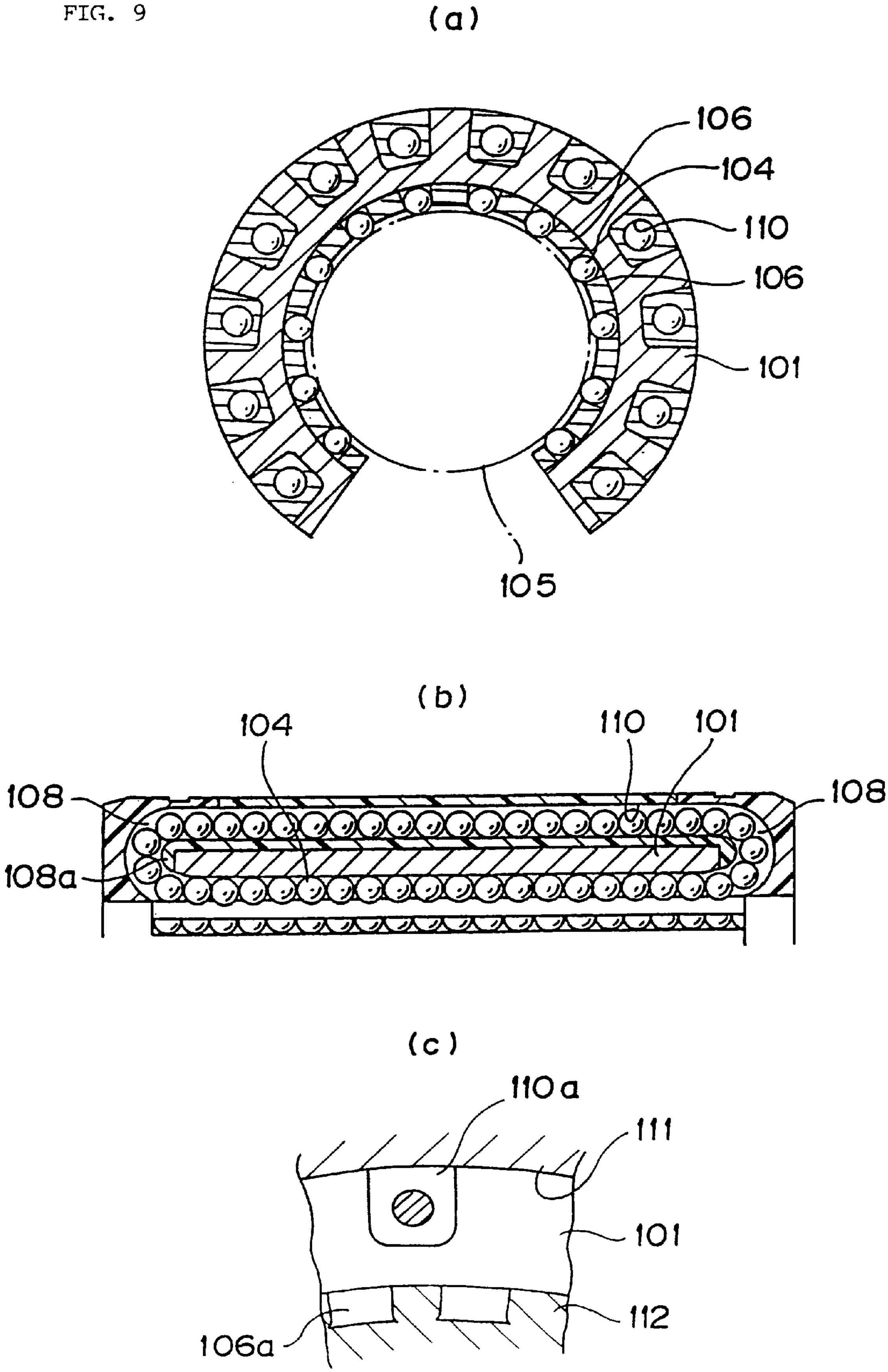


FIG. 9


(a)
106
104
110
106
101
105
(b)
104
110
101
108
108
108a
(c)
110a
111
101
112
106a

BALL SPLINE UNIT AND METHOD OF FORMING OUTER CYLINDER OF BALL SPLINE UNIT

TECHNICAL FIELD

The present invention relates to a ball spline unit in which balls are disposed between a spline shaft and an outer cylinder and relates to a method of molding the outer cylinder of the ball spline unit.

BACKGROUND ART

The conventional ball spline unit of this type has a structure comprising a cylindrical outer cylinder to which a plurality of loaded ball rolling grooves are formed at an inner periphery of the outer cylinder. This outer cylinder is provided with a plurality of unloaded ball passages corresponding to the loaded ball rolling grooves. Both ends portions of the outer cylinder are provided with side covers each having a direction changing passage for communicating the loaded ball rolling grooves with the unloaded ball passages. Further, in order to prevent balls disposed in the loaded ball rolling grooves from dropping off, retainer portions are provided with the inner periphery of the outer cylinder along the loaded ball rolling grooves.

A spline shaft is inserted into the outer cylinder so that the outer cylinder is reciprocally moved. At an outer periphery of the spline shaft, there are formed with loaded ball rolling grooves corresponding to the loaded ball rolling grooves formed to the outer cylinder, and a number of balls are disposed between the loaded ball rolling grooves.

However, in the conventional spline unit described above, since a radius of curvature of the direction changing passage is small, sticks of the ball are liable to occur. In order to prevent the sticking of the balls, it is effective to increase the radius of curvature of the direction changing passage. However, such structure will result in increase of a size of the spline unit.

On the other hand, it has been conventionally attempted to lower a noise level and manufacturing cost of the spline unit by forming ball supporting portions, side covers and the unloaded ball passages as resin molded members for which high rigidity is not required.

However, each of the conventional resin molded members was a separately molded member which is separately formed form the outer cylinder. Therefore, an assembling process for integrating the molded members was required after completion of molding the respective members.

In this regard, one may happen to think of integrally molding the ball supporting portions or the like with the outer cylinder for the purpose of reducing the assembling steps.

As an example of such integrally molding technique, for example, a method of forming a linear motion ball bearing shown in U.S. Pat. No. 4,128,279 is well known.

As shown in FIG. **9**, the aforementioned linear motion ball bearing is constructed so as to comprise an outer cylinder **101** a part of which is cut out so as to have an opened sectional shape, and a shaft **105** to be inserted into the outer cylinder **101**.

A number of balls **104** arranged in an axial direction are disposed between the inner circumference of the outer cylinder **101** and the outer circumference of the shaft **105**, so that the outer cylinder **101** can linearly move along the shaft **105**. The balls **104** are arranged in a circumferential direction of the outer cylinder **101** so as to form a plurality of ball rows. Each of the ball rows is arranged so as to circulate through the direction changing passages **108** formed to both ends of the outer cylinder **101** and through the plurality of unloaded ball passages **110** provided to the outer circumference of the outer cylinder **101**. The balls **104** disposed in the loaded region between the outer cylinder **101** and the shaft **105** are retained by retainer portions **106** provided at both sides of the ball row so as to extend along the axial direction.

Further, afore-mentioned retainer portions **106**, inner peripheral portion **108***a* of the direction changing passage **108** and the unloaded ball passages **110** were integrally molded with the outer cylinder **101** by using an insert-molding method.

However, in a case of the conventional linear motion ball bearing described above, when the insert molding is performed, as shown in FIG. **9**(*c*), for example, the outer periphery of the outer cylinder **101** is tightly contact to a first molding die **111** while the inner periphery of the outer cylinder **101** is tightly contact to a second molding die **112** thereby to form cavities **106***a* and **110***a* for molding the retaining portions **106** and the unloaded ball passages **110**. However, it was difficult for the inner and outer peripheries of the outer cylinder **101** to accurately and tightly contact to the first and second cavities **111** and **112**, so that there was arisen a problem that a gap was liable to occur between the contacting surfaces, generating burrs.

In particular, when the burrs are generated between the contacting surfaces of the inner periphery of the outer cylinder **101** and the second molding die **112**, thus resulting in generation of the burrs at loaded ball rolling surfaces, so that such burrs are required to be removed. However, it is very difficult and practically impossible to remove such burrs generated at inner portions between the retaining portions **106** and **106**.

When such burrs exist, the circulation of the balls **104** is obstructed, so that a feeding accuracy is deteriorated. In the worst case, the balls **104** are jammed or clogged up to stop a machine using the spline unit, thus resulting in serious influence on productivity.

The present invention has been conceived for solving the afore-mentioned problems encountered in the prior arts, and an object of the present invention is to provide a ball spline unit enabling the balls to smoothly circulate without increasing the size of the ball spline unit.

Further, another object is to provide a method of molding an outer cylinder of the ball spline unit which is capable of being integrally molded by accurately setting positions of resin portions to be formed to the outer cylinder.

DISCLOSURE OF THE INVENTION

The present invention provides a ball spline unit comprising a cylindrical outer cylinder of which inner periphery is formed with a plurality of loaded ball rolling grooves, a plurality of unloaded ball passages corresponding to the ball rolling grooves formed to the outer cylinder, side covers each having a direction changing passage for connecting the loaded ball rolling grooves to the unloaded ball passages, the side covers being provided at both end portions of the outer cylinder, retainer portions provided along the the loaded ball rolling grooves so as to prevent balls in the loaded ball rolling grooves from dropping off, a spline shaft inserted into the outer cylinder, an outer periphery of the spline shaft being formed with loaded ball rolling grooves corresponding to the loaded ball rolling grooves formed to the outer cylinder, and a number of balls disposed between the outer cylinder and the loaded ball rolling grooves formed to the spline shaft so as to endlessly circulate through the direction changing passages and the unloaded ball passages,

wherein a ball chain having a number of spacer portions disposed between the respective balls of the number of balls and having connecting portions for connecting the adjacent spacer portions is provided, and

wherein at least one of the unloaded ball passage, retainer portions and ball direction changing passage inner peripheral portions is integrally molded with the outer cylinder in accordance with an insert molding method in which the outer cylinder is positioned within a molding die with reference to the loaded ball rolling grooves.

According to the structure described above, the balls in the direction changing passage are drawn by the ball chain and moved, so that the balls are smoothly moved even if the curvature radius of the direction changing passage is relatively small. Therefore, the balls can be smoothly circulated and moved without increasing the size of the outer cylinder.

Further, the balls would not collide to each other at the time of rolling and transferring, so that the noise generation can be reduced. In addition, the balls would not collide to also the inner peripheral surface of the unloaded ball passage, the noise generation can be further reduced.

On the other hand, at least one of the unloaded ball passage, ball retaining portions and ball direction changing passage inner peripheral portions are integrally molded by the insert molding with reference to the loaded ball rolling grooves formed to the inner periphery of the outer cylinder. Owing to this structure, the assembling process can be simplified and reduced.

In addition, there is no fear of causing irregularities due to the assembling error at joint portions to be formed between the ball direction changing passage and the loaded ball rolling grooves and between the direction changing passage and the unloaded ball rolling grooves, so that the circulation of the balls can be performed smoothly and the noise generation can be also reduced.

Furthermore, the outer cylinder is positioned in the molding die with reference to the loaded ball rolling grooves, so that it becomes possible to prevent the burrs from generating at a portion between the loaded ball rolling grooves and the molding die. Once the burrs are generated at the loaded ball rolling grooves, it is impossible to remove the burrs. In order to remove the burrs, the outer cylinder is obliged to be broken. Therefore, it is greatly important to prevent the generation of the burrs.

In addition, when grooves for accommodating the connected portions of the ball chain are formed in an entire circumference of the unloaded ball rolling grooves, the retainer portions and the ball direction changing passage, run-out of the ball chain can be prevented.

On the other hand, when the ball chain is constructed so that each of the balls can be retained by the respective spacer portion, an operation of assembling the balls into the outer cylinder can be completed by only inserting the ball chain retaining the balls in a form of continuous chain.

Further, even if the outer cylinder is drawn or detached from the spline shaft, the balls are retained by the ball chain, so that the retainer portions may be omitted.

The ball chain has a function of circulating the ball while providing a predetermined gap between the respective balls and is not always required to have a retentive function of preventing the balls from dropping off. In a case where the ball chain having no such retentive function is used, the balls are required to be retained when the outer cylinder is detached from the spline shaft, so that it is preferable to provide the retainer portion to the outer cylinder. However, if the outer cylinder is not required to retain the balls, it goes without saying that the retainer portion can be omitted.

In addition, in the structure described above, even in a state where a guide portion for guiding the ball chain is provided to the unloaded ball passage, the retainer portion and the ball direction changing passage, it is possible to use the spline unit by assembling only the balls without using the ball chain. Namely, this structure of the outer cylinder can be applied to both the following two cases, i.e., a case where the balls are assembled into the ball chain, then the ball chain is attached to the outer cylinder and a case where only the balls are attached to the outer cylinder without using the ball chain.

On the other hand, it is preferable that the inner periphery of the outer cylinder is formed with a plural set of loaded ball rolling groove sets in a circumferential direction, wherein each of the loaded ball rolling groove set consists of a pair of loaded ball rolling grooves adjacently arranged to each other, and the outer periphery of the spline shaft is formed with a plurality of corner portions positioned between the paired loaded ball rolling grooves which constitutes the loaded ball rolling groove set, and both side surfaces of the corner portions are provided with a pair of loaded ball rolling grooves corresponding to the paired loaded ball rolling grooves formed to the outer cylinder, while the inner periphery of the outer cylinder is formed with a plurality of unloaded ball passages corresponding to the respective loaded ball rolling grooves, wherein the unloaded ball passages are provided at portions between the plurality of the loaded ball rolling groove sets.

According to the structure described above, an outer diameter of the outer cylinder can be further reduced.

Furthermore, it is also preferable that the inner periphery of the outer cylinder is formed with a plural set of loaded ball rolling groove sets in a circumferential direction, in which of the loaded ball rolling groove set consists of a pair of loaded ball rolling grooves adjacently arranged to each other, and the outer periphery of the spline shaft is formed with a pair of loaded ball rolling grooves corresponding to the paired loaded ball rolling grooves formed to the outer cylinder, wherein the paired loaded ball rolling grooves formed to the spline shaft are formed at both side surfaces of a plurality of corner portions positioned between the paired loaded ball rolling grooves which constitutes the loaded ball rolling groove set, while the outer periphery of the outer cylinder is formed with a plurality of unloaded ball passages corresponding to the plurality of the loaded ball rolling groove.

In particular, the ball spline unit is characterized in that the unloaded ball passages to be formed to the outer periphery of the outer cylinder are arranged in a direction along a contact angle line connecting contact portions of the balls with respect to the respective loaded ball rolling grooves between which the balls are disposed.

According to this structure, a direction of the direction changing passage coincides with the rolling direction of the balls, so that the balls are smoothly rolled and moved.

A method of molding an outer cylinder according to the present invention is characterized by comprising the steps of:

providing a plural set of loaded ball rolling groove sets to an inner periphery of the outer cylinder in a circumferential direction, in which each of the loaded ball rolling groove sets consists of a pair of loaded ball rolling grooves arranged adjacently to each other;

disposing the outer cylinder to a portion between a first molding die and a second molding die arranged coaxially to each other, and providing a plurality of supporting convex portions for supporting the outer cylinder to an outer periphery of the first molding die which is positioned at inner peripheral side of the outer cylinder, the supporting convex portion engaging with the paired loaded ball rolling grooves of the respective loaded ball rolling groove sets formed to the outer cylinder; and

positioning the outer cylinder to the portion between the first and second molding dies with reference to the loaded ball rolling grooves so that the outer cylinder is supported by the plurality of the supporting convex portions, forming at least one of cavities, for forming first resin portions constituting unloaded ball passages, for forming second resin portions constituting retainer portions and for forming ball direction changing passage inner peripheral portions, to portions between the first and second molding portions and the outer cylinder, then injecting molding material into the cavities thereby to integrally mold the respective portions with the outer cylinder.

According to the method described above, the supporting convex portion formed to the first molding die is supported so as to be clamped by the paired loaded ball rolling grooves of the respective loaded ball rolling groove set formed to the outer cylinder. Therefore, even if a molding pressure is applied to the outer cylinder, the outer cylinder can be supported without causing any backlash in a rotating direction or in a direction orthogonal to a center axis, so that the molding material would not invade into the ball rolling grooves, thus preventing the generation of burrs.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**(*a*) is a longitudinal sectional view showing a first embodiment of a ball spline unit according to the present invention, and FIGS. **1**(*b*)–(*e*) are views showing structures of ball chain.

FIG. **2**(*a*) is a front vie w partially in section of the ball spline unit shown in FIG. **1**, and FIG. **2**(*b*) is a side view, half in section, of the ball spline unit shown in FIG. **2**(*a*).

FIG. **3**(*a*) is a cross sectional view showing an outer cylinder of the ball spline unit shown in FIG. **1**, FIG. **3**(*b*) is a view showing an end surface of the outer cylinder, FIG. **3**(*c*) i s a view partially i n section of a ball rolling groove in which ball chain is not used, and FIGS. **3**(*d*) and **3**(*e*) are partially sectional views of a ball rolling groove portions in which only a guide portion for preventing run-out of the ball chain is provided.

FIG. **4**(*a*) is a longitudinal sectional view of a side cover, FIG. **4**(*b*) is a rear end view of the side cover, and FIG. **4**(*c*) is a view showing a state where the outer cylinder and the side cover are engaged.

FIGS. **5**(*a*), (*b*) are views showing one embodiment of a method of molding an outer cylinder according to the present invention.

FIGS. **6**(*a*)–(*f*) are views showing modifications of the ball chain shown in FIG. **1**.

FIG. **7**(*a*) is a longitudinal sectional view showing a second embodiment of a ball spline unit according to the present invention, and FIGS. **7**(*b*)–(*d*) are views showing structures of ball chain.

FIG. **8**(*a*) is a sectional view showing a third embodiment of a ball spline unit according to the present invention, and FIGS. **8**(*b*)–(*d*) are views showing structures of ball chain.

FIG. **9** is a view showing a conventional linear motion bearing.

BEST MODE FOR EMBODYING THE INVENTION

In order to explain the present invention in more detail, the preferred embodiments of this invention will be described hereunder with reference to the accompanying drawings.

[Embodiment 1]

FIGS. **1** and **2** show an embodiment 1 of a ball spline unit according to the present invention.

In general, the ball spline unit **1** is constituted by comprising a cylindrical outer cylinder **3**, a pair of side covers **5** provided to both ends of the outer cylinder **3**, and a spline shaft **8** interfitted into an inner periphery of the outer cylinder **3** through a number of balls **9** so that the outer cylinder is relatively slidable with respect to the spline shaft **8**.

The outer cylinder **3** is a cylindrical body composed of metal having a high rigidity, and the inner periphery of the outer cylinder **3** is formed with a plurality of loaded ball rolling grooves **2**. The loaded ball rolling grooves **2** are constructed as a plural set of loaded ball rolling groove sets **2A** to be arranged in an circumferential direction, each of the loaded ball rolling groove sets **2A** consisting of a pair of loaded ball rolling grooves **2, 2** arranged adjacently to each other. In this embodiment, three sets of loaded ball rolling groove sets **2A** are provided at an equal interval in the circumferential direction.

On the other hand, the spline shaft **8** is inserted into the outer cylinder **3**, and an outer periphery of the spline shaft **8** is provided with three corner portions **8***a* at positions between the paired loaded ball rolling grooves **2, 2** which constitute the respective loaded ball rolling groove sets **2A**. Both side surfaces of the respective corner portions **8***a* are provided with a pair of loaded ball rolling grooves **7, 7** corresponding to the paired loaded ball rolling grooves **2, 2** formed to the outer cylinder **3**. Further, six rows of balls **9** are disposed between the six sets of loaded ball rolling grooves **2** and **7** arranged so as to oppose to each other, and the balls of the respective rows are applied with a predetermined preload.

A contact angle line L connecting contact points of each loaded ball **9** contacting to the loaded ball rolling grooves **2** and **7** is inclined with a predetermined angle α with respect to a radial line connecting a center of the ball to a center of the spline shaft **8**. The contact angle α is set so as to be linearly symmetric to each other with respect to a line connecting the center of the spline shaft **8** to the center of the corner portion **8***a*.

The six rows of balls **9** disposed between the respective loaded ball rolling grooves **2** and **7** are circulated and moved in such a manner that the balls **9** are moved from one end of the loaded ball rolling groove **2**, then moved into the unloaded ball passage **4**, which is formed in parallel with the loaded ball rolling groove **2**, through a direction changing passage **19** formed to one side cover **5**, then the balls **9** are moved through a direction changing passage **19** formed to the other side cover **5**, subsequently transferred again to the loaded ball rolling grooves **2** and **7**. The balls **9** are arranged over an entire circumference of a circulation passage consisting of a passage formed between the loaded ball rolling grooves **2** and **7**, the direction changing passages **19** and the unloaded ball passage **4**. The balls **9** are retained by a ball chain **60**.

The ball chain **60** comprises spacer portions **61** disposed between the respective balls **9** and connecting portions **62** for connecting the adjacent spacer portions **61**. Both ends of the ball chain **60** are not connected, and the ball chain **60** is attached in a state where a part of chain is cut off. In this regard, however, the ball chain **60** can be also formed in an endless shape by connecting both the end portions.

The spacer portion **61** comprises a flexible spacer plate **63** provided with a U-shaped structure having one side formed with a slit **65** and a pair of retention pieces **64** to which the adjacent balls **9** are seated respectively. The retention piece **64** is provided to right and left leg portions of the U-shaped spacer plate **63**, and each of the retention pieces **64** comprises a spherical crown-shaped concave portion **64***a* thereby to realize a structure enabling the balls **9** to be retained.

On the other hand, the connecting portion **62** is constituted by a belt-shaped member for connecting both sides of the spacer portion **61**. However, the connecting portion **62** may have a structure in which only one side of the respective spacer portion **61** is connected.

The ball chain **60** can be flexibly bent at a portion of the slit **65** formed to the spacer portion **61**. A bending direction of the ball chain **60** in the direction changing passage **19** is as follows. Namely, the ball chain **60** has a structure so that the ball chain **60** circulates by being bent in a direction so as to open the slit **65** while a bottom side of the U-shaped spacer plate **63** directs inward. As shown in FIGS. **1**(*b*) and (*d*), a width of the slit **65** can be appropriately selected in accordance with the curvature radius or the like of the direction changing passage **19**.

When the balls **9** are retained by the ball chain **60** as described above, the balls **9** in the direction changing passage **19** are drawn by the ball chain **60** and moved, so that the balls **9** are smoothly moved even if the curvature radius of the direction changing passage **19** is relatively small. Therefore, the balls **9** can be smoothly circulated and moved without increasing the size of the spline unit.

Particularly, in this embodiment, the respective spacer portions **61** is constituted by being provided with the slit **65** so as to be easily opened, the curvature radius of the direction changing passage **19** can be further decreased.

As shown in FIG. **3**(*a*), the loaded ball rolling grooves **2**, **2** constituting the respective loaded ball rolling groove set **2**A formed to the outer cylinder **3** are provided to both end portions of a first U-shaped groove **10** having a U-shape in cross section. However, the groove **10** is not limited to the U-shaped groove, and may be also constituted by a circular-arc-shaped groove.

In addition, a second U-shaped groove **11** to which the unloaded ball passage **4** is formed is provided to a portion between the aforementioned first U-shaped grooves **10** formed to the inner periphery of the outer cylinder **3**. A first resin portion **12** extending in an entire longitudinal direction of the outer cylinder **3** is integrally interfitted into the second U-shaped groove **11**. The first resin portion **12** has a circular-arc shape in section having a sufficient thickness, and a portion of the first resin portion **12** ranging from an outer end portion to a half thereof in a thickness direction is integrally interfitted into the second U-shaped groove **11**, while an inner end portion of the first resin portion **12** is inwardly projected from the inner periphery of the outer cylinder **3**.

Furthermore, the first resin portion **12** is formed with an unloaded ball passage **4**. The unloaded ball passage **4** is constituted by a circular through hole having a diameter slightly larger than that of the ball **9** and is formed so that a center position of the passage **4** coincides with an inner diameter line of the outer cylinder **3**.

In addition, side peripheries **6***a* in a circumferential direction of an inner end portion of the first resin portion **12** is projected toward a side of the adjacent first U-shaped groove **10**.

The outer circumference of the outer cylinder **3** is provided, at center portion thereof, with a lubricant guide groove **13** extending over an entire circumference of the outer cylinder **3** so as to supply the lubricant. The lubricant guide groove **13** is communicated with the second U-shaped groove **11** of the inner peripheral side through a first communication hole **14**. In addition, the first resin portion **12** is provided with a second communication hole **15** for communicating the aforementioned first communication hole **14** with the respective unloaded ball passage **4**. Further, the outer periphery of the outer cylinder **3** is provided with a key groove **3***a* extending in an axial direction.

The aforementioned first U-shaped groove **10** is provided with a second resin portion **16** for retaining the ball **9**. A side periphery in a circumferential direction of the second resin portion **16** and a side periphery in a circumferential direction of the first resin portion **12** are opposed to each other with a distance smaller than the diameter of the ball **9** thereby to constitute the retainer portions **6***a* and **6***b* for preventing the ball **9** from dropping-off.

As shown in FIG. **3**(*b*), the first resin portion **12** and the second resin portion **16** are integrally connected at a ring-shaped third resin portion **18** which is bonded to both end surfaces of the outer cylinder **3**. An end portion of the linearly extending loaded ball rolling groove **2** and an end portion of the unloaded ball passage **4** are opened to the end surface of the third resin portion **18**, and circular-arc-shaped direction changing passage inner peripheral portions **19***a* are provided between the loaded ball rolling groove **2** and the unloaded ball passage **4**.

On the other hand, as shown in FIG. **4**, the side cover **5** to be attached to the end surfaces of the outer cylinder **3** is a ring-shaped member, and has a ring-shaped end surface which abuts against the ring-shaped end surface of the third resin portion **18**. This end surface is formed with a circular-arc groove as concavity for constituting a direction changing outer periphery portion **19***b* so as to correspond to the direction changing passage inner peripheral portions **19***a* formed to six portions of the end surface of the third resin portion **18**.

In addition, the outer peripheral portion of the side cover **5** is provided with a ring-shaped wall **22** which engages with an outer peripheral surface of the third resin portion **18** formed to a side of the outer cylinder **3**. The inner periphery of the ring-shaped wall **22** is provided with an engaging projection **23** which engages with an engaging groove **21** formed to the outer periphery of the third resin portion **18**. An end surface of the ring-shaped wall **22** abuts against an end surface of the outer cylinder **5**.

The aforementioned unloaded ball passage **4**, the retainer portions **6***a* and **6***b*, and the inner periphery portion **19***a* and the outer periphery portion **19***b* of the ball direction changing passage **19** are provided with guide grooves **66** as guide portions for guiding the ball chain **60**. The guide grooves **66** are formed over an entire circumference so that one side peripheries of the connecting portion **62** and the retainer plate **63** of the ball chain **60** are accommodated into the guide grooves **66**, thereby to prevent the run-out of the ball chain **60** during the rolling of the balls.

That is, the guide grooves **66** are linearly formed to the inner peripheral surface of the unloaded ball passage **4** of the first resin portion **12**, side peripheral portions **12***a*, **16***a* opposing to each other in a circumferential direction of the first resin portion **12** and the second resin portion **16** constituting the retainer portions. In addition, a circular-arc-shaped guide grooves **66** are formed to the direction changing inner peripheral portion **19***a* and the direction changing outer peripheral portion **19***b* to be formed to the side cover **5**.

By the way, even if the outer cylinder **3** is detached from the spline shaft **8**, the balls are retained by the ball chain **60**, so that the aforementioned retainer portions **6***a,* **6***b* are not always necessary. However, when the retainer portions **6***a,* **6***b* are provided, as shown in FIG. **3**(*c*), the outer cylinder **3** can cope with a case where only the balls **9** are attached to the outer cylinder **3** without using the ball chain **60**. Namely, one outer cylinder **3** can be commonly applied to both the following two specifications, i.e., a specification of a type using ball chain and a specification of a type using only the balls, thus being advantageous.

In particular, in a case where only the balls are provided, the guide grooves **66** for the ball chain **60** can be utilized as lubricant supplying groove for supplying lubricants such as grease or the like.

In addition, even in a case where the retainer portions **6***a,* **6***b* are omitted, it is preferable to provide a guide portion for the ball chain for the purpose of preventing the run-out of the ball chain **60**. In this case, for example, as shown in FIG. **3**(*d*), the aforementioned guide portion can be constituted by a guide wall **66***a* for guiding one side surfaces of the connecting portion **62** and the spacer portion **63** of the ball chain **60**. Further, as shown in FIG. **3**(*e*), the guide portion can be also constituted by a guide wall **66***b* having a stepped-shape.

All of the first resin portion **12** for constituting the unloaded ball passage, the first and second resin portions **12**, **17** for constituting the retainer portions **6**, and the third resin portion **18** for constituting the rolling member direction changing passage inner peripheral portion **19***a* is integrally molded with the outer cylinder **3** in accordance with the insert molding method in which the outer cylinder **3** is disposed in the molding die.

FIG. **5** is a view showing an interfitting state of the outer cylinder **3** and the molding die at the time of the insert molding.

The insert molding of the outer cylinder **3** is carried out in accordance with the following steps. Namely, the outer cylinder **3** is disposed between a first molding die **40** and a second molding die **41** that are coaxially arranged to each other with reference to the loaded ball rolling grooves **2** thereby to form a cavity **12***a* for forming the first resin portion **12** for constituting the unloaded ball passage **4**, a cavity **16***a* for forming the second resin portion **16** for constituting the retainer portions, a cavity **19***c* for forming the ball direction changing passage inner peripheral portions **19***a,* and a cavity **18***a* for forming the third resin portion **18**. Then, a resin material is injected into the respective cavities **12***a,* **16***a,* **18***a* and **19***c* thereby to form the first resin portion **12**, the second resin portion **16**, the third resin portion **18** and the direction changing passage inner peripheral portion **19***a*.

That is, the first molding die **40** is provided with a supporting convex portion **42** for supporting the outer cylinder **3** by engaging with the respective loaded ball rolling grooves **2** formed to the outer cylinder **3**. The supporting convex portion **42** has a circular arc-shape in section corresponding to the circular arc-shape in section of the inner peripheral shape of the loaded ball rolling grooves **2**, and tightly interfits into the loaded ball rolling grooves **2**. Further, A core member **43** for forming the unloaded ball passage **4** is inserted into the cavity **12***a* for forming the first resin portion, the cavity **12***a* being formed between the first molding die **40** and the second molding die **41**.

Furthermore, the supporting convex portion **42** and the core member **43** are formed with convex projections **42***a* and **43***a* corresponding to the guide grooves **66** for accommodating the side peripheries of the connecting portions **62** and the retainer plates **63** of the ball chain **60**, whereby the guide grooves **66** are also integrally molded.

As described above, the outer cylinder **3** is positioned between the first and second molding dies **40** and **41** with reference to the loaded ball rolling grooves **2**, so that the generation of burrs can be prevented at a portion between the loaded ball rolling grooves **2** and the first molding die **40**. In particular, in this embodiment, the ball rolling groove sets are basically provided at three portions, and the outer cylinder **3** is positioned by the first molding die **40** at three points. In addition, there is provided an angular-contact structure, so that the positioning in a rotational direction can be also carried out, and the outer cylinder **3** can be accurately positioned with respect to the first molding die **40**.

In addition, when a grinding work of the outer periphery of the outer cylinder **3** to be insert-molded is performed with reference to the loaded ball rolling grooves **2**, a gap between the contact surfaces of the second molding die **41** and the outer periphery of the outer cylinder **3** inserted into the molding die can be set as small as possible, so that it becomes possible to prevent also the generation of burrs at outer circumferential side.

By the way, in order to prevent the generation of burrs, it is not always necessary for the contacting surfaces of the outer cylinder **3** and the supporting convex portion **42** of the molding die **40** to completely and tightly contact to each other. The gap may be allowed as far as the a size of the gap is sufficiently small to prevent the molding material from invading into the molding die.

As in the present invention, when the outer periphery of the outer cylinder **3** is finished by the grinding work and the outer cylinder **3** is disposed within the molding die with reference to the loaded ball rolling grooves **2**, a gap of the outer periphery can be set to a predetermined small size capable of preventing the molding material from invading thereinto.

In addition, not only the gap of the outer periphery of the outer cylinder **3** but also a gap between the loaded ball rolling grooves **2** of the inner periphery side and the first molding die **40** can be set to a predetermined small size capable of preventing the molding material from invading thereinto. Furthermore, also the loaded ball rolling grooves **2** is finished by grinding work, so that the molding die and the loaded ball rolling grooves **2** will contact to each other with a gap having a small extent.

As described above, when the small gaps are provided to portions between the outer and inner peripheries of the first and second molding dies **40**, **41** and the outer cylinder **3**, it becomes possible to easily attach the outer cylinder **3** and to effectively prevent the generation of the burrs.

As described above, since all of the unloaded ball passage **4**, ball retaining portions **6** and the direction changing passage inner peripheral portions **19***a* are integrally molded by the insert molding method with reference to the loaded ball rolling grooves **2** formed to the inner periphery of the outer cylinder **3**, the assembling process can be remarkably simplified and reduced.

In addition, there is no fear of causing irregularities due to the assembling error at joint portions to be formed between the direction changing passage **19** and the loaded ball rolling grooves **6** and between the direction changing passage **19** and the unloaded ball rolling grooves **4**, so that the circulation of the balls can be performed smoothly and the noise generation can be also reduced.

In this embodiment, although all of the unloaded ball passage **4**, ball retainer portions **6** and the direction changing passage inner peripheral portions **19***a* are integrally molded with the outer cylinder by the insert molding method, at least one of those members may also be formed by the insert molding method.

FIG. **6** are views showing modifications of the ball chains to be used in the above embodiments.

FIGS. **6**(*a*) and **6**(*b*) show a ball chain in which, among the connecting portions **62** provided both sides of the spacer portions **61**, slits **62** are provided to the connecting portions **62** of the same side as the slit of the spacer portions **62**. According to the structure described above, as shown in FIG. **6**(*c*), the slit **67** of the connecting portion **62** together with the slit **65** of the spacer portion **61** are opened in the direction changing passage, so that the curvature radius of the direction changing passage can be further reduced.

Of course, as shown in FIG. **6**(*d*), it is also possible to arrange the slits **65**, **67** so that sides of the slits are located at inside of the direction changing passage.

FIG. **6**(*e*) shows an example in which cut-outs **68** are formed to a side periphery opposed to the slit **65** of the spacer portion **61** of the ball chain **60** to be more easily deformable.

FIG. **6**(*f*) shows an example in which slits **69** are formed to one side connecting portions **62** among the connecting portions **62** provided at both sides of the ball for connecting the adjacent spacer portions **61** without forming slits **65** to the spacer portions **61** to be more fittably bent.

Next, other embodiments of the present invention will be explained hereunder.

In the explanation of the respective embodiments, the reference numerals are used to denote the same elements or members as those of the first embodiment (Embodiment 1), and the detailed explanations of the same elements or members are omitted.

[Embodiment 2]

FIG. **7** shows a second embodiment of the present invention. This embodiment 2 is an example in which the loaded ball passages are formed to the outer periphery of the outer cylinder.

This embodiment 2 is different from the embodiment 1 in a point that the loaded ball passages **4** are formed to the outer peripheral side of the outer cylinder **3**. Namely, the second U-shaped grooves **51** are formed to the outer peripheral side of the outer cylinder **3**, and the unloaded ball passages **4** are formed to the second resin portions **51** integrally molded so as to fill the second resin portions **52**.

In this case, the ball chain is constituted by comprising retainer pieces **71**, **71** as a pair of spacer portions disposed between the balls **9** and belt-shaped connecting portions **72** for connecting both sides of the respective retainer pieces **71**, in which the belt-shaped connecting portion **72** is formed in a belt shape as a whole. In the direction changing passage **19**, the ball chain changes its moving direction by bending a surface including both the sides of the belt-shaped connecting portions **72**.

In this embodiment, slits are not provided to the retainer piece **71** as the spacer portion. According to this structure, the ball chain can be more stably guided in comparison with the ball chain **60** of the embodiment 1 provided with slits **65**. In the embodiment 1, the unloaded ball passages are formed to the inner periphery of the outer cylinder, so that a difference in a length between the outer and inner circumferential lengths of a circulation track is increased. Therefore, in order to realize the smooth direction changing, the slit **65** is formed at outer side portion of the paired retainer pieces **64**.

In particular, in a case where the spline shaft **8** is rotated with a high speed, a centrifugal force to be applied to the ball increases. In the case of the embodiment 1, however, a circulating direction of the ball chain **60** is orthogonal to a direction to which the centrifugal force is applied, so that a friction force caused between the ball chain and the guide groove is disadvantageously increased when the ball chain **60** is deformed by the centrifugal force. As a result, there may be a fear that the smooth circulation of the ball chain will be obstructed.

In contrast, according to this embodiment 2, both sides of the ball are connected by the belt-shaped connecting portion **72**, the circulating direction of the ball chain **70** is close to the direction to which the centrifugal force is applied in comparison with that of the embodiment 1, so that the deformation of the ball chain **70** occurs along the circulating direction of the ball chain **70**. As a result, an influence of the centrifugal force can be lowered.

[Embodiment 3]

FIG. **8** shows a third embodiment of the present invention.

This embodiment 3 of a ball spline unit is formed by providing the unloaded ball passages **4** to the outer peripheral side of the outer cylinder **3** in the same manner as in the embodiment 2. In particular, the ball spline unit has a structure of that the unloaded ball passages **4** to be formed to the outer periphery of the outer cylinder **3** are arranged in a direction along a contact angle line L connecting contact portions of the balls **9** with respect to the respective loaded ball rolling grooves **2** and **7** between which the balls **9** are disposed.

According to this structure, a direction of the direction changing passage **19** coincides with the rolling direction of the balls, so that the balls **9** are smoothly rolled and moved.

The outer periphery of the outer cylinder **3** is formed with a second U-shaped grooves **51**, and the unloaded ball passages **4** are formed to the second resin portions **51** integrally molded so as to fill the second U-shaped grooves **52**. As described above, since the unloaded ball passages **4** are formed to the outer peripheral side of the outer cylinder **3**, the concave portions as formed in the embodiment 1 are not formed at portions of inner periphery of the outer cylinder **3** to which the first resin portions **12** are provided. As a result, the first resin portions **12** are molded in a form of circular-arc-shape having a uniform thickness.

In addition, in the same manner as in the embodiment 2, the ball chain **70** is constituted by comprising retainer pieces **71**, **71** as spacer portions disposed between the balls **9** and connecting portions **72** for connecting both sides of the respective retainer pieces **71**, in which each of the connecting portions **72** is formed in a belt shape as a whole. In the direction changing passage **19**, the ball chain **70** changes its moving direction by bending a surface including the both sides of the belt-shaped connecting portions **72**.

In this embodiment 3, the circulating direction of the ball chain **70** is further close to the direction to which the centrifugal force is applied in comparison with that of the embodiment 2, so that an influence of the centrifugal force can be further lowered than that of the embodiment 2, whereby the ball chain can be smoothly circulated.

According to the present invention as described above, since a number of balls are retained by the ball chain, the ball chain is smoothly moved even if the curvature radius of the direction changing passage is relatively small. Therefore, the balls can be smoothly circulated and moved without increasing an outer diameter of the outer cylinder.

Further, the balls would not collide with each other at the time of rolling and transferring and would also not collide with the inner peripheral surface of the unloaded ball passage, so that the noise generation can be reduced thereby to improve a low-noise property.

In addition, since at least one of the unloaded ball passage, ball retaining portions and ball direction changing passage inner peripheral portions are integrally molded by the insert molding with reference to the loaded ball rolling grooves formed to the inner periphery of the outer cylinder, the assembling process can be simplified and reduced. At the same time, there is no fear of causing irregularities due to the assembling error at joint portions to be formed between the ball direction changing passage and the loaded ball rolling grooves and between the direction changing passage and the unloaded ball rolling grooves, so that the circulation of the balls can be performed smoothly and it becomes possible for the balls to smoothly circulated and moved in co-operation with the guiding function of the ball chain.

Furthermore, since the outer cylinder is positioned in the molding die with reference to the loaded ball rolling grooves and molded, it becomes possible to prevent the burrs from generating at a portion between the loaded ball rolling grooves and the molding die.

In addition, when grooves for accommodating the connected portions of the ball chain are formed in an entire circumference of the unloaded ball rolling grooves, the retainer portions and the ball direction changing passage, run-out of the ball chain can be prevented.

Furthermore, when the ball chain has a function of retaining the balls, an operation of assembling the balls into the outer cylinder can be completed by only inserting the ball chain retaining a number of balls in a form of continuous chain.

On the other hand, when the inner periphery of the outer cylinder at portions between the plurality of the loaded ball rolling groove sets is formed with a plurality of unloaded ball passages corresponding to the respective loaded ball rolling grooves, it becomes possible to further reduce an outer diameter of the outer cylinder.

In addition, when the outer peripheral portion of the outer cylinder is formed with a plurality of unloaded ball passages corresponding to the respective loaded ball rolling grooves, and the unloaded ball passages are arranged along a contacting direction of the balls, a direction of the direction changing passage coincides with the rolling direction of the balls, so that the balls are smoothly rolled and moved.

Furthermore, according to the method of molding the outer cylinder of the present invention, the supporting convex portion formed to the first molding die is supported so as to be clamped by the paired loaded ball rolling grooves of the respective loaded ball rolling groove set by utilizing the ball contacting structure of the outer cylinder, so that even if a molding pressure is applied to the outer cylinder, the outer cylinder can be supported without causing any backlash in a rotating direction or in a direction orthogonal to a center axis. As a result, the molding material would not invade into the ball rolling grooves, thus securely preventing the generation of burrs.

INDUSTRIAL APPLICABILITY

The present invention can be widely applicable to ball spline units each comprising an outer cylinder and a circulation passages formed to the outer cylinder for endlessly circulating the balls. In particular, since the ball spline unit is constructed by using a ball chain so that the ball can be smoothly moved even if the curvature radius of the direction changing passage is relatively small, the ball spline unit can be formed in a small size. In addition, the assembling of the balls into the outer cylinder can be easily performed, and the assembling workability is excellent.

What is claimed is:

1. A ball spline unit comprising:

an outer cylinder of which inner periphery is formed with a plurality of loaded ball rolling grooves;

a plurality of unloaded ball passages corresponding to said ball rolling grooves formed to said outer cylinder;

side covers each having a direction changing passage for connecting said loaded ball rolling grooves to said unloaded ball passages, said side covers being provided at both end portions of said outer cylinder;

retainer portions provided along said loaded ball rolling grooves so as to prevent balls in the loaded ball rolling grooves from dropping off;

a spline shaft inserted into said outer cylinder, an outer periphery of said spline shaft being formed with loaded ball rolling grooves corresponding to said loaded ball rolling grooves formed to said outer cylinder; and

a number of balls disposed between said outer cylinder and said loaded ball rolling grooves formed to said spline shaft so as to endlessly circulate through said direction changing passages and said unloaded ball passages;

wherein a ball chain comprising a number of spacer portions disposed between the respective balls of a number of balls and connecting portions for connecting the adjacent spacer portions is provided, and

wherein at least one of said unloaded ball passage, retainer portions and ball direction changing passage inner peripheral portions is integrally molded with the outer cylinder in accordance with an insert molding method in which the outer cylinder is positioned within a molding die with reference to the loaded ball rolling grooves.

2. A ball spline unit according to claim **1**, wherein said unloaded ball passage, said retainer portions and said ball direction changing passage are provided with a guide portion for guiding said ball chain.

3. A ball spline unit comprising:

an outer cylinder of which inner periphery is formed with a plurality of loaded ball rolling grooves;

a plurality of unloaded ball passages corresponding to said ball rolling grooves formed to said outer cylinder;

side covers each having a direction changing passage for connecting said loaded ball rolling grooves to said unloaded ball passages, said side covers being provided at both end portions of said outer cylinder;

a spline shaft inserted into said outer cylinder, an outer periphery of said spline shaft being formed with loaded ball rolling grooves corresponding to said loaded ball rolling grooves formed to said outer cylinder; and

a number of balls disposed between said outer cylinder and said loaded ball rolling grooves formed to said spline shaft so as to endlessly circulate through said direction changing passages and said unloaded ball passages;

wherein a ball chain comprising a number of spacer portions disposed between the respective balls of a number of balls and connecting portions for connecting the adjacent spacer portions is provided, and

wherein at least one of the unloaded ball passage and ball direction changing passage inner peripheral portions is integrally molded with the outer cylinder in accordance with an insert molding method in which the outer cylinder is positioned within a molding die with reference to the loaded ball rolling grooves.

4. A ball spline unit according to claim **3**, wherein said unloaded ball passage and said ball direction changing passage are provided with a guide portion for guiding said ball chain.

5. A ball spline unit according to any one of claims **1**, **2**, **3** and **4**, wherein said ball chain is constructed so that each of the balls is retained by the respective spacer portions provided between the balls.

6. A ball spline unit comprising:

an outer cylinder of which inner periphery is formed with a plurality of loaded ball rolling grooves;

a plurality of unloaded ball passages corresponding to said ball rolling grooves formed to said outer cylinder;

side covers each having a direction changing passage for connecting said loaded ball rolling grooves to said unloaded ball passages, said side covers being provided at both end portions of said outer cylinder;

retainer portions provided along said loaded ball rolling grooves so as to prevent balls in the loaded ball rolling grooves from dropping off;

a spline shaft inserted into said outer cylinder, an outer periphery of said spline shaft being formed with loaded ball rolling grooves corresponding to said loaded ball rolling grooves formed to said outer cylinder; and

a number of balls disposed between said outer cylinder and said loaded ball rolling grooves formed to said spline shaft so as to endlessly circulate through said direction changing passages and said unloaded ball passages;

wherein at least one of said unloaded ball passage, retainer portions and ball direction changing passage inner peripheral portions is integrally molded with the outer cylinder in accordance with an insert molding method in which the outer cylinder is positioned within a molding die with reference to the loaded ball rolling grooves, and said unloaded ball passage, said retainer portions and said ball direction changing passage are provided with a guide portion for guiding said ball chain in which a number of balls are interlinked; and

wherein only a number of said balls are attached to said outer cylinder without using a ball chain.

* * * * *

US006142671A

United States Patent [19]

Ise

[11] **Patent Number: 6,142,671**

[45] **Date of Patent: Nov. 7, 2000**

[54] **LINEAR ROLLING MOTION GUIDE APPARATUS**

[75] Inventor: **Genjiro Ise**, Tokyo-to, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo-to, Japan

[21] Appl. No.: **09/371,857**

[22] Filed: **Aug. 11, 1999**

[30] **Foreign Application Priority Data**

Aug. 18, 1998 [JP] Japan 10-232044

[51] **Int. Cl.**[7] **F16C 29/06**

[52] **U.S. Cl.** **384/45**

[58] **Field of Search** 384/43, 44, 45, 384/49, 51

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,693,040	9/1987	Teramachi	384/45 X
4,934,834	6/1990	Morita	384/45
5,851,073	12/1998	Takeuchi	384/45
5,951,168	9/1999	Teramachi et al.	384/45
5,993,064	11/1999	Teramachi et al.	384/43

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Young & Thompson

[57] **ABSTRACT**

A linear rolling motion guide apparatus comprises a track member as a guide rail formed with a track extending in a longitudinal direction thereof, a movable member as a movable block formed with a rolling member circulation passage including a loaded rolling member rolling track corresponding, in position, to the track of the track member, a number of rolling members such as balls rolling in the rolling member circulation passage, the movable member being arranged to be movable relatively to the track member by a rolling motion of the rolling member and a rolling member connection assembly, as a retainer, mounted to the movable member, the rolling member connection assembly having a flexible belt-shaped member supporting the rolling members in series to be rotatable. The movable member is formed with a single material and the movable member is integrally formed with guide portions, for guiding the flexible belt-shaped member, to both sides of the loaded rolling member rolling track with the same material as that of the movable member through the same manufacturing process therefor.

13 Claims, 8 Drawing Sheets

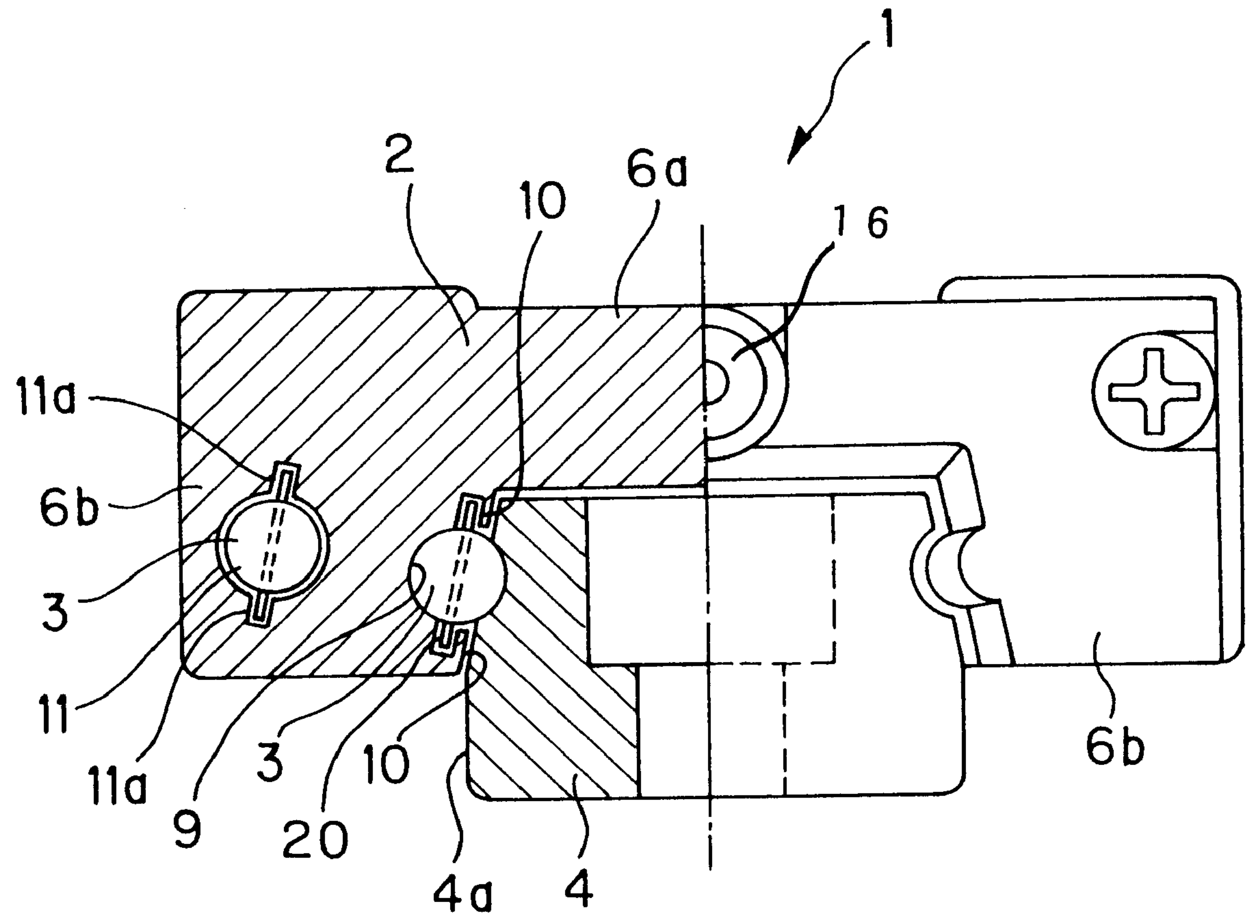


FIG.1

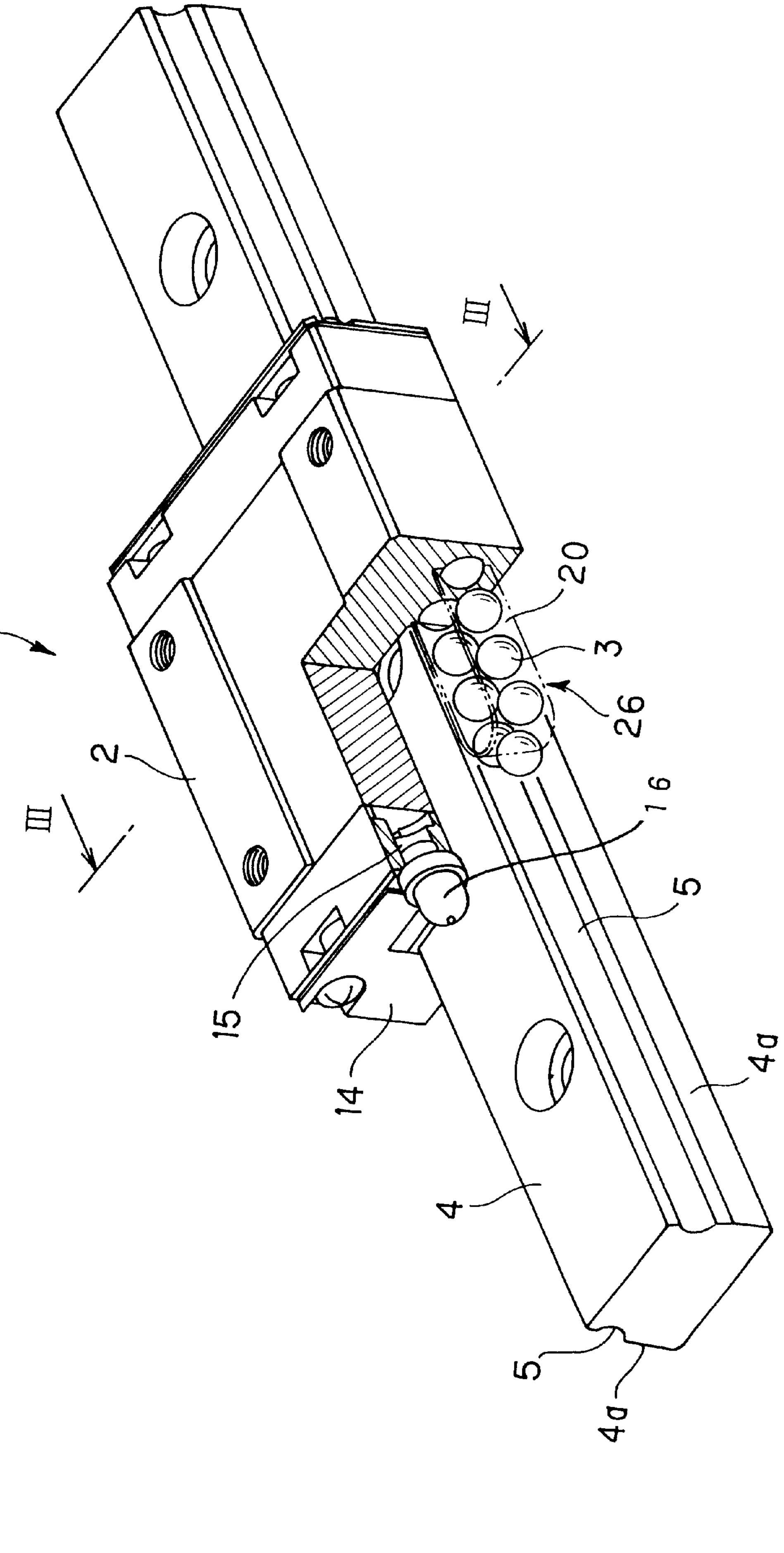


FIG. 2

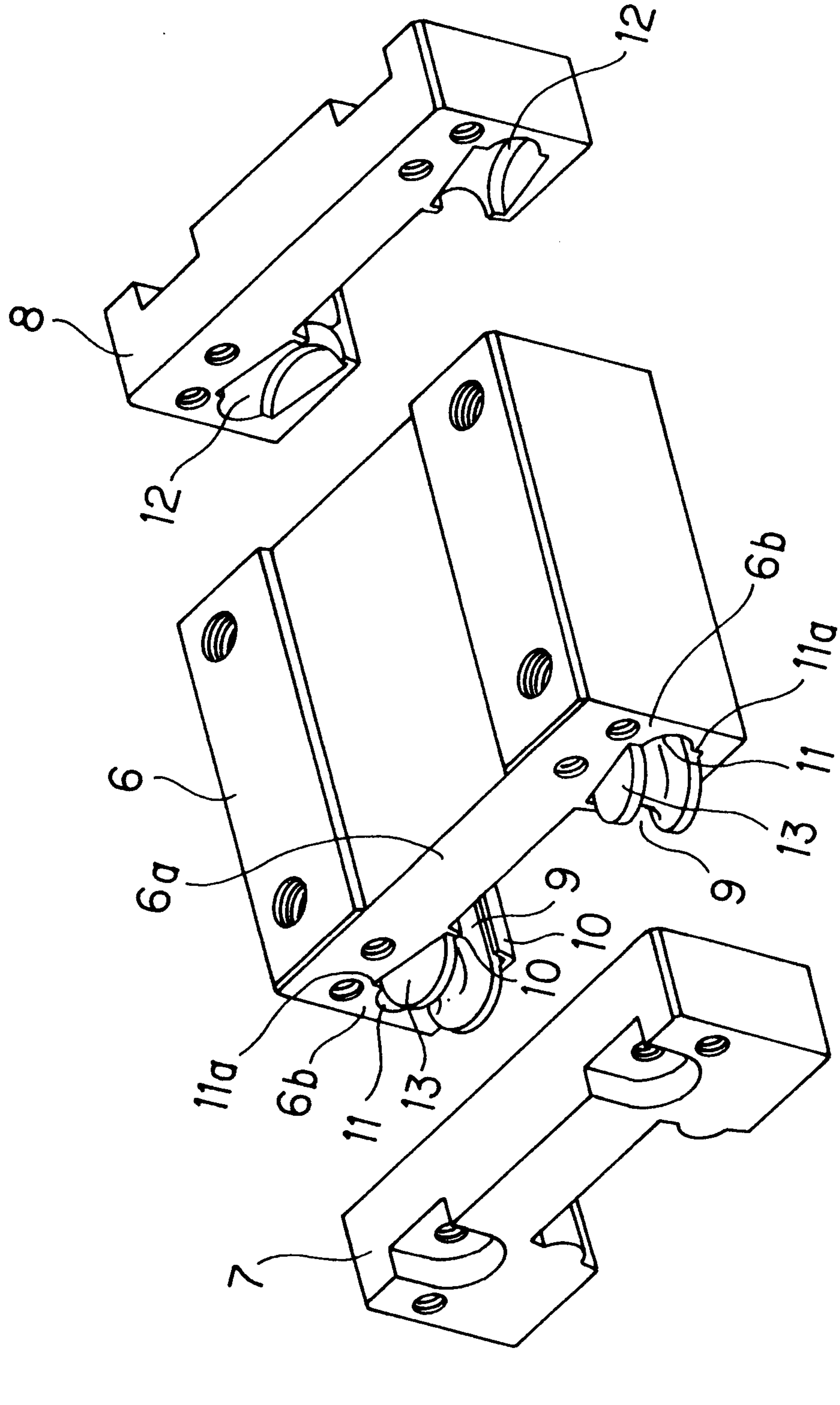


FIG. 3

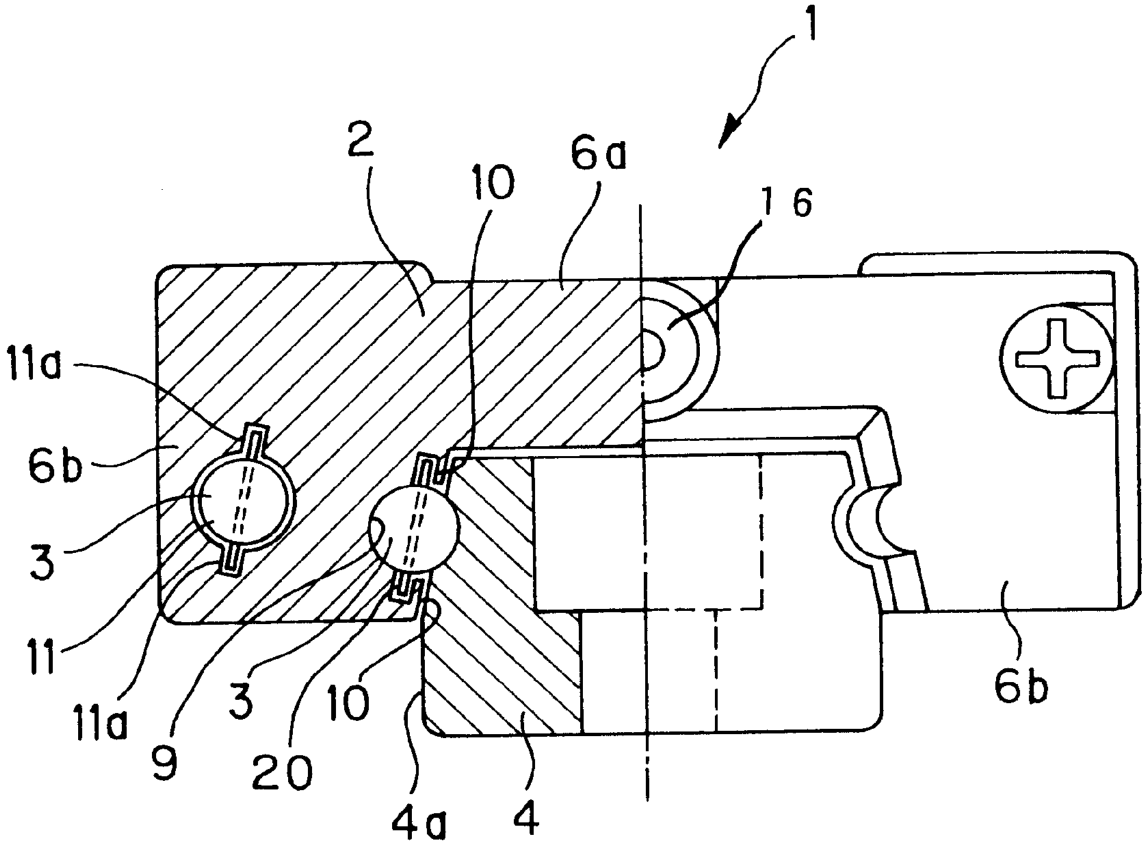


FIG. 4A

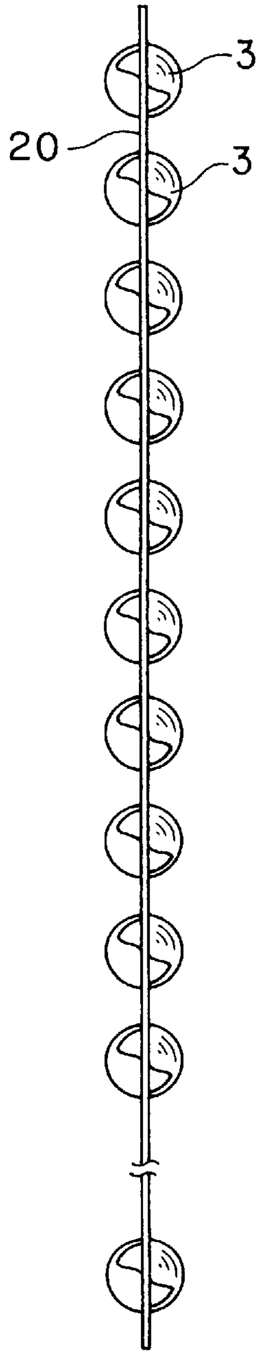


FIG. 4B

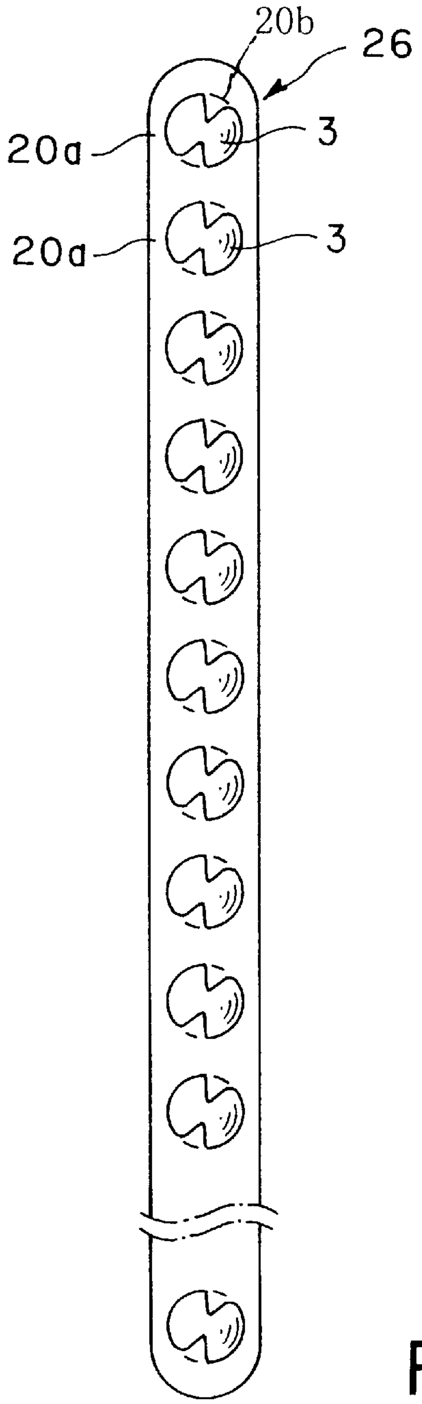


FIG. 4C

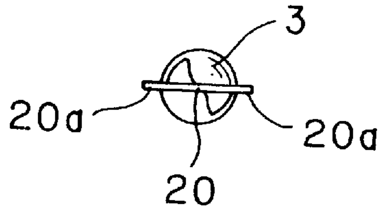


FIG. 5

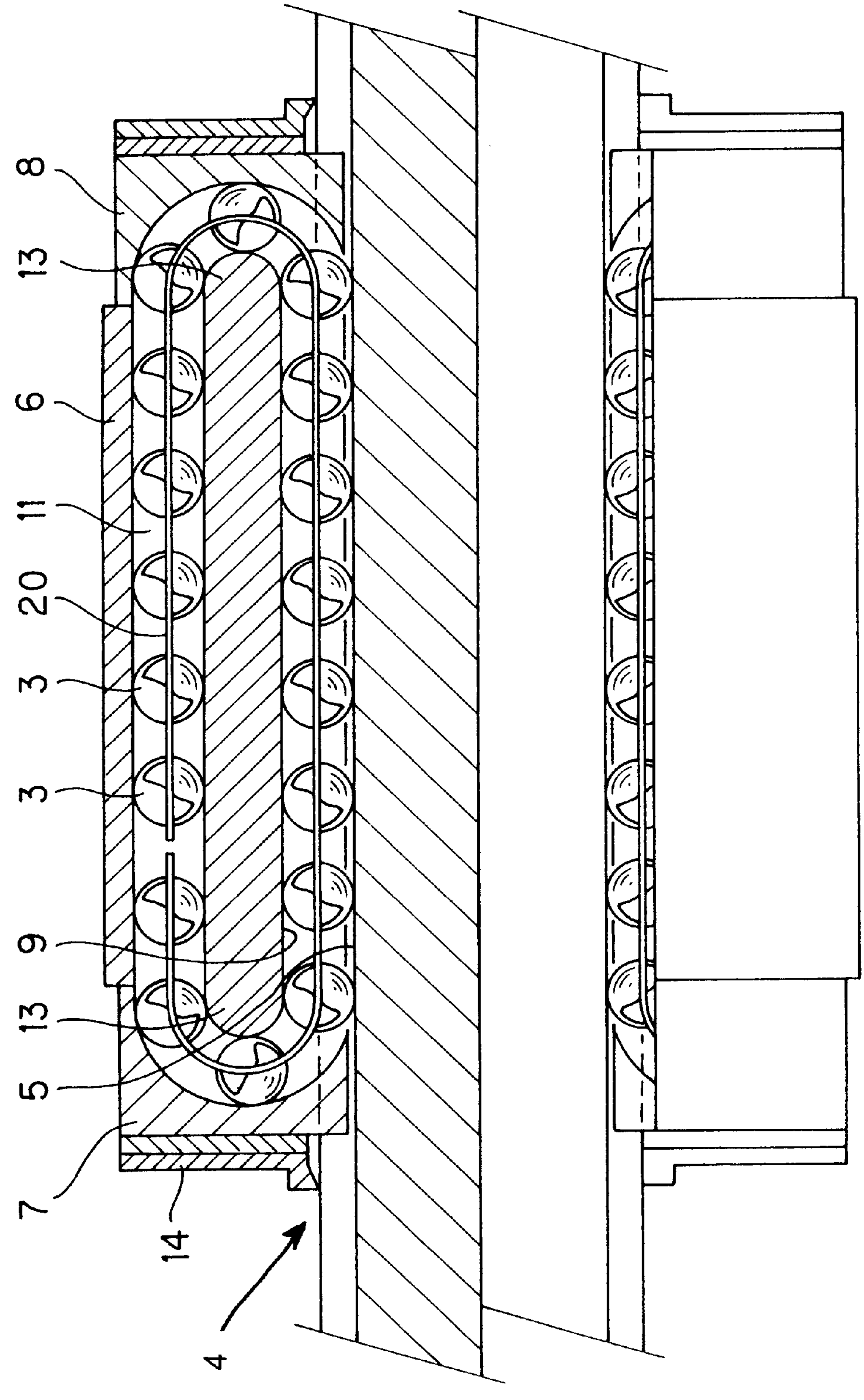


FIG. 6

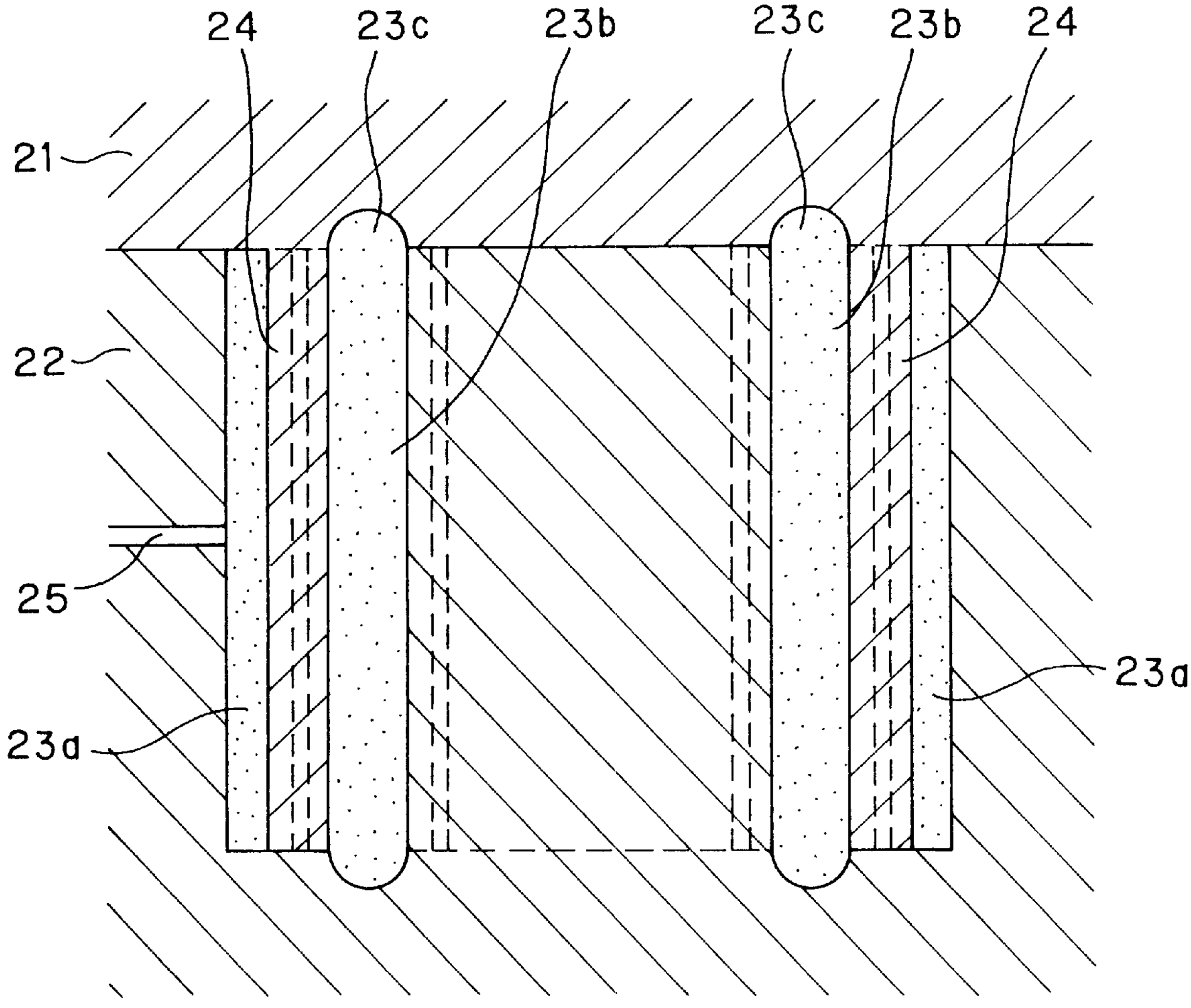


FIG. 7

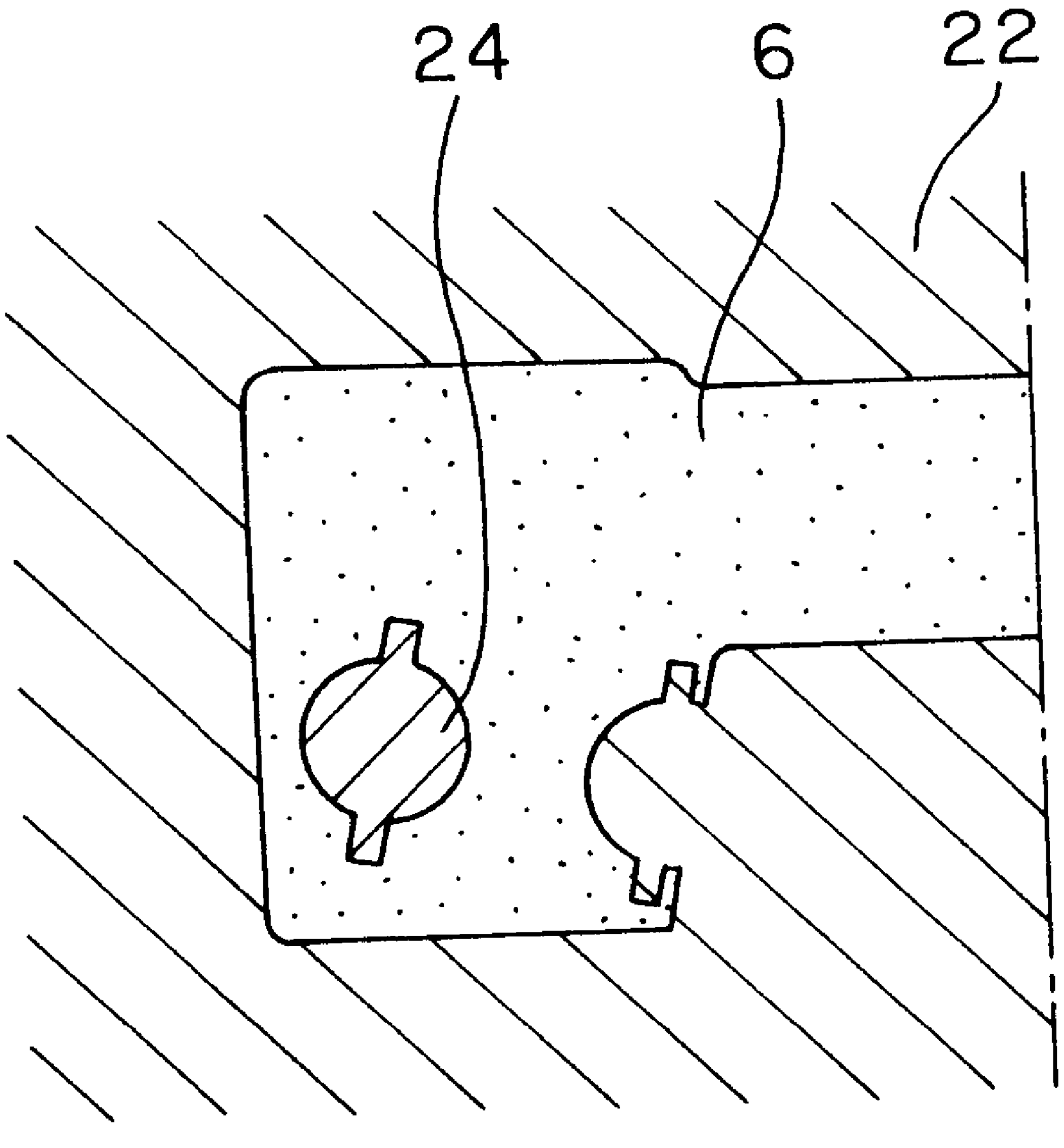


FIG. 8

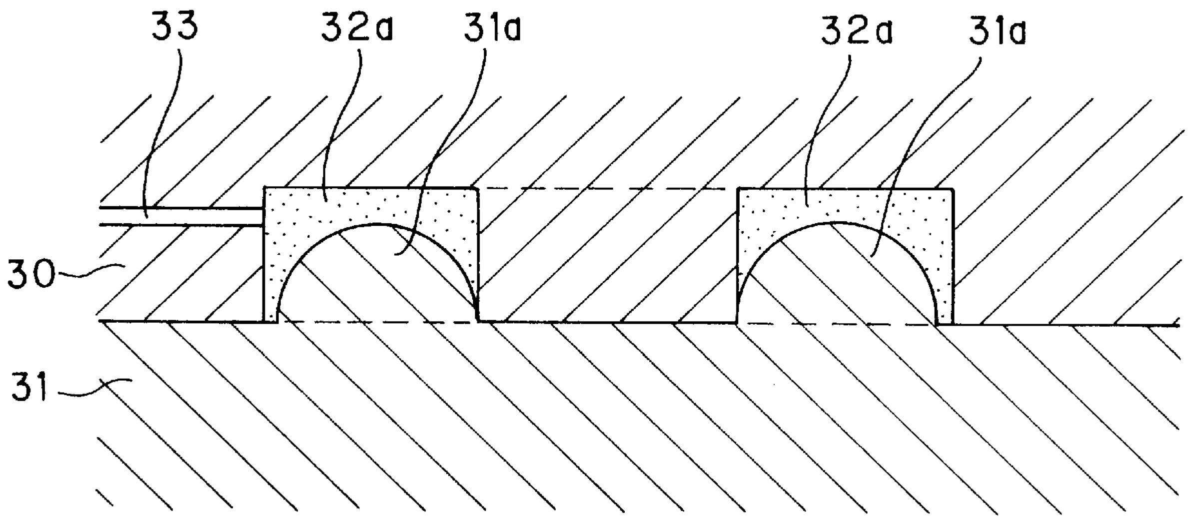
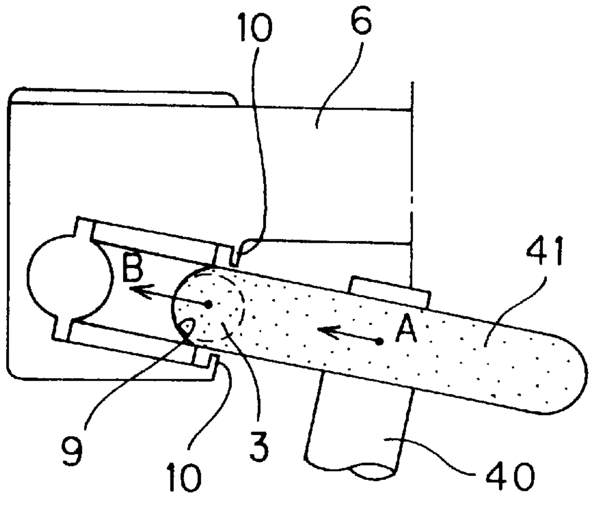


FIG. 9



LINEAR ROLLING MOTION GUIDE APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a linear rolling motion guide apparatus particularly provided with a connection belt assembly for supporting rolling members continuously in series.

In a known linear rolling motion guide apparatus, a movable block (movable member) and a track rail (track member) are assembled to be relatively movable by a number of rolling members such as balls. The track rail is formed, along a longitudinal direction thereof, with a track along which the rolling members are rolled, and the movable block is formed with a rolling member circulation passage including a loaded track opposing (corresponding) to the track of the track rail when assembled. The rolling members are accommodated in an arranged state in the rolling member circulation passage and rolled on the track rail and circulated in the circulation passage, while being loaded load, in accordance with the relative motion between the track rail and the movable block.

With the known linear motion guide apparatus mentioned above, there is also provided a structure in which the rolling members are supported or held in series by a belt member having flexibility. According to such support structure, the generation of noises and abrasion which may be caused through the friction of adjacent rolling members can be prevented and the coming-off of the rolling members at a time of removing the movable block from the track rail can be also prevented.

The movable member is provided with linear guide portions along the loaded track for guiding side edge portions of the belt member projecting on both sides of the rolling members, and such guide portions are formed of a steel plate, for example, as a member independent from the movable block. Furthermore, a portion of the movable block to which the load is applied is formed of a metal material having a large mechanical strength and a portion to which any load is not applied is formed of a synthetic resin material. In such structure, the guide portion for guiding the belt member is formed of a synthetic resin (which may be called hereinlater merely resin) integrally with the movable block.

However, the fact that the guide portion is formed of the steel plate other than the material forming the movable block requires many parts or members and also requires another working for fastening the guide portions to the movable block by means of screws or the like after the formation of the movable block. Furthermore, it is troublesome and difficult to fasten the guide portions to the movable block by means of screws at a small space between the movable block and the track rail.

Incidentally, in the structure in which the resin guide portion is integrally formed with a resin portion of the movable block, there is required another working step for integrally molding the guide portions with the resin to a movable block body made of metal after the metal movable block body has been formed. Moreover, since the movable block is thus formed with the resin portion, it is inconvenient to use such movable block in a high temperature atmosphere or vacuum environment.

SUMMARY OF THE INVENTION

An object of the present invention is to substantially eliminate defects or drawbacks encountered in the prior art

mentioned above and to provide a linear rolling motion guide apparatus with reduced components or parts and reduced assembling workings at a time of forming a guide portion for guiding a flexible belt member to a movable block (movable member).

This and other objects can be achieved according to the present invention by providing a linear rolling motion guide apparatus comprising:

a track member formed with a track extending in a longitudinal direction thereof;

a movable member formed with a rolling member circulation passage including a loaded rolling member rolling track corresponding, in position, to the track of the track member;

a number of rolling members, such as balls or rollers, rolling in the rolling member circulation passage, the movable member being arranged to be movable relatively to the track member by a rolling motion of the rolling members; and

a rolling member connection assembly mounted to the movable member, the rolling member connection assembly having a flexible belt-shaped member supporting the rolling members in series to be rotatable,

the movable member being formed with a single material and the movable member being integrally formed with guide portions, for guiding the flexible belt-shaped member, to both sides of the loaded rolling member rolling track with the same material as that of the movable member through the same manufacturing process therefor.

In preferred embodiments of the above aspect, the movable member is formed by injection molding a mixture material of metal powder and synthetic material, removing the synthetic material thereafter through a heat treatment or chemical treatment and then sintering the material.

The rolling member circulation passage includes a rolling member return passage arranged substantially in parallel to the loaded rolling member rolling passage, the rolling member return passage being formed with a guide groove, for guiding the flexible belt-shaped member, integrally to the movable member through the same manufacturing process therefor.

The rolling member circulation passage includes a pair of rolling member rolling direction changing passages connecting the loaded rolling member rolling track and the rolling member return passage, each of the rolling member rolling direction changing passage includes an inner peripheral portion and an outer peripheral portion, the inner peripheral portion being formed of the same material as that of the movable member through the same manufacturing process therefor, the outer peripheral portion being formed with a body different from that of the movable member, and when the inner peripheral portions and the outer peripheral portions of a pair of rolling member rolling direction changing passage are mated with each other, a guide groove for guiding the belt-shaped member is formed to the rolling member return passage.

The linear rolling motion guide apparatus further comprises a pair of end plates disposed at both longitudinal end portions of the movable member and the end plates constitute the outer peripheral portions of the rolling member rolling direction changing passages. The outer peripheral portion is formed by injection molding a mixture material of metal powder and synthetic material, removing the synthetic material thereafter through a heat treatment or chemical treatment and then sintering the material.

The flexible belt-shaped member is formed of a metal such as thin sheet of stainless steel plate.

The loaded rolling member rolling track is ground by means of a grinder through a space between the guide portions formed to both the side portions of the loaded rolling member rolling track.

More in detail, the track member is a guide rail having substantially a rectangular cross section and the movable member is a movable block having two leg portions so as to provide substantially a ⊐-shaped cross section, the guide rail being arranged between the leg portions so that said track formed to the guide rail accords, in position, with the loaded rolling member rolling track formed to the movable block.

The flexible belt-shaped member is a retainer composed of a belt-shaped plate and a number of holes which are arranged with equal interval with each other and in which the rolling member is held to be rotatable and side edge portions of the belt-shaped plate are guided by the guide portions when the retainer is assembled with the movable member.

According to the characteristic features of the present invention mentioned above, since the movable member and the guide portions are formed of the same material such as metal and synthetic resin at the same time for carrying out an injection molding process or casting process, constructional parts or elements and assembling steps can be effectively reduced for manufacturing the linear rolling motion guide apparatus.

Furthermore, when the movable member is formed through a metal injection molding process, the movable member can be formed with fine and complicated structure, as well as the guide portions. In such case, the guide portions are also formed of the metal material, and accordingly, even if the guide portion is formed in thin shape between the movable member and the track member, the guide portions can provide sufficient strength. In addition, in a prior art including a case in which a resin part is formed integrally with a metal movable member, burr may be caused between the movable member and the resin part. However, according to the present invention in which the guide portions and the movable member are formed integrally through the injection molding process, such burr is not caused.

Still furthermore, according to the present invention, since the guide groove is formed integrally with the rolling member return passage, the number of parts or elements and assembling steps can be effectively reduced. Moreover, the side edge portions of the flexible belt-shaped member as retainer are guided by the guide groove of the rolling member return passage, so that the vibration of the flexible belt-shaped member can be effectively suppressed, thus the predetermined track being properly and stably maintained, and the rolling members such as balls can also be stably rolled on the predetermined track.

Still furthermore, since the inner peripheral portion of the rolling member rolling direction changing passage is integrally formed with the movable member, the number of parts or elements and assembling steps can be effectively reduced. Furthermore, in the rolling member rolling direction changing passage, the flexible belt-shaped member is guided by the guide groove, so that the vibration of the flexible belt-shaped member in this passage can be also effectively suppressed, thus the predetermined track being properly and stably maintained, and the rolling members such as balls supported by the flexible belt-shaped member can also be stably rolled on the predetermined track.

Still furthermore, according to the present invention, all the parts or members constituting the linear rolling motion guide apparatus can be formed of metal material, so that the apparatus can be used in a high temperature condition and a vacuum condition in which an apparatus formed of resin parts such as in the prior art is not used.

Still furthermore, the loaded rolling member rolling track can be ground between the guide portions by coinciding the contact angle direction of the rolling members with the cutting direction of the grinding member even in a case where the guide portions are integrally formed with the loaded rolling member rolling track, so that the surface thereof can be smoothly ground, resulting in the smooth circulation of the rolling members such as balls.

The nature and further characteristic features of the present invention will be made more clear from the following descriptions made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** is a perspective view of a linear rolling motion guide apparatus according to one embodiment of the present invention;

FIG. **2** is a developed perspective view showing a movable block body and end plates of the linear rolling motion guide apparatus of FIG. **1**;

FIG. **3** is a sectional view taken along the line III—III of FIG. **1**;

FIG. **4** shows a retainer and a plurality of balls of the linear motion guide apparatus of FIG. **1** and includes FIG. **4**A of a side view, FIG. **4**B of a plan view and FIG. **4**C of a front view;

FIG. **5** is a bottom view including a half-sectional portion of the structure shown in FIG. **1**;

FIG. **6** is a partial view showing one example of a movable block forming mold;

FIG. **7** is a sectional view of FIG. **6**;

FIG. **8** is a partial view showing one example of an end plate forming mold; and

FIG. **9** is a schematic view showing a loaded rolling groove grinding working.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. **1** showing a perspective view of a linear rolling motion guide apparatus **1** of the present invention, a movable block **2** as movable member is supported by a guide rail **4** as track member by a number of rolling members **3**, **3**, - - - , **3**, i.e. balls in this embodiment so that the movable block **2** is linearly movable along the guide rail **4**. It is to be noted that, in a modified example, the movable block **2** may be formed as stationary side and the guide rail **4** may formed as movable side.

The guide rail **4** has an elongated structure and has substantially a rectangular cross section and has both lateral side surfaces to which a pair of ball rolling grooves **5**, as tracks for rolling the balls **3**, **3**, - - - , **3**, are formed along the entire longitudinal lengths thereof.

The movable block **2** is composed, as shown in FIG. **2**, of a movable block body **6** and end plates **7** and **8** mounted to both longitudinal ends of the movable block body **6**. The movable block body **6** has substantially a gate (⊐)-shaped cross section and provided with a horizontal portion **6***a* opposing to an upper surface of the guide rail **4** and a pair of leg portions **6***b*, **6***b* opposing to the lateral side surfaces

4*a*, 4*a* of the guide rail **4**, when the guide rail **4** is arranged in the ⊐-shaped space of the movable block body **6**. The paired leg portions **6***b*, **6***b* are formed, at inside surfaces thereof, with loaded ball rolling grooves **9**, **9** as loaded tracks corresponding to ball rolling grooves **5**, **5** formed to the side surfaces **4***a*, **4***a* of the guide rail **4**. Guide portions **10**, **10** are formed to both side portions of the loaded ball rolling groove **9** linearly along the groove **9**, and the guide portions **10**, **10** are formed of the same material as that of the movable block body through the same manufacturing process therefor at a same time of forming the movable block body. The guide portions **10**, **10** are formed with thin thickness, as shown in FIG. **3**, in spaces between the inside surfaces of the leg portions **6***a*, **6***a* and the side surfaces **4***a*, **4***a* of the guide rail **4**, respectively. According to the formation of these guide portions **10**, **10**, guide grooves for guiding the side edge portions of retainers **20**, formed as flexible belt members, for supporting the balls **3**, **3**, - - - , **3** in series to be rotatable, are formed to both the side portions of the loaded ball rolling grooves **9**, **9**, respectively. Such connected arrangement of the balls **3**, **3**, - - - , **3** and the retainer **20** will be called "rolling member connection belt assembly **26**" hereinlater.

Furthermore, each of the paired leg portions **6***b*, **6***b* is formed with a ball return passage **11** as a rolling member return passage to be substantially parallel to the loaded ball rolling groove **9** and adapted to return the balls from one end of the loaded ball rolling groove **9** to the other end thereof through the ball return passage **11**. The ball return passage **11** has an inner diameter slightly larger than a diameter of the ball **3**. The ball return passage **11** is also formed integrally with a guide groove **11***a* for guiding the side edge portion of the retainer **20** in the manner substantially the same as that mentioned with respect to the movable block body **6**.

With reference to FIG. **2**, each of the end plates **7** and **8** has a gate (⊐)-shaped cross section as like as the sectional shape of the movable block body **6**. The end plate **7** (**8**) is formed with an outer peripheral portion **12** of a ball rolling direction changing passage for scooping the balls **3** rolling in the loaded ball rolling groove **9** to guide the balls **3** to the ball return passage **11** and, reversely, for again guiding the balls **3** from the ball return passage **11** to the loaded ball rolling groove **9**. The movable block body **6** is formed, at both the longitudinal end portions, with rounded pieces (R-pieces) **13** formed as inner peripheral portions constituting the ball rolling direction changing passages. The end plate **7** (**8**) is formed with a body different from that of the movable block body **6**.

When the end plates **7** and **8** are mounted correctly in positions to the movable block body **6**, the rounded pieces **13** and the outer peripheral portions **12** constitute, in combination, the ball rolling direction changing passages at both the longitudinal end portions of the movable block **2** and guide grooves for guiding the side edge portions of the retainers **20** can be formed as like as the formation of the ball return passage **11**.

The ball rolling direction changing passages, the loaded ball rolling grooves **9** and the ball return passages **11** are called in combination "rolling member circulation passage".

The movable block body **6** and the end plates **7** and **8** are formed with single material or substance through a metal injection molding (MIM) process. This MIM process includes the steps of injection molding a mixture composed of metal powder and synthetic material (mainly in fine grain or particle form), removing the synthetic material component through a thermal treatment or chemical treatment and performing a sintering treatment.

That is, in the first step, a binder composed of fine synthetic material particles is added to the metal powder, kneading the mixture of the binder and the metal powder into pellet and then injection molding the pellet by using a known injection molding machine. In this step, there is utilized fine metal powder, as starting material, consisting of metal element of C, Si, Mn, Cr, Mo, W, V, Ti, Fe or the like having a powder (particle) diameter of about 10 μm. Further, the "single material" mentioned above means only one kind of these metal elements and also means an alloy of these metal elements, and a polyethylene or the like may be used as the binder.

In the next step, the injection molded product is heat treated in a furnace to vaporize the binder component and then remove the same through thermal treatment or chemical treatment. Thereafter, the metal body is preliminarily sintered thereby to obtain a molded part having a sufficient stability. In a subsequent sintering step, a molded product having a high relative density nearly of 100%.

According to the adoption of such metal injection molding (MIM) process, a product having fine and complicated composition or structure can be manufactured without performing any cutting working. Thus, according to such MIM process, the guide portions **10** having fine and complicated structure can be simultaneously formed integrally with the movable block body **6**. Therefore, it becomes not necessary to form the guide portions **10** separately from the movable block body **6**, and hence, the assembling working and the number of constituent components can be effectively reduced. Furthermore, an adequate mechanical strength of the product can be obtained by increasing the relative density of the metal injection mold product, so that the guide portion **10** can maintain adequate strength even if it be formed with thin thickness in a narrow space between the movable block body **6** and the guide rail **4**.

Furthermore, through the MIM process mentioned above, the fine guide grooves **11***a* can be formed to the ball return passages **11** of the movable block body **6**, and the end plates **7** and **8** having a complicated structure, with the outer peripheral portions **12** of the ball rolling direction changing passages being formed, can be also formed. Still furthermore, the guide grooves for guiding the side edge portions **20***a* of the retainer **20** can be also formed to the ball rolling direction changing passages constituted by the end plates **7** and **8** and the rounded pieces (R-pieces) **13**, **13**.

As can be seen from FIG. **2**, threaded portions for screw engagement are formed to the end surfaces of the movable block body **6** for fastening the end plates **7** and **8** to the movable block body **6**, and threaded portions for screw engagement are also formed to the upper surface of the movable block body **6** for securing a material mounted thereon. The end plates **7** and **8** are formed with holes into which fastening screws are engaged for securely mounting the end plates to the movable block body and holes into which fastening screws are engaged for fixing end face seals **14** (FIG. **1**) for preventing dust or dirt from entering into the end plates **7** and **8**. Furthermore, as shown in FIG. **1**, the end plate **7** is formed with a lubricant passage **15** extending towards the ball rolling direction changing passage, and a grease nipple **16** is fitted to the lubricant passage **15**.

A number of balls **3** are held continuously by a retainer **20** having a flexibility and formed in shape of belt as shown in FIG. **4**. The retainer **20** is formed with a number of ball holes **20***b* with equal interval from each other and the balls **3** are held in the ball holes **20***a*, respectively, to be rotatable. The retainer **20** is also formed with side edge portions **20***a* on both width sides thereof. Furthermore, the longitudinal ends of the retainer **20** is formed so as to provide round end portions so that the retainer **20** can be easily and smoothly inserted into the movable block **2**. The retainer **20** is preferably formed of a stainless steel plate in shape of belt having an elastic or flexible property.

FIG. **5** shows a state of the balls **3** rolling between the loaded ball rolling groove **5** and the ball rolling groove **5** as the loaded area and between the ball return passage **11** and the ball rolling direction changing passage as the non-loaded area. According to the arrangement in which a number of balls **3** are held continuously in series by the retainer **20**, noises and abrasion of the balls **3** caused by the mutual friction of the balls **3** can be prevented. Furthermore, in the absence of the retainer, resistance, which is applied to the balls **3** at the time when the balls **3** moves from the non-loaded area to the loaded area, is increased and, hence, the smooth ball rolling motion is obstructed by such resistance. However, according to the location of the retainer **20**, the balls **3** can be smoothly taken into the loaded area and, hence, smoothly moved from the non-loaded area to the loaded area. Still furthermore, the side edge portions **20***a* of the retainer **20** can be guided in the entire length thereof by the guide portion **10** formed along the loaded ball rolling groove of the movable block **6**, the guide groove formed to the ball rolling direction changing passage and the guide groove **11***a* formed to the ball return passage **11**, so that the vibration of the entire structure of the retainer **20** at the time of the ball circulation can be restricted. Therefore, the retainer **20** can be moved on a predetermined track throughout the entire periphery of the endless circulation passage, and hence, the balls **3** held by the retainer **20** can be also moved on the predetermined track.

As mentioned above, according to the present invention, parts or elements, including the retainer, constituting the linear rolling motion guide apparatus can be formed of metal materials, so that the linear rolling motion apparatus thus manufactured can be used in an environment of a temperature of more than 80° C. in which a conventional linear rolling motion guide apparatus formed of materials including resin can not be used. Furthermore, in a prior art, when the linear rolling motion guide apparatus is used in a vacuum environment, gas is generated from the resin material part and, hence, the vacuum condition cannot be kept. However, according to the metal structure of the present invention, the gas cannot be generated and, hence, it becomes possible to use the linear rolling motion guide apparatus in the vacuum condition. Further, it is preferred to use a solid lubricant in the use at a high temperature environment.

FIGS. **6** and **7** show schematic views of a mold for molding the movable block **6** according to the present invention.

With reference to FIG. **6**, the mold is composed of an upper mold half **21** and a lower mold half **22** between which cavities are defined for forming the movable block **6**. The cavities are formed on both the lateral sides of the lower mold half **22** and each of the cavities includes a cavity portion **23***a* for forming an outside portion of a leg portion **6***b* of the movable block **6**, a cavity portion **23***b* for forming an inside portion of the leg portion **6***b*, the loaded ball rolling groove **9** thereof and the guide portion **10**, and a cavity portion **23***c* for forming the round (R) piece portions **13** to the front end rear portions of the leg portion **6***b*. On the other hand, the upper mold half **21** is formed with a pin **24** for forming the ball return passage **11**. The lower mold half **22** is also formed with a gate **25** communicating with the cavity portion **23***a*. According to such structure, the pellet formed by kneading the metal powder and the synthetic materialrinjected into the cavities **23***a*, **23***b* and **23***c* through the gate **25**.

FIG. **8** shows a schematic view of a mold for molding the end plates **7** and **8**, and the mold is composed of an upper mold half **30** and a lower mold half **31** between which cavities **32***a* for molding leg portions of the end plates **7** and **8** are formed. The lower mold half **31** is formed with circular (arcuate) projections **31***a* for forming outer peripheral portions **12** of the ball rolling direction changing passages. The upper mold half **30** is formed with a gate **33** communicating with the cavity **32***a*, and the metal powder is injected into the cavity **32***a* through the gate **33**.

FIG. **9** is a view for showing a grinding operation for grinding the loaded ball rolling groove **9**, which is ground by an outer peripheral portion of a grinding wheel **41**, in shape of disc, fixed to the front end of a rotation shaft **40**. According to the present invention, the loaded ball rolling groove **9** can be ground through the guide portions **10** formed on both sides of the groove **9**.

In a circular arc structure in which the loaded ball rolling groove **9** is formed in a single arcuate shape, the grinding working is performed by making approximately coincide a cutting direction (direction A in FIG. **9**) of the grinding wheel **41** with the contact angle direction of the loaded ball rolling groove **9** (direction B in FIG. **9**), the contact angle direction being a direction of a line connecting the center point of the ball **3** and a contact point of the ball **3** to the circular arc groove. On the other hand, in a Gothic arc structure in which the loaded ball rolling groove **9** is formed by two arcuate portions, a grinding wheel having two arcuate portions having outer peripheries corresponding to the shape of the Gothic arc groove, i.e. so-called, formed grinding wheel, will be utilized.

Further, it is to be noted that the present invention is not limited to the described embodiments and many other changes and modifications may be made without departing from the scopes of the appended claims.

For example, in the above embodiment, although the single row of balls is arranged on each side surface of the guide rail **4**, the number of rows and arranging portions thereof can be optionally be changed in accordance with the magnitude or direction of load to be applied to the balls. Moreover, the guide rail **4** may have various shapes of cross section other than that mentioned hereinabove.

Furthermore, the track member **4** may be formed as a spline shaft and the movable member **2** may be formed as an outer cylinder which is movable with respect to the spline shaft through a number of rolling members such as balls or rollers.

What is claimed is:

1. A linear rolling motion guide apparatus comprising:

a track member formed with a track extending in a longitudinal direction thereof;

a movable member formed with a rolling member circulation passage including a loaded rolling member rolling track corresponding, in position, to said track;

a number of rolling members rolling in the rolling member circulation passage, said movable member being arranged to be movable relatively to said track member by a rolling motion of the rolling members; and

a rolling member connection assembly mounted to the movable member, said rolling member connection assembly having a flexible belt-shaped member supporting the rolling members in series to be rotatable, said movable member being integrally formed with guide portions, for guiding said flexible belt-shaped member, to both sides of the loaded rolling member rolling track with the same material as that of the movable member through the same manufacturing process therefor.

2. A linear rolling motion guide apparatus according to claim **1**, said movable member is formed with a single material.

3. A linear rolling motion guide apparatus according to claim **1**, wherein said movable member is formed by injection molding a mixture material of metal powder and synthetic material, removing the synthetic material thereafter through a heat treatment or chemical treatment and then sintering the material.

4. A linear rolling motion guide apparatus according to claim **1**, wherein said rolling member circulation passage includes a rolling member return passage arranged substantially in parallel to the loaded rolling member rolling passage, said rolling member return passage being formed with a guide groove, for guiding said flexible belt-shaped member, integrally to the movable member through the same manufacturing process therefor.

5. A linear rolling motion guide apparatus according to claim **1**, wherein said rolling member circulation passage includes a pair of rolling member rolling direction changing passages connecting said loaded rolling member rolling track and said rolling member return passage, each of said rolling member rolling direction changing passages includes an inner peripheral portion and an outer peripheral portion, said inner peripheral portion being formed of the same material as that of the movable member through the same manufacturing process therefor, said outer peripheral portion being formed with a body different from that of the movable member, and when the inner peripheral portions and the outer peripheral portions of a pair of rolling member rolling direction changing passage are mated with each other, a guide groove for guiding said belt-shaped member is formed to the rolling member return passage.

6. A linear rolling motion guide apparatus according to claim **5**, further comprising a pair of end plates disposed at both longitudinal end portions of the movable member and said end plates constitute said outer peripheral portions of the rolling member rolling direction changing passages.

7. A linear rolling motion guide apparatus according to claim **5**, wherein said outer peripheral portion is formed by injection molding a mixture material of metal powder and synthetic material, removing the synthetic material thereafter through a heat treatment or chemical treatment and then sintering the material.

8. A linear rolling motion guide apparatus according to claim **1**, wherein said flexible belt-shaped member is formed of a metal material.

9. A linear rolling motion guide apparatus according to claim **8**, wherein said flexible belt-shaped member is formed of a sheet of stainless steel plate.

10. A linear rolling motion guide apparatus according to claim **1**, wherein said loaded rolling member rolling track is ground by means of a grinder through a space between said guide portions formed to both the side portions of the loaded rolling member rolling track.

11. A linear rolling motion guide apparatus according to claim **1**, wherein said track member is a guide rail having substantially a rectangular cross section and said movable member is a movable block having two leg portions so as to provide substantially a gate (コ)-shaped cross section, said guide rail being arranged between said leg portions so that said track formed to the guide rail accords in position with said loaded rolling member rolling track formed to the movable block.

12. A linear rolling motion guide apparatus according to claim **1**, wherein said flexible belt-shaped member is a retainer composed of a belt-shaped plate and a number of holes which are arranged with equal interval with each other and in which the rolling member is held to be rotatable and side edge portions of said belt-shaped plate are guided by said guide portions when the retainer is assembled with the movable member.

13. A linear rolling motion guide apparatus according to claim **1**, wherein said rolling members are balls.

* * * * *

US006132093A

United States Patent [19]

Michioka et al.

[11] **Patent Number: 6,132,093**

[45] **Date of Patent: Oct. 17, 2000**

[54] **LINEAR MOTION GUIDING APPARATUS**

[75] Inventors: **Hidekazu Michioka**; **Katsuya Iida**; **Masahiro Yoshihashi**; **Hiroaki Mochizuki**; **Tadashi Hirokawa**, all of Tokyo-to, Japan

[73] Assignee: **THK, Co., Ltd.**, Tokyo-To, Japan

[21] Appl. No.: **09/088,491**

[22] Filed: **Jun. 2, 1998**

[30] **Foreign Application Priority Data**

Jun. 16, 1997 [JP] Japan 9-175336
Apr. 30, 1998 [JP] Japan 10-136062

[51] **Int. Cl.**[7] **F16C 29/06**
[52] **U.S. Cl.** **384/45**
[58] **Field of Search** 384/45, 43, 44; 464/168

[56] **References Cited**

FOREIGN PATENT DOCUMENTS

0 400 200 12/1990 European Pat. Off. .
2 175 054 11/1986 United Kingdom .
2 180 303 3/1987 United Kingdom .

Primary Examiner—Lenard A. Footland
Attorney, Agent, or Firm—Young & Thompson

[57] **ABSTRACT**

A linear motion guiding apparatus comprises a guide rail provided with a ball running groove, and a movable block movably arranged along the guide rail through balls. The movable block is provided with a ball running counter-groove, a ball returning passage arranged away from the ball running counter-groove and direction changing passages for connecting these members. A resin-formed body for forming a ball circulation passage comprises a pair of ball passage forming portions, a returning passage forming portion and a pair of direction changing passage-inner guide forming portions. The resin-formed body is separately formed from a body of the movable block. At least two portions of (a) the ball passage forming portions, (b) the returning passage forming portion, (c) one of the direction changing passage-inner guide forming portions and (d) another of the of direction changing passage-inner guide forming portions are connected with each other through integral forming so that the resin-formed body can be built in the body of the movable block.

3 Claims, 44 Drawing Sheets

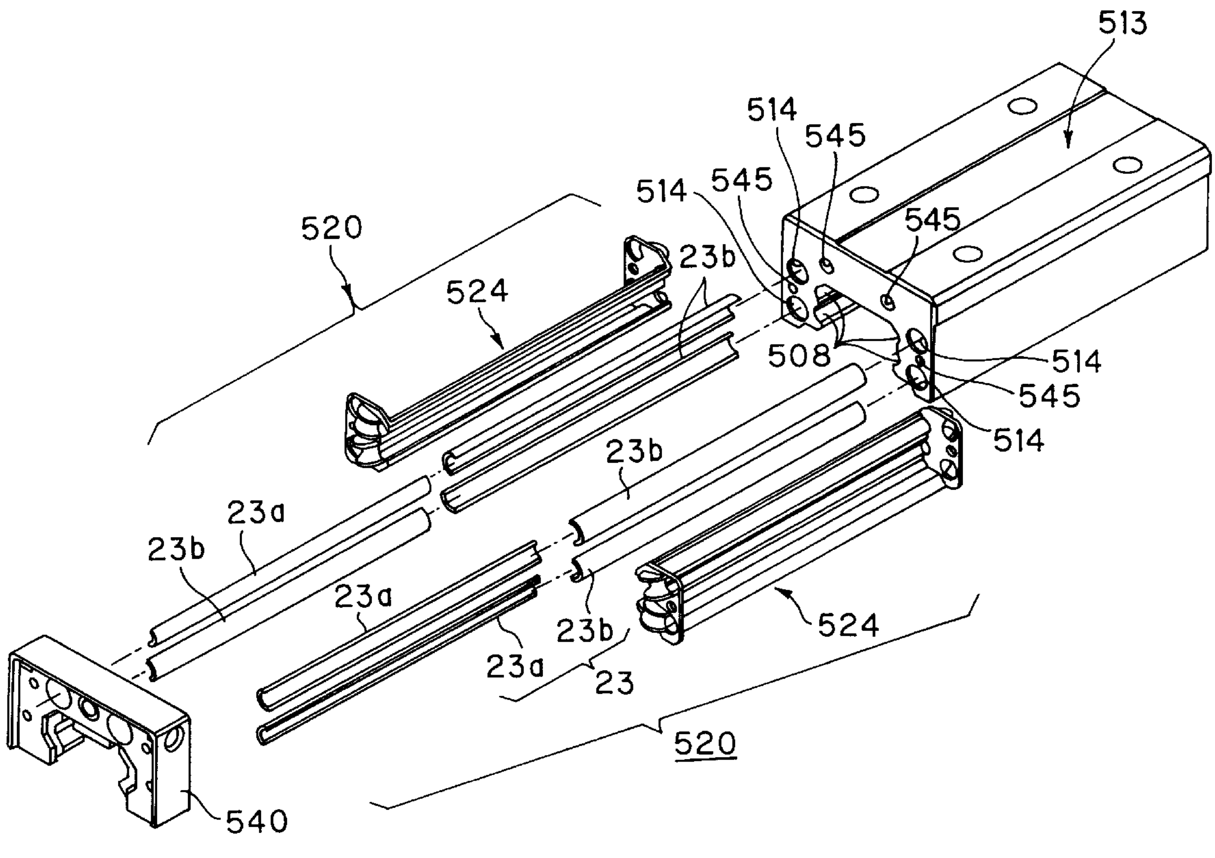


FIG. 1

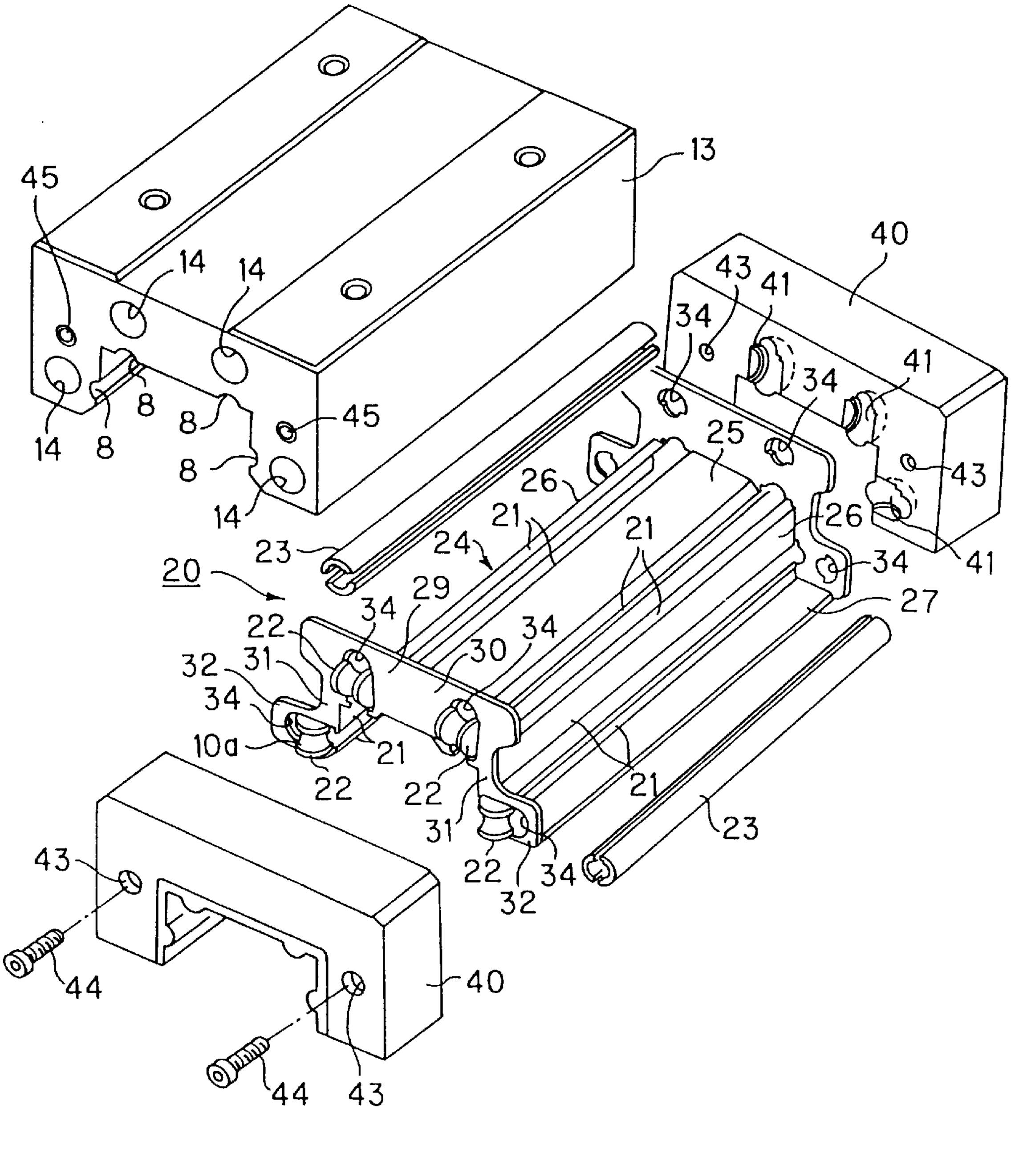

13
45
14
14
14
8
8
14
8
8
45
8
14
40
43
41
34
41
34
25
43
26
26
41
21
21
24
23
20
34
29
27
22
34
31
30
32
34
10a
21
22
22
31
21
23
22
34
32
43
44
40
44
43

FIG. 2(a)

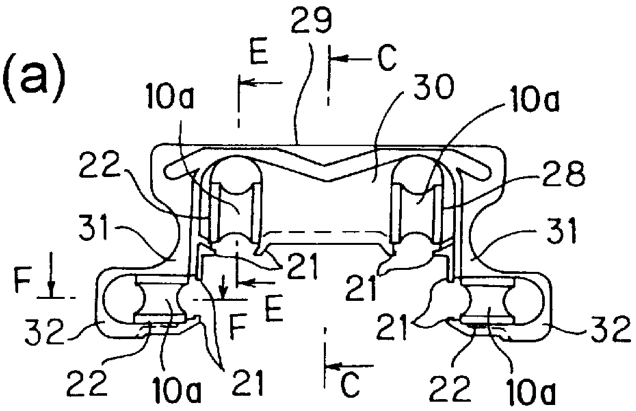


FIG. 2(b)

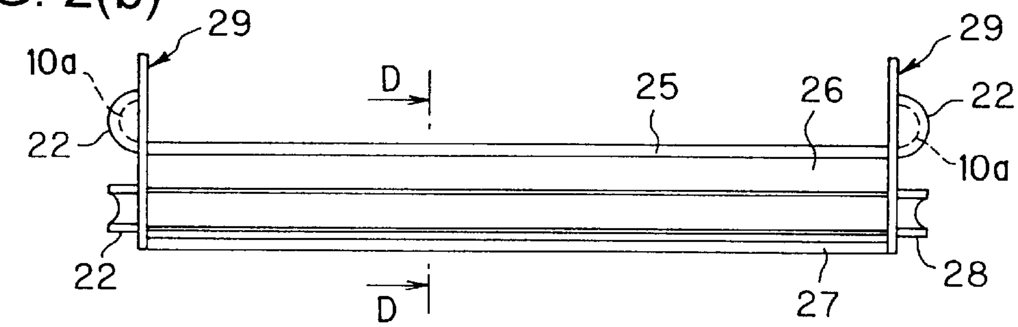


FIG. 2(c)

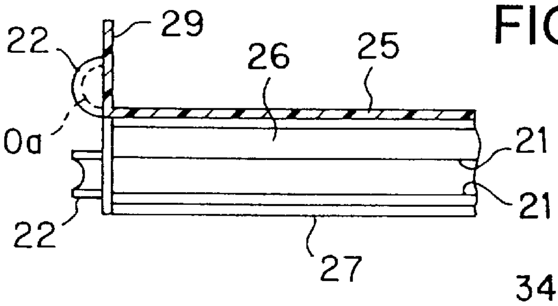


FIG. 2(d)

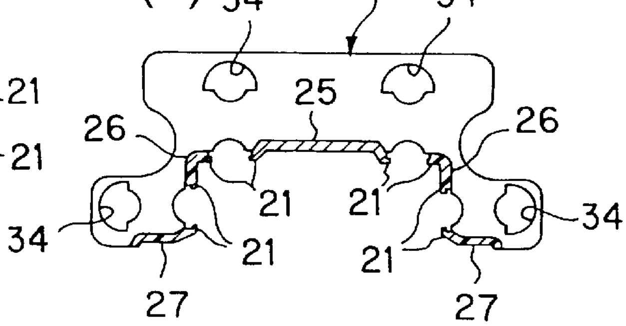


FIG. 2(e)

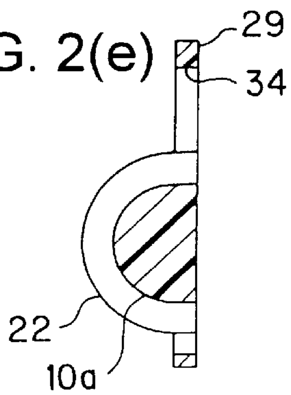


FIG. 2(f)

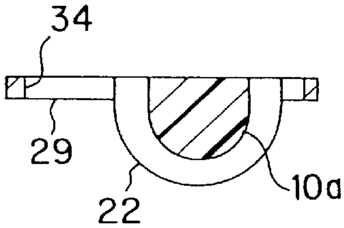


FIG. 3(a)

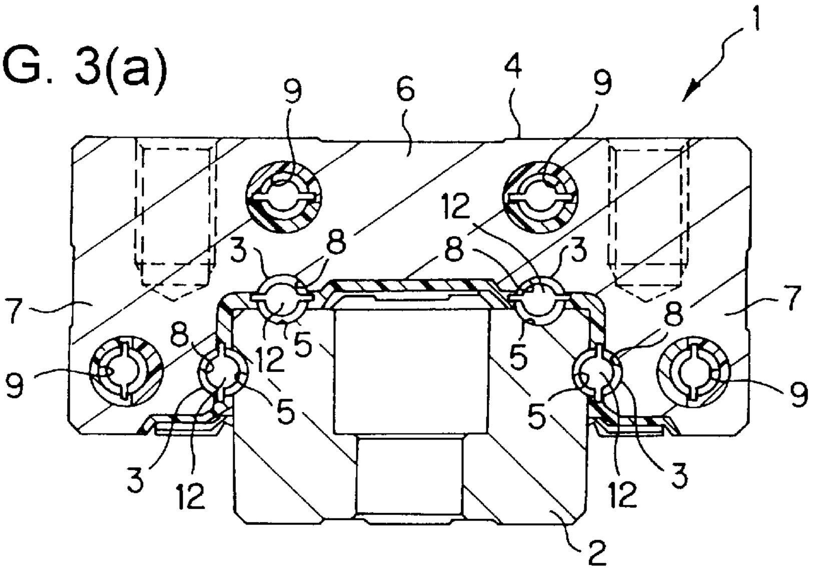


FIG. 3(b)

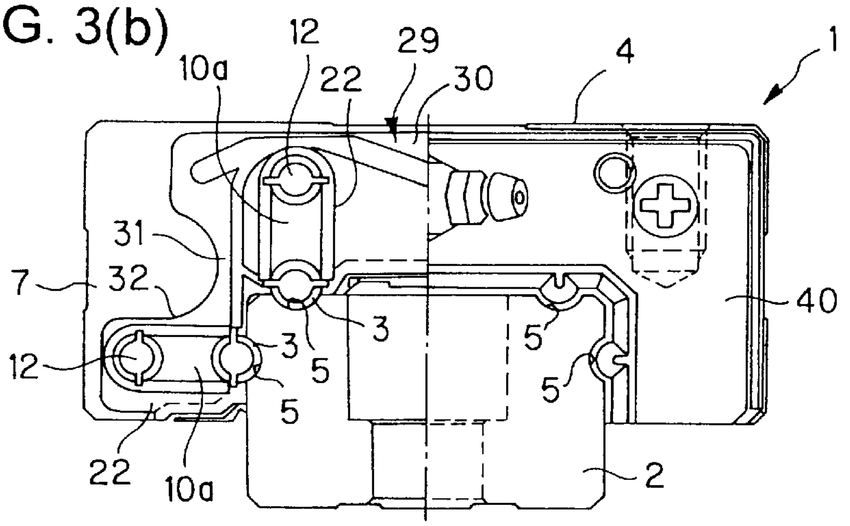


FIG. 3(c)

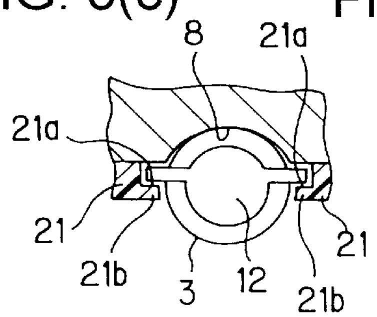


FIG. 3(d)

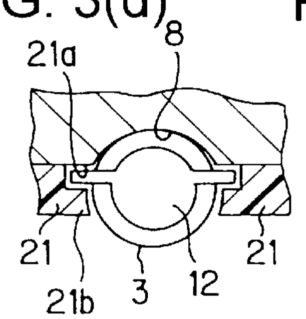


FIG. 3(e)

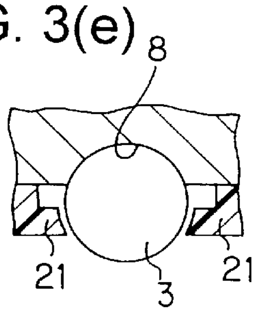


FIG. 3(f)

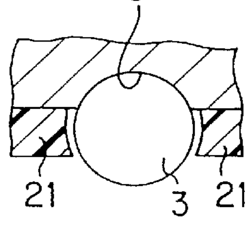


FIG. 4(a)

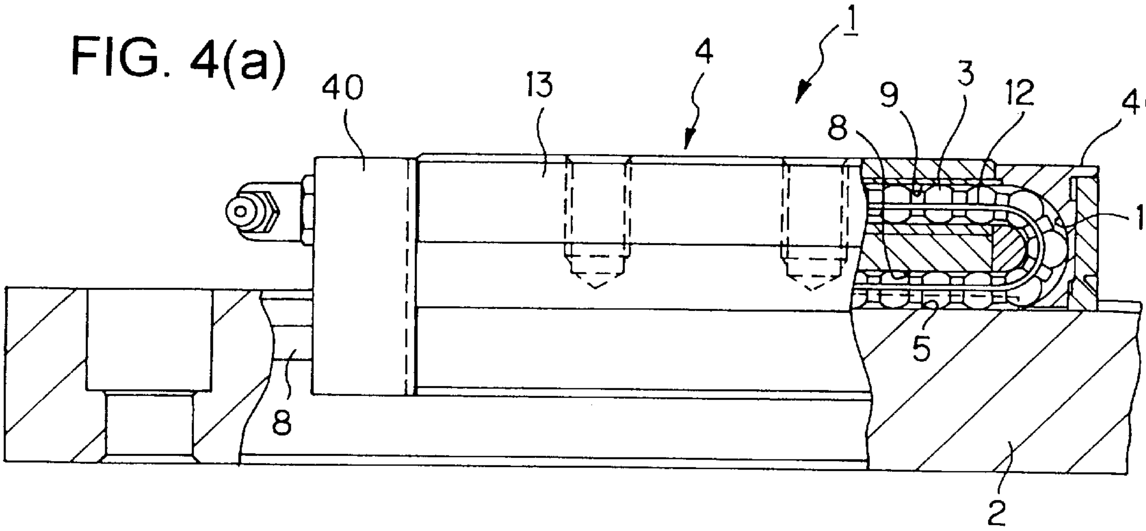


FIG. 4(b)

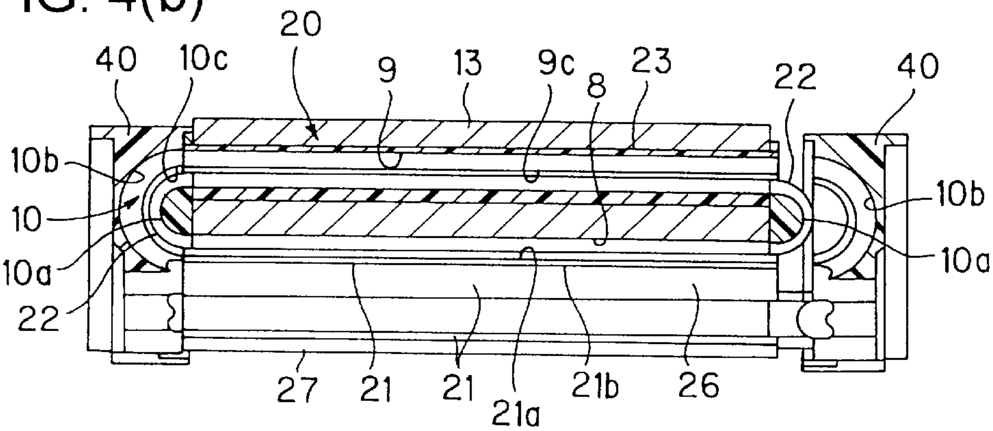


FIG. 4(c)

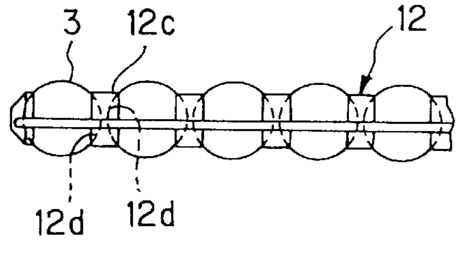


FIG. 4(d)

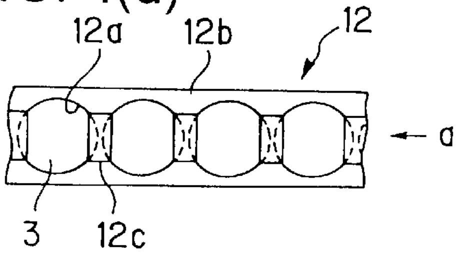


FIG. 4(e)

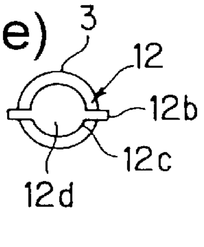


FIG. 5(a)

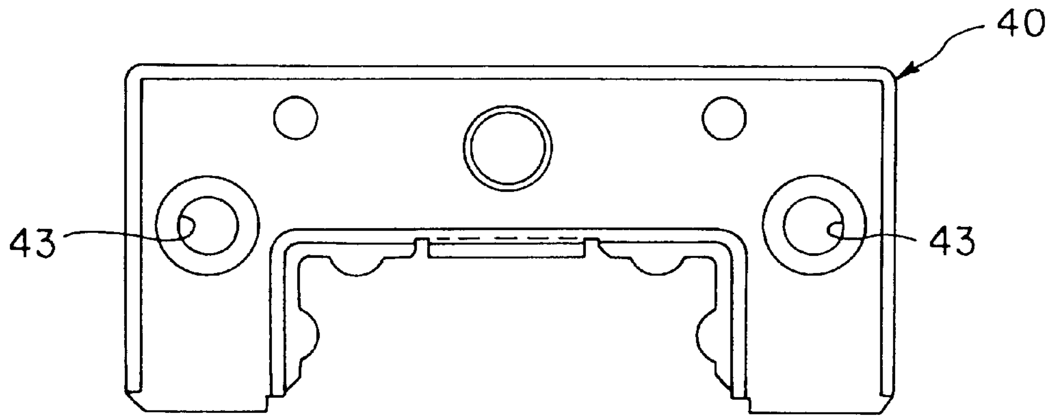


FIG. 5(b)

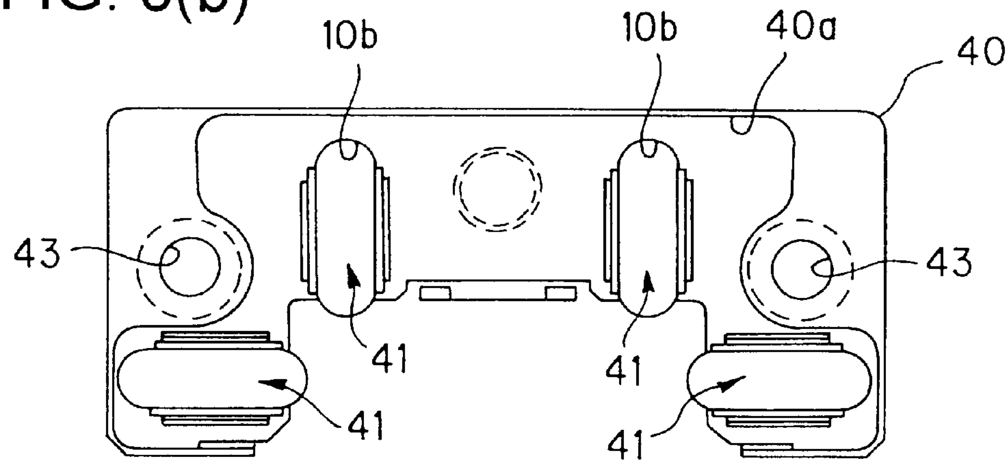


FIG. 5(c)

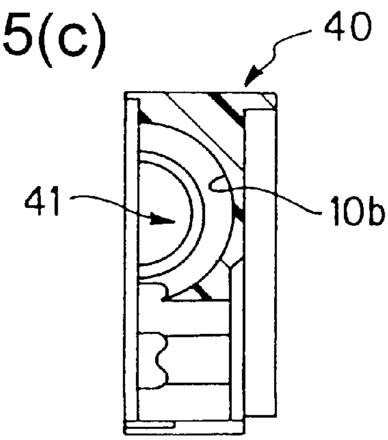


FIG. 6(a)

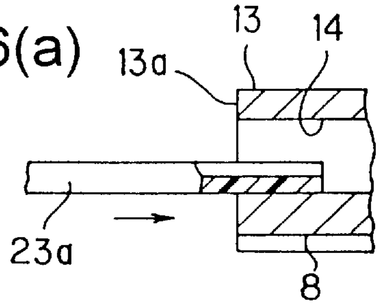


FIG. 6(b)

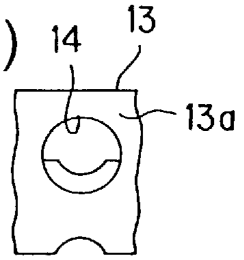


FIG. 6(c)

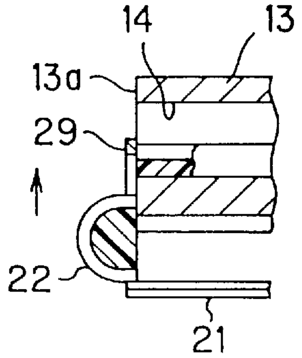


FIG. 6(d)

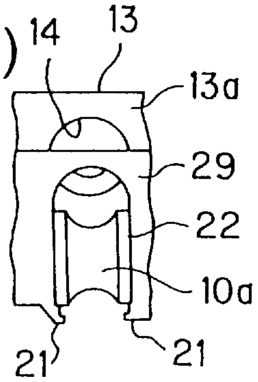


FIG. 6(e)

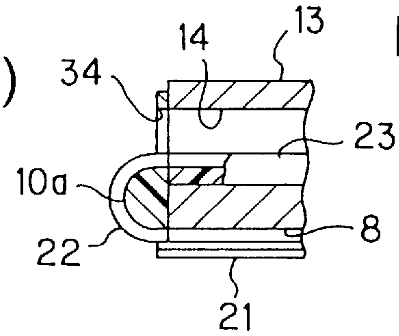


FIG. 6(f)

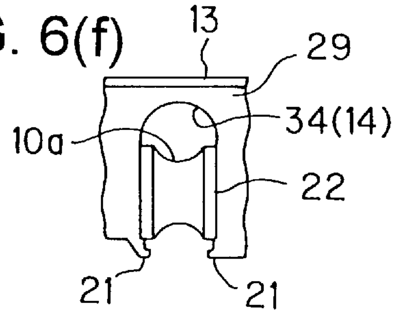


FIG. 6(g)

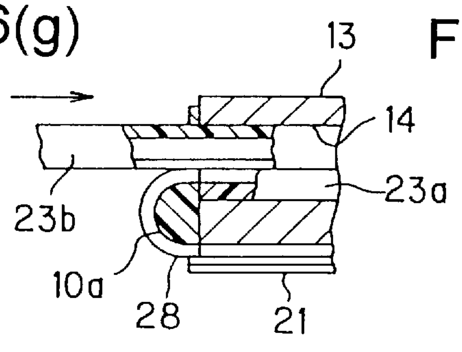


FIG. 6(h)

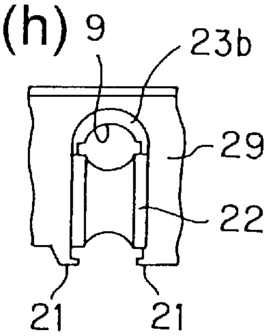


FIG. 6(i)

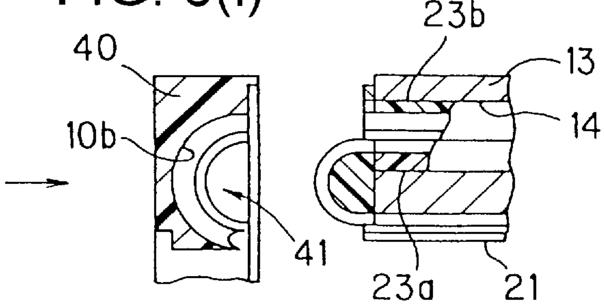


FIG. 7(a)

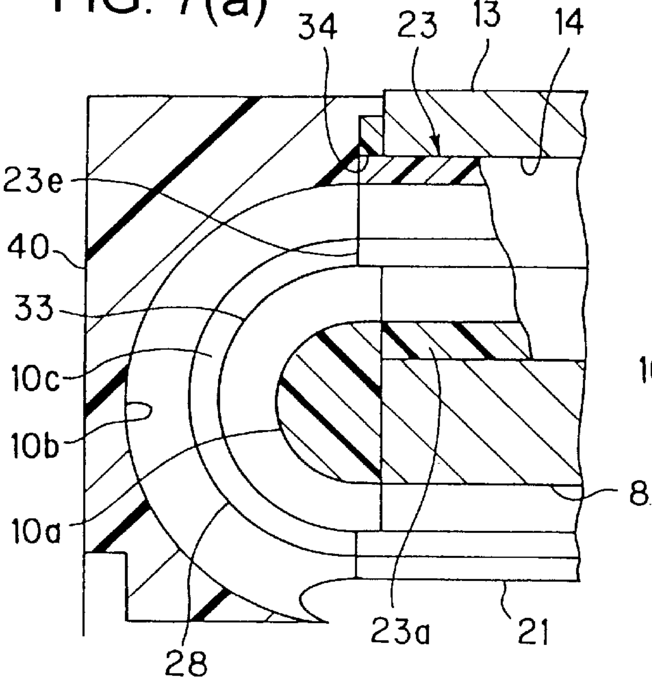


FIG. 7(b)

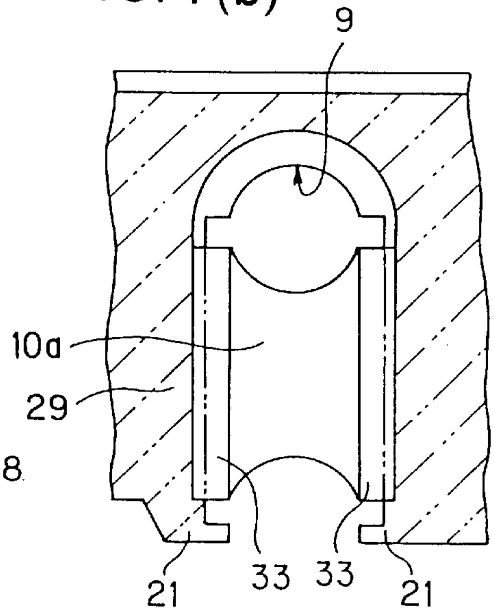


FIG. 7(c)

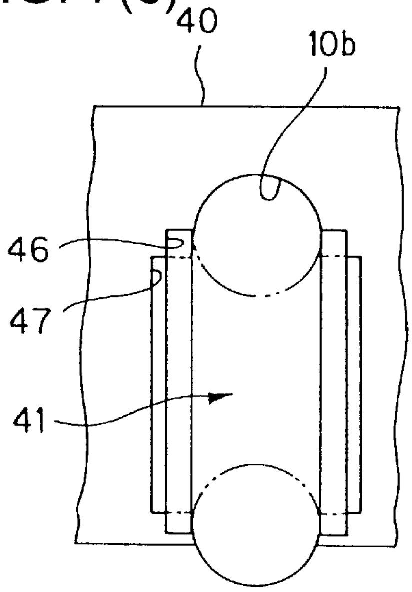


FIG. 7(e)

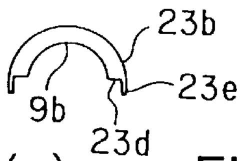


FIG. 7(d)

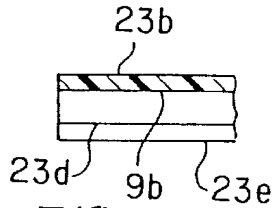


FIG. 7(g)

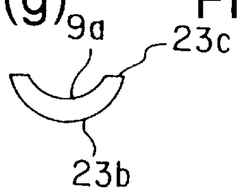
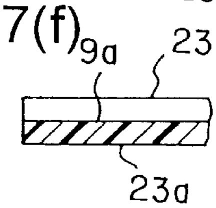


FIG. 7(f)



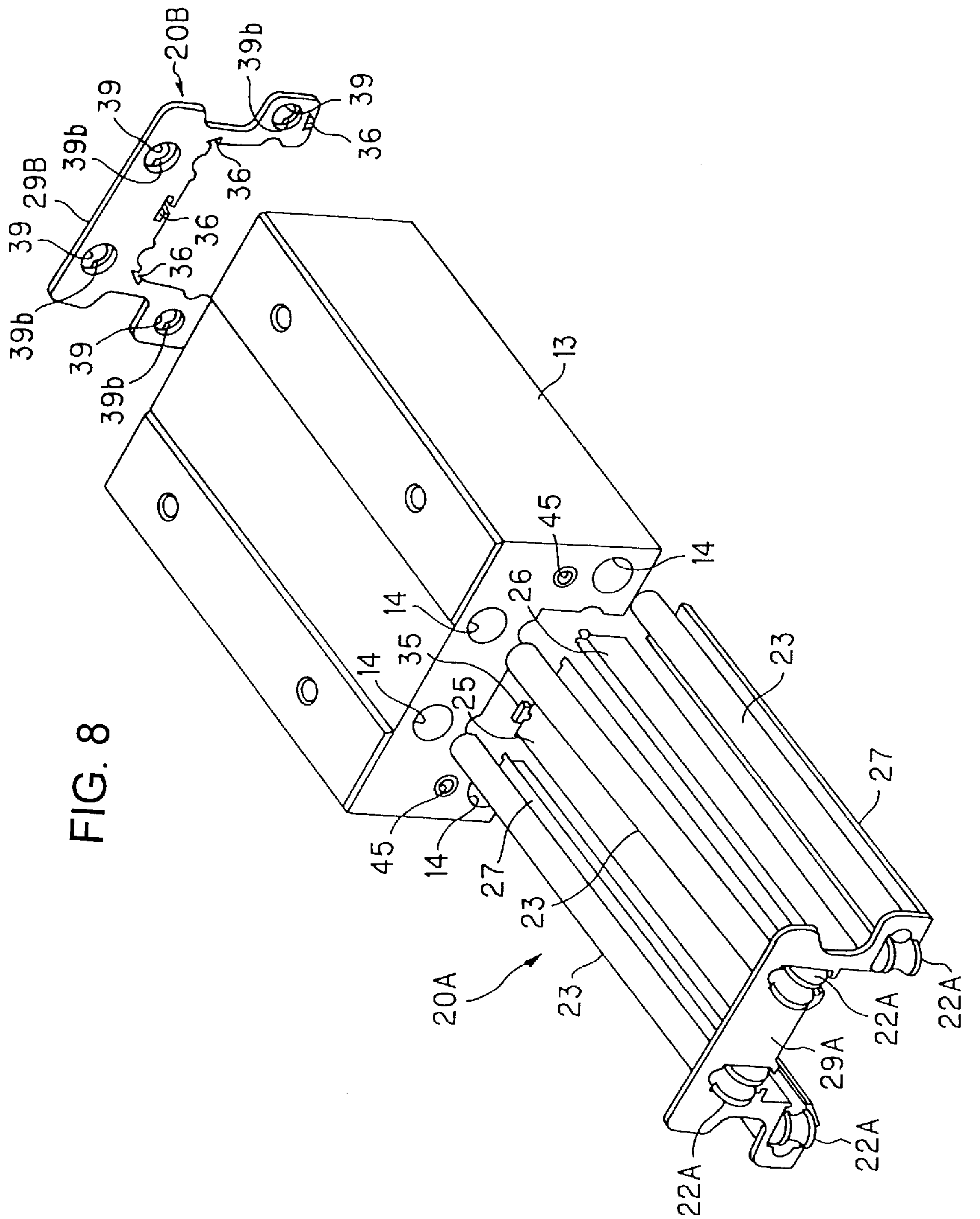

20B
39b
39
36
39
39b
29B
36
36
39
36
39b
39
39b
13
45
14
26
14
35
23
14
25
27
45
14
27
23
20A
23
22A
22A
29A
22A
22A
22A

FIG. 8

FIG. 9(a)

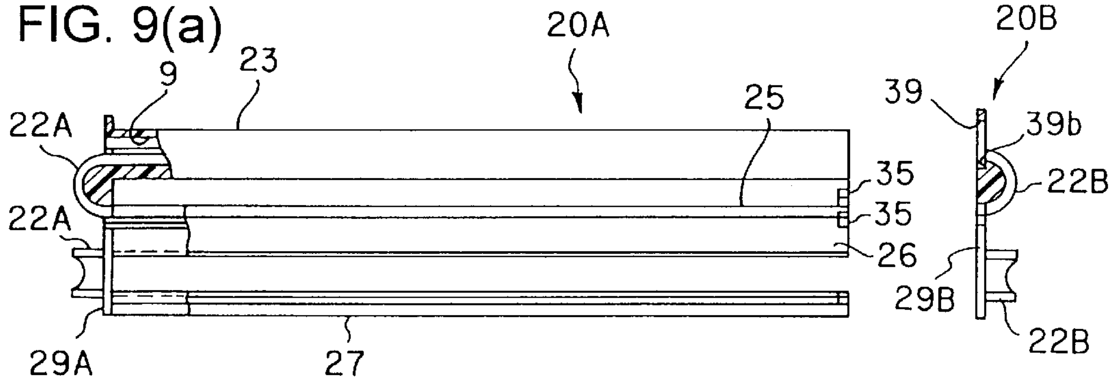


FIG. 9(b)

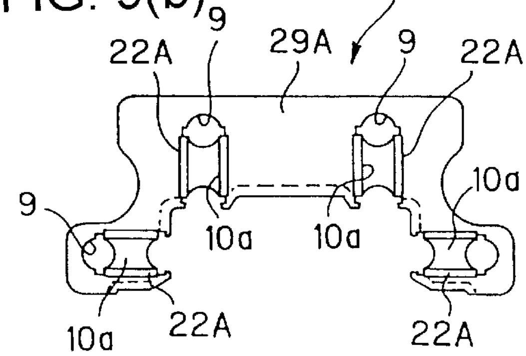


FIG. 9(c)

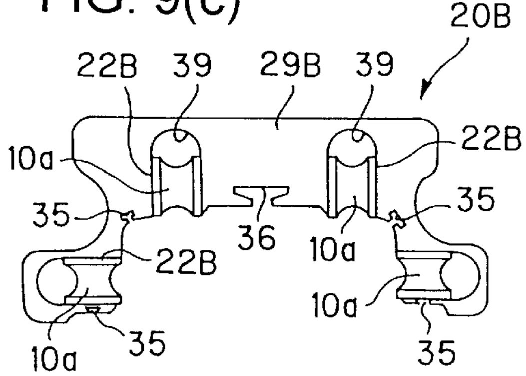


FIG. 9(d)

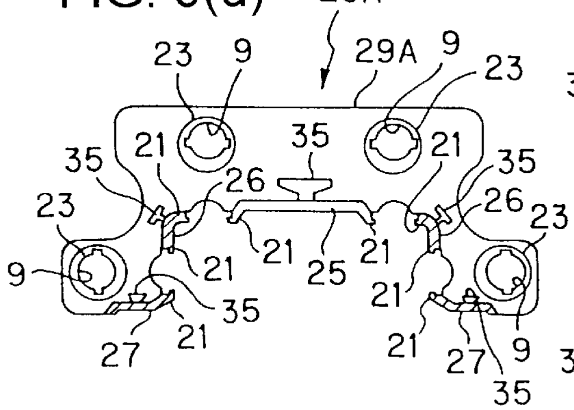
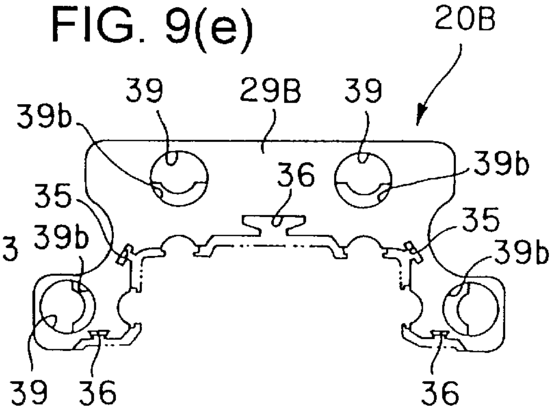
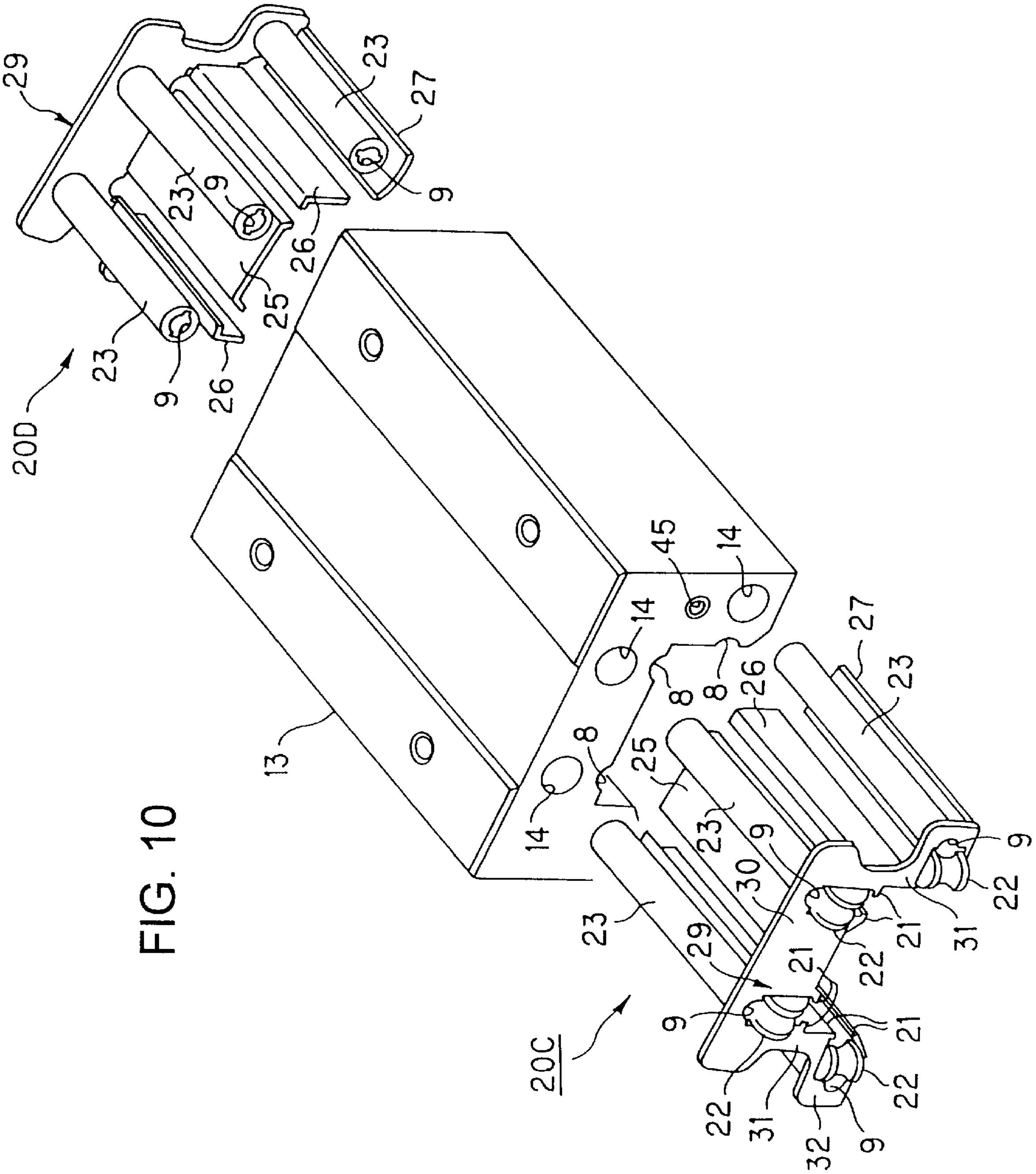


FIG. 9(e)





29
23
27
9
23
9
26
25
23
9
26
20D
13
45
14
14
8
8
8
27
23
26
25
23
14
9
9
30
23
22
21
31
29
22
21
21
21
9
20C
22
22
31
32
9

FIG. 10

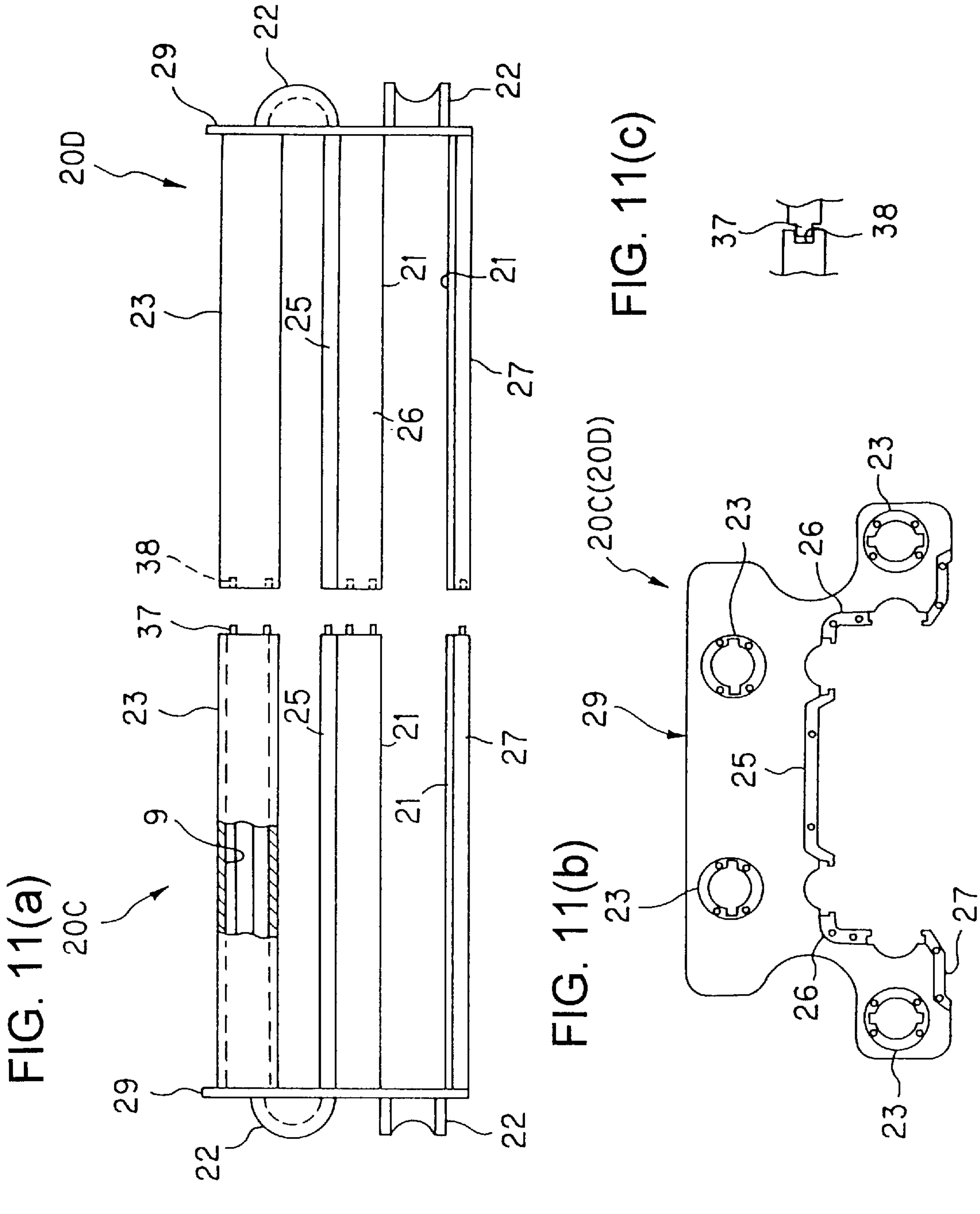


FIG. 11(a)

FIG. 11(b)

FIG. 11(c)

FIG. 12

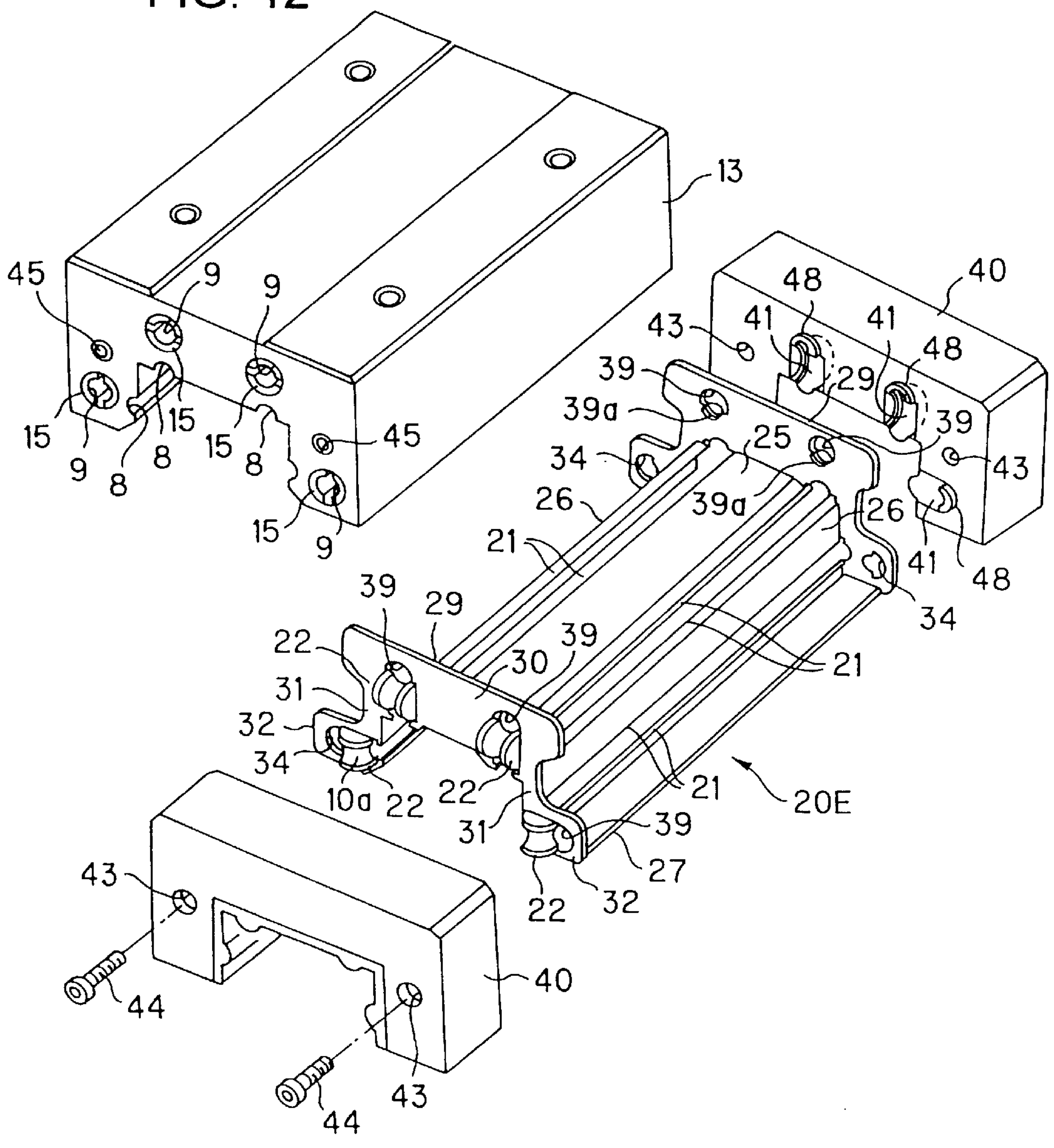

13
40
48
43
41
41
48
39
29
39a
39
43
34
25
26
39a
26
21
41
48
34
39
29
39
21
22
30
31
32
34
10a
22
22
21
20E
31
39
27
22
32
43
40
44
43
44
45
9
9
45
15
15
15
9
8
8
8
45
15
9
15
9

FIG. 13(a)

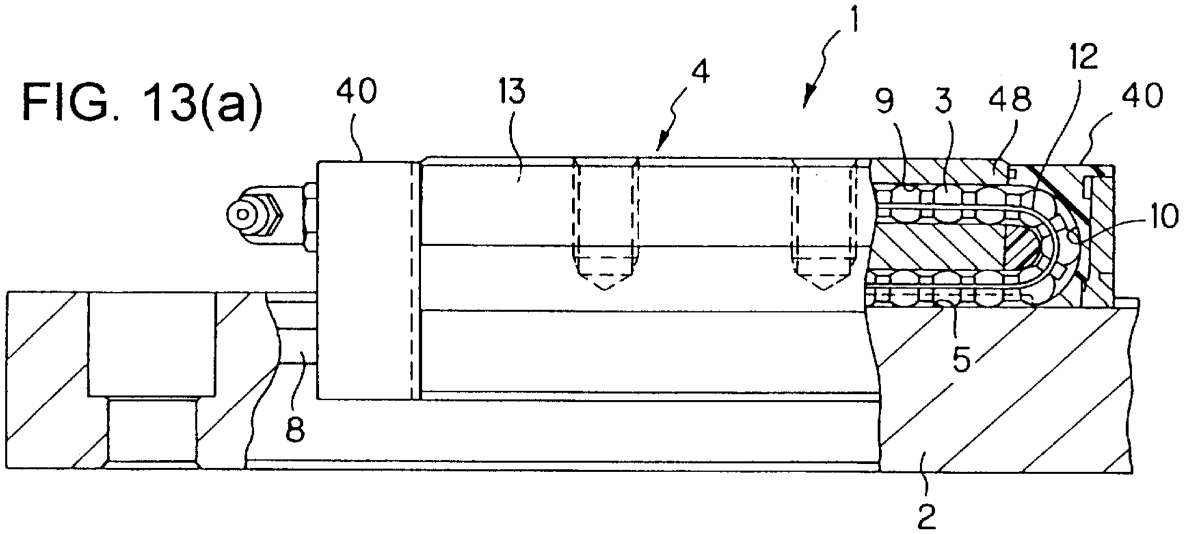


FIG. 13(b)

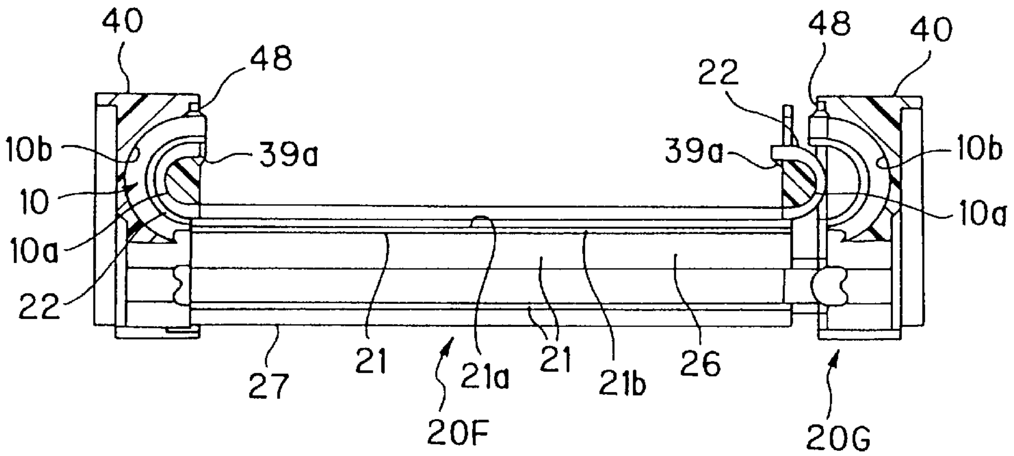


FIG. 14(a)

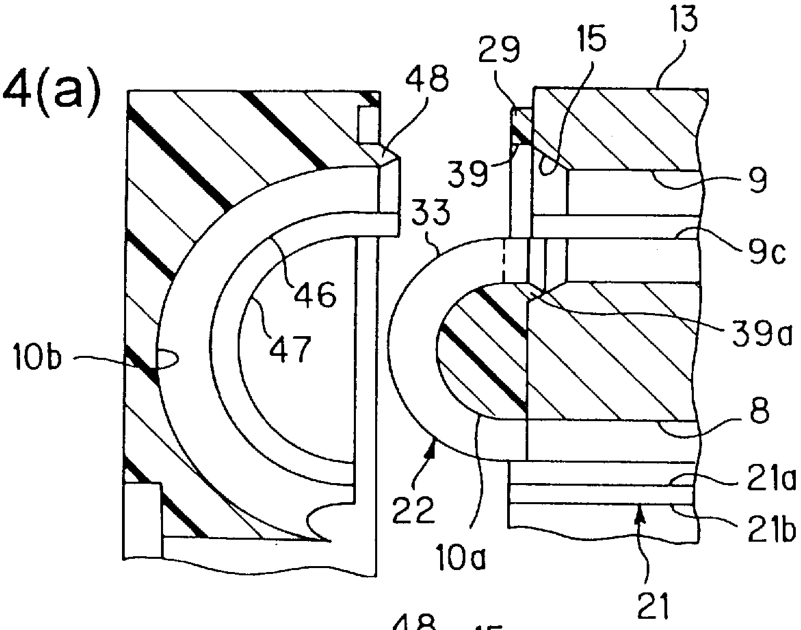


FIG. 14(b)

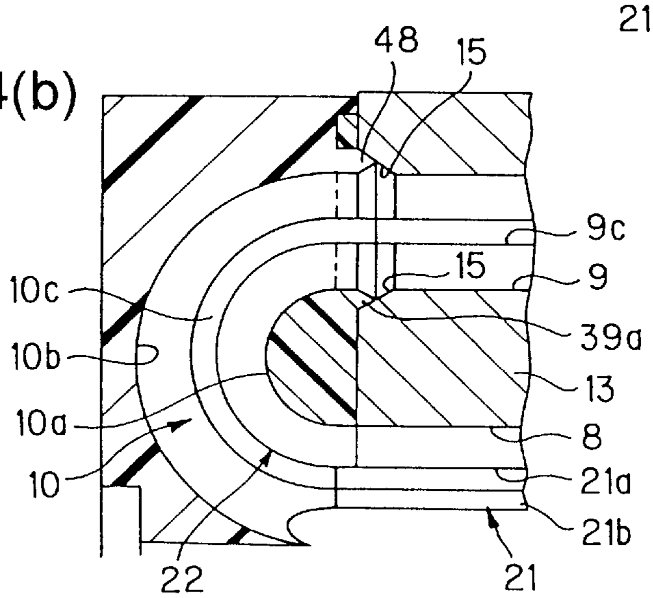


FIG. 14(c)

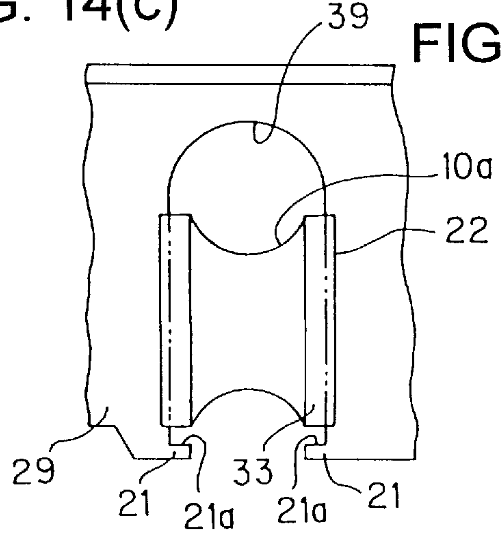


FIG. 14(d)

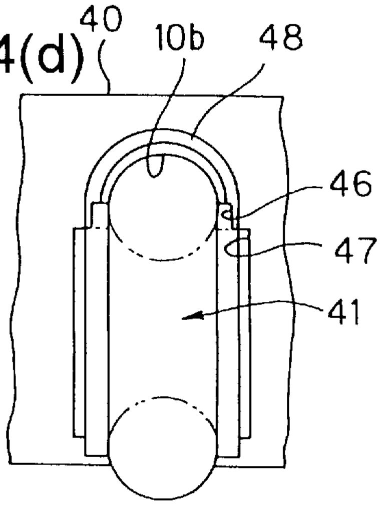


FIG. 15

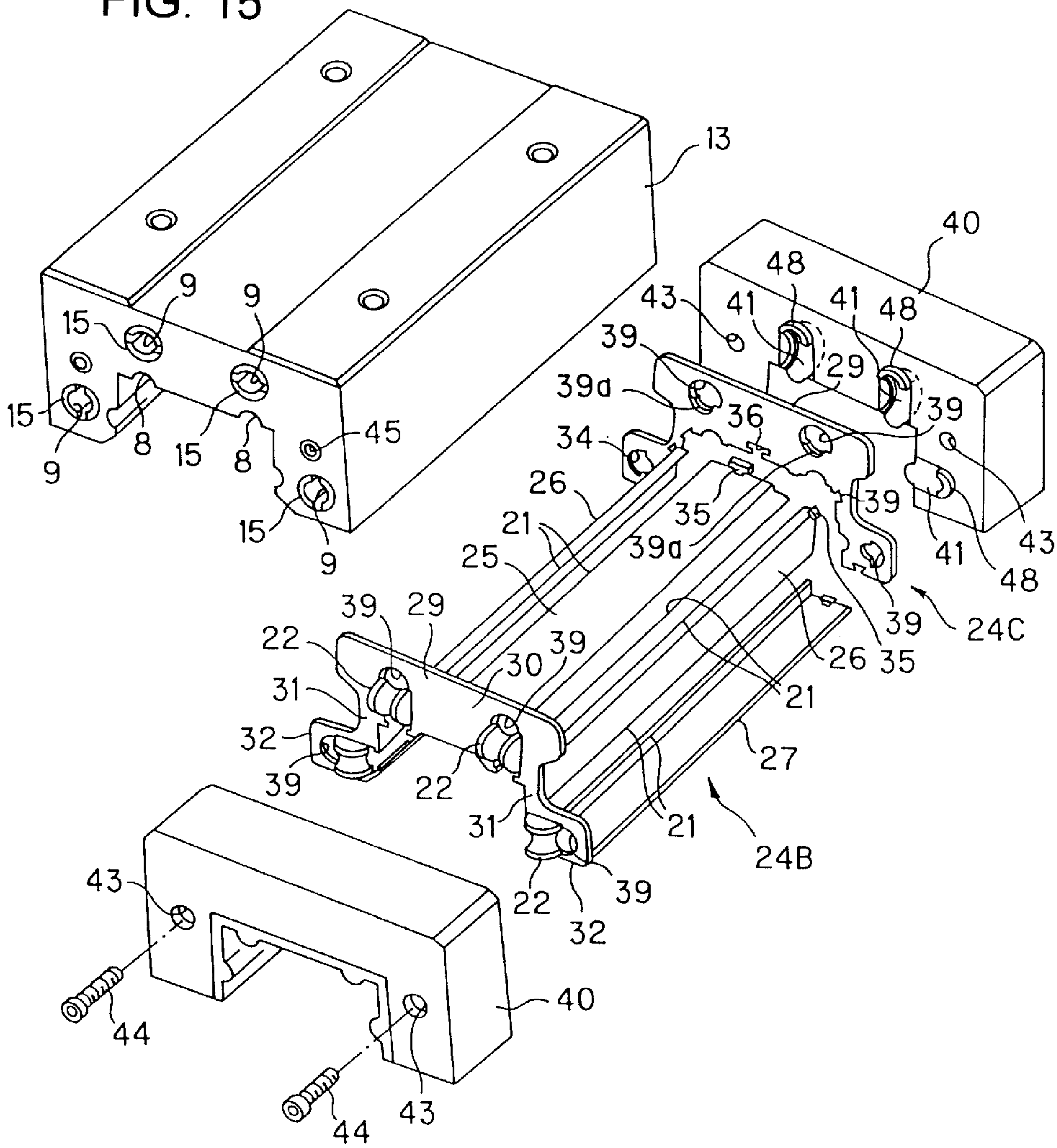

13
40
48
41
48
43
41
29
39
39a
36
39
34
35
39
43
26
35
41
48
21
39a
25
39
24C
39
29
26
35
22
39
30
21
31
32
27
39
22
31
21
24B
43
22
39
32
40
44
44
43
15
9
9
15
15
8
15
8
45
9
9
15
9

FIG. 16(a)

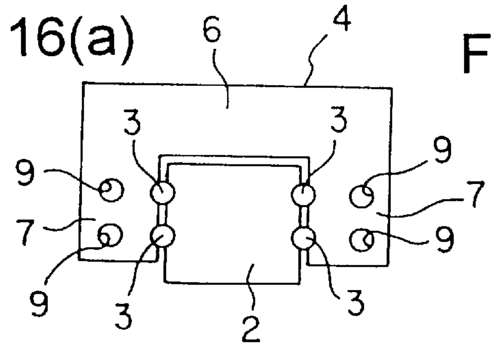


FIG. 16(b)

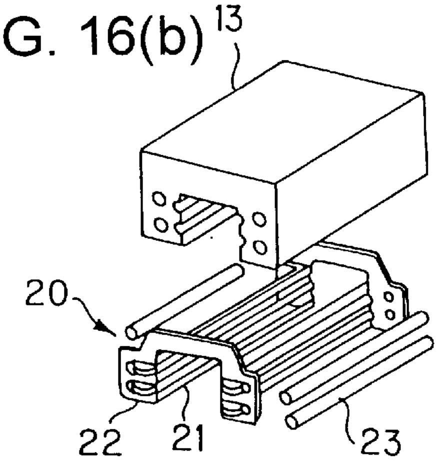


FIG. 16(c)

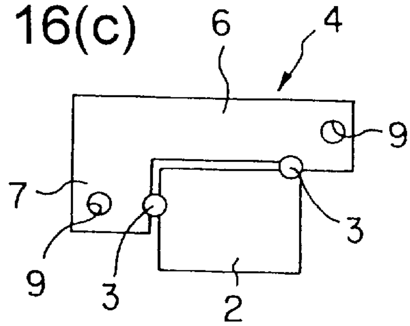


FIG. 16(d)

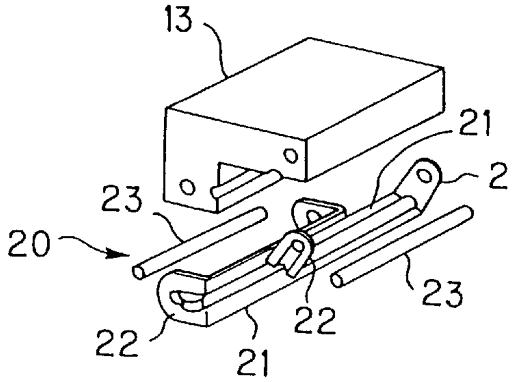


FIG. 16(e)

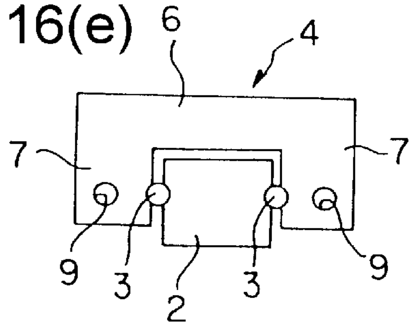


FIG. 16(f)

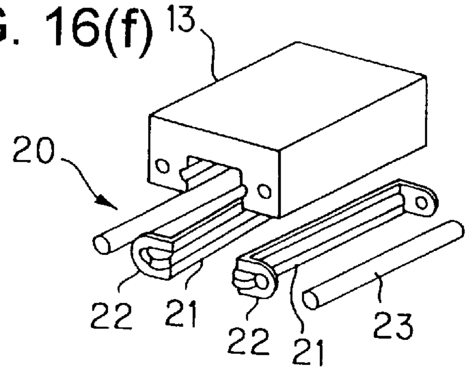


FIG. 16(g)

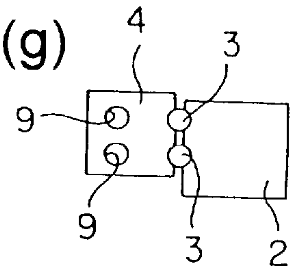


FIG. 16(h)

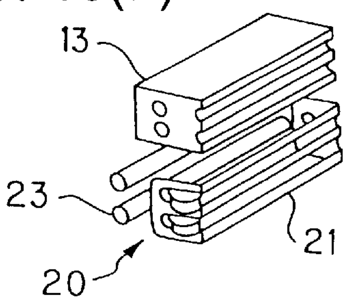


FIG. 17

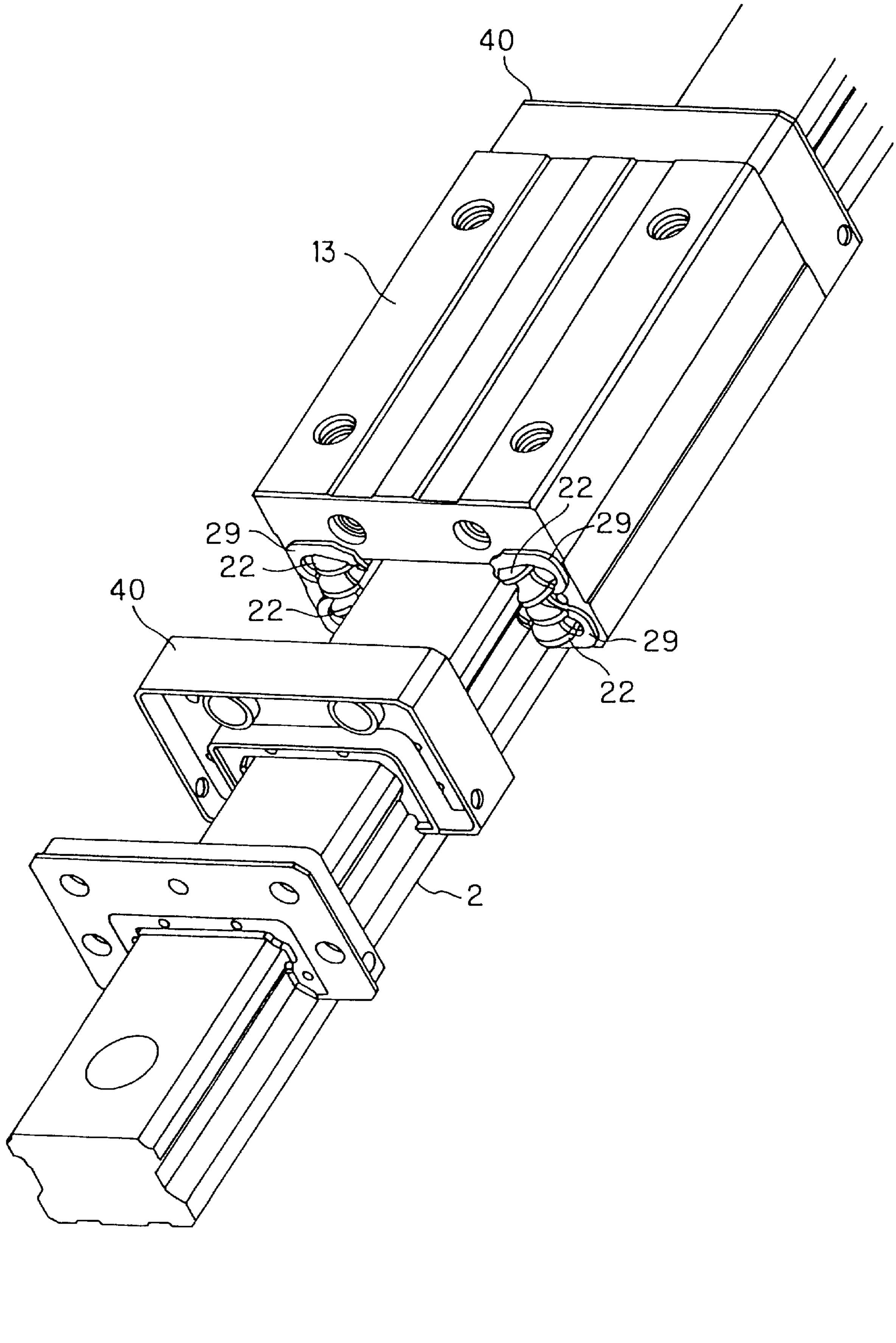


FIG. 18

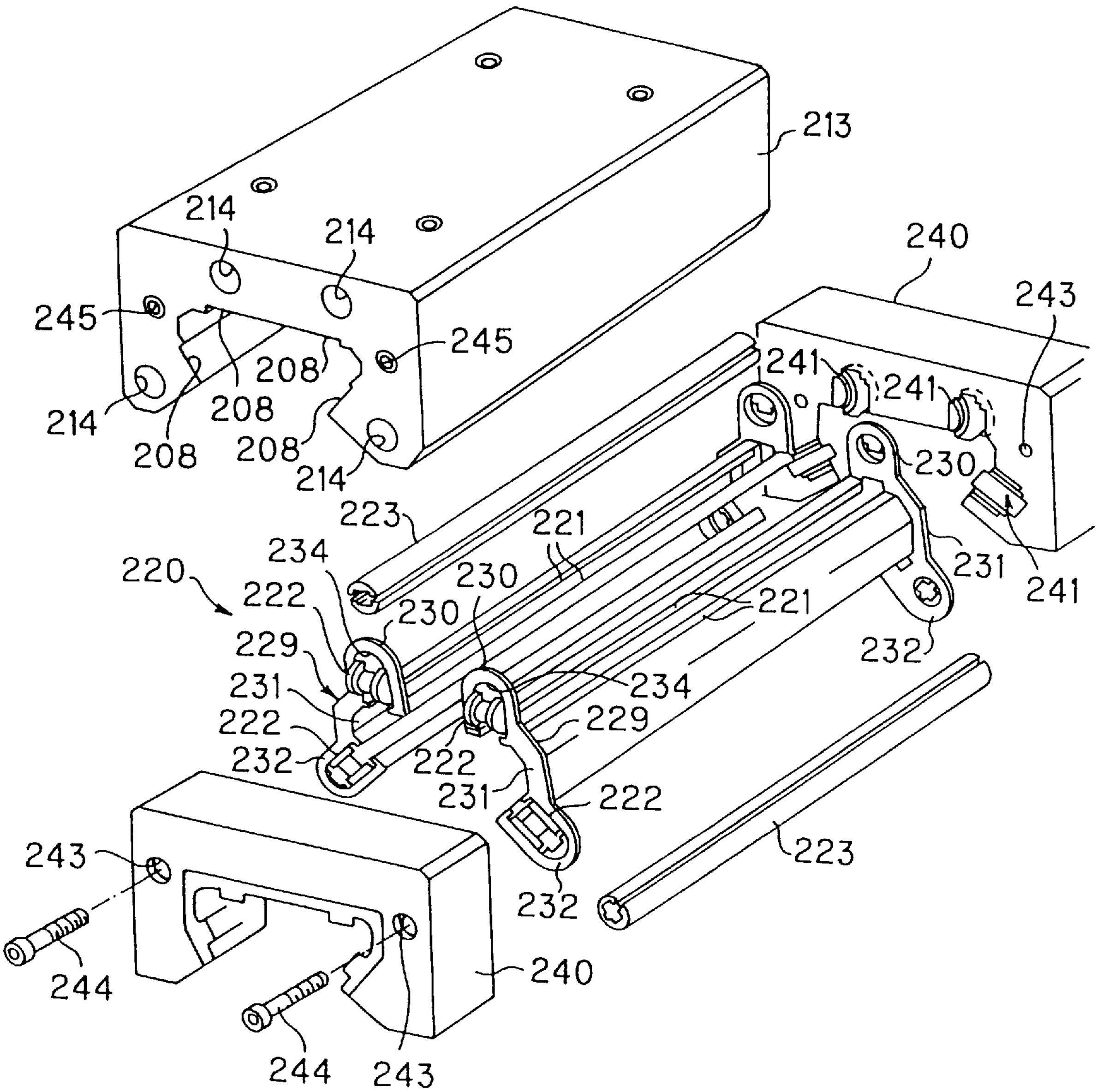

213
214
214
245
245
208
208
208
208
214
214
240
243
241
241
230
241
223
221
234
220
222
230
229
231
222
232
230
221
232
234
229
222
231
222
243
223
232
244
240
244
243

FIG. 19(a)

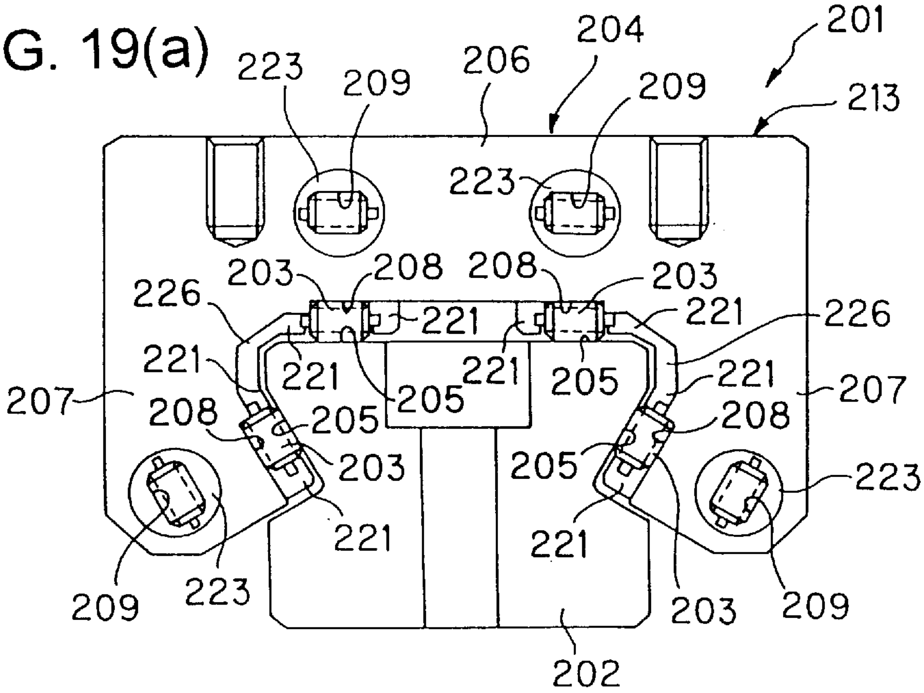


FIG. 19(b)

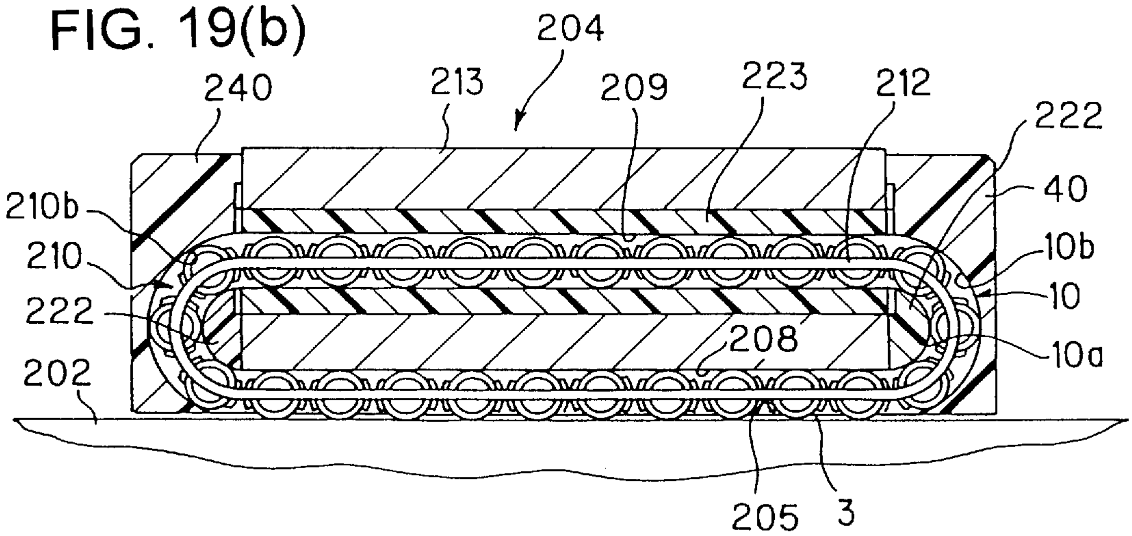


FIG. 19(c)

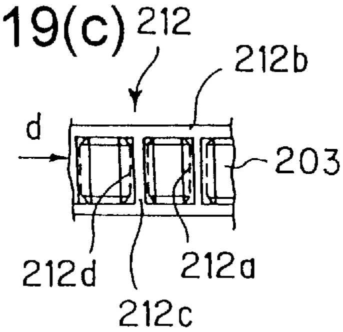
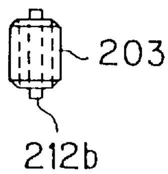


FIG. 19(d)



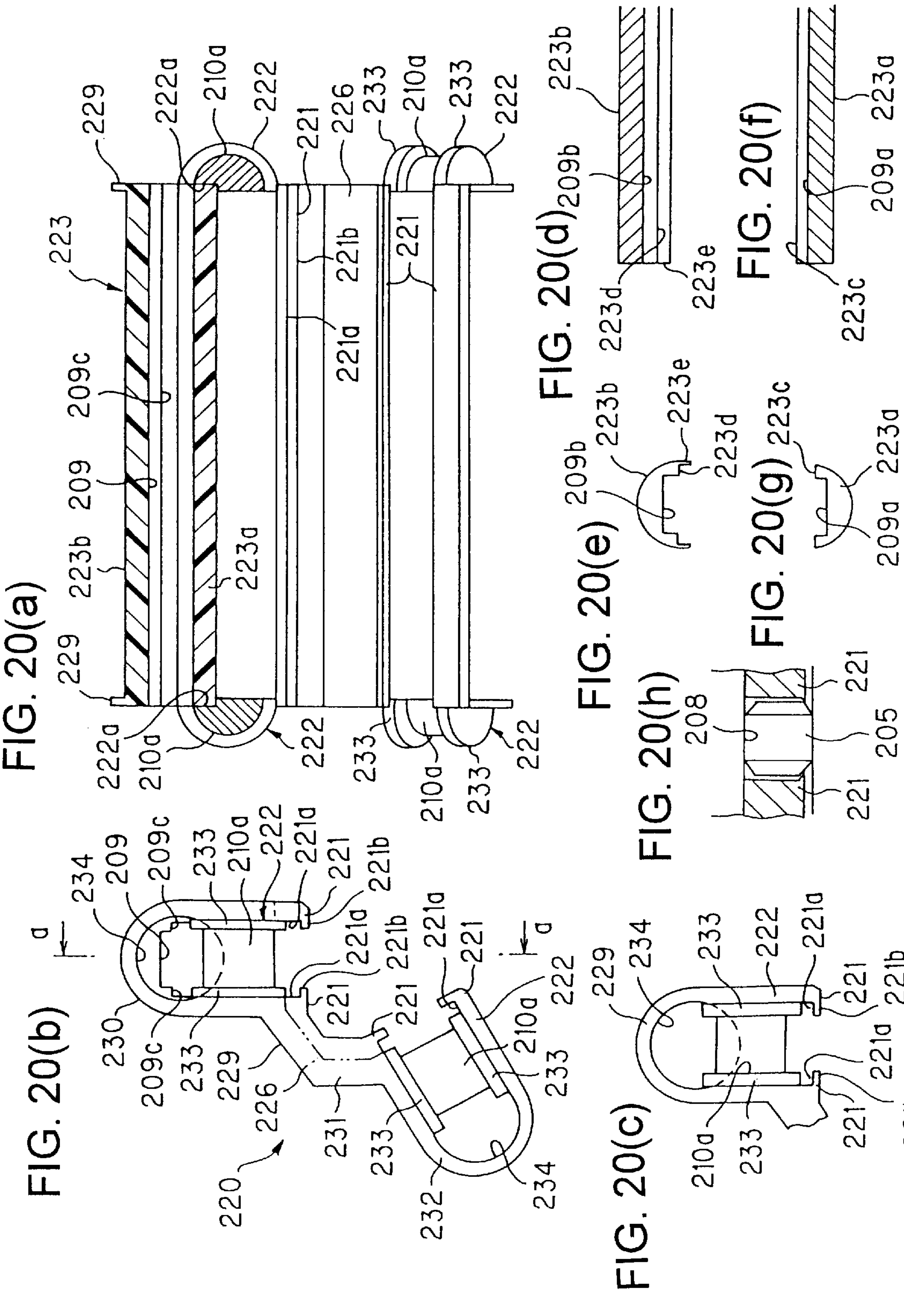


FIG. 20(a)

FIG. 20(b)

FIG. 20(c)

FIG. 20(d)

FIG. 20(e)

FIG. 20(f)

FIG. 20(g)

FIG. 20(h)

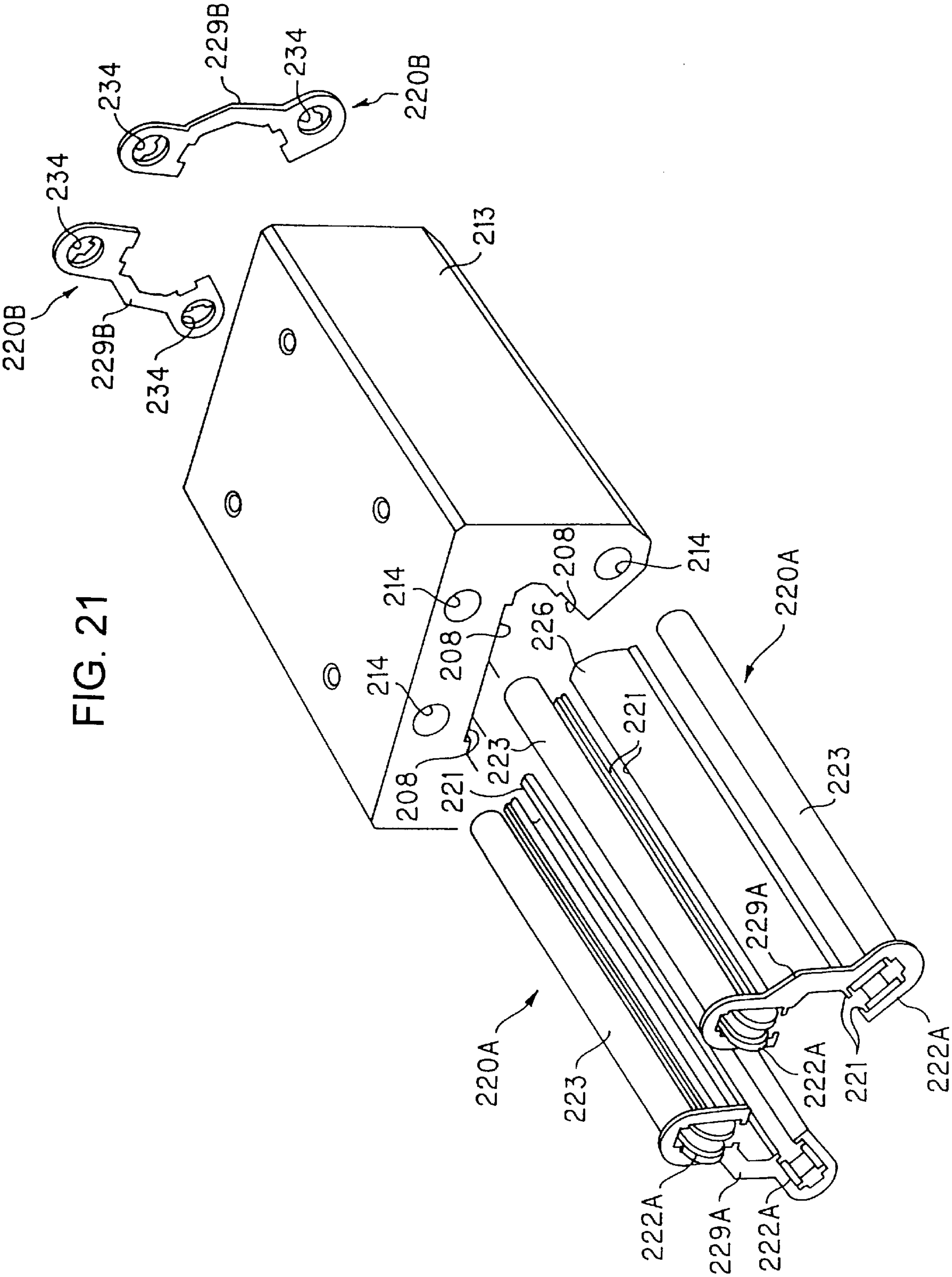


FIG. 21

FIG. 22(a)

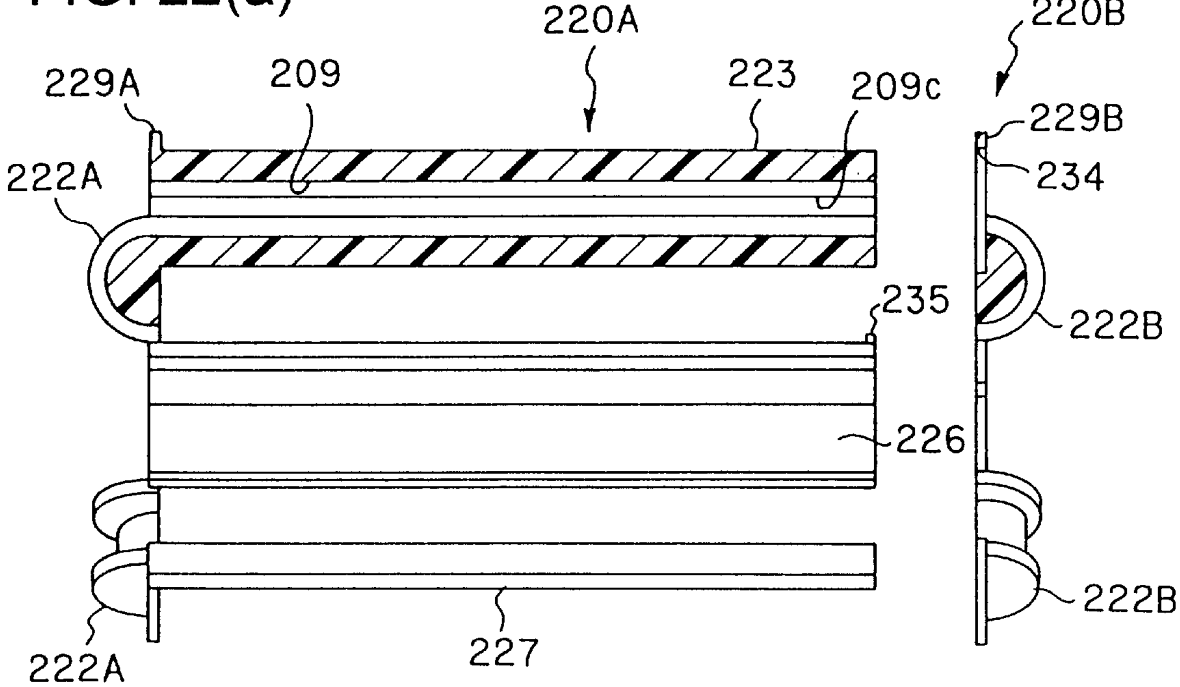


FIG. 22(b)

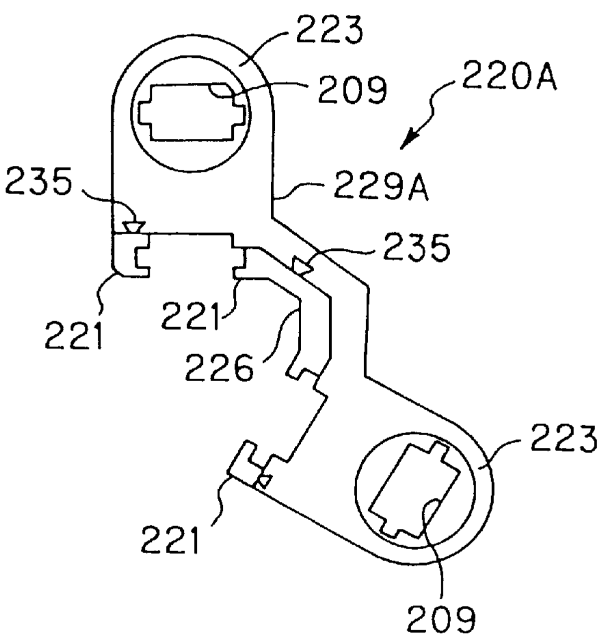
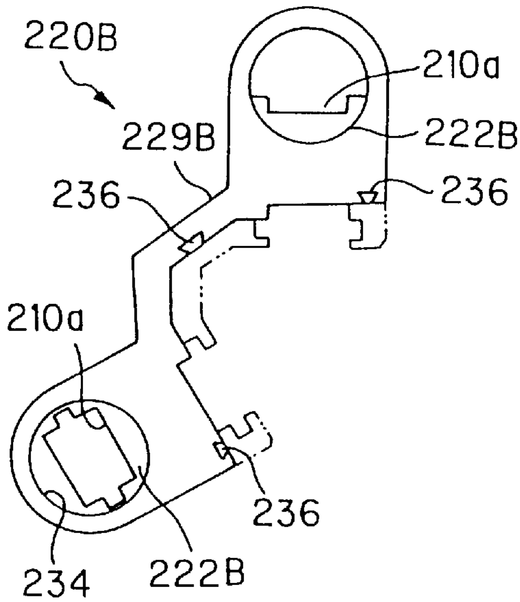


FIG. 22(c)



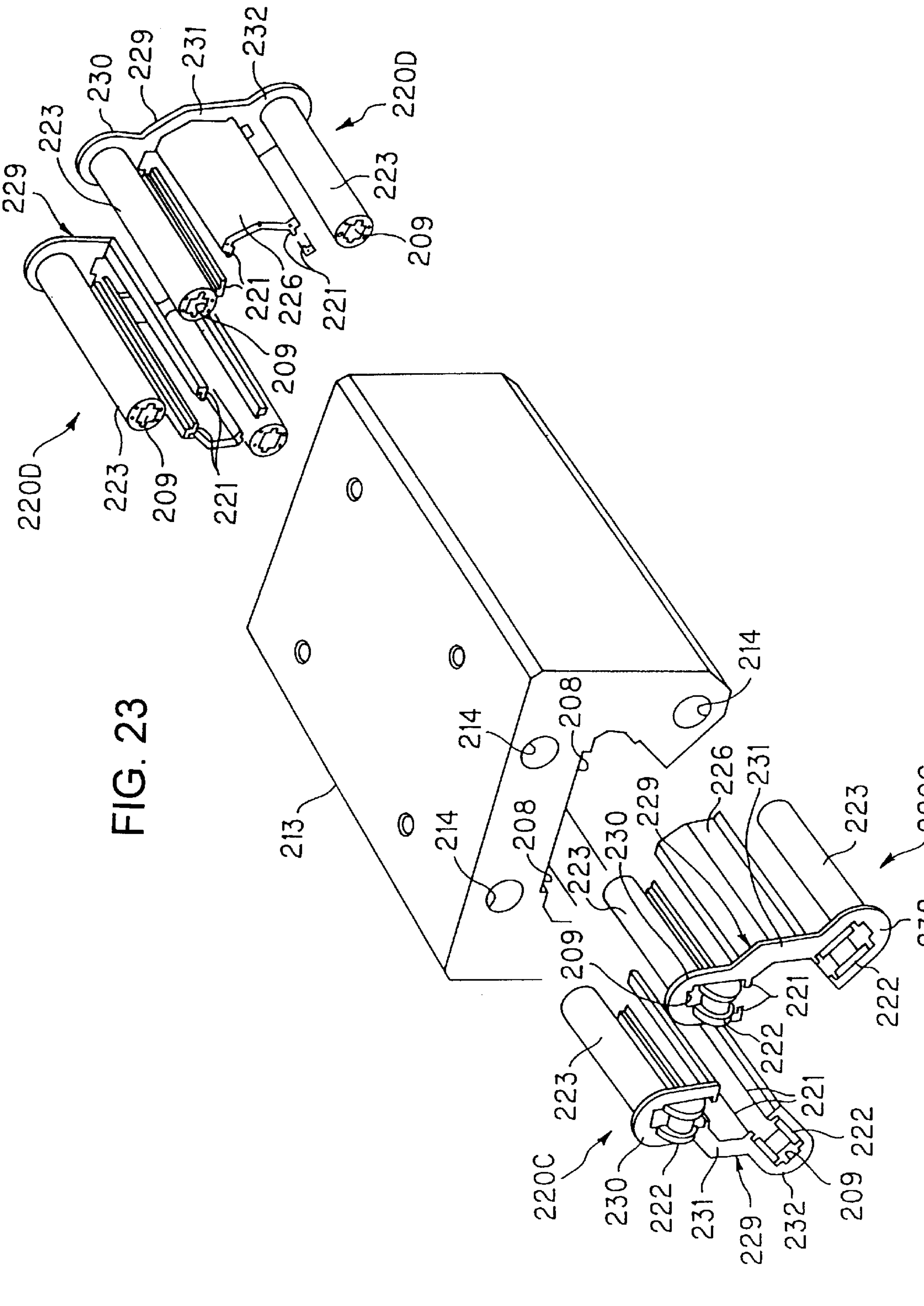

220D
223
209
221
229
223
230
229
231
232
220D
223
209
221
226
221
209
213
214
208
214
208
214
223
230
229
226
231
223
220C
232
222
221
222
209
223
220C
230
222
231
229
232
209
221
222

FIG. 23

FIG. 24(a)

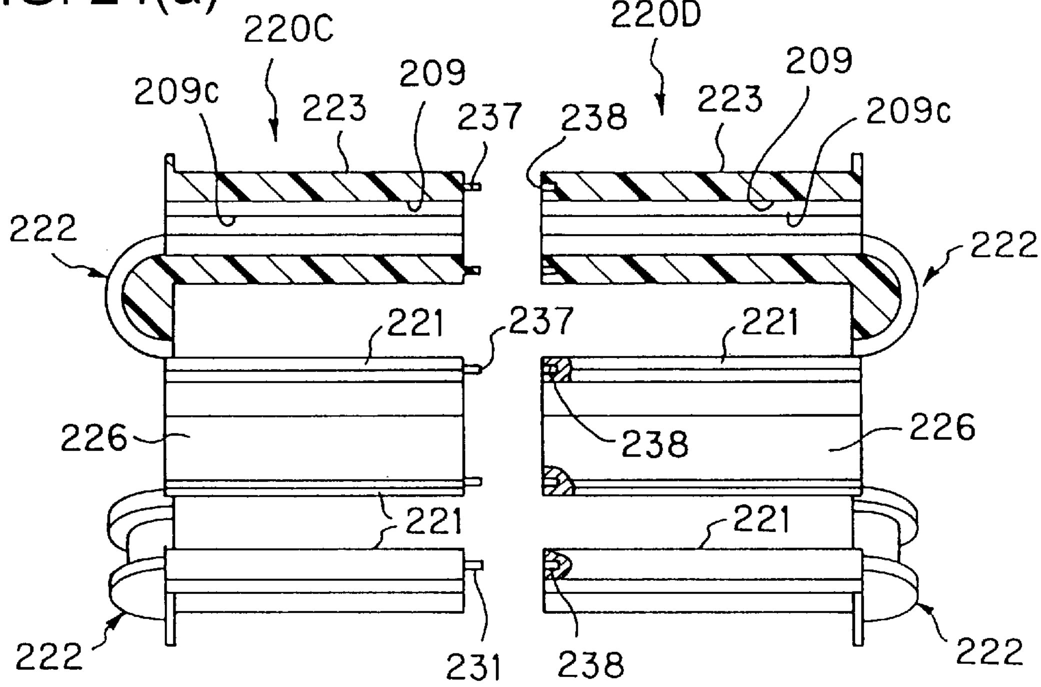


FIG. 24(b)

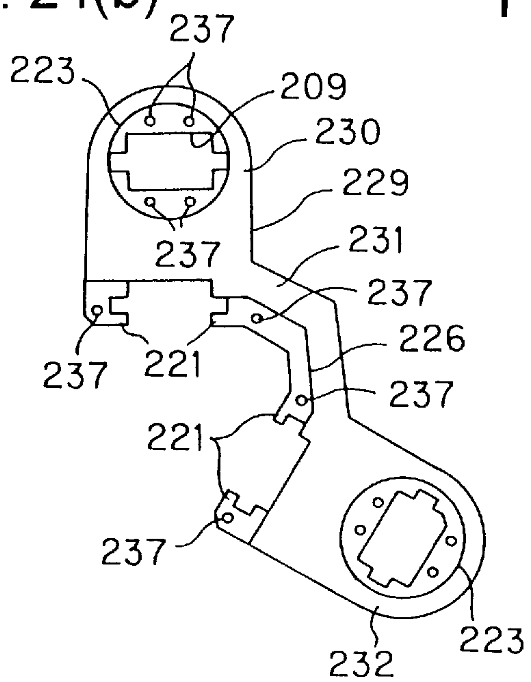


FIG. 24(c)

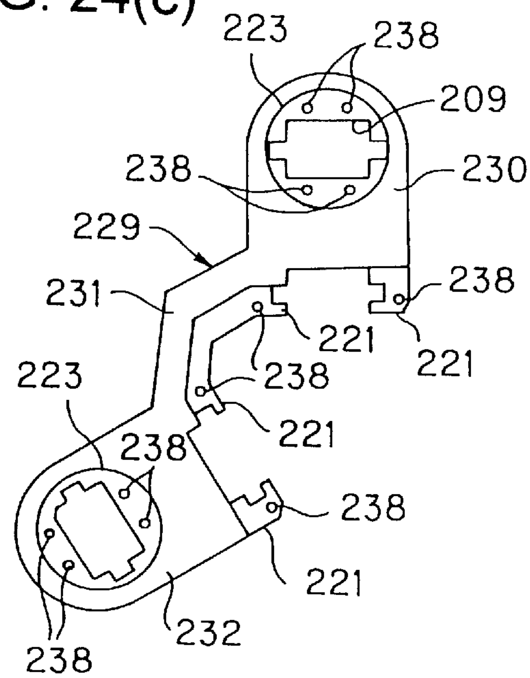
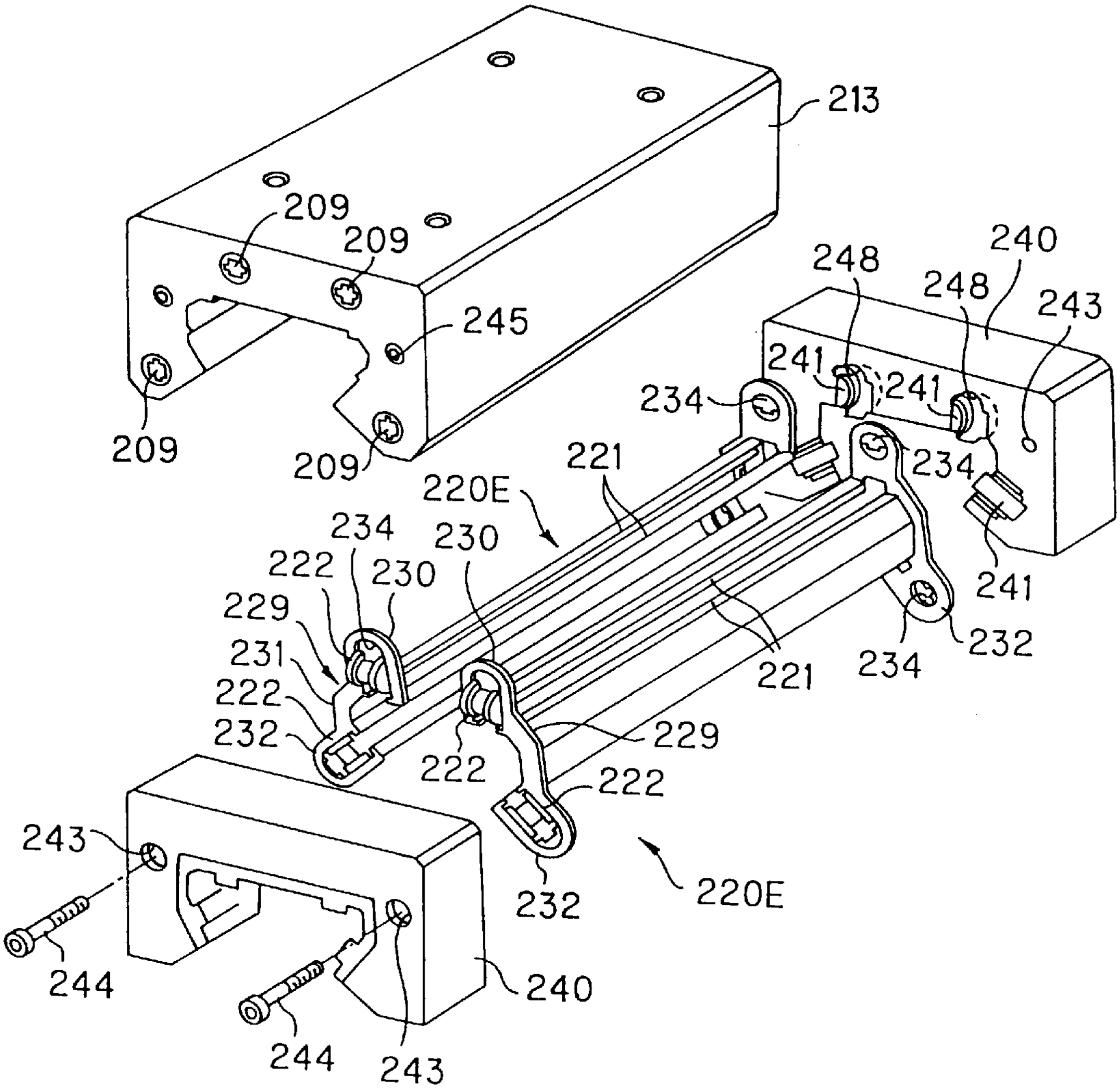


FIG. 25


213
209
209
209
209
245
248
248
240
243
241
241
234
234
241
221
220E
234
230
222
230
229
231
222
232
232
234
221
229
222
222
232
220E
243
244
244
243
240

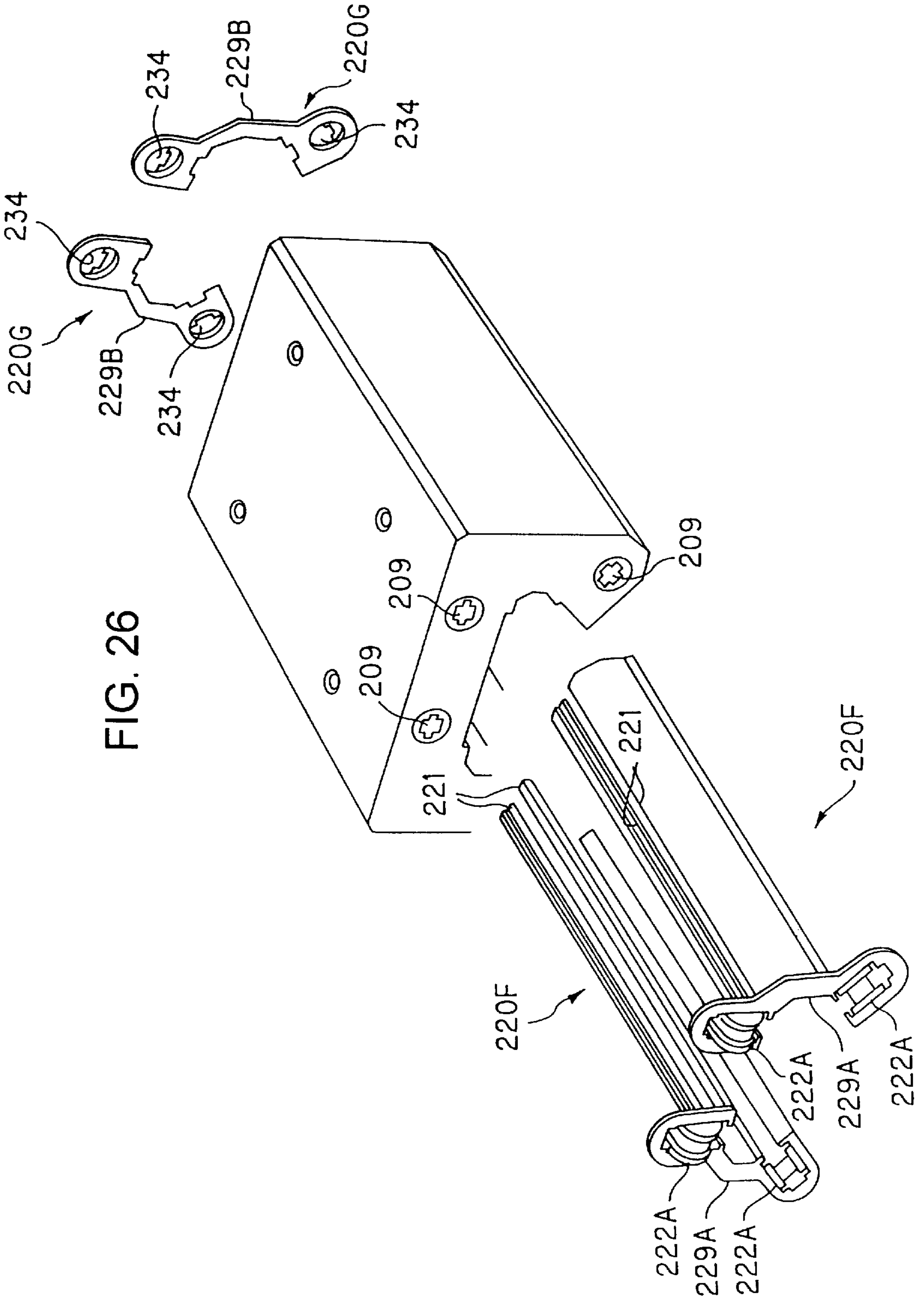
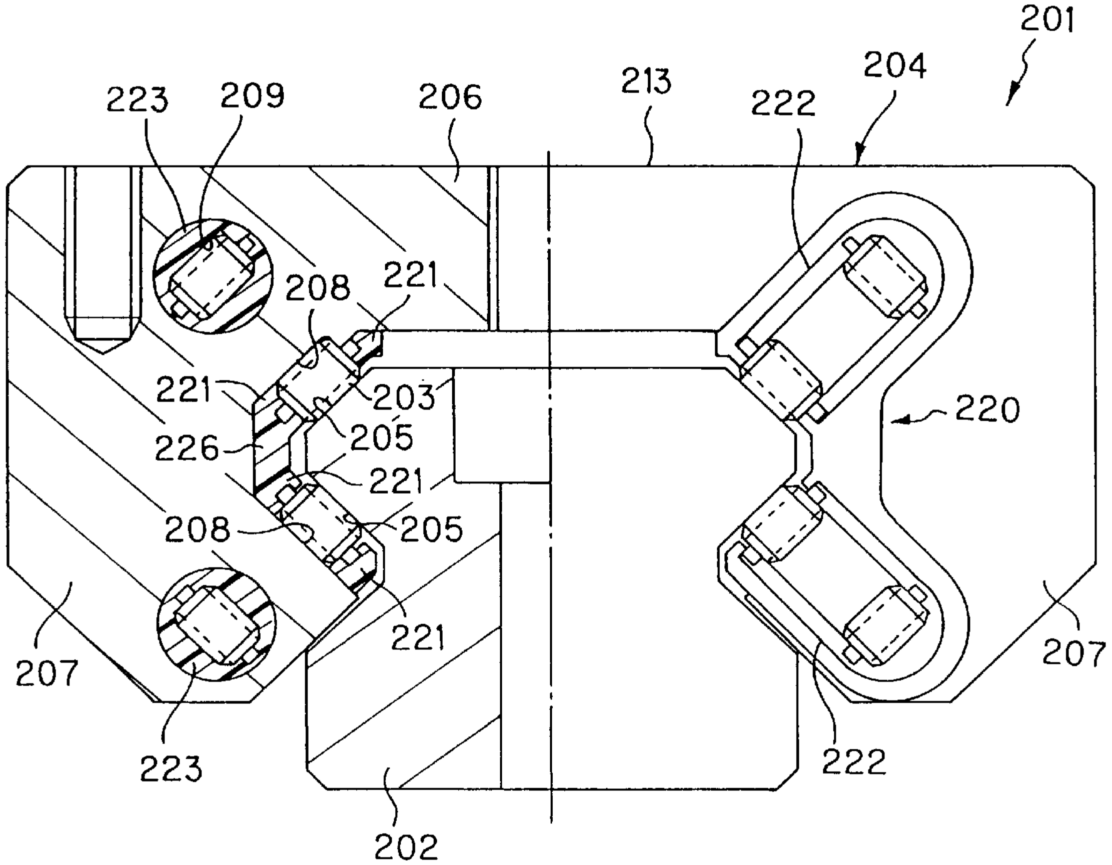

234
229B
220G
234
234
220G
229B
234
209
209
209
221
221
220F
220F
222A
229A
222A
222A
229A
222A

FIG. 26

FIG. 27



201
204
213
206
209
223
222
221
208
221
203
205
226
221
208
205
220
221
207
207
223
222
202

FIG. 28

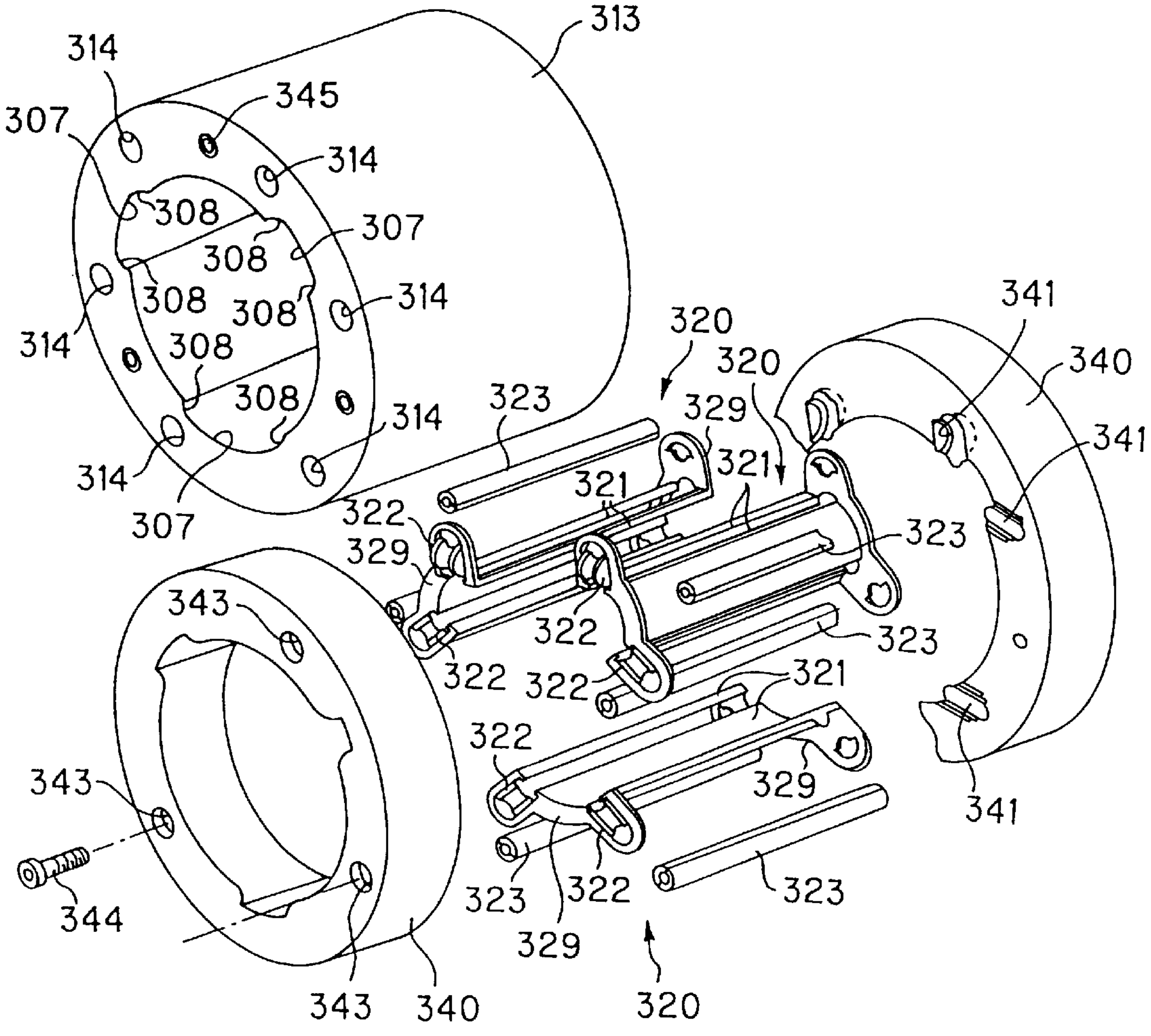

313
314
345
307
314
308
308
307
308
314
308
314
308
314
308
314
307
320
320
323
329
321
321
341
340
341
322
329
323
343
322
323
322
322
321
322
329
343
344
323
322
323
341
329
343
340
320

FIG. 29(a)

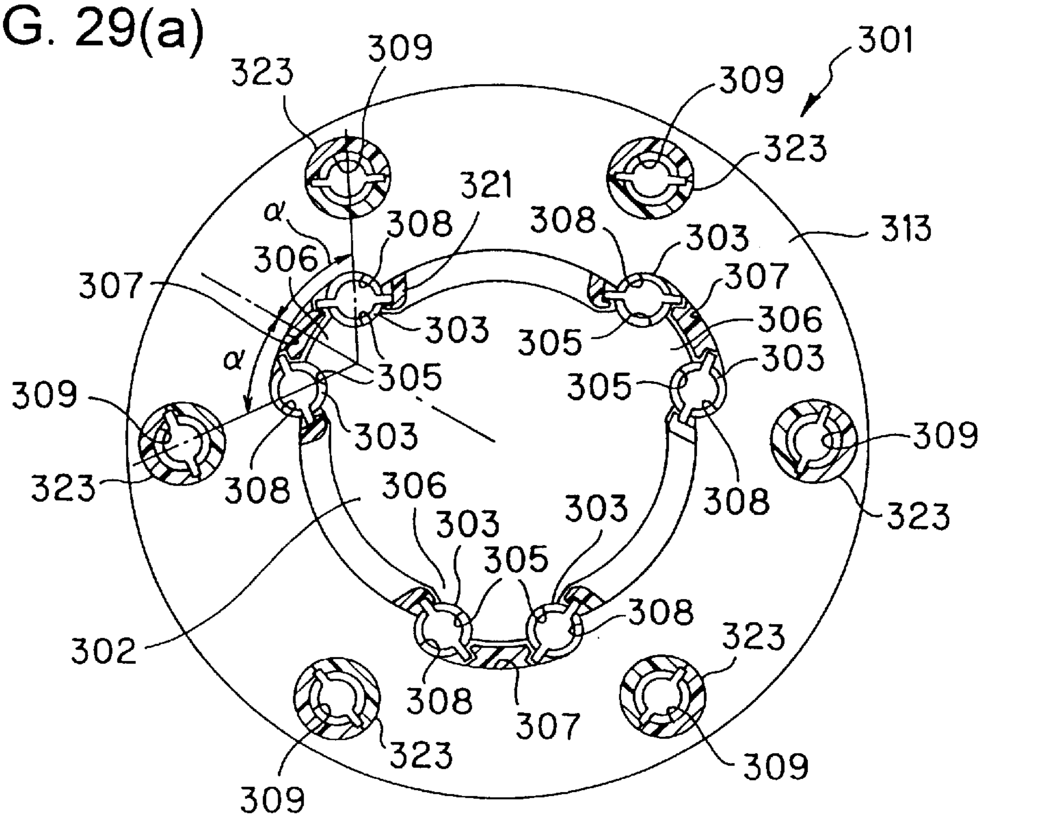


FIG. 29(b)

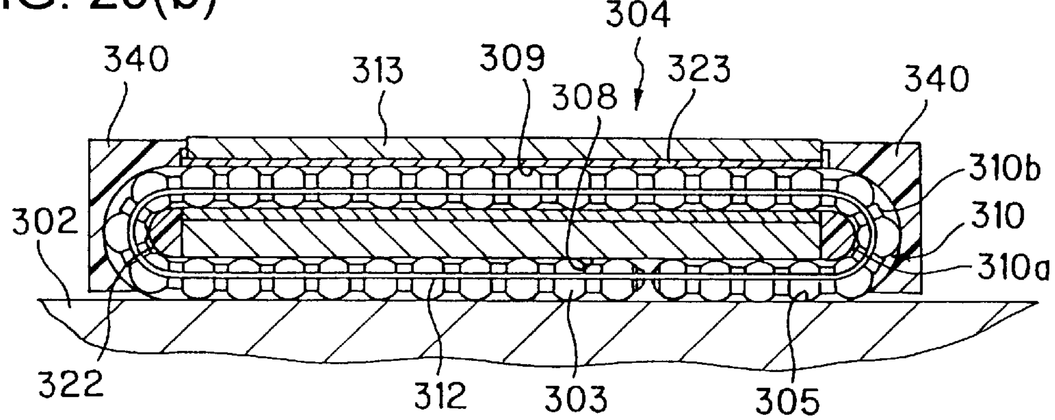
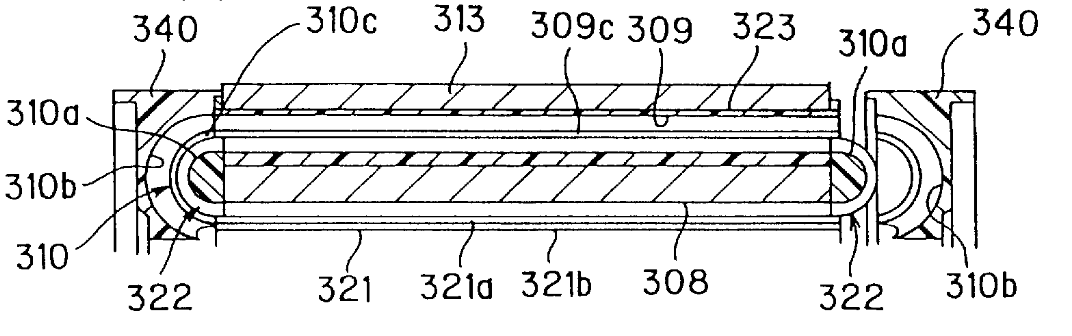


FIG. 29(c)



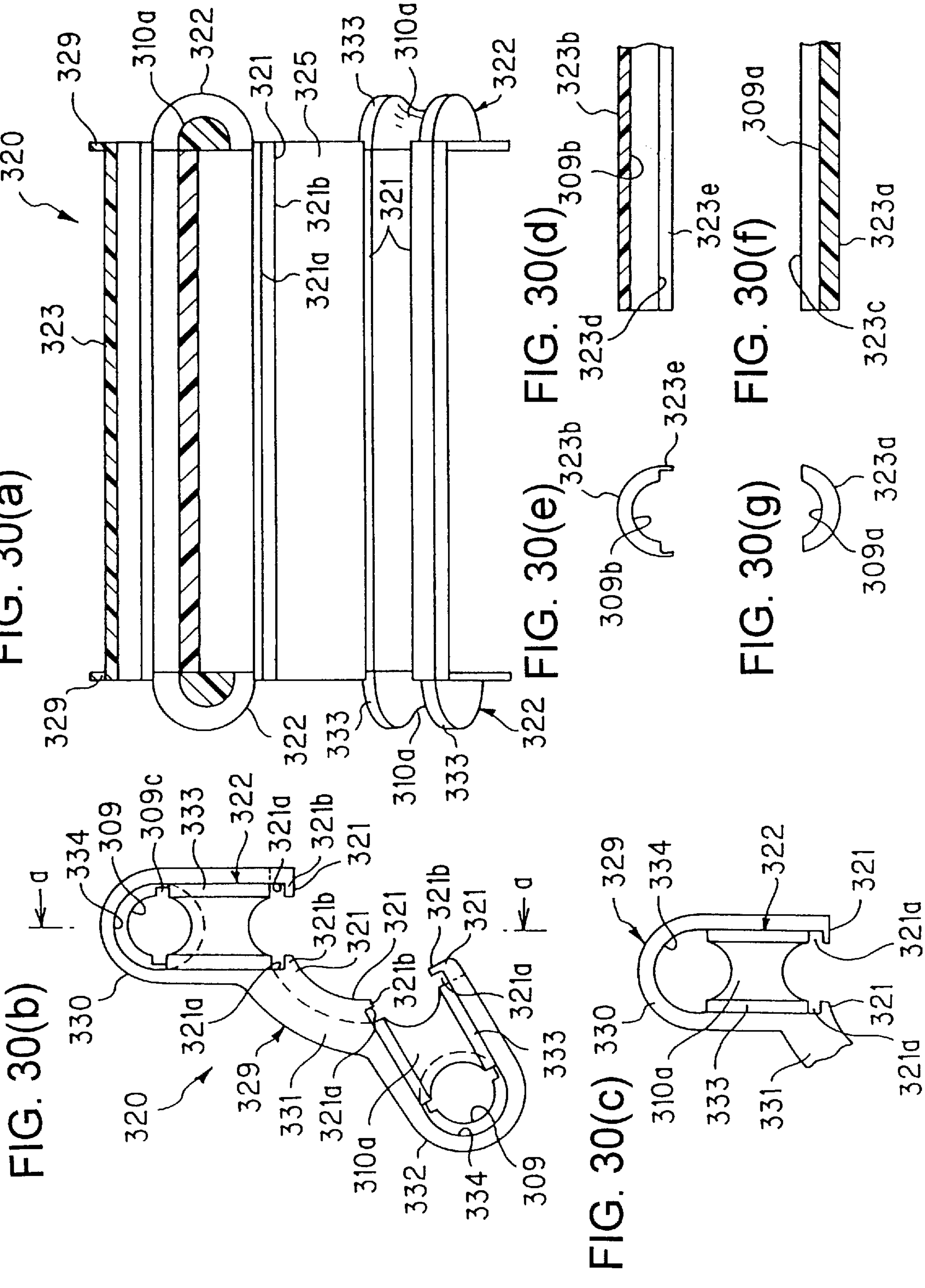


FIG. 30(a)

FIG. 30(b)

FIG. 30(c)

FIG. 30(d)

FIG. 30(e)

FIG. 30(f)

FIG. 30(g)

FIG. 31

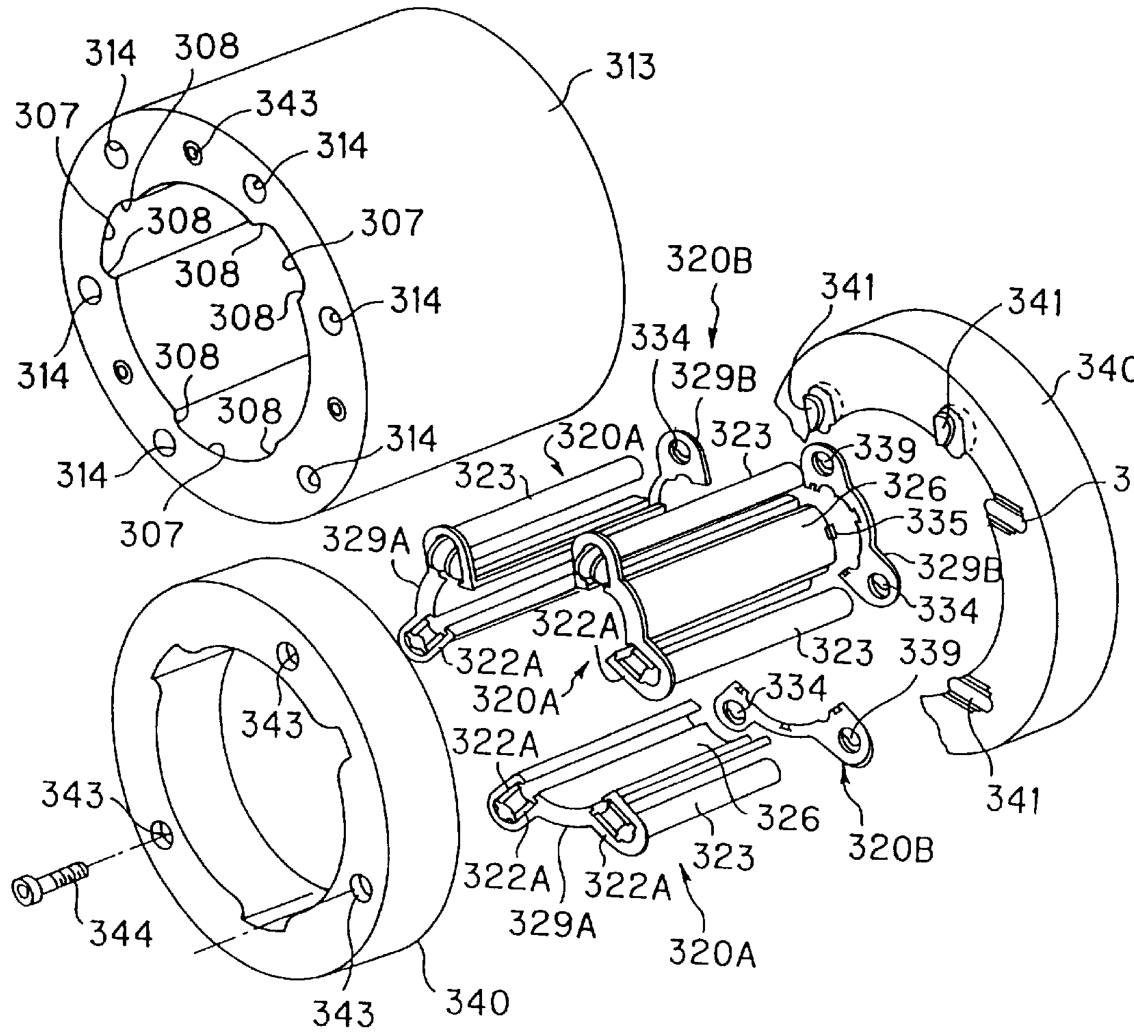

314
308
313
307
343
314
308
307
308
320B
308
314
341
341
314
308
334
340
308
329B
314
308
320A
323
339
314
323
326
341
307
329A
335
329B
322A
334
322A
323
339
320A
334
343
322A
343
326
341
320B
344
322A
322A
323
329A
320A
343
340

FIG. 32(a)

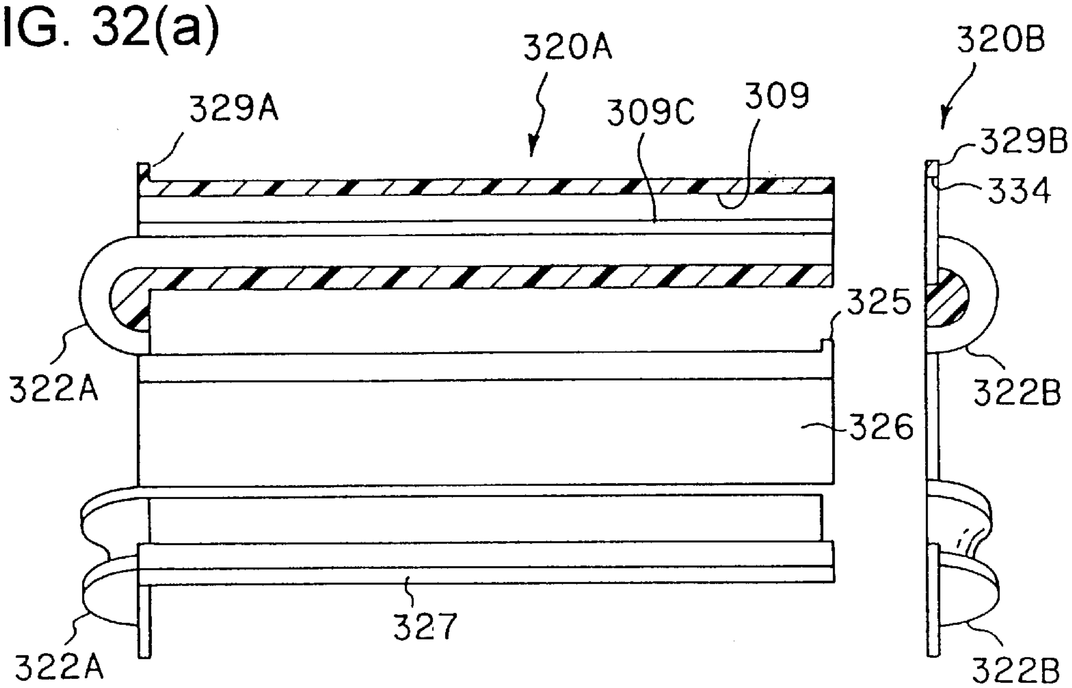


FIG. 32(b)

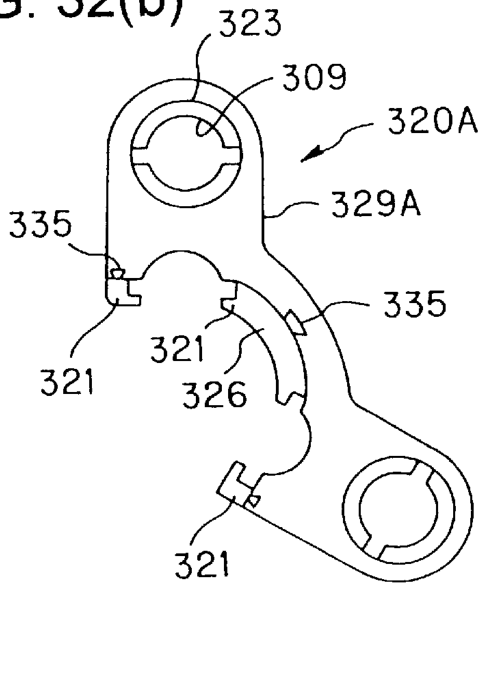


FIG. 32(c)

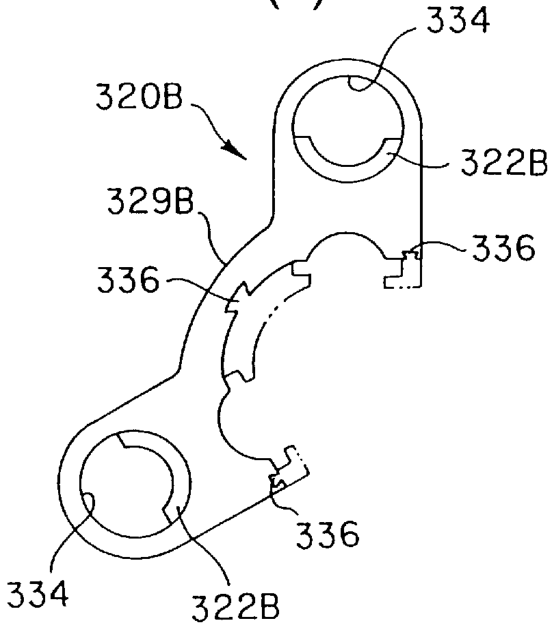


FIG. 33

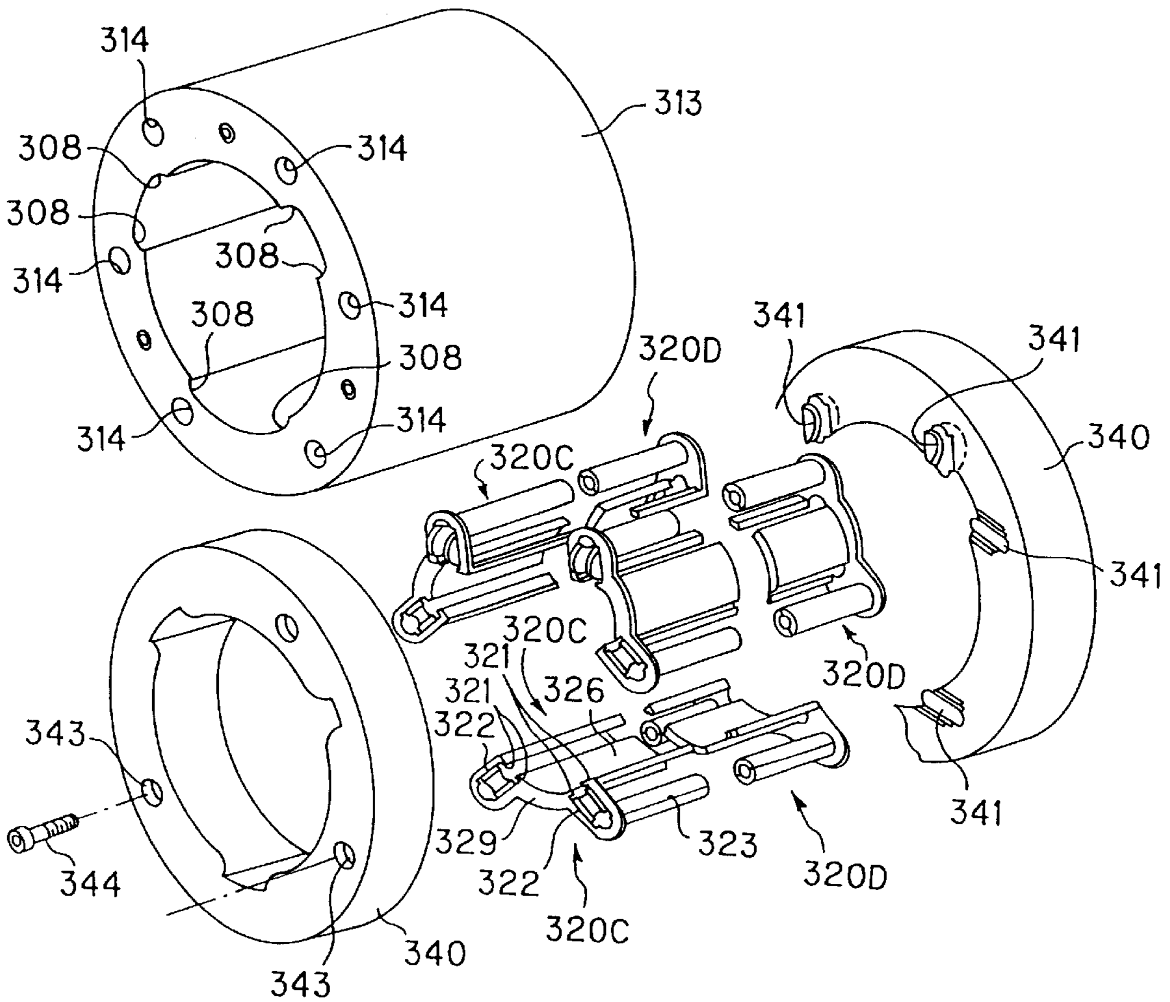

314
308
314
313
308
308
314
314
308
341
308
320D
341
314
314
340
320C
341
320C
321
320D
321
326
343
322
341
344
329
322
323
320D
320C
340
343

FIG. 34(a)

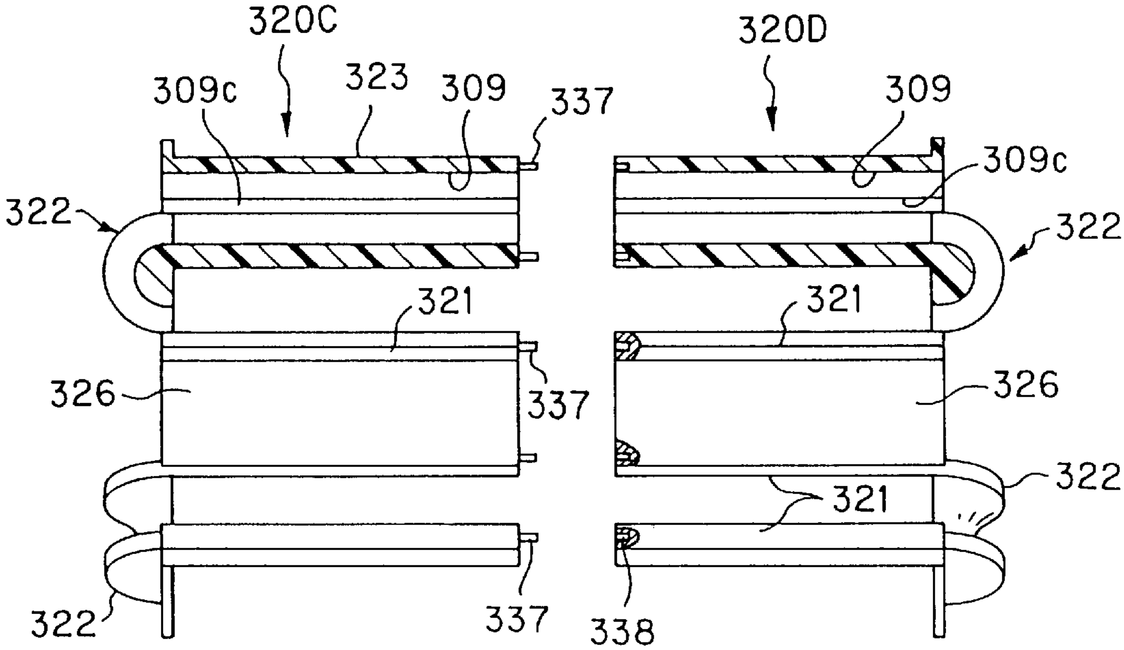


FIG. 34(b)

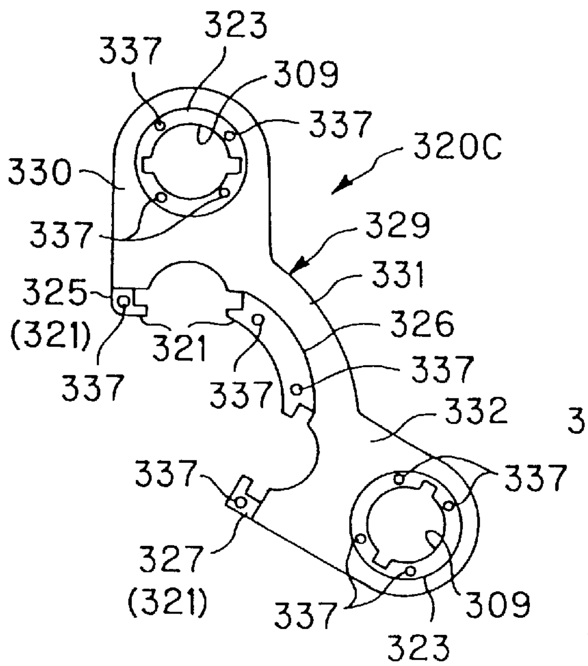


FIG. 34(c)

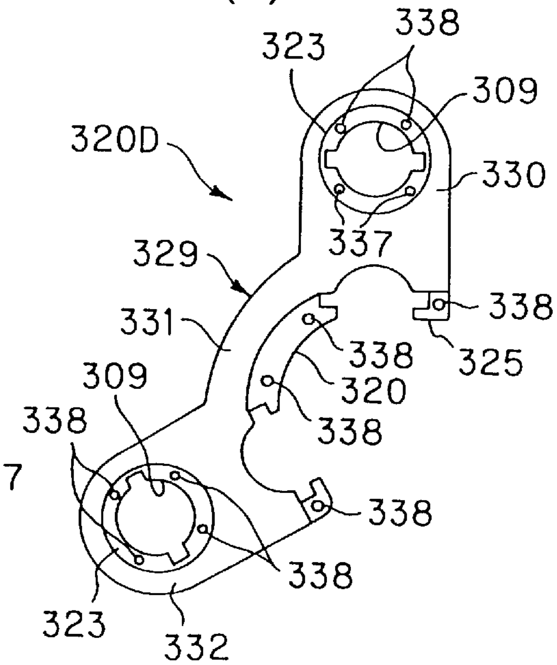


FIG. 35

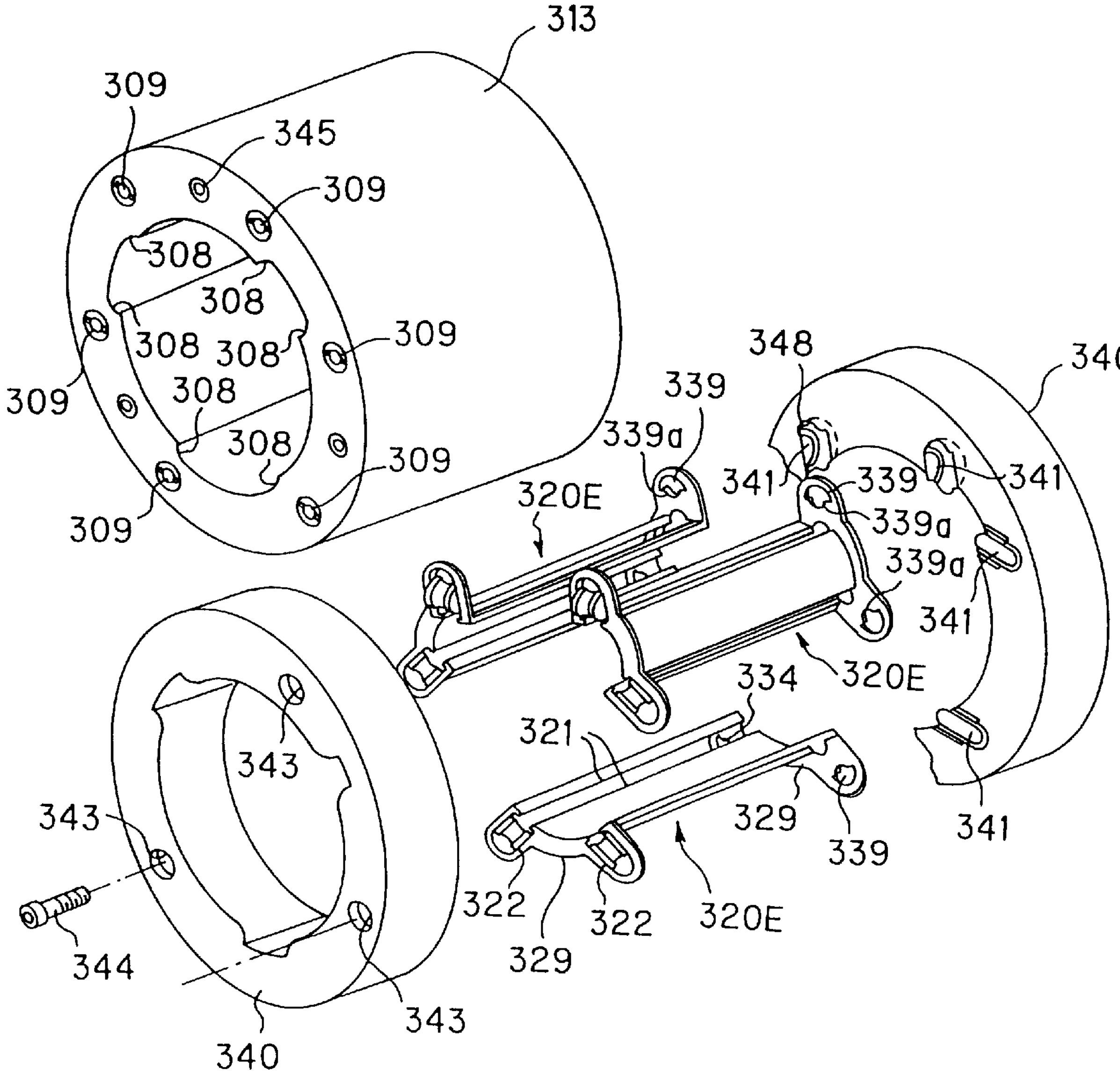

313
309
345
309
308
308
308
308
309
309
308
308
309
309
348
340
339
339a
341
339
341
320E
339a
339a
341
320E
334
321
343
343
329
339
341
322
322
320E
329
344
343
340

FIG. 36

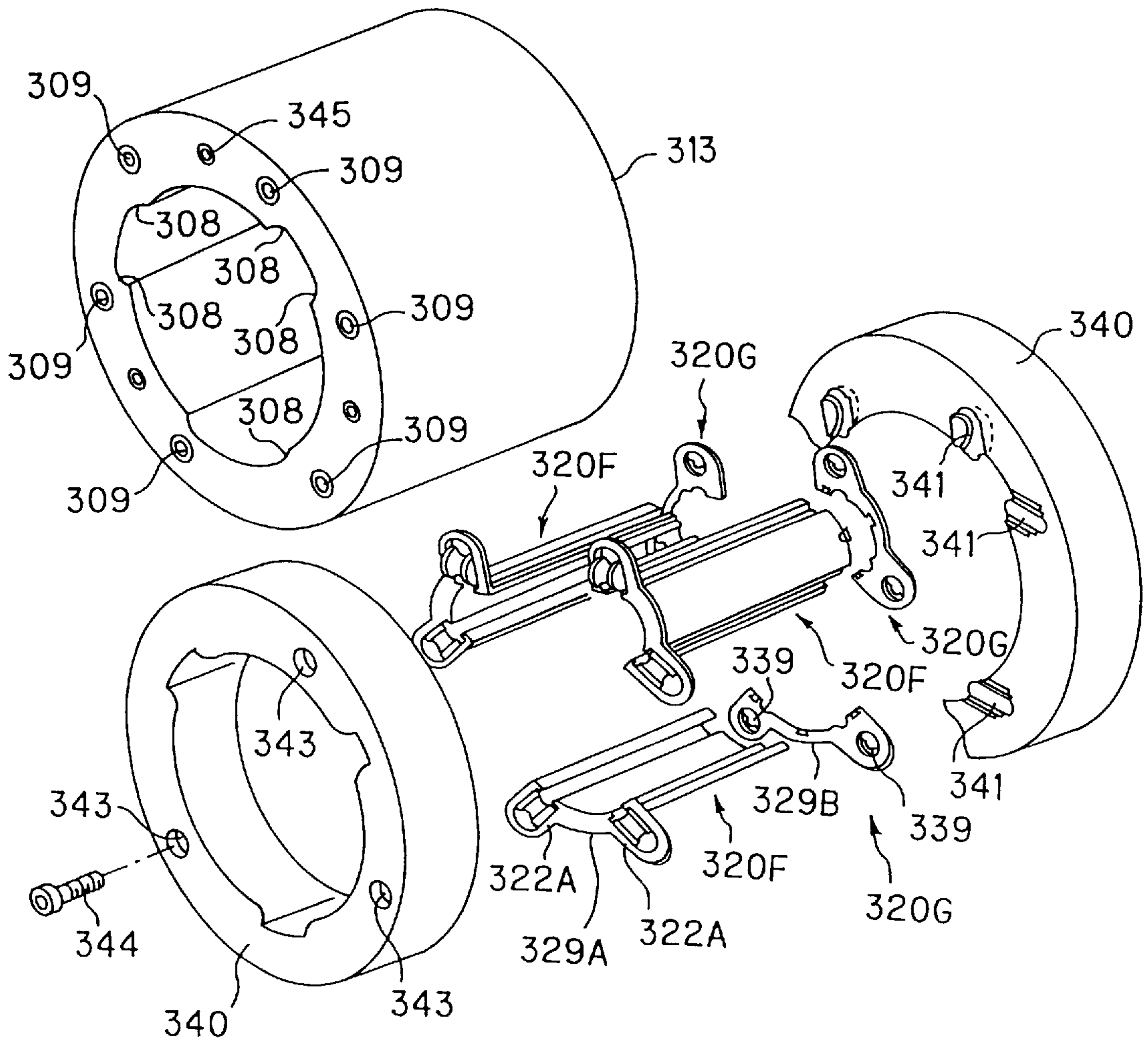

309
345
309
313
308
308
308
308
309
309
308
309
309
309
320G
340
341
341
320F
320G
339
320F
343
343
341
329B
339
320F
322A
320G
344
329A
322A
340
343

FIG. 37

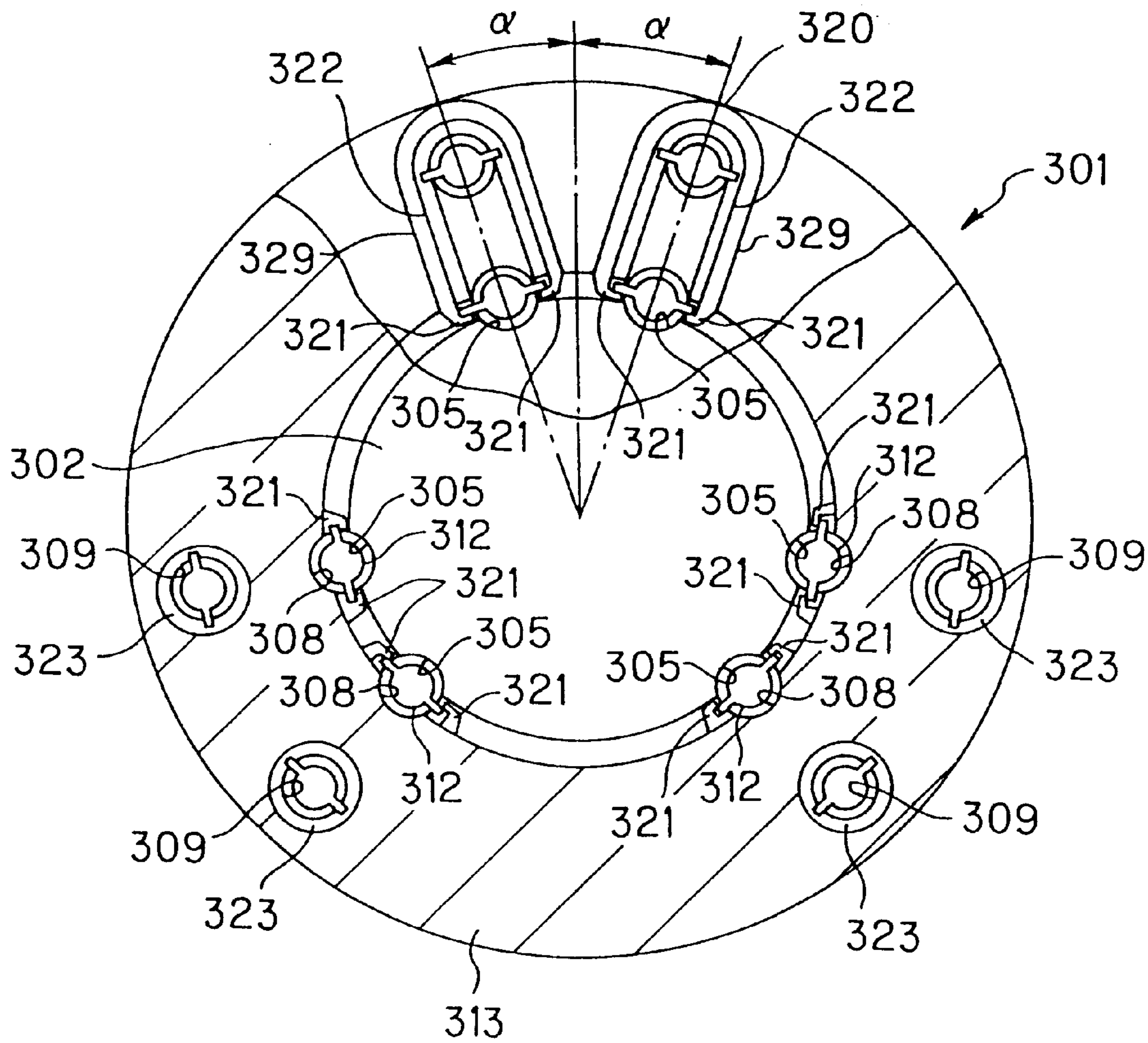

α
α
320
322
322
301
329
329
321
321
305
321
321
305
321
302
321
312
305
308
305
309
309
312
321
308
321
321
305
323
323
308
305
321
308
312
321
312
309
309
321
323
323
313

FIG. 38(a)

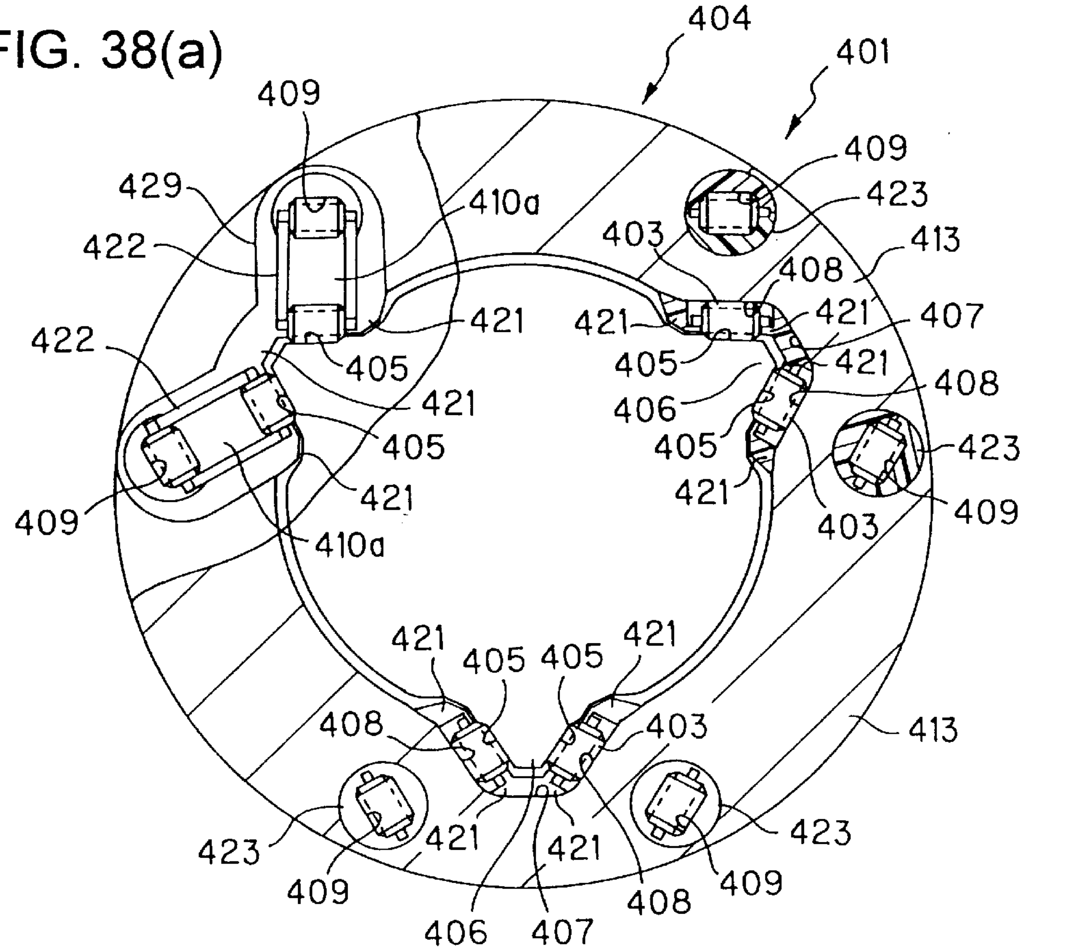


FIG. 38(b)

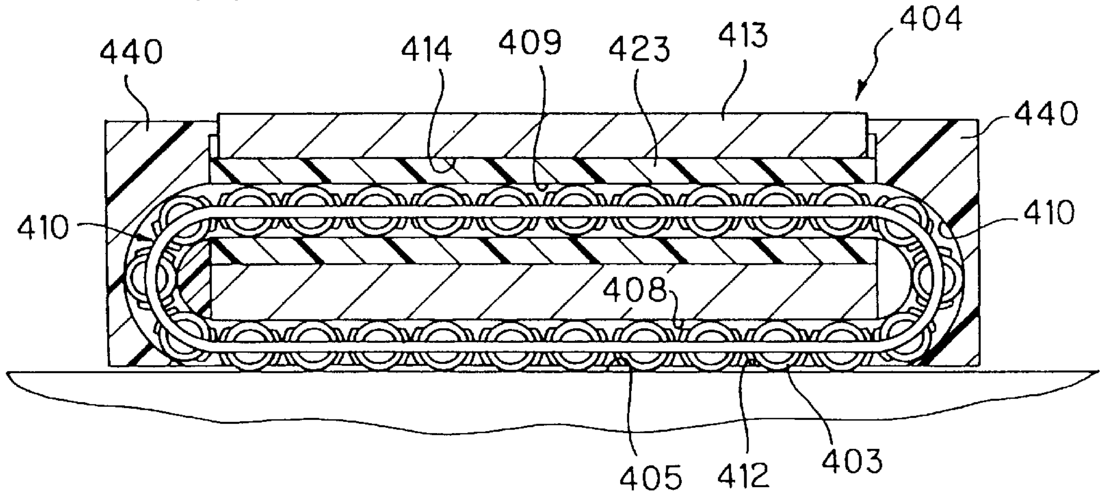


FIG. 39(a)

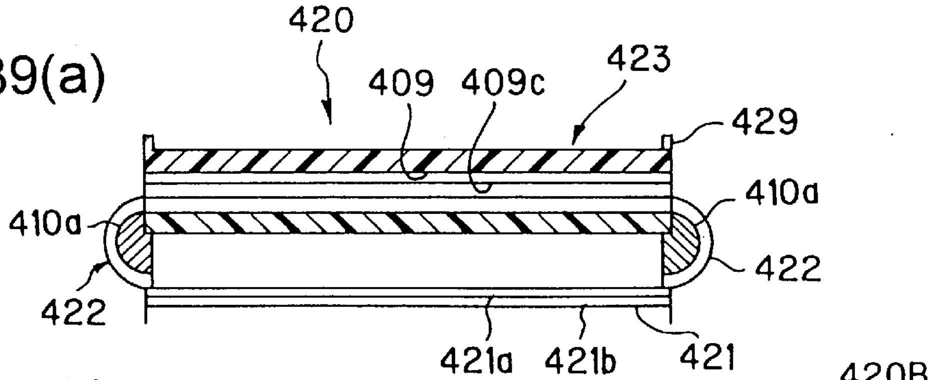


FIG. 39(b)

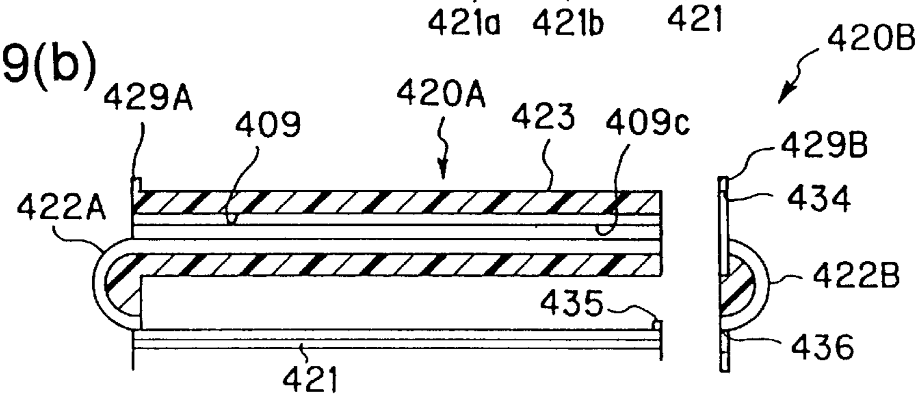


FIG. 39(c)

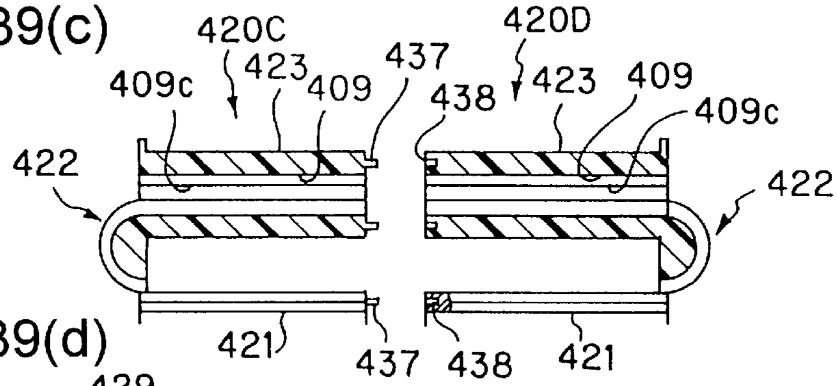


FIG. 39(d)

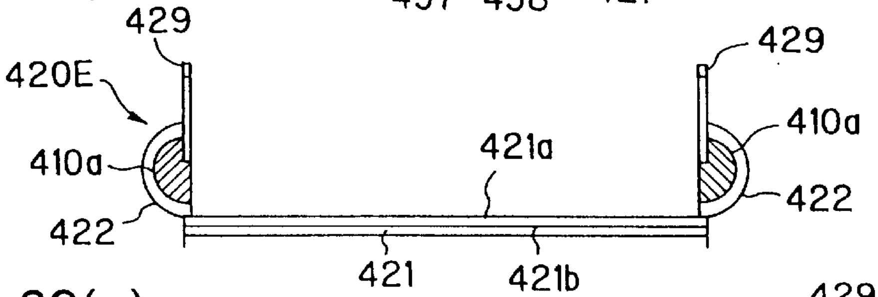


FIG. 39(e)

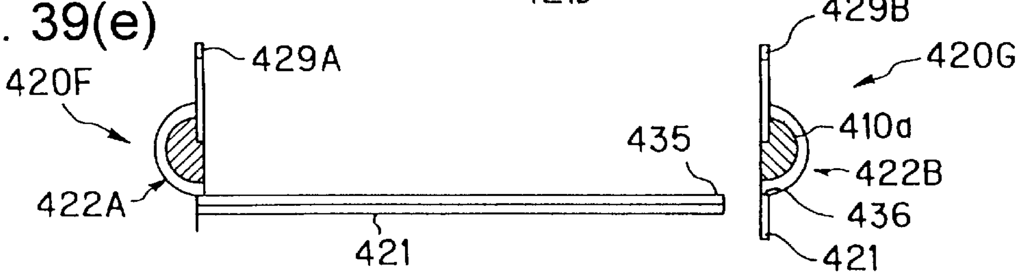


FIG.40(a)

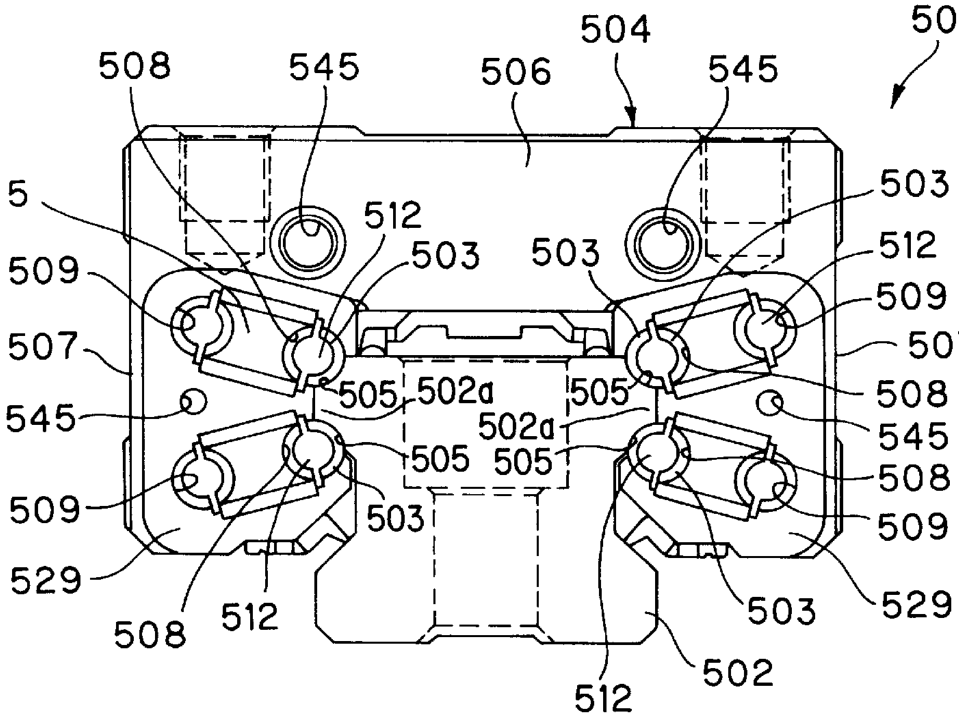


FIG.40(b)

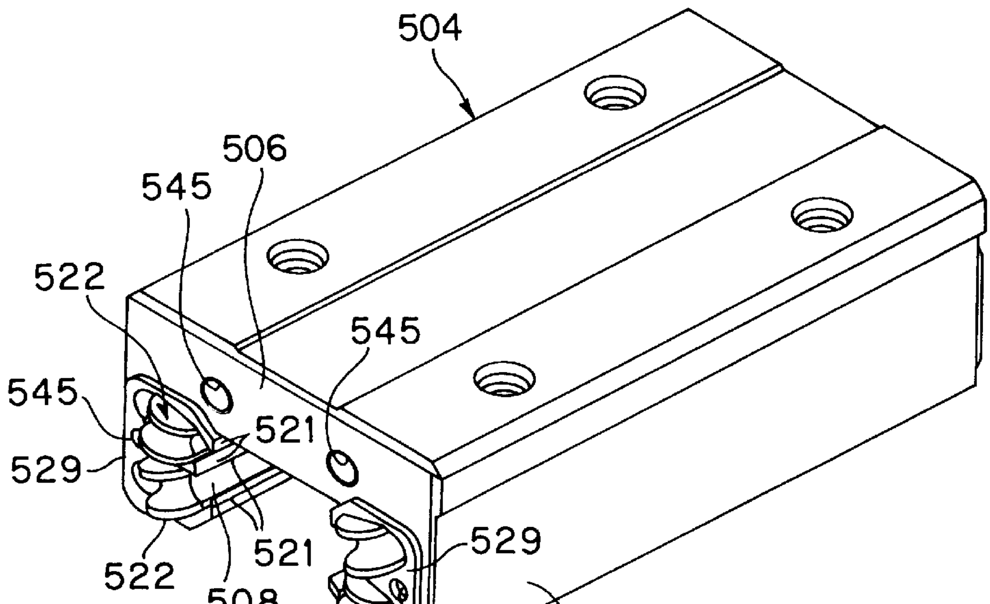
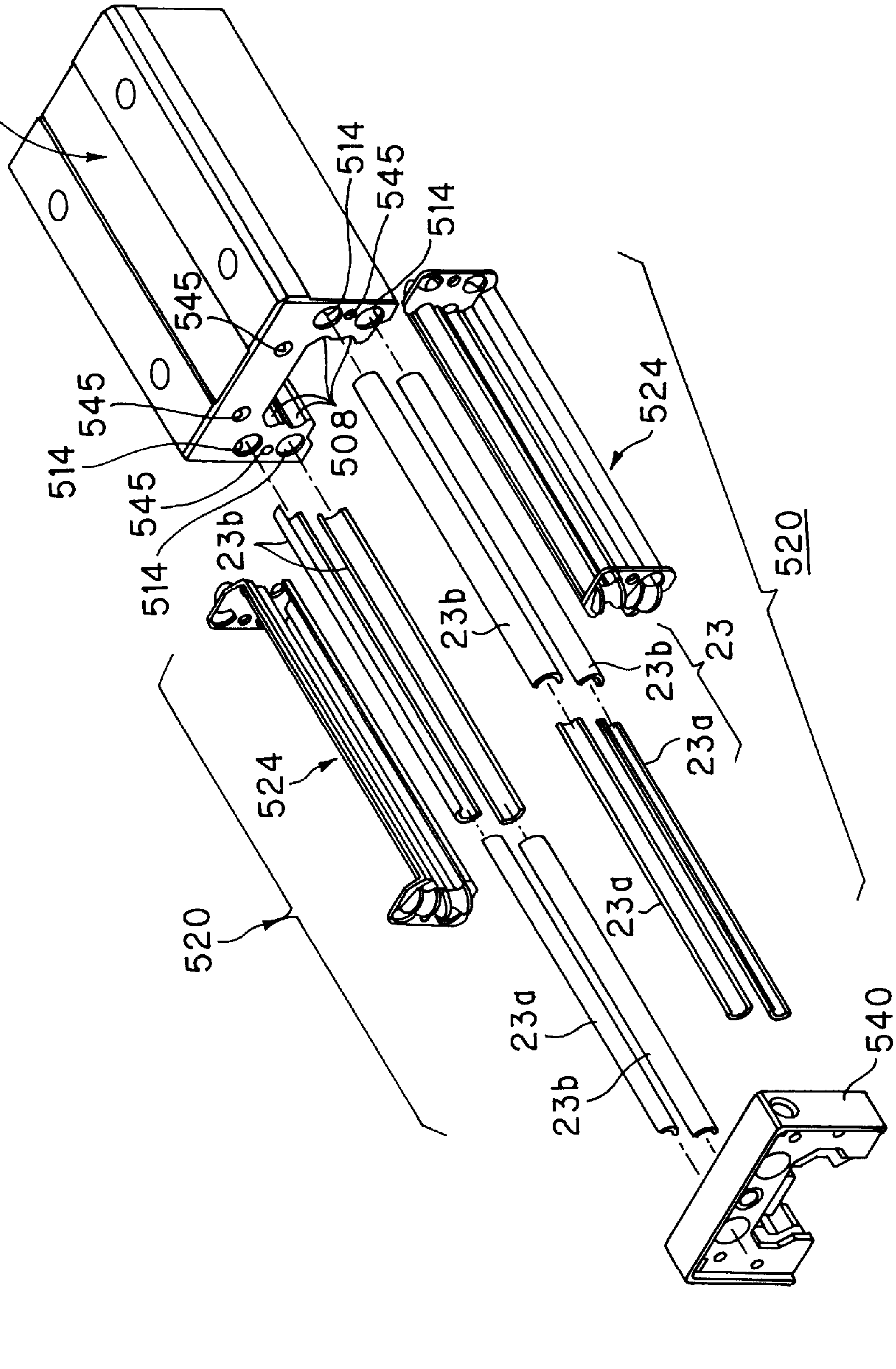


FIG.41



513
514
545
514
545
545
514
545
508
514
23b
524
23b
23b
23
23a
520
524
520
23a
23a
23b
540

FIG.42(a)

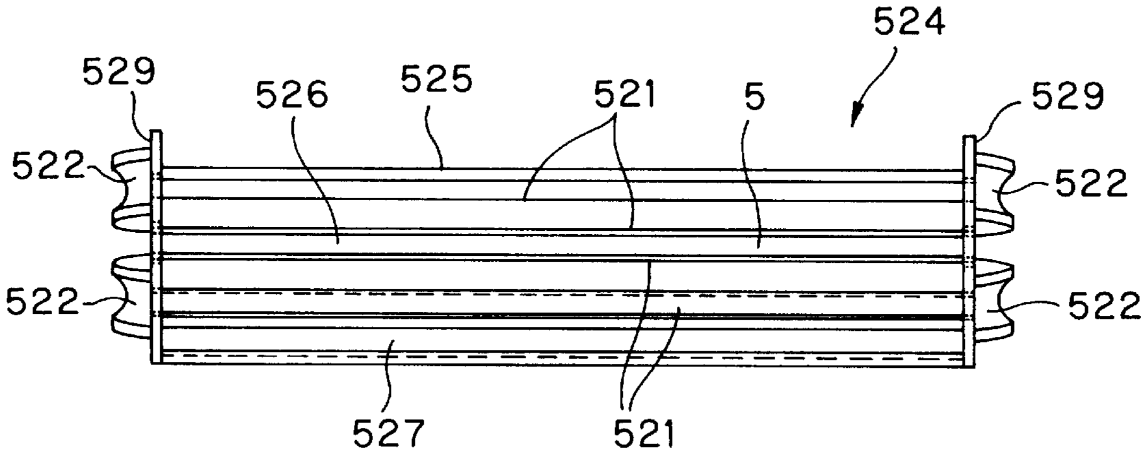


FIG.42(b)

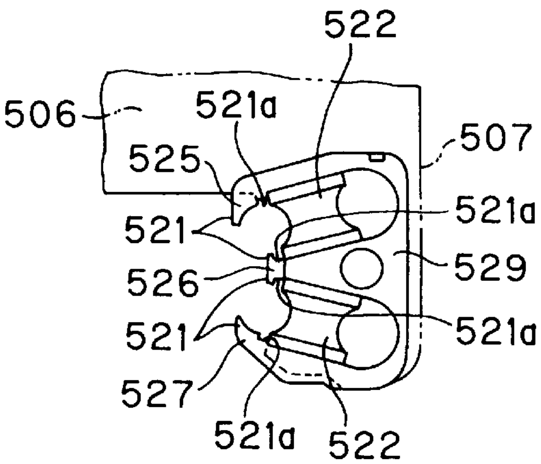


FIG.42(c)

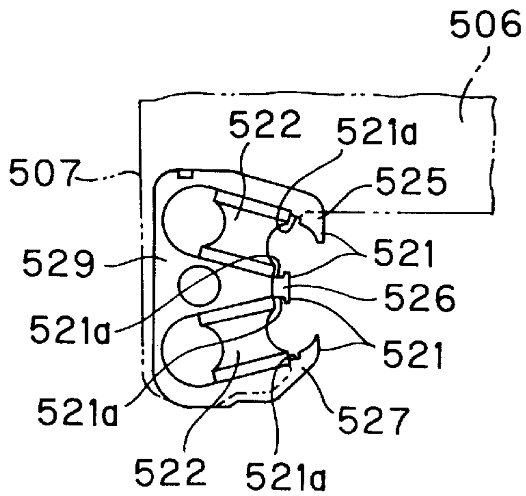


FIG.43(a)

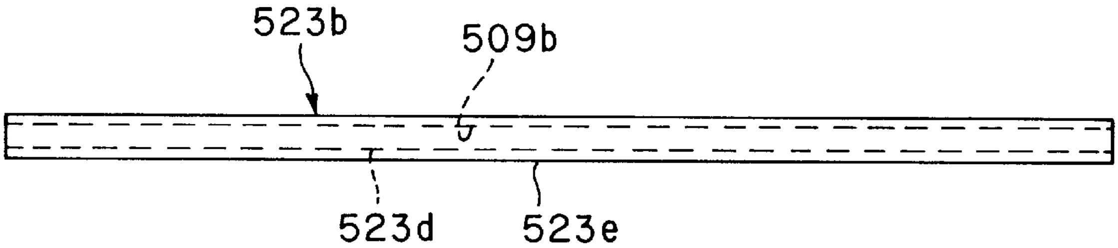


FIG.43(b)

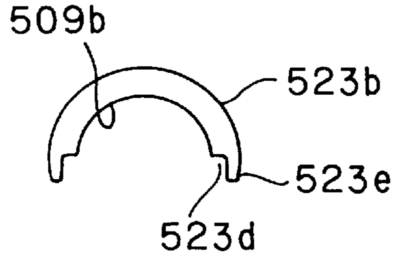


FIG.43(c)

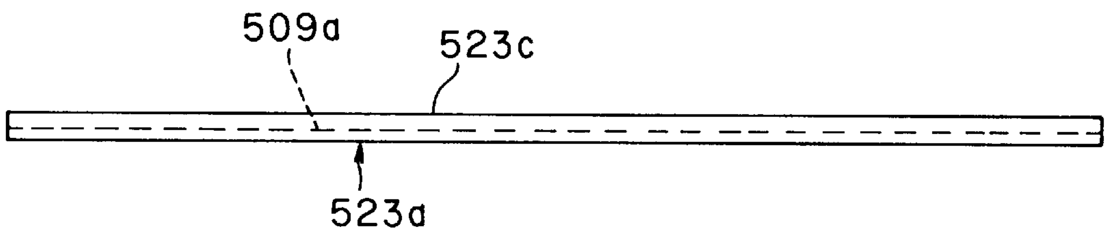


FIG.43(d)

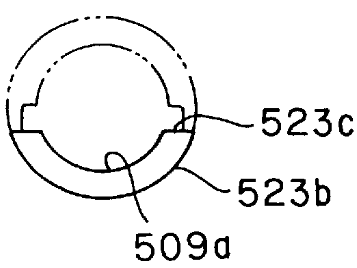


FIG.44(a)

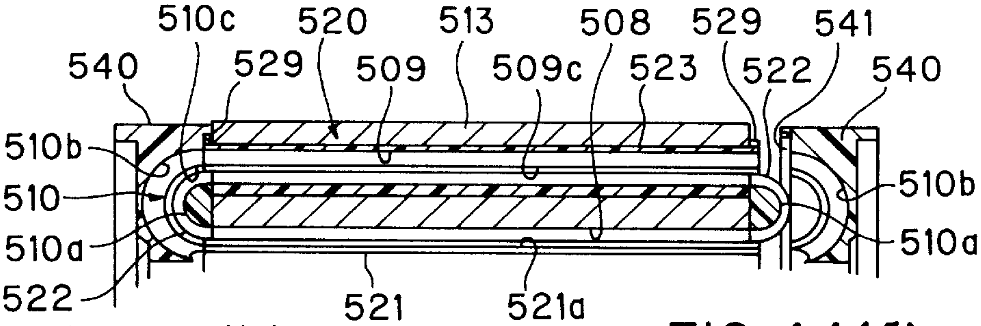


FIG.44(b)

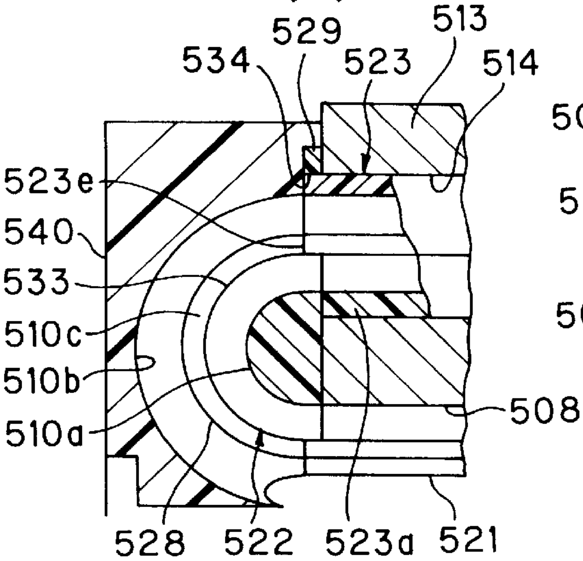


FIG.44(f)

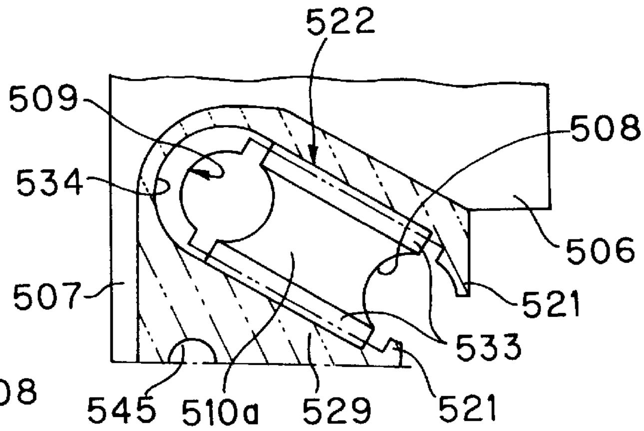


FIG.44(g)

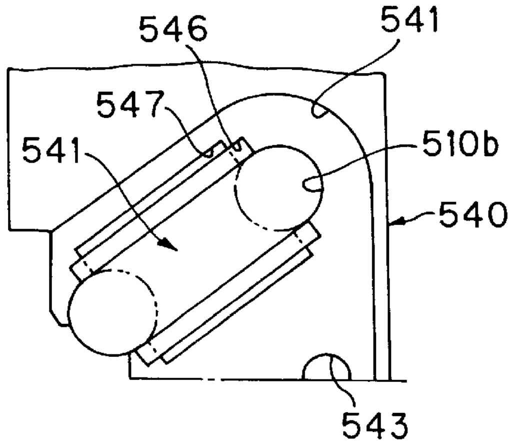


FIG.44(c)

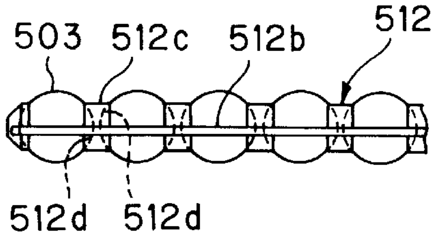


FIG.44(d)

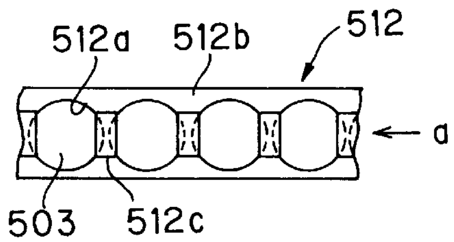
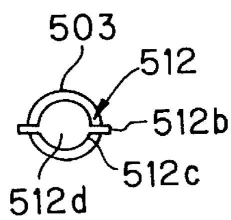


FIG.44(e)



LINEAR MOTION GUIDING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a linear motion guiding apparatus in which a passage forming member formed of resin is built into a body of movable member.

2. Description of the Related Art

The applicant has already proposed a technical idea that, in a movable block of a linear motion guiding apparatus, a pair of ball passage forming portions extending along the opposite longitudinal sides of a loaded-ball running groove, a ball returning passage forming portion and a pair of direction changing passage-inner guide forming portions were integrally formed of resin with a body of the movable block (refer to Japanese Patent Provisional Publication No. H7-317,762).

More specifically, when a resin forming is carried out, the body of the movable block is inserted in a die, and the ball passage forming portions, the direction changing passage-inner guide forming portions or the ball returning passage forming portion is integrally formed with the block body.

In the conventional movable block obtained by the integral forming, the block body is inserted in the die, as mentioned above. When the block body has a large size, a large-scaled die is required to be used. It is not easy to prepare such a large-scaled die, and there is actual restriction in size. The ball passage forming portions located at the opposite longitudinal sides of the ball running groove extending along the longitudinal direction of the block body are thin and long, with the result that molten resin may not reach every part of the space for forming the ball passage forming portions during the resin forming treatment.

Increase in number of gates formed on the die may solve the above-mentioned problem of misrun of the molten resin. However, when the block body is inserted in the die, the block body may deteriorate the run of the molten resin.

When the movable block has a pair of wing portions, which face right and left-hand side portions of the guide rail so that the guide rail is held between the wing portions, and there are four trains of balls between the right and left-hand side portions of the guide rail and the right and left-hand wing portions of the moving block, and more specifically, the upper and lower trains of balls are arranged at each of a gap between the right-hand side portion of the guide rail and the corresponding right-hand wing portion of the moving block and another gap between the left-hand side portion of the guide rail and the corresponding left-hand wing portion of the moving block, the block body inserted in the die may deteriorate the run of the molten resin in the width direction of the moving block.

SUMMARY OF THE INVENTION

An object of the present invention is therefore to provide a linear motion guiding apparatus in which a resin-formed body for forming a rolling member circulation passage is formed separately from a body of a movable member so as to permit easy formation of the resin-formed body, and such a resin-formed body is able to be built in the body of the movable member, ensuring integral formability of the maximum number of unit parts for defining the rolling member circulation passage.

In order to attain the aforementioned object, a linear motion guiding apparatus comprises:

a guide member provided with a rolling member running track, and

a movable member arranged so as to be movable along the guide member through a large number of rolling members, said movable member being provided with (i) a rolling member running counter-track corresponding to the rolling member running track of said guide member, (ii) a rolling member returning passage arranged away from said rolling member running counter-track by a prescribed distance and in parallel therewith and (iii) a pair of direction changing passages for connecting the rolling member running counter-track and the rolling member returning passage to permit circulation of the rolling members,

characterized in that:

a resin-formed body for forming a rolling member circulation passage comprises a pair of rolling member passage forming portions extending along both longitudinal sides of said rolling member running counter-track, a returning passage forming portion for forming the rolling member returning passage and a pair of direction changing passage-inner guide forming portions for forming inner peripheral guide portions of said direction changing passages, said resin-formed body being separately formed from a body of said movable member; and

at least two portions of (a) said pair of rolling member passage forming portions, (b) said returning passage forming portion, (c) one of said pair of direction changing passage-inner guide forming portions and (d) another of said pair of direction changing passage-inner guide forming portions are connected with each other through integral forming so that said resin-formed body can be built in the body of said movable member.

Embodiments of the combination of these portions (a) to (d) for the resin-formed body for forming the rolling member circulation passage may include the following three examples:

the first example in which the resin-formed body comprises (i) an integral body of the pair of rolling member passage forming portions and the pair of direction changing passage-inner guide forming portions, and (ii) the returning passage forming portion separately formed from the integral body

the second example in which the resin-formed body comprises (i) an integral body of the pair of rolling member passage forming portions, the returning passage forming portion and one of the pair of direction changing passage-inner guide forming portions, and (ii) another of the pair of direction changing passage-inner guide forming portions separately formed from the integral body; and

the third example in which the resin-formed body is manufactured by preparing an integral body of the pair of rolling member passage forming portions, the returning passage forming portion and the pair of direction changing passage-inner guide forming portions, and then dividing the pair of rolling member passage forming portions and the returning passage forming portion in longitudinal intermediate portions thereof into respective two parts.

According to the present invention, the resin-formed body for forming the rolling member circulation passage is separately formed from the body of the movable member. Even if the movable member has a large size, the flow of molten resin is not therefore restricted by the body of the movable member unlike the conventional prior art in which the body of the movable member and the resin-formed body are integrally formed with each other, and it is possible to ensure proper run of molten resin through increase in a number of gates in the die, thus leading to an excellent formability. In general, it is hard to achieve proper run of molten resin especially at the rolling member passage forming portions extending along the longitudinal sides of the rolling member running counter-track, and it is therefore effective to separately form the resin-formed body from the body of the movable member in the same manner as the present invention.

The rolling member circulation passage is formed by the resin-formed body. Therefore, the direct positioning can be achieved in the relative positional relationship between the direction changing passage-inner guide forming portions and the rolling member passage forming portion, as well as the relative positional relationship between the direction changing passage-inner guide forming portions and the returning passage forming portion, and the continuity of the rolling member circulation passage is properly ensured, thus leading to smooth run of the rolling members.

Since the rolling member passage forming portions are located along the both longitudinal sides of the rolling member running counter-track, the direction changing passage-inner guide forming portions having a proper relative positional relationship with the rolling member passage forming portions are accurately set on the both ends of the rolling member running counter-track.

Maintenance of a proper relative positional relationship of the direction changing passage-inner guide forming portions with the rolling member returning passage causes the direction changing passage-inner guide forming portions to be accurately connected to the inner surface of the rolling member returning passage.

Especially, change in a running direction of the rolling members takes place in the connection area of the rolling member passage forming portions with the direction changing passage-inner guide forming portions as well as in the connection area of the direction changing passage-inner guide forming portions with returning passage forming portion. When two portions in such a connection area are connected with each other by integral forming, a step for assembling these two portions is not required, thus making it possible to ensure a smooth continuity of these two portions without being affected by accuracy of assembly.

The rolling member returning passage may be a through-hole formed in the body of the movable member, the resin formed-body may comprise the pair of direction changing passage-inner guide forming portions and the rolling member passage forming portions extending along the both longitudinal sides of the rolling member running counter-track, and the rolling member passage forming portions and at least one of the pair of direction changing passage-inner guide forming portions may be connected with each other through integral forming.

When the rolling member passage forming portions and the direction changing passage-inner guide forming portions are integrally formed with each other so as to provide the smooth connection area in this manner, it is possible to achieve the smooth run of the rolling members in the connection area of these portions, thus improving circulation property of the rolling member without providing any returning passage forming portion made of resin. Such a construction causes easy manufacture of the apparatus due to no existence of the returning passage forming portion.

The present invention may have additional features that a rolling member retainer is provided, the rolling member retainer being able to retain the rolling members in a train with a prescribed distance kept between adjacent two of the rolling members, and the rolling member retainer having side edge portions projecting from both sides of each of the rolling members; and guide grooves for guiding the side edge portions of the rolling member retainer are formed on an entire periphery of the rolling member circulation passage.

The present invention may have additional features that a retaining portion is provided on the rolling member passage forming portion, for preventing the rolling member retainer being out of place, when the movable member is removed from the guide member, and a guide portion is continuously formed on the entire periphery of the rolling member circulation passage, for guiding the side edge portions of the rolling member retainer.

Such provision of the rolling member retainer permits the smooth run of the rolling members by means of the rolling member retainer, due to proper maintenance of continuity of the guide portion for the rolling member retainer.

Since the guide portion for the rolling member retainer having a small thickness is not formed by inserting the body of the movable member in a die and then injecting molten resin into the die, but is separately formed from the body of the movable member, position of gates can freely be determined without being restricted by the body of the movable member, with the result that molten resin can reach, during formation of the guide portion, the entire space therefor, which is formed in the die.

The present invention may have additional features that each of the direction changing passage-inner guide forming portions has a thin sheet portion, which is to be brought into contact with the end face of the body of the movable member, and each of the direction changing passage-inner guide forming portions is connected to the rolling member passage forming portions or the returning passage forming portion by means of the thin sheet portion.

When each of the direction changing passage-inner guide forming portions is connected to the rolling member passage forming portions by means of the thin sheet portion, deformation of the thin sheet portion can absorb distortion, which occurs between the direction changing passage-inner guide forming portion and the rolling member passage forming portion, or between the direction changing passage-inner guide forming portion and the returning passage forming portion. Accordingly, it is possible to maintain an accurate positional relationship between the end of the direction changing passage-inner guide forming portion and the rolling member passage forming portion or between the direction changing passage-inner guide forming portion and the returning passage forming portion.

The thin sheet portion is urged against the flat end face of the body of the movable member by a clamping force, which is applied to the side cover plate. The position of the direction changing passage-inner guide forming portion can therefore be corrected through deformation of the thin sheet portion, even when the direction changing passage-inner guide forming portion is not correctly positioned relative to the end face of the body of the movable member. In addition, the thin sheet portion can firmly be secured between the side cover plate and the body of the movable member by the clamping force, which is applied to the side cover plate, thus preventing the direction changing passage-inner guide forming portion from being incorrectly placed.

The apparatus of the present invention may have the construction that the guide member comprises a guide rail; the movable member comprises a movable block, which is provided with a horizontal portion, which faces an upper surface of the guide rail and a pair of wing portions, between which the guide rail is held at right and left-hand side surfaces thereof; two trains of the rolling members are arranged in a gap between the upper surface of the guide rail and a lower surface of the movable block, and a single train of the rolling members is arranged in each of gaps between the right and left-hand side surfaces of the guide rail and both of the wing portions, so as to provide a total number of trains of four.

The apparatus of the present invention may have the construction that the guide member comprises a guide rail; the movable member comprises a movable block, which is provided with a pair of wing portions, between which the guide rail is held at right and left-hand side surfaces thereof; and two trains of the rolling members are arranged in each of gaps between the right and left-hand side surfaces of the guide rail and both of the wing portions, so as to provide a total number of trains of four.

In these cases, the respective four direction changing passage-inner guide forming portions may be formed into an integral body, or the respective two direction changing passage-inner guide forming portions at each of the right and left-hand sides of the movable block may be formed into an integral body.

The apparatus of the present invention may have the construction that the guide member comprises a guide rail; the movable member is provided with a horizontal portion, which faces an upper surface of the guide rail and a single wing portion, which faces one side surface of the guide rail; a single train of the rolling members is arranged in a gap between the one side surface of the guide rail and the single wing portion, and another single train of the rolling members is arranged in a gap between the upper surface of the guide rail and a lower surface of the horizontal portion in a vicinity of a corner of the guide rail.

The apparatus of the present invention may have the construction that the guide member comprises a guide rail; the movable member comprises a movable block, which is provided with a pair of wing portions, between which the guide rail is held at right and left-hand side surfaces thereof; and a single train of the rolling members is arranged in each of gaps between the right and left-hand side surfaces of the guide rail and both of the wing portions, so as to provide a total number of trains of two.

The apparatus of the present invention may have the construction that the guide member comprises a guide rail; the movable member comprises a movable block arranged along one side surface of the guide rail; and two trains of the rolling members are arranged in a gap between the one side surface of the guide rail and the movable block.

The apparatus of the present invention may have the construction that the guide member comprises a spline shaft; and the movable member comprises an outer tube, which is movably supported on the spline shaft through a plurality of trains of the rolling members.

In addition, according to the present invention, there is also provided a linear motion guiding apparatus comprising:

a guide rail provided with two rolling member running tracks on each of right and left-hand side surfaces of the guide rail, so as to provide a total number of the rolling member running tracks of four; and

a movable block provided with a pair of wing portions, between which the guide rail is held at the right and left-hand side surfaces thereof, each of said wing portions having on an inner surface thereof two rolling member running counter-tracks corresponding to said two rolling member running tracks of the guide rail, so as to provide a total number of the rolling member running counter-tracks of four, said movable block having four endless circulation passages, which are formed by four rolling member returning passages arranged in parallel with said four rolling member running counter-tracks, respectively, and rolling member returning passages for connecting both ends of each of said four rolling member running counter-tracks with both ends of each of said four rolling member returning passages, respectively

characterized in that:

a resin-formed body comprises, for each of said endless circulation passages, a pair of rolling member passage forming portions extending along both longitudinal sides of said rolling member running counter-track, a returning passage forming portion for forming the rolling member returning passage and a pair of direction changing passage-inner guide forming portions for forming inner peripheral guide portions of said direction changing passages, said resin-formed body being separately formed from a body of said movable block;

said resin-formed body is divided into two body-parts, which are arranged on the wing portions of the movable block, respectively, so as to form the two endless circulation passages at an inner side of each of the wing portions; and

in each of the two body-parts, the rolling member running counter-track and the pair of direction changing passage-inner guide forming portions are formed into an integral body, and the returning passage forming portion is separately formed from said integral body.

According to the present invention, the resin-formed body for forming the rolling member circulation passage is separately formed from the body of the movable block. Even if the movable block has a large size, the flow of molten resin is not therefore restricted by the body of the movable block unlike the conventional prior art in which the body of the movable block and the resin-formed body are integrally formed with each other, and it is possible to ensure proper run of molten resin through increase in a number of gates in the die, thus leading to an excellent formability. In general, it is hard to achieve proper run of molten resin especially at the rolling member passage forming portions extending along the longitudinal sides of the rolling member running counter-track, and it is therefore effective to separately form the resin-formed body from the body of the movable block in the same manner as the present invention.

Especially, since the resin-formed body is divided into the two body-parts, each of which forms two endless circulation passages, a proper run of molten resin can be ensured, even when the block of the movable block has a larger width.

The rolling member circulation passage is formed by the resin-formed body. Therefore, the direct positioning can be achieved in the relative positional relationship between the direction changing passage-inner guide forming portions and the rolling member passage forming portion, as well as the relative positional relationship between the direction changing passage-inner guide forming portions and the returning passage forming portion, and the continuity of the rolling member circulation passage is properly ensured, thus leading to smooth run of the rolling members.

Since the rolling member passage forming portions are located along the both longitudinal sides of the rolling member running counter-track, the direction changing passage-inner guide forming portions having a proper relative positional relationship with the rolling member passage forming portions are accurately set on the both ends of the rolling member running counter-track.

Maintenance of a proper relative positional relationship of the direction changing passage-inner guide forming portions with the rolling member returning passage causes the direction changing passage-inner guide forming portions to be accurately connected to the inner surface of the rolling member returning passage.

Especially, change in a running direction of the rolling members takes place in the connection area of the rolling member passage forming portions with the direction changing passage-inner guide forming portions. When these two portions in such a connection area are connected with each other by integral forming, a step for assembling these two portions is not required, thus making it possible to ensure a smooth continuity of these two portions without being affected by accuracy of assembly.

The present invention may have additional features that a rolling member retainer is provided, the rolling member retainer being able to retain the rolling members in a train with a prescribed distance kept between adjacent two of the rolling members, and the rolling member retainer having side edge portions projecting from both sides of each of the rolling members; and guide grooves for guiding the side edge portions of the rolling member retainer are formed on an entire periphery of the rolling member circulation passage.

Such provision of the rolling member retainer permits the smooth run of the rolling members by means of the rolling member retainer, due to proper maintenance of continuity of the guide portion for the rolling member retainer.

Since the guide portion for the rolling member retainer having a small thickness is not formed by inserting the body of the movable block in a die and then injecting molten resin into the die, but is separately formed from the body of the movable block, position of gates can freely be determined without being restricted by the body of the movable block, with the result that molten resin can reach, during formation of the guide portion, the entire space therefor, which is formed in the die.

The present invention may have additional features that each of the direction changing passage-inner guide forming portions has a thin sheet portion, which is to be brought into contact with the end face of the body of the movable block, and each of the direction changing passage-inner guide forming portions is connected to the rolling member passage forming portions or the returning passage forming portion by means of the thin sheet portion.

When each of the direction changing passage-inner guide forming portions is connected to the rolling member passage forming portions by means of the thin sheet portion, deformation of the thin sheet portion can absorb distortion, which occurs between the direction changing passage-inner guide forming portion and the rolling member passage forming portion, or between the direction changing passage-inner guide forming portion and the returning passage forming portion. Accordingly, it is possible to maintain an accurate positional relationship between the end of the direction changing passage-inner guide forming portion and the rolling member passage forming portion or between the direction changing passage-inner guide forming portion and the returning passage forming portion.

The thin sheet portion is urged against the flat end face of the body of the movable member by a clamping force, which is applied to the side cover plate. The position of the direction changing passage-inner guide forming portion can therefore be corrected through deformation of the thin sheet portion, even when the direction changing passage-inner guide forming portion is not correctly positioned relative to the end face of the body of the movable block. In addition, the thin sheet portion can firmly be secured between the side cover plate and the body of the movable block by the clamping force, which is applied to the side cover plate, thus preventing the direction changing passage-inner guide forming portion from being incorrectly placed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic disassembling perspective view illustrating a movable block of a linear motion guiding apparatus of the first embodiment of the present invention;

FIG. **2** shows a resin frame member as shown in FIG. **1**, as one of resin-formed bodies for forming a ball circulation passage, and more specifically,

FIG. **2**(*a*) is a front view of the resin frame member,

FIG. **2**(*b*) is a side view thereof,

FIG. **2**(*c*) is a cross-sectional view cut along the line C—C as indicated in FIG. **2**(*a*),

FIG. **2**(*d*) is a cross-sectional view cut along the line D—D as indicated in FIG. **2**(*b*),

FIG. **2**(*e*) is an enlarged cross-sectional view cut along the line E—E as indicated in FIG. **2**(*a*) and

FIG. **2**(*f*) is an enlarged cross-sectional view cut along the line F—F as indicated in FIG. **2**(*a*);

FIG. **3**(*a*) is a front view having a cross-section, illustrating the linear motion guiding apparatus of the first embodiment of the present invention as shown in FIG. **1**,

FIG. **3**(*b*) is a front view of the apparatus as shown in FIG. **3**(*a*), in which a half portion of a side cover plate is omitted, and

FIGS. **3**(*c*) to (*f*) are partially cross-sectional views illustrating embodiments of the structure of a ball passage forming portion and the vicinity thereof, as shown in FIG. **3**(*a*);

FIG. **4**(*a*) is a side view having a partial cross section, of the linear motion guiding apparatus of the first embodiment of the present invention,

FIG. **4**(*b*) is a cross-sectional view of a ball circulation passage of the movable block as shown in FIG. **4**(A), from which a ball retainer is removed,

FIG. **4**(*c*) is a partial side view of the ball retainer,

FIG. **4**(*d*) is a plan view of the ball retainer as shown in FIG. **4**(*c*) and

FIG. **4**(*e*) is a view of the ball retainer, with sight being placed in a direction of an arrow of "a" as indicated in FIG. **4**(*d*);

FIG. **5** shows a side cover plate of the movable block, and more specifically,

FIG. **5**(*a*) is a front view of the side cover plate,

FIG. **5**(*b*) is a back view thereof and

FIG. **5**(*c*) is a transverse sectional view thereof at its central portion;

FIGS. **6**(*a*) to **6**(*i*) are descriptive views illustrating steps for assembling the movable block as shown in FIG. **1**;

FIG. **7**(*a*) is an enlarged partial view of the direction changing passage as shown in FIG. **4**(*b*),

FIG. **7**(*b*) is a partial side view of the direction changing passage as shown in FIG. **4**(*b*), in which the side cover plate is removed,

FIG. **7**(*c*) is a partial side view illustrating a recess portion, which forms the direction changing passage in the side cover plate as shown in FIG. **7**(*a*),

FIG. 7(*d*) is a partial cross-sectional view of an outer peripheral side-half pipe member for forming a part of a resin pipe as shown in FIG. **7**(*a*),

FIG. 7(*e*) is a side view of the outer peripheral side-half pipe member as shown in FIG. **7**(*d*),

FIG. 7(*f*) is a partial cross-sectional view of an inner peripheral side-half pipe member for forming another part of the resin pipe as shown in FIG. **7**(*a*),

FIG. 7(*g*) is a side view of the inner peripheral side-half pipe member as shown in FIG. **7**(*f*);

FIG. **8** is a schematic disassembling perspective view illustrating the first modification of the resin-formed body for forming the ball circulation passage in the first embodiment of the present invention;

FIG. **9**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in FIG. **8**,

FIG. **9**(*b*) is a view illustrating the first resin frame of the resin-formed body,

FIG. **9**(*c*) is a view illustrating the second resin frame thereof,

FIG. **9**(*d*) is a back view of the first resin frame and

FIG. **9**(*e*) is a back view of the second resin frame;

FIG. **10** is a schematic disassembling perspective view illustrating the second modification of the resin-formed body for forming the ball circulation passage in the first embodiment of the present invention;

FIG. **11**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in FIG. **10**,

FIG. **11**(*b*) is a side view illustrating the connecting end of one of divided resin frames, as shown in FIG. **11**(*a*) and

FIG. **11**(*c*) is an enlarged cross-sectional view illustrating the connecting portion of the resin frames;

FIG. **12** is a schematic disassembling perspective view illustrating the third modification of the resin-formed body for forming the ball circulation passage in the first embodiment of the present invention;

FIG. **13**(*a*) is a side view having a partial cross section, illustrating the linear motion guiding apparatus, in which the movable block as shown in FIG. **12** is used, and

FIG. **13**(*b*) is a cross-sectional view of the resin-formed body for forming the ball circulation passage as shown in FIG. **13**(*a*);

FIG. **14**(*a*) is an enlarged partial cross-sectional view of the direction changing passage as shown in FIG. **13**(*b*), which is formed in the side cover plate removed from the ball passage forming portion,

FIG. **14**(*b*) is a partial cross-sectional view illustrating the side cover as shown in FIG. **14**(*a*), which is secured to the ball passage forming portion,

FIG. **14**(*c*) is a partial side view illustrating the ball passage forming portion, in which the side cover plate as shown in FIG. **14**(*a*) is removed, and

FIG. **14**(*d*) is a partial side view illustrating a recess portion, which forms the direction changing passage in the side cover plate as shown in FIG. **14**(*a*);

FIG. **15** is a schematic disassembling perspective view illustrating the fourth modification of the resin-formed body for forming the ball circulation passage in the first embodiment of the present invention;

FIGS. **16**(*a*) to **16**(*h*) are descriptive views illustrating the other embodiments of arrangement of the trains of balls in the linear motion guiding apparatus of the first embodiment of the present invention;

FIG. **17** is a perspective view illustrating the constructional elements other than the resin-formed body for forming the ball circulation passage of the linear motion guiding apparatus as shown in FIG. **16**(*a*), which is provided with two trains of balls at each of the both sides;

FIG. **18** is a schematic disassembling perspective view illustrating a movable block of a linear motion guiding apparatus of the second embodiment of the present invention;

FIG. **19**(*a*) is a front view illustrating the linear motion guiding apparatus of the second embodiment of the present invention as shown in FIG. **18**,

FIG. **19**(*b*) is a partial cross-sectional view illustrating one ball circulation passage of the apparatus as shown in FIG. **19**(*a*),

FIG. **19**(*c*) is a partial plan view of a roller retainer as shown in FIG. **19**(*b*) and

FIG. **19**(*d*) is a view of the roller retainer, with sight being placed in a direction of an arrow of "d" as indicated in FIG. **19**(*c*);

FIG. **20** shows the resin-formed body for forming the ball circulation passage as shown in FIG. **18**, and more specifically,

FIG. **20**(*a*) is a cross-sectional view cut along the line a—a as indicated in FIG. **20**(*b*),

FIG. **20**(*b*) is a front view of the resin-formed body for forming the ball circulation passage as shown in FIG. **20**(*a*),

FIG. **20**(*c*) is a partial side view of the resin-formed body for forming the ball circulation passage, in which the resin pipe as shown in FIG. **20**(*a*) is removed,

FIG. **20**(*d*) is a cross-sectional view of an outer peripheral side-half pipe member for forming a part of a resin pipe as shown in FIG. **20**(*a*),

FIG. **20**(*e*) is a side view of the outer peripheral side-half pipe member as shown in FIG. **20**(*d*),

FIG. **20**(*f*) is a cross-sectional view of an inner peripheral side-half pipe member for forming another part of the resin pipe as shown in FIG. **20**(*a*),

FIG. **20**(*g*) is a side view of the inner peripheral side-half pipe member as shown in FIG. **20**(*f*) and

FIG. **20**(*h*) is a partial cross-sectional view illustrating the constructional example of the roller passage forming portion, in which the roller retainer is not used;

FIG. **21** is a schematic disassembling perspective view illustrating the first modification of the resin-formed body for forming the ball circulation passage in the second embodiment of the present invention;

FIG. **22**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in FIG. **21**,

FIG. **22**(*b*) is a view illustrating the first resin frame as shown in FIG. **22**(*a*), with sight being placed on the divided end side thereof and

FIG. **22**(*c*) is a view illustrating the second resin frame as shown in FIG. **22**(*a*), with sight being placed on the divided end side thereof;

FIG. **23** is a schematic disassembling perspective view illustrating the second modification of the resin-formed body for forming the ball circulation passage in the second embodiment of the present invention;

FIG. **24**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in FIG. **23**, FIG. **24**(*b*) is a view illustrating one resin frame as shown in FIG. **24**(*a*), with sight being placed on the divided end side thereof and

FIG. **24**(*c*) is a view illustrating the other resin frame as shown in FIG. **24**(*a*), with sight being placed on the divided end side thereof;

FIG. **25** is a schematic disassembling perspective view illustrating the third modification of the resin-formed body for forming the ball circulation passage in the second embodiment of the present invention;

FIG. **26** is a schematic disassembling perspective view illustrating the fourth modification of the resin-formed body for forming the ball circulation passage in the second embodiment of the present invention;

FIG. **27** is a front view having a cross-sectional half portion, illustrating the other embodiment of arrangement of the trains of balls in the linear motion guiding apparatus of the second embodiment of the present invention;

FIG. **28** is a schematic disassembling perspective view of an outer tube of a ball-spline as a linear motion guiding apparatus of the third embodiment of the present invention;

FIG. **29**(*a*) is a front view having a cross-section, illustrating the ball spline of the third embodiment of the present invention, in which the outer tube as shown in FIG. **28** is used,

FIG. **29**(*b*) is a partial cross-sectional view illustrating one ball circulation passage of the apparatus as shown in FIG. **29**(*a*) and

FIG. **29**(*c*) is a disassembling cross-sectional view illustrating the construction of the ball circulation passage, in which the roller retainer as shown in FIG. **29**(*b*) is removed;

FIG. **30** shows the resin-formed body for forming the ball circulation passage as shown in FIG. **29**, and more specifically,

FIG. **30**(*a*) is a cross-sectional view cut along the line a—a as indicated in FIG. **30**(*b*),

FIG. **30**(*b*) is a front view of the resin-formed body for forming the ball circulation passage as shown in FIG. **30**(*a*),

FIG. **30**(*c*) is a partial side view of the resin-formed body for forming the ball circulation passage, in which the resin pipe as shown in FIG. **30**(*a*) is removed,

FIG. **30**(*d*) is a cross-sectional view of an outer peripheral side-half pipe member for forming a part of a resin pipe as shown in FIG. **30**(*a*),

FIG. **30**(*e*) is a side view of the outer peripheral side-half pipe member as shown in FIG. **30**(*d*),

FIG. **30**(*f*) is a cross-sectional view of an inner peripheral side-half pipe member for forming another part of the resin pipe as shown in FIG. **30**(*a*) and

FIG. **30**(*g*) is a side view of the inner peripheral side-half pipe member as shown in FIG. **30**(*f*);

FIG. **31** is a schematic disassembling perspective view illustrating the first modification of the resin-formed body for forming the ball circulation passage in the third embodiment of the present invention;

FIG. **32**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in FIG. **31**,

FIG. **32**(*b*) is a view illustrating the first resin frame as shown in FIG. **32**(*a*), with sight being placed on the divided end side thereof and

FIG. **32**(*c*) is a view illustrating the second resin frame as shown in FIG. **32**(*a*), with sight being placed on the divided end side thereof;

FIG. **33** is a schematic disassembling perspective view illustrating the second modification of the resin-formed body for forming the ball circulation passage in the third embodiment of the present invention;

FIG. **34**(*a*) is a disassembling side view having a partial cross-section, illustrating the resin-formed body for the ball circulation passage as shown in FIG. **33**,

FIG. **34**(*b*) is a view illustrating one resin frame as shown in FIG. **34**(*a*), with sight being placed on the divided end side thereof and

FIG. **34**(*c*) is a view illustrating the other resin frame as shown in FIG. **34**(*a*), with sight being placed on the divided end side thereof;

FIG. **35** is a schematic disassembling perspective view illustrating the third modification of the resin-formed body for forming the ball circulation passage in the third embodiment of the present invention;

FIG. **36** is a schematic disassembling perspective view illustrating the fourth modification of the resin-formed body for forming the ball circulation passage in the third embodiment of the present invention;

FIG. **37** is a front view having a partial cross-section, illustrating the another embodiment of arrangement of the trains of balls in the ball spline as the linear motion guiding apparatus of the third embodiment of the present invention;

FIG. **38**(*a*) is a front view having a partial cross-section, illustrating a roller-spline as the linear motion guiding apparatus of the fourth embodiment of the present invention, in which a side cover plate is removed, and

FIG. **38**(*b*) is a longitudinal partial cross-sectional view of one roller circulation passage as shown in FIG. **38**(*b*);

FIG. **39**(*a*) is a partial cross-sectional view illustrating the constructional example of the resin-formed body for forming the roller circulation passage of the roller spline as shown in FIG. **38**, and

FIGS. **39**(*b*) to **39**(*e*) are views illustrating the first to fourth modifications of the resin-formed body for forming the roller circulation passage;

FIG. **40**(*a*) is a front view of the movable block of the linear motion guiding apparatus of the fourth embodiment of the present invention, in which the side cover plate is removed, and

FIG. **40**(*b*) is a perspective view of the movable block as shown in FIG. **40**(*a*);

FIG. **41** is a schematic disassembling perspective view of the resin-formed bodies for forming the ball circulation passage as shown in FIG. **40**;

FIG. **42**(*a*) is a front view of the resin frame composing the resin-formed body for forming the ball circulation passage, as shown in FIG. **41**,

FIG. **42**(*b*) is a left-hand side view of the resin-formed body as shown in FIG. **42**(*a*) and

FIG. **42**(*c*) is a right-hand side view of the resin-formed body as shown in FIG. **42**(*a*);

FIG. **43** shows a resin pipe for forming a part of the resin-formed body for forming the ball circulation passage, as shown in FIG. **41**, and more specifically,

FIG. **43**(*a*) is a front view of an outer peripheral side-half pipe member,

FIG. **43**(*b*) is a side view of the outer peripheral side-half pipe member as shown in FIG. **43**(*a*),

FIG. **43**(*c*) is a front view of an inner peripheral side-half pipe member,

FIG. 43(*d*) is a side view of the inner peripheral side-half pipe member as shown in FIG. **43**(*c*); and

FIG. **44**(*a*) is a cross-sectional view of one ball circulation passage, in which the ball retainer is removed from the movable block as shown in FIG. **40**(*a*),

FIG. **44**(*b*) is an enlarged partial view of the direction changing passage as shown in FIG. **44**(*a*),

FIG. **44**(*c*) is a partial side view of the ball retainer,

FIG. **44**(*d*) is a plan view of the ball retainer as shown in FIG. **44**(*c*),

FIG. **44**(*e*) is a view of the ball retainer, with sight being placed in a direction of an arrow of "a" as indicated in FIG. **44**(*d*),

FIG. **44**(*f*) is a partial side view of the direction changing passage as shown in FIG. **44**(*b*), in which the side cover plate is removed, and

FIG. **44**(*g*) is a partial side view illustrating a recess portion, which forms the direction changing passage in the side cover plate as shown in FIG. **44**(*b*).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now, embodiments of a linear motion guiding apparatus the present invention will be described in detail below with reference to the accompanying drawings.

First Embodiment

FIGS. **1** to **7** show a linear motion guiding apparatus of the first embodiment of the present invention.

The linear motion guiding apparatus **1** is provided with a guide rail **2** as a guide member, which extends linearly, and a movable block **4** as a movable member, which is arranged so as to be movable along the guide rail **2** through a large number of balls **3** as rolling members.

The guide rail **2** is formed into a long bar shape having a rectangular cross-section. Two ball running grooves **5, 5** as a rolling member running track are formed on the horizontal upper surface of the guide rail **2**, and a single ball running groove **5** as the rolling member running track is formed on each of the right and left-hand vertical surfaces of the guide rail **2**, so as to provide a total number of grooves **5** of four.

The movable block **4** is formed as a block body having an inverse U-shaped cross-section, with its opening end being directed downwardly. The block body is provided with a horizontal portion **6**, which faces the upper surface of the guide rail **2** and with a pair of wing portions **7, 7**, which extend downwardly from the right and left ends of the horizontal portion **6** and face the right and left-hand side surfaces of the guide rail **2**, respectively. The horizontal portion **6** has on its lower surface two ball running counter-grooves **8, 8** as a rolling member running counter-track, which correspond to the ball running grooves **5, 5** formed on the upper surface of the guide rail **2**. Each of the wing portions **7, 7** has on its inner surface a single ball running counter-groove **8** as the rolling member running counter-track, which corresponds to the respective ball running grooves **5, 5** formed on the right and left-hand side surfaces of the guide rail **2**.

In addition, in the movable block **4**, there are formed four ball returning passages **9, 9, 9, 9** as a rolling member returning passage, which are provided in parallel with the four ball running counter-grooves **8, 8, 8, 8**, respectively, as well as four pairs of direction changing passages **10, 10, 10, 10** each having a U-shape, for connecting the respective both ends of the ball running counter-grooves **8, 8, 8, 8** with the respective both ends of the ball returning passages **9, 9, 9, 9**, so as to form four endless circulation passages. The ball returning passages **9, 9** respectively corresponding to the ball running grooves **5, 5** formed on the upper side of the guide rail **2** are formed in the horizontal portion **6**. The other ball returning passages **9, 9** respectively corresponding to the ball running grooves **5, 5** formed on the right and left-hand vertical surfaces of the guide rail **2** are formed in the wing portions **7, 7** of the movable block **4**, respectively.

In each of the four endless circulation passages in this embodiment, the balls **3** are retained in the form of train by means a ball retainer **12** as a rolling member retainer, as shown in FIG. **4** so that the balls **3** can be circulated while being guided by the ball retainer **12**.

The ball retainer **12** comprises a flexible belt portion **12*b***, which is provided with ball holes **12*a*** for respectively receiving the balls **3**, and spacing portions **12*c*** provided between the adjacent two balls **3, 3**. The belt portion **12*b*** has a width longer than the diameter of the ball **3** so that the both side edges of the belt portion **12*b*** extend outwardly from the ball **3**.

The spacing portion **12*c*** is provided with a ball supporting spherical recess **12*d*** corresponding to the spherical surface of the ball **3**. The ball **3** is supported on its both sides by a pair of supporting spherical recesses **12*d*** so as to prevent the ball **3** from coming off the belt portion **12*b***. In this embodiment, the one end of the belt portion **12*b*** is not connected to the other end thereof, thus forming a strip-shaped belt having the both ends. The one end of the belt portion **12*b*** may be connected to the other end thereof so as to form an endless belt.

The movable block **4** is composed of a block body **13** having ball running counter-grooves **8, 8, 8, 8**, a resin-formed body **20** for forming ball circulation passages, which is inserted in the block body **13**, and a pair of side cover plates **40, 40** secured to the both end surfaces of the block body **13**, in which the resin-formed body **20** is inserted.

Each of the ball circulation passages of the resin-formed body **20** comprises a pair of ball passage forming portions **21, 21** extending along both longitudinal sides of the ball running counter-groove **8**, a pair of direction changing passage-inner guide forming portions **22, 22** provided on the both side surfaces of the block body **13**, and a resin pipe **23** as a returning passage forming portion, which is inserted into a through-hole formed in the block body **13**. In this embodiment, the ball passage forming portions **21, 21** and the pair of direction changing passage-inner guide forming portions **22, 22** are integrally formed with each other into an integral body, and the resin pipe **23** is separately formed from the above-mentioned integral body. More specifically, there is used a construction that the ball passage forming portions **21, 21** and the pair of direction changing passage-inner guide forming portions **22, 22** are integrally connected with each other through integral forming to form an integral resin frame **24**, and the four resin pipes **23** can respectively be inserted into the block body **13**.

The ball passage forming portions **21, 21** are provided with guide grooves for guiding the both side edges of the belt portion **12*b*** of the ball retainer **12** in a loaded area. The guide grooves can prevent the ball retainer **12** not only from being swung during run of the ball, but also from being sagged by engaging the side edges of the belt portion **12*b*** with the guide groove **21*a***, when the movable block **4** is removed from the guide rail **2**. The balls **3** are supported by the ball retainer **12**. More specifically, the ball retainer **12** is supported by a jaw portion of the guide groove **21*a***, with the result that the balls **3** are kept in its proper position so as not to come off the movable block **4**.

In this embodiment, a distance between the pair of ball passage forming portions **21, 21** arranged in parallel with each other on the both longitudinal sides of the ball running counter-groove **8** is slightly larger than the diameter of the ball **3**. The balls **3** come off the ball running counter-groove **8**, if the ball retainer **12** is not used. When an amount of projection of the jaw portion **21***b* is predetermined so that a distance between the pair of ball passage forming portions **21, 21** is slightly smaller than the diameter of the ball **3** as shown in FIG. **3**(*d*), it is however possible to prevent the balls **3** from coming off the ball running counter-groove **8** even without the ball retainer **12**. Such a construction can apply not only to the case where the balls **3** are inserted into the ball circulation passage with the use of the ball retainer **12**, but also to the case where the balls are inserted therein without the ball retainer **12**. The distance between the pair of ball passage forming portions **21, 21** may be slightly smaller than the diameter of the ball **3** so that the ball passage forming portions **21, 21** directly hold the ball **3** without the use of the ball retainer **12** as shown in FIG. **3**(*e*).

Guide grooves **9***c*, **10***c* are also formed in the ball returning passage **9** and the direction changing passage **10** as non-loaded areas, in order to guide the side edges of the belt portion **12***b*. The guide grooves **9***c*, **10***c* are connected to the above-mentioned guide groove **21***a* in the loaded area so as to form an endless groove on the entire periphery.

When the ball retainer **12** is not used as shown in FIG. **3**(*f*), the distance between the pair of ball passage forming portions **21, 21** arranged on the both longitudinal sides of the ball running counter-groove **8**, which portions do not have any jaw portions **21**, may be slightly smaller than the diameter of the ball **3**, thus preventing the balls **3** from coming off the ball running counter-groove **8**.

The four sets of ball passage forming portions **21, 21** are composed of the first thin connecting plate portion **25** extending longitudinally along the under surface of the horizontal portion **6** of the block body **13**, a pair of second connecting plate portions **26, 26**, which have an L-shaped cross section and extend in the longitudinal direction of the block body **13** along the corner portions between the horizontal portion **6** and the wing portions **7, 7** of the block body **13**, and a pair of third connecting plate portions **27, 27**, which extend in the longitudinal direction of the block body **13** along the lower surfaces of the wing portions **7, 7** of the block body **13**.

More specifically, the right and left-hand side edges of the first connecting plate portion **25** and the upper edges of the pair of right and left-hand second connecting plate portions **26, 26** are located at the both sides of the respective ball running counter-grooves **8, 8** provided on the under surface of the horizontal portion **6**, so as to form the ball passage forming portions **21, 21; 21, 21**. The lower edges of the second connecting plate portions **26, 26** and the inner edges of the third connecting plate portions **27, 27** are located at the both sides of the respective ball running counter-grooves **8, 8** provided on the respective inner surface of the wing portions **7, 7**, so as to form the other ball passage forming portions **21, 21; 21, 21**.

The direction changing passage-inner guide forming portion **22** has a thin sheet portion **29**, which is to be connected to the end surface of the block body **13**. The ball passage forming portions **21, 21** and the resin pipe **23** are connected through the above-mentioned thin sheet portion **29**. In this embodiment, the direction changing passage-inner guide forming portions **22, 22** and the ball passage forming portions **21, 21** are connected by means of the thin sheet portion **29** through integral forming. The resin pipe **23** is inserted in a hole **34** formed on the thin sheet portion **29** so as to make a faucet joint, and fixed to the thin sheet portion **29**.

The thin sheet portion **29** has the first end plate portion **30** corresponding to the end surface of the horizontal portion **6** of the block body **13**, a pair of third end plate portions **32, 32** corresponding to the end surfaces of the wing portions **7, 7** and the second end plate portions **31, 31** for connecting the first end plate portion **30** and the respective third end plate portions **32, 32**. The first end plate portion **30** has the direction changing passage-inner guide forming portions **22, 22**, which are formed so as to project corresponding to the two trains of balls **3, 3** on the upper surface side of the guide rail **2**. Each of the third end plate portions **32, 32** has the direction changing passage-inner guide forming portion **22**, which is formed so as to project corresponding to the single train of balls **3** on the side surface of the guide rail **2**.

The first end plate portions **30, 30**, which are to be placed respectively on the both ends of the block body **13** are connected at its lower portion with the both ends of the first connecting plate portion **25** extending longitudinally between the first end plate portions **30, 30**. The second end plate portions **31, 31**, which are to be placed respectively on the both ends of the block body **13** are connected at its inner edge portion with the both ends of the second connecting plate portion **26** extending longitudinally between the second end plate portions **31, 31**. The other second end plate portions **31, 31** have the same connecting structure. The third end plate portions **32, 32**, which are to be placed respectively on the both ends of the block body **13** are connected at its inner edge portion with the both ends of the third connecting plate portion **27** extending longitudinally between the third end plate portions **32, 32**. The other third end plate portions **32, 32** have the same connecting structure. A single resin frame **24** is formed in this way.

Each of the direction changing passage-inner guide forming portions **22** has a semi-cylindrical shape. On the outer periphery of the direction changing passage-inner guide forming portion **22**, there is formed an inner guide groove **10***a* having a semi-circular cross section so as to form the inner guide portion for the direction changing passage **10**. The one end of the inner guide groove **10***a* is connected to the end of the ball running counter-groove **8**. Accordingly, the one end of the inner guide groove **10***a* has the same cross-sectional shape as the ball running counter-groove **8** so as to make an alignment of the one end of the inner guide groove **10***a* with the end of the ball running counter-groove **8**. The other end of the inner guide groove **10***a* of the direction changing passage **10** is connected to the end of the ball returning passage **9**. Accordingly, the other end of the inner guide groove **10***a* has the same cross-sectional shape as the ball returning passage **9** so as to make an alignment of the other end of the inner guide groove **10***a* with the end of the ball returning passage **9**.

Cylindrical flange portions **33, 33** are formed on the both ends of the inner guide groove **10***a*. The distance between the respective outer surfaces of the cylindrical flange portions **33, 33** is larger than the width of the belt portion **12***b*. The cylindrical flange portions **33, 33** form a retainer-guide groove **10***c* for the ball retainer **12** in cooperation with a semi-circular recess portion having cutouts, which is formed on the inner periphery of the recess of the side cover plate **40** described later.

The both ends of the inner guide groove **10***a* for the direction changing passage **10** extend to the contacting surface of the first and third end plate portions **30, 32** with the end surface of the block body **13** so as to be connected to the respective ends of the ball running counter-groove **8** and the ball returning passage **9**. Pipe inserting holes **34, 34, 34, 34** having a semi-circular shape, in which the ends of the resin pipes **23** are to be inserted are formed on the first and third end plate portions **30, 32**.

As shown in FIG. **7**, the resin pipe **23** is composed of an inner peripheral side-half pipe member **23***a* located in the inner peripheral side of the ball circulation passage, which is continuously connected to the inner guide groove **10***a* for the direction changing passage, and an outer peripheral side-half pipe member **23***b* located in the outer peripheral side of the ball circulation passage, which is continuously connected to an outer guide groove **10***b* for the direction changing passage **10**, which is formed on the side cover plate **40**. The inner peripheral side-half pipe member **23***a* has a groove portion **9***a* having a semi-circular cross section, and side edge portions **23***c* extending longitudinally along the groove portion **9***a*.

The outer peripheral side-half pipe member **23***b* is formed into a linear member having the same circular cross section as the outer guide groove **10***b* for the direction changing passage, which is formed on the side cover plate **40**. The outer peripheral side-half pipe member **23***b* has a groove portion **9***b*, which is continuously connected to the outer guide groove **10***b*, and side edge portions **23***d* extending longitudinally along the groove portion **9***b*. The side edge portions **23***d* is provided on its outer edges with projections **23***e*, which are to be brought into contact with the outer edges of the side edge portions **23***c* of the inner peripheral side-half pipe member **23***a* to form the retainer-guide groove **9***c* for the ball retainer **12**.

The inner peripheral side-half pipe member **23***a* of the resin pipe **23** has the same length of the block body **13**. The inner peripheral side-half pipe member **23***a* is positioned so as to be brought into contact with the back surface of the direction changing passage-inner guide forming portion **22**.

The outer peripheral side-half pipe member **23***b* of the resin pipe **23** has on the other hand a longer length than the block body **13** by a length corresponding to the thickness of the thin sheet portion **29**. The outer peripheral side-half pipe members **23***b* are inserted in the inserting holes **34** of the first and third end plate portions **30, 32**. Longitudinal positional determination of the outer peripheral side-half pipe member **23***b* is made by bringing the both ends of the outer peripheral side-half pipe member **23***b* inserted in the inserting holes **34** into contact with the peripheral edge of the end portion of the outer guide grooves **10***b* for the direction changing passage, which are formed on the side cover plate **40**. The projections **23***e* formed on the both side edges of the outer peripheral side-half pipe member **23***b* come into contact with the outer edges of the cylindrical flange portions **33** formed on the direction changing passage-inner guide forming portion **22** to form a part of the guide groove **10***c*, and the outer peripheral side-half pipe member **23***b* and the inner peripheral side-half pipe member **23***a* are restricted to be turned in the inserting hole **14**.

The resin pipes **23** and the direction changing passage-inner guide forming portions **22** are accurately positioned through the inserting holes **34** formed on the first and third end plate portions **30, 32** of the thin sheet portion **29** and a proper assembling is carried out in this manner.

As shown in FIG. **5**, the side cover plate **40** is provided with an inserting recess portion **40**a, in which the thin sheet portion **29** is inserted, four recess portions **41** having the outer guide grooves **10***b* for the direction changing passage, into which portions the direction changing passage-inner guide forming portions **22** are fitted, and screw-fixing portions for securing the side cover plate **40** to the block body **13**. In the screw-fixing portions, the side cover plate **40** is fixed to the block body **13** by inserting bolts **44** into holes **43** formed on the side cover plate **40** and engaging the bolts with screwed holes **45** formed on the end surface of the block body **13**. The holes **43** are located between the first and third end plate portions **30, 32** of the thin sheet portion **29**.

As shown in FIG. **7**, the outer guide groove **10***b* for the direction changing passage in the recess portion **41** has on its side edges larger-diameter arcuate recesses **46**, which form the retainer-guide groove **10***c* in cooperation with the cylindrical flange portions **33** of the direction changing passage-inner guide forming portions **22**, and a smaller-diameter arcuate recesses **47**, in which the cylindrical flange portions **33** are inserted. The direction changing passage-inner guide forming portion **22** provided with the inner guide groove **10***a* for the direction changing passage is fitted into the recess portion **41** of the side cover plate **40**, and the thin sheet portion **29** is received in the inserting recess portion **40**a of the side cover plate **40**. The thin sheet portion **29** is held between the side cover plate **40** and the end surface of the block body **13** through a clamping force so as to be firmly fixed therebetween.

The direction changing passage-inner guide forming portions **22** and the ball passage forming portion **21** are connected through the thin sheet portion **29**, thus making it possible to maintain an accurate positional relationship of the end of the inner guide groove **10***a* for the direction changing passage formed in the direction changing passage-inner guide forming portion **22** relative to the ball passage forming portions **21, 21**, as well as an accurate positional relationship of the inner guide groove **10***a* for the direction changing passage relative to the ball returning passage **9**.

The thin sheet portion **29** located in the vicinity of the direction changing passage-inner guide forming portion **22** is uniformly urged against the flat end surface of the block body **13** through a clamping force applied to the side cover plate **40** (see FIG. **7**). Even when the direction changing passage-inner guide forming portion **22** is not located in a correct position, the thin sheet portion **29** changes its shape on the end surface of the block body **13**, thus permitting the correct positioning of the direction changing passage-inner guide forming portion **22**. The thin sheet portion **29** is firmly clamped and fixed through a clamping force, which is applied to the side cover plate **40**, and frictional force caused by such a clamping step may prevent an unfavorable movement of the inner guide groove **10***a* for the direction changing passage.

The side cover plate **40** is secured to the block body **13** so that the direction changing passage-inner guide forming portion **22** assembled to the block body **13** is fitted into the recess portion **41** of the side cover plate **40**. Such a fitting step permits to make an accurate positioning of the side cover plate **40** relative to the block body **13**.

FIG. **6** shows assembling steps for the above-described resin-formed body for forming the ball circulation passage.

First, the inner peripheral side-half pipe member **23***a* of the resin pipe **23** is inserted in the through-hole **14** of the block body **13** (see FIGS. **6**(*a*) and **6**(*b*)).

Then, the resin frame **24** obtained by integral forming is inserted in the recess of the block body **13**, while causing the thin sheet portions **29** at the both ends of the resin frame **24** to slide on the respective end surfaces of the block body **13** (see FIGS. **6**(*c*) and **6**(*d*)). The first connecting plate portion **25** of the resin frame **24** comes into contact with the under surface of the horizontal portion **6**, thus making positional determination in the vertical direction of the resin frame **24**. The second connecting plate portion **26** and the third connecting plate portion **27** of the resin frame **24** come into contact with the respective inner surfaces of the wing portions **7**, **7** of the block body **13**, thus making positional determination of the ball passage forming portions **21**, **21** and the direction changing passage-inner guide forming portion **22** (see FIGS. **6**(*e*) and **6**(*f*)). At this time, the inserting hole **34** of the thin sheet portion **29** is aligned with the through-hole **14** of the block body **13**.

Then, the outer peripheral side-half pipe member **23***b* is inserted in the through-hole **14** from the inserting hole **34**, thus completing the assembling step of the resin-formed body **20** for forming the ball circulation passage (see FIGS. **6**(*g*) and **6**(*h*)).

Then, the one side cover plate **40** is secured to the one end surface of the block body **13** by a clamping step, the ball retainer **12** holding the balls is inserted, and the other side cover plate **40** is secured to the other end surface of the block body **13** by the same clamping step, thus completing the assembling step of the movable block **4**.

According to the present invention, the resin-formed body **20** for forming the ball circulation passage is separately formed from the block body **13**. Even when the movable block **4** has a larger size, there is no restriction of flow of molten resin by the block body **13**, unlike the case where the block body **13** is integrally formed with the resin-formed body **20**. Increase in number of gates formed on a die may ensure proper run of the molten resin, thus improving the formability. Especially, the ball passage forming portions **21**, **21** located at the opposite longitudinal sides of the ball running groove **8** are thin, with the result that molten resin may not reach every part of the space for forming the ball passage forming portions **21**, **21**. It is therefore effective to form the resin-formed body **20** separately from the block body **13** in accordance with the embodiment of the present invention.

The continuous circulation passage is formed by the resin-formed body **20**, and it is therefore possible to make positional determination of the inner guide groove **10***a* for the direction changing passage relative to the ball passage forming portions **21**, **21**, as well as positional determination of the inner guide groove **10***a* for the direction changing passage relative to the ball returning passage **9**, thus ensuring continuity of the circulation passage so as to make smooth circulation of the balls **3**.

When the proper positional relationship of the inner guide groove **10***a* for the direction changing passage relative to the ball passage forming portions **21**, **21**, is maintained, the ball passage forming portions **21**, **21** are located at the longitudinal both sides of the ball running groove **8** so as to be aligned with the ends of the inner guide groove **10***a* for the direction changing passage.

When the proper positional relationship of the inner guide groove **10***a* for the direction changing passage relative to the ball returning passage **9** is maintained, the inner guide groove **10***a* for the direction changing passage can be aligned with the inner groove **23***a* of the ball returning passage **9**.

The connecting portion of the ball passage forming portions **21**, **21** and the direction changing passage-inner guide forming portion **22** is obtained by integral forming, thus permitting omission of an assembling step of the connecting portion. Although the running direction of the balls **3** is changed in such a connecting portion, the above-mentioned integral structure may ensure continuity of the circulation passage, without being affected by assembling accuracy. It is therefore possible to make smooth run of the balls **3** from the ball running passage between the ball running groove **5** and the ball running counter-groove **8** to the direction changing passage **10**, as well as from the direction changing passage **10** to the ball returning passage **9**.

Description will be given of modifications of the resin-formed body **20** for forming the ball circulation passage, which is divided into parts. In the description of the modifications, modified features will only be explained in comparison with the first embodiment of the present invention. The same reference numerals will be given to the same components as those in the first embodiment of the present invention, and description thereof will be omitted.

First Modification

FIGS. **8** and **9** show the first modification of the resin-formed body **20** for forming the ball circulation passage, which is described in the first embodiment.

In the first modification, the resin-formed body **20** for forming the ball circulation passage is composed of the first resin-formed frame **20**A, which is obtained by integrally connecting both of the ball passage forming portions **21**, **21** and the resin pipes **23** at their ends with the direction changing passage-inner guide forming portions **22**A for one side, and the second resin-formed frame **20**B, which is provided with the direction changing passage-inner guide forming portions **22**B for the other side and separately formed from the first resin-formed frame **20**A.

In this case, the ball passage forming portions **21**, **21** are integrally connected with the direction changing passage-inner guide forming portions **22**A through the thin sheet portion **29**A as in the first embodiment.

The direction changing passage-inner guide forming portions **22**A are also integrally connected with the resin pipes **23** through the thin sheet portion **29**A. In this case, the resin pipe **23** is formed into a tubular integral body, although the half pipe members are used in the first embodiment. Accordingly, there exists no inserting hole **34** in the thin sheet portion **29**A, and the ball returning passage **9** is exposed on the thin sheet portion **29**A.

The first resin-formed frame **20**A and the second resin-formed frame **20**B are connected, as shown in FIG. **9**, by means of a joint method using the combination of a recess and a projection to be inserted therein, such as a faucet joint method. In the illustrated example, a recess portion **36** of a dove-tail groove is formed in the second resin-formed frame **20**B, and an engaging projection **35** to be engaged with the recess portion **36** is formed, on the other hand, in the ball passage forming portions **21**, **21**.

In this case, the resin pipe **23** of the first resin-formed frame **20**A is inserted in the through-hole **14** of the block body **13**, and the first, second and third connecting plate portions **25**, **26**, **27** are inserted along the under surface of the horizontal portion **6** of the block body **13** and the inner surfaces of the wing portions **7**,**7**.

Then, the engaging projections **35** formed at the respective free end portions of the first, second and third connecting plate portions **25**, **26**, **27** are engaged with the recess portions **36** formed on the thin sheet portion **29**B of the second resin-formed frame **24**B, which is arranged on the other end surface of the block body **13**.

The recess portions **36** may be formed on the first resin-formed frame **20**A and the engaging projections **35** may be formed on the second resin-formed frame **20**B. The connecting method is not limited to the method described above, and there may be used any conventional connecting method, in which the ends of the divided parts can be maintained in a proper connecting position and connected.

Second Modification

FIGS. **10** and **11** show the second modification of the resin-formed body **20** for forming the ball circulation passage, which is described in the first embodiment.

In the second modification, the resin-formed body **20** for forming the ball circulation passage, which has been obtained by integrally forming both of the ball passage forming portions **21, 21** and the resin pipes **23** as a returning passage forming portion with a pair of direction changing passage-inner guide forming portions **22, 22**, is divided at the middle portion of each of the ball passage forming portions **21, 21** and the resin pipes **23** into two parts. More specifically, the ball passage forming portions **21, 21** and the resin pipes **23** are divided at their middle portion into the respective two half parts, and each of the thus divided two half parts is integrally formed with the direction changing passage-inner guide forming portions **22, 22**, thus forming two resin-formed frames **20**C, **20**D having substantially the same shape.

Four sets of the ball passage forming portions **21, 21** are formed on the first, second and third connecting plate portions **25, 26, 27**. Recess portions **38** and engaging projections **37** to be inserted therein are formed on the divided ends of the first, second and third connecting plate portions **25, 26, 27** and the divided ends of the resin pipes **23**.

Third Modification

FIGS. **12** to **14** show the third modification of the resin-formed body **20** for forming the ball circulation passage, which is described in the first embodiment.

In the third modification, there is not used the resin pipe **23** as a returning passage forming portion described in the first embodiment, and a resin-formed frame **20**E is obtained by integrally forming the first, second and third connecting plate portions **25, 26, 27** having the ball passage forming portions **21, 21** with the thin sheet portions **29, 29** each having the pair of direction changing passage-inner guide forming portions **22, 22**. The ball returning passage **9** is composed as a through-hole formed in the block body **13**.

In this case, an engaging projection **39***a*, which is engageable with a tapered portion **15** formed in the opening end of the ball returning passage **9** may be formed in the opening end of the ball hole **39** of the thin sheet portion **29**. Such a construction permits to make a proper connection of the end of the ball returning passage **9** and the direction changing passage-inner guide forming portion **22**.

In the illustrated example, an arcuate engaging projection **48** is additionally formed on the connection portion of the outer guide groove **10***b* for the direction changing passage with the ball returning passage **9**. The engaging projection **48** can be fitted into the ball hole **39** of the thin sheet portion **29** and engaged with the tapered portion **15** of the opening end of the ball returning passage **9**.

Fourth Modification

FIG. **15** shows the fourth modification of the resin-formed body **20** for forming the ball circulation passage, which is described in the first embodiment.

In the fourth modification, there is not used the resin pipe **23** described in the third modification, a resin-formed frame **24**B is obtained by integrally forming the ball passage forming portions **21** with the direction changing passage-inner guide forming portions **22** for the one side, the other resin-formed frame **24**C provided with the direction changing passage-inner guide forming portions **22** for the other side is separately formed from the above-mentioned resin-formed frame **24**B, and the resin-formed frames **24**B, **24**C are connected with each other by engagement of the engaging projection **35** with the recess **36**. The structure other than the above-mentioned construction is the same as that of the third modification.

Modifications of the Ball Train

In the first embodiment and the first to fourth modifications, there is described that two trains of the balls are provided on the upper surface of the guide rail **2** and the single train of the balls is provided on each of the side surfaces of the guide rail **2**, so as to provide the total number of trains of four. In the present invention, the other type of ball trains can however be applied as shown in FIG. **16**. With respect to the division of the resin-formed body **20** for forming the ball circulation passage, all the modifications as shown in FIG. **16** are based on the divisional pattern of the first embodiment. All the divisional patterns of the first to fourth modifications may however be applied to the modifications of the ball train as shown in FIG. **16**.

In the example as shown in FIGS. **16**(*a*) and **16**(*b*), two lower and upper trains of the balls as rolling members are provided on each of the gaps between the right and left-hand side surfaces of the guide rail **2** and the inner surfaces of the right and left-hand wing portions **7, 7** of the movable block **13**, so as to provide the total number of trains of four.

FIG. **16**(*b*) shows the resin-formed body **20** in which all the ball passage forming portions for the four trains of the balls are integrally formed with each other. The resin-formed body **20** may however be divided into two resin-formed bodies **20, 20**, which correspond to two trains of the balls for each of the right and left-hand sides of the guide rail **2**, as shown in FIG. **18**.

In the example as shown in FIGS. **16**(*c*) and **16**(*d*), the movable block **4** is provided with the horizontal portion **6** facing the upper surface of the guide rail **2** and a single wing portion **7** facing the one side surface of the guide rail **2**. The single train of the balls **3** as rolling members is provided between the one side surface of the guide rail **2** and the single wing portion **7** of the movable block **4**, and the other single train of the balls **3** is provided between the upper surface of the guide rail **2** and the lower surface of the horizontal portion in the vicinity of the corner of the guide rail **2**, so as to provide the total number of trains of two.

In the example as shown in FIGS. **16**(*e*) and **16**(*f*), the movable block **4** is provided with a pair of wing portions **7, 7** between which the guide rail **2** is held at its right and left-hand surfaces. The single train of the balls **3** is provided in each of the gaps between the right and left-hand surfaces of the guide rail **2** and the inner surfaces of the right and left-hand wing portions **7, 7** of the movable block **4**, so as to provide the total number of trains of two.

In the example as shown in FIGS. **16**(*g*) and **16**(*h*), the movable block **4** is arranged along the one side surface of the guide rail **2**. Two upper and lower trains of the balls **3** are provided between the one side surface of the guide rail **2** and the movable block **4**.

Second Embodiment

FIGS. **18** to **20** show a linear motion guiding apparatus of the second embodiment of the present invention.

In the second embodiment, rollers are used as rolling members. More specifically, the linear motion guiding apparatus comprises a guide rail **202** as a guide member, extending linearly, and a movable block **204** arranged so as to be movable along the guide rail **202** through a large number of rollers **203** as rolling members.

The guide rail **202** is formed into a long bar shape having a rectangular cross-section. Two roller running surfaces **205, 205** as a rolling member running track are formed on the horizontal upper surface of the guide rail **2**, and a single roller running surface **205** as the rolling member running track is formed on each of the right and left-hand vertical surfaces of the guide rail **2**, so as to provide a total number of surfaces **5** of four.

The movable block **204** is formed as a block body having an inverse U-shaped cross-section, with its opening end being directed downwardly. The block body is provided with a horizontal portion **206**, which faces the upper surface of the guide rail **202** and with a pair of wing portions **207, 207**, which extend downwardly from the right and left ends of the horizontal portion **206** and face the right and left-hand side surfaces of the guide rail **202**, respectively. The horizontal portion **206** has on its lower surface two roller running counter-surfaces **208, 208** as a rolling member running counter-track, which correspond to the roller running surfaces **205, 205** formed on the upper surface of the guide rail **202**. Each of the wing portions **207, 207** has on its inner surface a single roller running counter-surface **208** as the rolling member running counter-track, which corresponds to the respective roller running surfaces **205, 205** formed on the right and left-hand side surfaces of the guide rail **202**.

In addition, in the movable block **204**, there are formed four roller returning passages **209, 209, 209, 209** as a rolling member returning passage, which are provided in parallel with the four roller running counter-surfaces **208, 208, 208, 208**, respectively, as well as four pairs of direction changing passages **210, 210, 210, 210** each having a U-shape, for connecting the respective both ends of the roller running counter-surfaces **208, 208, 208, 208** with the respective both ends of the roller returning passages **209, 209, 209, 209**, so as to form four endless circulation passages.

The roller returning passages **209, 209** respectively corresponding to the roller running surfaces **205, 205** formed on the upper side of the guide rail **202** are formed in the horizontal portion **206**. The other roller returning passages **209, 209** respectively corresponding to the roller running surfaces **205, 205** formed on the right and left-hand vertical surfaces of the guide rail **202** are formed in the wing portions **207, 207** of the movable block **204**, respectively.

In each of the endless circulation passages in this embodiment, the rollers **3** are retained in the form of train by means a roller retainer **212** as a rolling member retainer so that the rollers **203** can be circulated while being guided by the roller retainer **212**.

As shown in FIGS. **19**(*b*) to **19**(*d*), the roller retainer **212** comprises a flexible belt portion **212***b*, which is provided with roller holes **212***a* for respectively receiving the rollers **203**, and spacing portions **212***c* provided between the adjacent two rollers **203, 203**. The belt portion **212***b* has a width longer than the diameter of the roller **203** so that the both side edges of the belt portion **212***b* extend outwardly from the roller **203**.

The spacing portion **212***c* is provided with a roller supporting recess **212***d* corresponding to the cylindrical surface of the roller **203**. The roller **203** is supported on its both sides by a pair of supporting recesses **212***d* so as to prevent the roller **203** from coming off the belt portion **212***b*. In this embodiment, the one end of the belt portion **212***b* is not connected to the other end thereof, thus forming a strip-shaped belt having the both ends. The one end of the belt portion **212***b* may be connected to the other end thereof so as to form an endless belt.

As shown in FIGS. **18** and **20**, the movable block **204** is composed of a metallic block body **213** having roller running counter-surfaces **208, 208, 208, 208**, a resin-formed body **220** for forming roller circulation passages, which is inserted in the block body **213**, and a pair of side cover plates **214, 214** secured to the both end surfaces of the block body **213**, in which the resin-formed body **220** is inserted.

In the second embodiment, four circulation passages are formed by two resin-formed bodies **220, 220** for forming the roller circulation passage, which are arranged at the right and left-hand sides.

Each of the roller circulation passages of the resin-formed bodies **220** comprises a pair of roller passage forming portions **221, 221** extending along both longitudinal sides of the roller running counter-surface **208**, a pair of direction changing passage-inner guide forming portions **222, 222** provided on the both side surfaces of the block body **213**, and a resin pipe **223** as a returning passage forming portion, which is inserted into a through-hole formed in the block body **213**.

The roller passage forming portions **221, 221** are provided with guide surfaces for guiding the both side edges of the belt portion **212***b* of the roller retainer **212** in a loaded area as illustrated in detain in FIG. **20**. The guide grooves can prevent the roller retainer **212** not only from being swung during run of the roller, but also from being sagged by engaging the side edges of the belt portion **212***b* with the guide groove **221***a*. The rollers **203** are supported by the roller retainer **212**. More specifically, the roller retainer **212** is supported by a jaw portion of the guide groove **221***a*, with the result that the rollers **203** are kept-in its proper position so as not to come off the movable block **204**.

In this embodiment, the one end of the belt portion **212***b* is not connected to the other end thereof, thus forming a strip-shaped belt having the both ends. The one end of the belt portion **212***b* may be connected to the other end thereof so as to form an endless belt.

Guide grooves **209***c*, **210***c* are also formed in the roller returning passage **209** and the direction changing passage **210** as non-loaded areas, in order to guide the side edges of the belt portion **212***b*. The guide grooves **209***c*, **210***c* are connected to the above-mentioned guide groove **221***a* in the loaded area so as to form an endless groove on the entire periphery.

In each of the resin-formed bodies **220, 220** for forming the roller circulation passage, the roller passage forming portions **221, 221** and the pair of the direction changing passage-inner guide forming portions **222, 222** are integrally formed with each other. The resin pipe **223** for forming the roller returning passage **209** is separately formed from the resin-formed bodies **220, 220**. More specifically, the one ends of the two pairs of the roller passage forming portions **221, 221** are integrally connected with the ends of the pair of direction changing passage-inner guide forming portions **222, 222** to form a single resin frame **220**A so that the thus formed resin frame **220**A can be inserted into the block body **213**. The other resin frame **220**A has the same construction.

The roller passage forming portions **221, 221** to be arranged on the upper surface of the guide rail **202** are integrally connected with the other roller passage forming portions **221, 221** to be arranged on the side surface of the guide rail **202** by means of a thin connecting plate portion **226**.

The direction changing passage-inner guide forming portion **222** is integrally formed with a thin sheet portion **229**, which is to be brought into contact with the end surface of the block body **213**.

The thin sheet portion **229** has the first end plate portion **230**, which is to be brought into contact with the end surface of the horizontal portion **206** of the block body **213**, the third end plate portion **232**, which is to be brought into contact with the end surface of the wing portion **207**, and the second end plate portion **231**, which is arranged at the corner between the horizontal portion **206** and the wing portion **207** on the end surface of the block body **213**, and connects the first end plate portion **230** with the third end plate portion **232**.

The pair of roller passage forming portions **221, 221**, which are arranged on the both longitudinal sides of the roller running surface **208** are integrally formed on the inside edge of the first end plate portion **230** and the inside edge of the third end plate portion **232**, respectively. The both ends of the connecting plate portion **226** are integrally connected with the inside edges of the second plate portions **231, 231**.

Each of the direction changing passage-inner guide forming portions **222** has a semi-cylindrical shape. On the outer periphery of the direction changing passage-inner guide forming portion **222**, there is formed an inner guide groove **210***a* having a rectangular cross section so as to form the inner guide portion for the direction changing passage **210**. The one end of the bottom of the inner guide groove **210***a* is connected to the end of the roller running counter-surface **208**. Accordingly, the one end of the inner guide groove **210***a* has the same cross-sectional shape as the roller running counter-surface **208** so as to make an alignment of the one end of the inner guide groove **210***a* with the end of the roller running counter-surface **208**. The other end of the inner guide groove **210***a* of the direction changing passage **210** is connected to the end of the roller returning passage **229**. Accordingly, the other end of the inner guide groove **210***a* has the same cross-sectional shape as the roller returning passage **209** so as to make an alignment of the other end of the inner guide groove **210***a* with the end of the roller returning passage **209**.

Cylindrical flange portions **233, 233** are formed on the both ends of the inner guide groove **210***a*. The distance between the respective outer surfaces of the cylindrical flange portions **233, 233** is larger than the width of the belt portion **212***b*. The cylindrical flange portions **233, 233** form a guide groove **210***c* for the roller retainer **212** in cooperation with the side cover plate **240** described later.

The one end of the inner guide groove **210***a* for the direction changing passage **210** extends to the contacting surface of the first and third end plate portions **230, 232** with the end surface of the block body **213** so as to be connected to the end of the roller running counter-surface **208**. The other end of the inner guide groove **210***a* for the direction changing passage **210** extends to the end surface of the thin sheet portion **229**, which is apart from the block body **213**. A step portion **222***a* having a depth identical to the thickness of the thin sheet portion **229** is formed at the other end of the inner guide groove **210***a*. The inner peripheral side-half pipe member for the resin pipe **223** projects from the end surface of the block body **13** by a length identical to the thickness of the thin sheet portion **229**. The projected end of the half pipe member **223***a* is fitted into the step portion **222***a* of the thin sheet portion **229**.

Pipe inserting holes **234, 234** having a semi-circular shape, in which the ends of for the outer peripheral side-half pipe member **223***a* for the resin pipes **223** for forming the roller returning passage **209** are to be inserted are formed on the first and third end plate portions **230, 232** of the thin sheet portion **229**. The resin pipe **223** is inserted into the circular through-hole **214** formed in the block body **213** so that the inner peripheral surface of the resin pipe **223** form the roller returning passage **209**.

As shown in FIG. **20**, the resin pipe **223** is composed of the inner peripheral side-half pipe member **223***a*, which is continuously connected to the inner guide groove **210***a* for the direction changing passage, and the outer peripheral side-half pipe member **223***b*, which is continuously connected to the outer guide groove **210***b* for the direction changing passage **210**, which is formed on the side cover plate **240**. The inner peripheral side-half pipe member **223***a* has an inner groove portion **209***a* having a rectangular cross section, and side edge portions **223***b* extending longitudinally along the inner groove portion **209***a*. The longitudinal edge portions **223***c* of the inner peripheral side-half pipe member **223***a* has the same width as the flange portion **233** of the portion **228**.

The outer peripheral side-half pipe member **223***b* is formed into a linear member having the same rectangular cross section as the outer guide groove **210***b* for the direction changing passage, which is formed on the side cover plate **240**. The outer peripheral side-half pipe member **223***b* has a outer groove portion **209***b*, which is continuously connected to the outer guide groove **210***b*, and side edge portions **223***d* extending longitudinally along the outer groove portion **209***b*. The side edge portions **223***d* is provided on its outer edges with projections **223***e*, which are to be brought into contact with the side edge portions **223***c* of the inner peripheral side-half pipe member **223***a* to form the guide groove for the belt portion **212** of the roller retainer **212**.

The inner peripheral side-half pipe member **223***a* of the resin pipe **223** has the same length of the block body **213**. The inner peripheral side-half pipe member **223***a* is positioned so as to be brought into contact with the end surface of the direction changing passage-inner guide forming portion **222**, which is arranged on the side of the block body **213**.

The outer peripheral side-half pipe member **223***b* of the resin pipe **223** has on the other hand a longer length than the block body **213** by a length corresponding to the thickness of the first and third end plate portions of the thin sheet portion **229**, which are arranged on the both ends of the block body **213**. The outer peripheral side-half pipe members **223***b* are inserted in the inserting holes **234** of the first and third end plate portions **230, 232**. Longitudinal positional determination of the outer peripheral side-half pipe member **223***b* is made by bringing the both ends of the outer peripheral side-half pipe member **223***b* inserted in the inserting holes **234** into contact with the peripheral edge of the end portion of the outer guide grooves **210***b* for the direction changing passage, which are formed on the side cover plate **240**. The projections **223***e* formed on the both longitudinal side edges **223** of the outer peripheral side-half pipe member **223***b* come into contact with the cylindrical flange portions **233** at the side edges of the inner guide groove **210***a* of the direction changing passage-inner guide forming portion **222**, and the outer peripheral side-half pipe member **223***b* and the inner peripheral side-half pipe member **223***a* are restricted to be turned in the inserting hole **214**.

The resin pipes **223** and the direction changing passage-inner guide forming portions **222** are accurately positioned through the inserting holes **234** formed on the first and third end plate portions **230, 232** of the thin sheet portion **229** and a proper assembling is carried out in this manner.

The side cover plate **240** is provided with four recess portions **241** having the outer guide grooves **210***b* for the direction changing passage, into which the portions **228** of the direction changing passage-inner guide forming portions **222** are fitted, and screw-fixing portions for securing the side cover plate **240** to the block body **213**. In the screw-fixing portions, the side cover plate **240** is fixed to the block body **213** by inserting bolts **244** into holes **243** formed on the side cover plate **240** and engaging the bolts **244** with screwed holes **245** formed on the end surface of the block body **213**. The holes **243** are located between the first and third end plate portions **230, 232** of the thin sheet portion **229**.

The direction changing passage-inner guide forming portion **222** provided with the inner guide groove **210***a* for the direction changing passage is fitted into the recess portion **241** of the side cover plate **240**. The thin sheet portion **229** is held between the side cover plate **240** and the end surface of the block body **213** through a clamping force so as to be firmly fixed therebetween.

The direction changing passage-inner guide forming portions **222** and the roller passage forming portion **221** are connected through the thin sheet portion **229**, thus making it possible to maintain an accurate positional relationship of the end of the inner guide groove **210***a* for the direction changing passage relative to the roller passage forming portions **221**, as well as an accurate positional relationship of the inner guide groove **210***a* for the direction changing passage relative to the roller returning passage **209**.

The thin sheet portion **229** is uniformly urged against the flat end surface of the block body **213** through a clamping force applied to the side cover plate **240**. Even when the direction changing passage-inner guide forming portion **222** is not located in a correct position, the thin sheet portion **229** changes its shape, thus permitting the correct positioning of the direction changing passage-inner guide forming portion **222**. The thin sheet portion **229** is firmly clamped and fixed through a clamping force, which is applied to the side cover plate **240**, and frictional force caused by such a clamping step may prevent an unfavorable movement of the inner guide groove **210***a* for the direction changing passage.

Description will be given of modifications of the resin-formed body **220** for forming the roller circulation passage, which is divided into parts. In the description of the modifications, modified features will only be explained in comparison with the second embodiment of the present invention. The same reference numerals will be given to the same components as those in the second embodiment of the present invention, and description thereof will be omitted.

First Modification

FIGS. **21** and **22** show the first modification of the resin-formed body **20** for forming the ball circulation passage, which is described in the second embodiment.

In the first modification, the resin-formed body **220** for forming the ball circulation passage is composed of the first resin-formed frame **220**A, which is obtained by integrally connecting both of the roller passage forming portions **221**, **221** and the resin pipes **223** at their ends with the direction changing passage-inner guide forming portions **222**A for one side, and the second resin-formed frame **220**B, which is provided with the direction changing passage-inner guide forming portions **222**B for the other side and separately formed from the first resin-formed frame **220**A.

In this case, the roller passage forming portions **221**, **221** are integrally connected with the direction changing passage-inner guide forming portions **222**A through the thin sheet portion **229**A as in the second embodiment.

The direction changing passage-inner guide forming portions **222** are also integrally connected with the resin pipes **223** through the thin sheet portion **229**A. In this case, the resin pipe **223** is formed into a tubular integral body, although the half pipe members are used in the second embodiment. Accordingly, there exists no inserting hole **234** in the thin sheet portion **229**A, and the roller returning passage **209** is exposed on the thin sheet portion **229**A.

The first resin-formed frame **220**A and the second resin-formed frame **220**B are connected, as shown in FIG. **22**, by means of a joint method using the combination of a recess and a projection to be inserted therein, such as a faucet joint method. In the illustrated example, a recess portion **236** of a dove-tail groove is formed in the second resin-formed frame **220**B, and an engaging projection **235** to be engaged with the recess portion **236** is formed, on the other hand, in the roller passage forming portions **221**, **221**.

In this case, the resin pipe **223** of the first resin-formed frame **220**A is inserted in the through-hole **214** of the block body **213**, and the roller passage forming portions **221**, **221** and the connecting plate portion **226** are inserted along the under surface of the horizontal portion **206** of the block body **213** and the inner surfaces of the wing portions **207**,**207**.

Then, the engaging projections **235** formed at the roller passage forming portions **221**, **221** and the connecting plate portion **226** are engaged with the recess portions **236** formed on the thin sheet portion **229**B of the second resin-formed frame **224**B, which is arranged on the other end surface of the block body **213**.

The recess portions **236** may be formed on the first resin-formed frame **220**A and the engaging projections **235** may be formed on the second resin-formed frame **220**B. The connecting method is not limited to the method described above, and there may be used any conventional connecting method in which the ends of the divided parts can be maintained in a proper connecting position and connected.

Second Modification

FIGS. **23** and **24** show the second modification of the resin-formed body **220** for forming the ball circulation passage, which is described in the second embodiment.

In the second modification, the resin-formed body **220** for forming the roller circulation passage, which has been obtained by integrally forming both of the roller passage forming portions **221**, **221** and the resin pipes **223** as a returning passage forming portion with a pair of direction changing passage-inner guide forming portions **222**, **222**, is divided at the middle portion of each of the roller passage forming portions **221**, **221** and the resin pipes **223** into two parts. More specifically, the roller passage forming portions **221**, **221** and the resin pipes **223** are divided at their middle portion into the respective two half parts, and each of the thus divided two half parts is integrally formed with the direction changing passage-inner guide forming portions **222**, **222**, thus forming two resin-formed frames **220**C, **220**D having substantially the same shape.

Recess portions **238** and engaging projections **237** to be inserted therein are formed on the divided ends of the roller passage forming portions **221**, **221** and the divided ends of the connecting plate portion **226** and the divided ends of the resin pipes **223**.

Third Modification

FIGS. **25** to **26** show the third modification of the resin-formed body **220** for forming the roller circulation passage, which is described in the second embodiment.

In the third modification, there is not used the resin pipe **223** as a returning passage forming portion described in the second embodiment, and a resin-formed frame **220**E is obtained by integrally forming the both of the roller passage forming portions and the connecting plate portion **226** with the thin sheet portions **229**, **229** each having the pair of direction changing passage-inner guide forming portions **222**, **222**. The roller returning passage **209** is composed as a through-hole formed in the block body **213**.

In this case, an engaging projection **239***a*, which is engageable with a tapered portion **215** formed in the opening end of the roller returning passage **209** may be formed in the opening end of the roller hole **239** of the thin sheet portion **229**. Such a construction permits to make a proper connection of the end of the roller returning passage **209** and the direction changing passage-inner guide forming portion **222**.

In the illustrated example, an arcuate engaging projection **248** is additionally formed on the connection portion of the outer guide groove **210***b* for the direction changing passage with the roller returning passage **209**. The engaging projection **248** can be fitted into the roller hole **239** of the thin sheet portion **229** and engaged with the tapered portion **215** of the opening end of the roller returning passage **209**.

Fourth Modification

FIG. **26** shows the fourth modification of the resin-formed body **220** for forming the roller circulation passage, which is described in the second embodiment.

In the fourth modification, there is not used the resin pipe **223** described in the third modification, a resin-formed frame **220**F is obtained by integrally forming the roller passage forming portions **221** with the direction changing passage-inner guide forming portions **222** for the one side, the other resin-formed frame **220**F provided with the direction changing passage-inner guide forming portions **222** for the other side is separately formed from the above-mentioned resin-formed frame **220**F, and the resin-formed frames **220**F, **220**F are connected with each other by engagement of the engaging projection **235** with the recess **236**. The structure other than the above-mentioned construction is the same as that of the third modification.

Modifications of the Roller Train

In the second embodiment and the first to fourth modifications, there is described that two trains of the rollers are provided on the upper surface of the guide rail **2** and the single train of the rollers is provided on each of the side surfaces of the guide rail **2**, so as to provide the total number of trains of four. In the present invention, the other type of roller trains can however be applied as shown in the figures. With respect to the division of the resin-formed body **220** for forming the roller circulation passage, all the modifications are based on the divisional pattern of the first embodiment. All the divisional patterns of the first to fourth modifications may however be applied to the modifications of the roller train.

In the example as shown in FIG. **27**, two lower and upper trains of the rollers as rolling members are provided on each of the gaps between the right and left-hand side surfaces of the guide rail **202** and the inner surfaces of the right and left-hand wing portions **207**, **207** of the movable block **204**, so as to provide the total number of trains of four.

In this case, four inner guide portions **210***a* corresponding to the four trains of the rollers **203** are integrally formed with each other in the direction changing passage-inner guide forming portions **222**.

In the above description, the present invention is applied to the linear motion guiding apparatus, in which the movable block is arranged on the guide rail as a track shaft through the rolling members. The present invention may however be applied to a so-called ball-spline, in which an outer tube as a movable member is fitted on a spline shaft as a track shaft, as described below.

Third Embodiment

A ball spline **301** as shown in FIGS. **28** to **30** is of a so-called "angular contact" ball spline, and has a spline shaft **302** as a guide member extending linearly and an outer tube **304** arranged so as to be movable along the spline shaft **302** through balls **303** as a large number of rolling members.

The spline shaft **304** is formed into a long bar shape having a circular cross-section. The spline shaft **304** has on its outer periphery three projections **306**. Two ball running grooves **305**, **305** are formed on the both sides of each of the projections **306**, so as to provide the total number of groove of six.

The outer tube **304** has on its inner periphery three recesses **307** corresponding to the projections **306** of the spline shaft **302**, respectively. Ball running counter-grooves **308**, **308** are formed at the both corners of each of the recesses **307**, so as to correspond to the above-mentioned ball running grooves **305**, **305**.

In addition, the outer tube **304** has six ball returning passage **309**, **309**; **309**, **309**; **309**, **309**, which are in parallel with the six ball running counter-grooves **308**, **308**; **308**, **308**; **308**, **308**, and six direction changing passages **310**, **310**; **310**, **310**; **310**, **310** formed into a U-shaped tube, which connect the ends of the above-mentioned ball running counter-grooves **308**, **308**; **308**, **308**; **308**, **308** with the ends of the above-mentioned ball returning passage **309**, **309**; **309**, **309**; **309**, **309**. The outer tube **304** has six circulation passages in this manner.

The ball arranged at each of the both side surfaces of the projection **306** of the spline shaft **302** comes in contact, at its opposite points, with the ball running groove **305** and the ball running counter-groove **308**, respectively. A line connecting the above-mentioned contact points is referred to as the "contact angle line". A contact angle α, i.e., an angle between the contact angle line and the radius line, which connects the center of the spline shaft **302** and the central portion of the projection **306** is relatively large. The ball returning passage **309** is located on the contact angle line.

In this third embodiment, the balls **303** inserted in each of the circulation passages are connected with each other by means of a ball retainer **312** so as to form the train of the balls **303**. The balls **303** are guided by means of the ball retainer **312** and circulated in each of the circulation passages. The ball retainer **312** has the same structure as shown in FIG. **14** and the description thereof is therefore omitted.

The outer tube **304** is composed of a tubular main body **313** having the ball running counter-grooves **308**, **308**; **308**, **308**; **308**, **308**, three resin-formed bodies **320**, **320**, **320** for forming the ball circulation passage, which are to be inserted in the main body **313**, and a pair of side cover plates **314**, **314** secured on the both ends of the main body **313** after the insertion of the resin-formed bodies **320**, **320**, **320** in the main body **313**.

In the third embodiment, the six circulation passages are formed by the three resin-formed bodies **320**, **320**, **320**.

Each of the circulation passages **311** of the resin-formed bodies **320** for forming the ball circulation passage has a pair of the ball passage forming portions **321**, **321** extending along the longitudinal side edges of the ball running counter-groove **308**, a pair of direction changing passage-inner guide forming portions **322**, **322** provided on the both ends of the main body **313**, and resin pipes **323** as a returning passage forming portion, which are inserted in through-holes formed in the main body **313**.

The ball passage forming portions **321**, **321** are provided with guide grooves for guiding the both side edges of the belt portion **312***b* of the ball retainer **312** in a loaded area. The guide grooves can prevent the ball retainer **312** not only from being swung during run of the ball, but also from being sagged by engaging the side edges of the belt portion **312***b* with the guide groove **321***a*, when the outer tube **304** is removed from the spline shaft **302**. The balls **303** are supported by the ball retainer **312**. More specifically, the ball retainer **312** is supported by a jaw portion of the guide groove **321***a*, with the result that the balls **303** are kept in its proper position so as not to come off the outer tube **304**.

Guide grooves **309***c*, **310***c* are also formed in the ball returning passage **309** and the direction changing passage **310** as non-loaded areas, in order to guide the side edges of the belt portion **312***b*. The guide grooves **309***c*, **310***c* are connected to the above-mentioned guide groove **321***a* in the loaded area so as to form an endless groove on the entire periphery.

In each of the resin-formed bodies **320** for forming the ball circulation passage, the ball passage forming portions **321, 321** and the pair of the direction changing passage-inner guide forming portions **322, 322** are integrally connected with each other. The resin-formed body **320** is divided at the other portions into separate parts so as to be able to be inserted in the main body **313**. In the third embodiment, a single resin frame **324** is obtained by integrally connecting the ends of the four sets of ball passage forming portions **321, 321** with the end of the pair of direction changing passage-inner guide forming portions **322, 322**, and the thus obtained resin frame **324** is divided at the connecting portion of the returning passage forming portion **323** with the direction changing passage-inner guide forming portions **322, 322** into the separate parts so as to be able to be inserted in the main body **313**.

The adjacent two of the roller passage forming portions **321, 321, 321, 321** are integrally connected with each other by means of a thin connecting sheet portion **326**. The direction changing passage-inner guide forming portion **322** is integrally formed with the thin sheet portion **329**, which is to be brought into contact with the end surface of the main body **313**.

The thin sheet portion **329** is provided with the first end plate portions **330, 330** and the second end plate portion **231** for connecting the first end plate portions **330, 330** with each other. Each of the pair of ball passage forming portions **321, 321** is integrally connected with the inner edge of the first end plate portion **230**. The both ends of the connecting plate portion **326** are integrally connected with the inner edge of the second end plate portion **331**.

Each of the direction changing passage-inner guide forming portions **322** has a semi-cylindrical shape. On the outer periphery of the direction changing passage-inner guide forming portion **322**, there is formed an inner guide groove **310***a* having a semi-circular cross section so as to form the inner guide portion for the direction changing passage **310**. The one end of the inner guide groove **310***a* is connected to the end of the ball running counter-groove **308**. Accordingly, the one end of the inner guide groove **310***a* has the same cross-sectional shape as the ball running counter-groove **308** so as to make an alignment of the one end of the inner guide groove **310***a* with the end of the ball running counter-groove **308**. The other end of the inner guide groove **310***a* of the direction changing passage **310** is connected to the end of the ball returning passage **309**. Accordingly, the other end of the inner guide groove **310***a* has the same cross-sectional shape as the ball returning passage **309** so as to make an alignment of the other end of the inner guide groove **310***a* with the end of the ball returning passage **309**.

Cylindrical flange portions **333, 333** are formed on the both ends of the inner guide groove **310***a*. The distance between the respective outer surfaces of the cylindrical flange portions **333, 333** is larger than the width of the belt portion **312***b*. The cylindrical flange portions **333, 333** form a retainer-guide groove **310***c* for the ball retainer **312** in cooperation with the side cover plate **340** described later.

The both ends of the inner guide groove **310***a* for the direction changing passage **310** extend to the contacting surface of the first end plate portion **330** with the end surface of the main body **313** so as to be connected to the respective ends of the ball running counter-groove **308** and the ball returning passage **309**.

Pipe inserting holes **334, 334** having a semi-circular shape, in which the ends of for the outer peripheral side-half pipe member **323***a* for the resin pipes **323** for forming the roller returning passage **309** are to be inserted are formed on the first and third end plate portions **330, 332** of the thin sheet portion **329**. The resin pipe **323** is inserted into the circular through-hole **314** formed in the main body **313** so that the inner peripheral surface of the resin pipe **323** form the ball returning passage **309**.

The resin pipe **323** is composed of the inner peripheral side-half pipe member **323***a*, which is continuously connected to the inner guide groove **310***a* for the direction changing passage, and the outer peripheral side-half pipe member **323***b*, which is continuously connected to the outer guide groove **310***b* for the direction changing passage **310**, which is formed on the side cover plate **340**. The inner peripheral side-half pipe member **323***a* has an inner groove portion **309***a* having a rectangular cross section, and side edge portions **323***b* extending longitudinally along the inner groove portion **309***a*. The longitudinal edge portions **323***c* of the inner peripheral side-half pipe member **323***a* has the same width as the flange portion **333** of the direction changing passage-inner guide forming portion **322**.

The outer peripheral side-half pipe member **323***b* is formed into a linear member having the same rectangular cross section as the outer guide groove **310***b* for the direction changing passage, which is formed on the side cover plate **340**. The outer peripheral side-half pipe member **323***b* has a outer groove portion **309***b*, which is continuously connected to the outer guide groove **310***b*, and side edge portions **323***d* extending longitudinally along the outer groove portion **309***b*. The side edge portions **323***d* is provided on its outer edges with projections **323***e*, which are to be brought into contact with the side edge portions **323***c* of the inner peripheral side-half pipe member **323***a* to form the guide groove for the belt portion **312** of the ball retainer **312**.

The inner peripheral side-half pipe member **323***a* of the resin pipe **323** has the same length of the main body **313**. The inner peripheral side-half pipe member **323***a* is positioned so as to be brought into contact with the end surface of the direction changing passage-inner guide forming portion **322**, which is arranged on the side of the main body **313**.

The outer peripheral side-half pipe member **323***b* of the resin pipe **323** has on the other hand a longer length than the main body **313** by a length corresponding to the thickness of the first end plate portions **330, 330** of the thin sheet portion **329**, which are arranged on the both ends of the main body **313**. The outer peripheral side-half pipe members **323***b* are inserted in the inserting holes **334** of the first end plate portions **330, 332**. Longitudinal positional determination of the outer peripheral side-half pipe member **323***b* is made by bringing the both ends of the outer peripheral side-half pipe member **323***b* inserted in the inserting holes **334** into contact with the peripheral edge of the end portion of the outer guide grooves **310***b* for the direction changing passage, which are formed on the side cover plate **340**. The projections **323***e* formed on the both longitudinal side edges **323** of the outer peripheral side-half pipe member **323***b* come into contact with the outer edges of the cylindrical flange portions of the direction changing passage-inner guide forming portion **322** to form a guide groove, and the outer peripheral side-half pipe member **323***b* and the inner peripheral side-half pipe member **323***a* are restricted to be turned in the inserting hole **314**.

The resin pipes **323** and the direction changing passage-inner guide forming portions **322** as the ball returning passage forming portions are accurately positioned through the inserting holes **334** formed on the first end plate portion **330, 330** of the thin sheet portion **329** and a proper assembling is carried out in this manner.

The side cover plate **340** is provided with four recess portions **341** having the outer guide grooves **310***b* for the direction changing passage, into which the direction changing passage-inner guide forming portions **322** are fitted, and screw-fixing portions for securing the side cover plate **340** to the main body **313**. In the screw-fixing portions, the side cover plate **340** is fixed to the main body **313** by inserting bolts **344** into holes **343** formed on the side cover plate **340** and engaging the bolts **344** with screwed holes **345** formed on the end surface of the main body **313**. The holes **343** are located between the first end plate portions **330**, **330** of the thin sheet portion **329**.

The direction changing passage-inner guide forming portion **322** is fitted into the recess portion **341** of the side cover plate **340**. The thin sheet portion **329** is held between the side cover plate **340** and the end surface of the main body **313** through a clamping force so as to be firmly fixed therebetween.

The direction changing passage-inner guide forming portions **322** and the ball passage forming portion **321** are connected through the thin sheet portion **329**, thus making it possible to maintain an accurate positional relationship of the end of the inner guide groove **310***a* for the direction changing passage relative to the ball passage forming portions **321**, as well as an accurate positional relationship of the inner guide groove **310***a* for the direction changing passage relative to the ball returning passage **309**.

The thin sheet portion **329** is uniformly urged against the flat end surface of the main body **313** through a clamping force applied to the side cover plate **340**. Even when the direction changing passage-inner guide forming portion **322** is not located in a correct position, the thin sheet portion **329** changes its shape, thus permitting the correct positioning of the direction changing passage-inner guide forming portion **322**. The thin sheet portion **329** is firmly clamped and fixed through a clamping force, which is applied to the side cover plate **340**, and frictional force caused by such a clamping step may prevent an unfavorable movement of the inner guide groove **310***a* for the direction changing passage.

According to the present invention, only the ball running counter-groove **308** for the circulation passage **311** is formed of the main body **313** having high rigidity, and the other portions are formed of the resin-formed bodies **320** for forming the ball circulation passage. Precision working of the ball running counter-groove **308** of the main body **313** suffices, thus permitting reduction in steps for working and decrease in the production cost.

The resin-formed body **320** for forming the ball circulation passage is separately formed from the main body **313**. Even when the outer tube **304** has a larger size, there is no restriction of flow of molten resin by the main body **313**, unlike the case where the main body **313** is integrally formed with the resin-formed body **320**. Increase in number of gates formed on a die may ensure proper run of the molten resin, thus improving the formability. Especially, the ball passage forming portions **321**, **321** located at the opposite longitudinal sides of the ball running groove **308** are thin, with the result that molten resin may not reach every part of the space for forming the ball passage forming portions **321**, **321**. It is therefore effective to form the resin-formed body **320** separately from the main body **313** in accordance with the embodiment of the present invention.

The ball passage forming portions **321**, **321** are continuously and integrally connected with the direction changing passage-inner guide forming portions **322**, and the divided parts are jointed so as to make alignment of them to make a faucet joint. It is therefore possible to ensure a proper continuity of the connecting portion of the circulation passage and to make smooth run of the balls **303** from the ball running passage between the ball running groove **305** and the ball running counter-groove **308** to the direction changing passage **310**, as well as from the direction changing passage **310** to the ball returning passage **309**.

Description will be given of modifications of the resin-formed body **320** for forming the ball circulation passage, which is divided into parts. In the description of the modifications, modified features will only be explained in comparison with the third embodiment of the present invention. The same reference numerals will be given to the same components as those in the third embodiment of the present invention, and description thereof will be omitted.

First Modification

FIGS. **31** and **32** show the first modification of the resin-formed body **320** for forming the ball circulation passage, which is described in the third embodiment.

In the first modification, the resin-formed body **320** for forming the ball circulation passage is composed of the first resin-formed frame **320**A, which is obtained by integrally connecting both of the ball passage forming portions **321**, **321** and the resin pipes **323** at their ends with the direction changing passage-inner guide forming portions **322**A for one side, and the second resin-formed frame **320**B, which is provided with the direction changing passage-inner guide forming portions **322**B for the other side and separately formed from the first resin-formed frame **320**A.

In this case, the ball passage forming portion s **321**, **321** are integrally connected with the direction changing passage-inner guide forming portions **322**A through the thin sheet portion **329**A as in the first embodiment.

The direction changing passage-inner guide forming portions **322**A are also integrally connected with the resin pipes **323** through the thin sheet portion **329**A. In this case, the resin pipe **323** is formed into a tubular integral body, although the half pipe members are used in the third embodiment. Accordingly, there exists no inserting hole s**34** in the thin sheet portion **329**A, and the ball returning passage **309** is exposed on the thin sheet portion **329**A.

The first resin-formed frame **320**A and the second resin-formed frame **320**B are connected, as shown in FIG. **32**, by means of a joint method using the combination of a recess and a projection to be inserted therein, such as a faucet joint method. In the illustrated example, a recess portion **336** of a dove-tail groove is formed in the second resin-formed frame **320**B, and an engaging projection **335** to be engaged with the recess portion **336** is formed, on the other hand, in the ball passage forming portions **321**, **321**.

In this case, the resin pipe **323** of the first resin-formed frame **320**A is inserted in the through-hole **314** of the main body **313**, and the ball passage forming portions **321**, **321** and the connecting plate portion **236** are inserted along the inner surface of the recess **307** of the main body **313**.

Then, the engaging projections **335** formed at the respective free end portions of the ball passage forming portions **321**, **321** and the connecting plate portion **326** are engaged with the recess portions **336** formed on the thin sheet portion **329**B of the second resin-formed frame **324**B, which is arranged on the other end surface of the main body **313**.

The recess portions **336** may be formed on the first resin-formed frame **320**A and the engaging projections **335** may be formed on the second resin-formed frame **320**B. The connecting method is not limited to the method described above, and there may be used any conventional connecting method, in which the ends of the divided parts can be maintained in a proper connecting position and connected.

Second Modification

FIGS. **33** and **34** show the second modification of the resin-formed body **320** for forming the ball circulation passage, which is described in the third embodiment.

In the second modification, the resin-formed body **320** for forming the ball circulation passage, which has been obtained by integrally forming both of the ball passage forming portions **321, 321** and the resin pipes **323** as a returning passage forming portion with a pair of direction changing passage-inner guide forming portions **322, 322**, is divided at the middle portion of each of the ball passage forming portions **321, 321** and the ball returning passage forming portions **323** into two parts. More specifically, the ball passage forming portions **321, 321** and the ball returning passage forming portions **323** are divided at their middle portion into the respective two half parts, and each of the thus divided two half parts is integrally formed with the direction changing passage-inner guide forming portions **322, 322**, thus forming two resin-formed frames **320**C, **320**D having substantially the same shape.

Recess portions **338** and engaging projections **337** to be inserted therein are formed on the divided ends of the ball passage forming portions **321, 321**, the divided ends of the central connecting plate portion **326** and the divided ends of the resin pipes **323**.

Third Modification

FIG. **35** shows the third modification of the resin-formed body **320** for forming the ball circulation passage, which is described in the third embodiment.

In the third modification, there is not used the resin pipe **323** as a returning passage forming portion described in the first embodiment, and a resin-formed frame **320**E is obtained by integrally forming the ball passage forming portions, the connecting plate portions **326** with the thin sheet portions **329, 329** each having the pair of direction changing passage-inner guide forming portions **322, 322**. The ball returning passage **309** is composed as a through-hole formed in the main body **313**.

In this case, an engaging projection **339***a*, which is engageable with a tapered portion **315** formed in the opening end of the ball returning passage **309** may be formed in the opening end of the ball hole **339** of the thin sheet portion **329**. Such a construction permits to make a proper connection of the end of the ball returning passage **309** and the direction changing passage-inner guide forming portion **322**.

In the illustrated example, an arcuate engaging projection **348** is additionally formed on the connection portion of the outer guide groove **310***b* formed on the side cover plate **340** with the ball returning passage **309**. The engaging projection **48** can be engaged with the thin sheet portion **329**.

Fourth Modification

FIG. **36** shows the fourth modification of the resin-formed body **320** for forming the ball circulation passage, which is described in the third embodiment.

In the fourth modification, there is not used the resin pipe **323** described in the third modification, a resin-formed frame **320**F is obtained by integrally forming the ball passage forming portions **321** with the direction changing passage-inner guide forming portions **322** for the one side, the other resin-formed frame **320**G provided with the direction changing passage-inner guide forming portions **322** for the other side is separately formed from the above-mentioned resin-formed frame **320**F, and the resin-formed frames **320**F, **320**G are connected with each other by engagement of the engaging projection **335** with the recess **336**. The structure other than the above-mentioned construction is the same as that of the third modification.

In the third embodiment described above, there are used three sets of resin-formed bodies for forming the ball circulation passage, each of which is divided into two parts. Six sets of resin-formed bodies may however be used for the respective circulation passages. The single set of resin-formed body may also be used. In this case, the divisional method of the resin-formed body should be based on the first, second and fourth modifications described above, taking into consideration the difficulty of insertion of the resin-formed body into the main body of the outer tube.

Modifications of the Ball Train

In the third embodiment and the first to fourth modifications thereof, the ball spline has the angular contact type ball train. The present invention may also be applied to the ball spline having the radial contact type ball train as shown in FIG. **37**. In such a radial contact type ball train, the spline shaft has no projections on the outer periphery so as to reveal the circular cross-section, and the outer tube has no recesses on the inner periphery so as to reveal the hollow cylindrical shape. The radial contact type ball train has the smaller contact angle α than that of the angular contact type ball train. With respect to the divisional method of the resin-formed body **320** for forming the ball circulation passage, all the patterns described in the third embodiment and the first to fourth modifications thereof may be used.

In the example illustrated in FIG. **37**, six resin-formed bodies **320** for forming the ball circulation passage are separately provided from each other for the respective six ball trains. The two sets of resin-formed bodies **320** mentioned above may be integrally formed with each other so as to prepare three sets of resin-formed bodies **320** having the six ball circulation passages. The single resin-formed body having the six ball circulation passages may also be used.

Fourth Embodiment

FIGS. **38** and **39** illustrate the forth embodiment of the present invention. In the fourth embodiment, the present invention is applied to a roller spline, in which rollers are used as the rolling members.

The roller spline **401** as shown in FIG. **38** is composed of a spline shaft **402** as a guide member extending linearly, and an outer tube **404** arranged so as to be movable along the spline shaft **402** through the rollers **403** as the rolling members.

The spline shaft **402** is formed into a long bar shape having a modified cross-section. The spline shaft **402** has on its outer periphery three projections **406**. Two roller running surfaces **405, 405** are formed on the both sides of each of the projections **406**, so as to provide the total number of running surfaces of six.

The outer tube **404** has on its inner periphery three recesses **407** corresponding to the projections **406** of the spline shaft **402**, respectively. Roller running counter-surfaces **408, 408** are formed at the both corners of each of the recesses **407**, so as to correspond to the above-mentioned roller running surfaces **405, 405**.

In addition, the outer tube **404** has six roller returning passage **409, 409; 409, 409; 409, 409**, which are in parallel with the six roller running counter-surfaces **408, 408; 408, 408; 408, 408**, and six direction changing passages **410, 410; 410, 410; 410, 410** formed into a U-shaped tube, which connect the ends of the above-mentioned roller running counter-surfaces **408, 408; 408, 408; 408, 408** with the ends of the above-mentioned roller returning passage **409, 409; 409, 409; 409, 409**. The outer tube **404** has six circulation passages in this manner.

The rollers **403** inserted in each of the circulation passages are connected with each other by means of the same roller retainer **412** as the roller retainer **212** shown in FIG. **19**, so as to form the train of the rollers **403**. The rollers **403** are guided by means of the roller retainer **412** and circulated in each of the circulation passages.

The outer tube **404** is composed of a tubular main body **413** having the roller running counter-grooves **408, 408; 408, 408; 408, 408**, three resin-formed bodies **420, 420, 420** for forming the ball circulation passage, which are to be inserted in the main body **413**, and a pair of side cover plates **440, 440** secured on the both ends of the main body **413** after the insertion of the resin-formed bodies **420, 420, 420** in the main body **413**.

In the fourth embodiment, the six circulation passages are formed by the three resin-formed bodies **420, 420, 420** as in the third embodiment.

Each of the resin-formed bodies **420** for forming the ball circulation passage has a pair of the roller passage forming portions **421, 421** extending along the longitudinal side edges of the roller running counter-groove **408**, a pair of direction changing passage-inner guide forming portions **422, 422** provided on the both ends of the main body **413**, and resin pipes **423** as a returning passage forming portion, which are inserted in through-holes formed in the main body **413**.

The roller passage forming portions **421, 421** are provided with guide grooves for guiding the both side edges of the belt portion **412***b* of the roller retainer **412** in a loaded area. The guide grooves can prevent the roller retainer **412** not only from being swung during run of the roller, but also from being sagged by engaging the side edges of the belt portion **412***b* with the guide groove **421***a*, when the outer tube **404** is removed from the spline shaft **402**. The rollers **403** are supported by the roller retainer **412**. More specifically, the roller retainer **412** is supported by a jaw portion of the guide groove **421***a*, with the result that the rollers **403** are kept in its proper position so as not to come off the outer tube **404**.

Guide grooves **409***c*, **410***c* are also formed in the roller returning passage **409** and the direction changing passage **410** as non-loaded areas, in order to guide the side edges of the belt portion **412***b*. The guide grooves **409***c*, **410***c* are connected to the above-mentioned guide groove **421***a* in the loaded area so as to form an endless groove on the entire periphery.

When the roller retainer **412** is not used, the guide grooves **421***a*, **410***a*, **409***a* are not needed, and the jaw portions as shown in FIG. **20**(*h*) for supporting the ends of the roller are formed on the roller passage forming portions **421**.

In each of the resin-formed bodies **420** for forming the roller circulation passage, at least one of four connecting portions of the roller passage forming portions **421, 421** with the pair of the direction changing passage-inner guide forming portions **422, 422** are integrally connected with each other. The resin-formed body **420** is divided at the other portions into separate parts so as to be able to be inserted in the main body **413**.

The fundamental embodiment of the resin-formed body for forming the roller circulation passage, which is to be used for the spline unit is described in detail in the third embodiment. The structure of the resin-formed body for forming the roller circulation passage is described in detail in the second embodiment. Here, only the fundamental divisional pattern of the resin-formed body **420** for forming the roller circulation passage will be briefly described below with reference to FIG. **39**.

In FIG. **39**(*a*), the both ends of the four sets of roller passage forming portions **421, 421** are integrally connected with the respective one end of the pair of direction changing passage-inner guide forming portions **422, 422** to form a single resin frame **424**, and the both ends of each of the returning passage forming portions **423** are not connected with the other end of the direction changing passage-inner guide forming portion **422** so that these parts can be assembled into the main body **413**.

In FIG. **39**(*b*), the resin-formed body **420** for forming the roller circulation passage is composed of the first resin-formed frame **420**A, which is obtained by integrally connecting both of the roller passage forming portions **421, 421** and the resin pipes **423** as a returning passage forming portion at their ends with the direction changing passage-inner guide forming portions **422**A for one side, and the second resin-formed frame **420**B, which is provided with the direction changing passage-inner guide forming portions **422**B for the other side and separately formed from the first resin-formed frame **420**A.

In FIG. **39**(*c*), the resin-formed body **420** for forming the roller circulation passage, which has been obtained by integrally forming both of the roller passage forming portions **421, 421** and the resin pipes **423** as a returning passage forming portion with a pair of direction changing passage-inner guide forming portions **422, 422**, is divided at the middle portion of each of the roller passage forming portions **421, 421** and the returning passage forming portions **423** into two parts. More specifically, the roller passage forming portions **421, 421** and the resin pipes **423** are divided at their middle portion into the respective two half parts, and each of the thus divided two half parts is integrally formed with the direction changing passage-inner guide forming portions **422, 422**, thus forming two resin-formed frames **420**C, **420**D having substantially the same shape.

In FIG. **39**(*d*), there is not used the resin pipe **423** as shown in FIG. **39**(*a*), and a resin-formed frame **420**E is obtained by integrally forming both of the roller passage forming portions and the connecting plate portion **326** with the thin sheet portions **429, 429** each having the pair of direction changing passage-inner guide forming portions **422, 422**. The roller returning passage **409** is composed as a through-hole formed in the main body **413**.

In FIG. **39**(*e*), there is not used the resin pipe **423** as shown in FIG. **39**(*b*), and a resin-formed frame **420**F is obtained by integrally forming the roller passage forming portions **421** with the direction changing passage-inner guide forming portions **422** for the one side, the other resin-formed frame **420**G provided with the direction changing passage-inner guide forming portions **422** for the other side is separately formed from the above-mentioned resin-formed frame **420**F.

In FIGS. **39**(*a*) to **29**(*e*), the resin-formed frames are connected with each other by means of the conventional joint method such as a faucet joint, which uses engagement of the engaging projection with the recess.

Fifth Embodiment

FIGS. **40** to **44** show a linear motion guiding apparatus of the fifth embodiment of the present invention.

The linear motion guiding apparatus **501** is provided with a guide rail **502** as a guide member, which extends linearly, and a movable block **504** as a movable member, which is arranged so as to be movable along the guide rail **502** through a large number of balls **503** as rolling members.

The guide rail **502** is formed into a long bar shape having a rectangular cross-section. Two ball running grooves **505, 505** as a rolling member running track are formed on each of the right and left-hand side surfaces of the guide rail **502**, so as to provide a total number of grooves **505** of four. The guide rail **502** has on each of its side surfaces a projection **502***a*, on the upper and lower positions of which the ball running grooves **505, 505** are arranged.

The movable block **504** is formed as a block body having an inverse U-shaped cross-section, with its opening end being directed downwardly. The block body is provided with a horizontal portion **506**, which faces the upper surface of the guide rail **502** and with a pair of wing portions **507, 507**, which extend downwardly from the right and left ends of the horizontal portion **506** and face the right and left-hand side surfaces of the guide rail **502**, respectively. Each of the wing portions **507, 507** has on its inner surface two ball running counter-grooves **508, 508** as a rolling member running counter-track, which correspond to the ball running grooves **505, 505** formed on the right and left-hand side surfaces of the guide rail **502**.

Each of the right and left-hand wing portions **507, 507** of the movable block **504** has two ball returning passage forming portions **509, 509** formed therein, which extend in parallel with the ball running counter-grooves **508, 508**. At both the longitudinal ends of each of the wing portions **507, 507**, there are arranged direction changing passages **510, 510; 510, 510** for connecting the ends of the ball running counter-grooves **508, 508; 508, 508** with the ends of the ball returning passage **509, 509; 509, 509**. In summary, each of the wing portions **507, 507** of the movable block **504** has two endless circulation passages, in which the balls **503** are circulated, so as to provide the total number of passage of four.

In each of the four endless circulation passages in this embodiment, the balls **503** are retained in the form of train by means a ball retainer **512** as a rolling member retainer so that the balls **503** can be circulated while being guided by the ball retainer **512**.

As shown in FIGS. **44**(*c*) to **44**(*e*), the ball retainer **512** comprises a flexible belt portion **512***b*, which is provided with ball holes **512***a* for respectively receiving the balls **503**, and spacing portions **512***c* provided between the adjacent two balls **503, 503**. The belt portion **512***b* has a width longer than the diameter of the ball **503** so that the both side edges of the belt portion **512***b* extend outwardly from the ball **503**.

The spacing portion **512***c* is provided with a ball supporting spherical recess **512***d* corresponding to the spherical surface of the ball **503**. The ball **503** is supported on its both sides by a pair of supporting spherical recesses **512***d* so as to prevent the ball **503** from coming off the belt portion **512***b*. In this embodiment, the one end of the belt portion **512***b* is not connected to the other end thereof, thus forming a strip-shaped belt having the both ends. The one end of the belt portion **512***b* may be connected to the other end thereof so as to form an endless belt.

As shown in FIG. **41**, the movable block **504** is composed of a block body **513** having ball running counter-grooves **508, 508, 508, 508**, a pair of right and left-hand resin-formed bodies **520, 520** for forming ball circulation passages, which is inserted in the block body **513**, and a pair of side cover plates **540** (only one cover plate **540** is illustrated) secured to the both end surfaces of the block body **13**, in which the resin-formed bodied **520, 520** are inserted.

Each of the right and left-hand resin-formed bodies **520, 520** for forming the ball circulation passage forms two endless circulation passages. The right and left-hand resin-formed bodies **520, 520** have the symmetrical shape. One of them will be described below and the description of other thereof will be omitted.

More specifically, the resin-formed body **520** for forming the ball circulation passage is composed of a resin frame **524** obtained by integrally forming the ball passage forming portions **521, 521** extending along both longitudinal sides of the ball running counter-groove **508** with the pair of direction changing passage-inner guide forming portions **522, 522** (see FIG. **42**); and a pair of resin pipes **523, 523** as a returning passage forming portion, which are to be inserted in through-holes **514, 514** formed in the block body **513** (see FIG. **43**). The ball passage forming portions **521, 521** are integrally formed with the pair of direction changing passage-inner guide forming portions **522, 522** to form the resin frame **524** as an integral body, and the pair of resin pipes **523, 523** are separately formed from such an integral body, so that these parts can be assembled into the block body **513**.

As shown in FIG. **42**, the ball passage forming portions **521, 521** are provided with guide grooves for guiding the both side edges of the belt portion **512***b* of the ball retainer **512** in a loaded area. The guide grooves can prevent the ball retainer **512** not only from being swung during run of the ball, but also from being sagged by engaging the side edges of the belt portion **512***b* with the guide groove **521***a*, when the movable block **504** is removed from the guide rail **502**. The balls **503** are supported by the ball retainer **512**. More specifically, the ball retainer **512** is supported by a jaw portion of the guide groove **521***a*, with the result that the balls **503** are kept in its proper position so as not to come off the movable block **504**.

The distance between the pair of ball passage forming portions **521, 521** arranged in parallel with each other on the both longitudinal sides of the ball running counter-groove **508** is slightly smaller than the diameter of the ball **503**. In such a construction, it is possible to prevent the balls **503** from coming off the ball passage forming portions **521, 521** even when the ball retainer **512** is not used.

Guide grooves **509***c*, **510***c* are also formed, as shown in FIGS. **44**(*a*) and **44**(*b*), in the ball returning passage **509, 509** and the direction changing passage **510, 510** as non-loaded areas, in order to guide the side edges of the belt portion **512***b*. The guide grooves **509***c*, **510***c* are connected to the above-mentioned guide groove **521***a* in the loaded area so as to form an endless groove on the entire periphery.

The ball passage forming portions **521, 521; 521, 521** are composed, as shown in FIG. **42**(*a*), of the first connecting plate portion **525** extending longitudinally along the corner between the horizontal portion **506** and the wing portion **507** of the block body **513** in the longitudinal direction of the block body **513**; the second connecting plate portion **526** extending longitudinally between the ball running counter-grooves **508, 508** on the inner surface of each of the wing portions **507** of the block body **513**; and a pair of third connecting plate portions **527** extending along the under surface of the wing portion **507** of the block body **513** in the longitudinal direction thereof.

The upper edge of the first connecting plate portion **525** and the lower edge of the second connecting plate portion **526**, which face to each other, are placed on the opposite longitudinal sides of the upper ball running counter-groove **508** provided in the wing portion **507**, so as to form the ball passage forming portions **521, 521**. The lower edge of the second connecting plate portion **526** and the upper edge of the third connecting plate portion **527**, which face to each other, are placed on the opposite longitudinal sides of the lower ball running counter-groove **508** provided in the wing portion **507**, so as to form the ball passage forming portions **521, 521**.

As shown in FIGS. **44**(*a*), **44**(*b*) and **44**(*c*), the direction changing passage-inner guide forming portions **522** and the ball passage forming portions **521, 521** are connected by means of the thin sheet portion **529** through integral forming. The resin pipe **523** is inserted in a hole **534** formed on the thin sheet portion **529** so as to make a faucet joint, and fixed to the thin sheet portion **529**.

The thin sheet portion **529** has the direction changing passage-inner guide forming portions **522**, **522**, which are formed so as to project corresponding to the two trains of balls **503**, **503** on the side surface of the guide rail **502**. The both ends of the first, second and third connecting plate portions **525**–**527** are connected to the thin sheet portion **529** to be arranged on the end of the block body **513** so as to form the single resin frame **524**.

Each of the direction changing passage-inner guide forming portions **522** has a semi-cylindrical shape. On the outer periphery of the direction changing passage-inner guide forming portion **522**, there is formed an inner guide groove **510***a* having a semi-circular cross section so as to form the inner guide portion for the direction changing passage **510**. The one end of the inner guide groove **510***a* is connected to the end of the ball running counter-groove **508**. Accordingly, the one end of the inner guide groove **510***a* has the same cross-sectional shape as the ball running counter-groove **508** so as to make an alignment of the one end of the inner guide groove **510***a* with the end of the ball running counter-groove **508**. The other end of the inner guide groove **510***a* of the direction changing passage **510** is connected to the end of the ball returning passage **509**. Accordingly, the other end of the inner guide groove **510***a* has the same cross-sectional shape as the ball returning passage **509** so as to make an alignment of the other end of the inner guide groove **510***a* with the end of the ball returning passage **509**.

Cylindrical flange portions **533**, **533** are formed on the both ends of the inner guide groove **510***a*. The distance between the respective outer surfaces of the cylindrical flange portions **533**, **533** is larger than the width of the belt portion **512***b*. The cylindrical flange portions **533**, **533** form a retainer-guide groove **510***c* for the ball retainer **512** in cooperation with a semi-circular recess portion having cutouts, which is formed on the inner periphery of the recess of the side cover plate **5040** described later.

The both ends of the inner guide groove **510***a* for the direction changing passage **510** extend to the contacting surface of the thin sheet portion **529** with the end surface of the block body **513** so as to be connected to the respective ends of the ball running counter-groove **508** and the ball returning passage **509**. Pipe inserting holes **534**, **534** having a semi-circular shape, in which the ends of the resin pipes **523** are to be inserted are formed on the thin sheet portion **529**.

As shown in FIG. **43**, the resin pipe **523** is composed of an outer peripheral side-half pipe member **523***b* located in the outer peripheral side of the ball circulation passage, which is continuously connected to the outer guide groove **510***b* for the direction changing passage **510** of the side cover plate **540**, and an inner peripheral side-half pipe member **523***a* located in the inner peripheral side of the ball circulation passage, which is continuously connected to an inner guide groove **510***a* for the direction changing passage **510** of the side cover plate **540**.

The inner peripheral side-half pipe member **523***a* has a groove portion **509***a* having a semi-circular cross section, and side edge portions **523***c* extending longitudinally along the groove portion **509***a*, as shown in FIGS. **43**(*c*) and **43**(*d*). The outer peripheral side-half pipe member **523***b* is formed into a linear member having the same circular cross section as the outer guide groove **510***b* for the direction changing passage, which is formed on the side cover plate **540**. The outer peripheral side-half pipe member **523***b* has a groove portion **509***b*, which is continuously connected to the outer guide groove **510***b*, and side edge portions **523***d* extending longitudinally along the groove portion **509***b*. The side edge portions **523***d* is provided on its outer edges with projections **523***e*, which are to be brought into contact with the outer edges of the side edge portions **523***c* of the inner peripheral side-half pipe member **523***a* to form the retainer-guide groove **509***c* for the ball retainer **512**.

The inner peripheral side-half pipe member **523***a* of the resin pipe **523** has the same length of the block body **513**. The inner peripheral side-half pipe member **523***a* is positioned so as to be brought into contact with the back surface of the direction changing passage-inner guide forming portion **522**.

The outer peripheral side-half pipe member **523***b* of the resin pipe **523** has on the other hand a longer length than the block body **513** by a length corresponding to the thickness of the thin sheet portion **529**. The outer peripheral side-half pipe members **523***b* are inserted in the inserting holes **534**. Longitudinal positional determination of the outer peripheral side-half pipe member **523***b* is made by bringing the both ends of the outer peripheral side-half pipe member **523***b* inserted in the inserting holes **534** into contact with the peripheral edge of the end portion of the outer guide grooves **510***b* for the direction changing passage, which are formed on the side cover plate **540**. The projections **523***e* formed on the both side edges of the outer peripheral side-half pipe member **523***b* come into contact with the outer edges of the cylindrical flange portions **533** formed on the direction changing passage-inner guide forming portion **522** to form a part of the guide groove **510***c*, and the outer peripheral side-half pipe member **523***b* and the inner peripheral side-half pipe member **523***a* are restricted to be turned in the inserting hole **514**.

The resin pipes **523** and the direction changing passage-inner guide forming portions **522** are accurately positioned through the inserting holes **534** formed on the thin sheet portion **529** and a proper assembling is carried out in this manner.

As shown in FIGS. **44**(*f*) and **44**(*g*), the side cover plate **540** is provided with an inserting recess portion **540**a, in which the thin sheet portion **529** is inserted, recess portions **541** having the outer guide grooves **510***b* for the direction changing passage, into which portions the direction changing passage-inner guide forming portions **522** are fitted, and screw-fixing portions for securing the side cover plate **540** to the block body **513**. In the screw-fixing portions, the side cover plate **540** is fixed to the block body **513** by inserting bolts (not shown) into holes **543** formed on the side cover plate **540** and engaging the bolts with screwed holes **545** formed on the end surface of the block body **513**. The holes **543** are located at four positions, i.e., the position corresponding to the thin sheet portion **529** between the direction changing passage-inner guide forming portions **522**, **522** of each of the resin-formed bodies **520**, **520**, and the positions in the vicinity of the thin sheet portions **529**, **529** on the horizontal portion **506**.

As shown in FIG. **44**(*g*), the outer guide groove **510***b* for the direction changing passage in the recess portion **541** has on its side edges larger-diameter arcuate recesses **546**, which form the retainer-guide groove **510***c* in cooperation with the cylindrical flange portions **533** of the direction changing passage-inner guide forming portions **522** as shown in FIG. **44**(*f*), and a smaller-diameter arcuate recesses **547**, in which the cylindrical flange portions **533** are inserted. The direction changing passage-inner guide forming portion **522** provided with the inner guide groove **510***a* for the direction changing passage is fitted into the recess portion **541** of the side cover plate **540**, and the thin sheet portion **529** is received in the inserting recess portion **540***a* of the side cover plate **540**. The thin sheet portion **529** is held between the side cover plate **540** and the end surface of the block body **513** through a clamping force so as to be firmly fixed therebetween.

The direction changing passage-inner guide forming portions **522** and the ball passage forming portion **521** are connected through the thin sheet portion **529**, thus making it possible to maintain an accurate positional relationship of the end of the inner guide groove **510***a* for the direction changing passage formed in the direction changing passage-inner guide forming portion **522** relative to the ball passage forming portions **521**, **521**, as well as an accurate positional relationship of the inner guide groove **510***a* for the direction changing passage relative to the ball returning passage **509**.

The thin sheet portion **529** located in the vicinity of the direction changing passage-inner guide forming portion **522** is uniformly urged against the flat end surface of the block body **513** through a clamping force applied to the side cover plate **540** (see FIG. **44**). Even when the direction changing passage-inner guide forming portion **522** is not located in a correct position, the thin sheet portion **529** changes its shape on the end surface of the block body **513**, thus permitting the correct positioning of the direction changing passage-inner guide forming portion **522**. The thin sheet portion **529** is firmly clamped and fixed through a clamping force, which is applied to the side cover plate **540**, and frictional force caused by such a clamping step may prevent an unfavorable movement of the inner guide groove **510***a* for the direction changing passage.

The side cover plate **540** is secured to the block body **513** so that the direction changing passage-inner guide forming portion **522** assembled to the block body **513** is fitted into the recess portion **541** of the side cover plate **40**. Such a fitting step permits to make an accurate positioning of the side cover plate **540** relative to the block body **513**.

Now, description will be given of assembling steps for the above-mentioned resin-formed bodies **520** for forming the ball circulation passage.

First, the inner peripheral side-half pipe member **523***a* of the resin pipe **523** is inserted in the through-hole **514** of the wing portion **507** of the block body **513**.

Then, the resin frame **524** obtained by integral forming is inserted in the recess of the block body **513**, while causing the thin sheet portions **529** at the both ends of the resin frame **524** to slide on the respective end surfaces of the wing portion **507** of the block body **513**. The first connecting plate portion **525** of the resin frame **524** comes into contact with the corner portion between the horizontal portion **506** and the wing portion **507**, thus making positional determination in the vertical direction of the resin frame **524**. The second connecting plate portion **526** and the third connecting plate portion **527** of the resin frame **524** come into contact with the respective inner surfaces of the wing portions **507** of the block body **513**, thus making positional determination of the ball passage forming portions **521**, **521** and the direction changing passage-inner guide forming portions **522**, **522**. At this time, the inserting holes **534**, **534** of the thin sheet portion **529** are aligned with the through-holes **514**, **514** of the block body **513**.

Then, the outer peripheral side-half pipe members **523***b*, **523***b* are inserted in the through-holes **514**, **514** from the inserting holes **534**, **534**, thus completing the assembling step of one of the resin-formed bodies **520**, **520** for forming the ball circulation passage.

The assembling step of the other of the resin-formed bodies **520**, **520** is carried out in the same manner.

Then, the one side cover plate **540** is secured to the one end surface of the block body **513** by a clamping step, the ball retainer **512** holding the balls is inserted, and the other side cover plate **540** is secured to the other end surface of the block body **513** by the same clamping step, thus completing the assembling step of the movable block **504**.

According to the present invention, the resin-formed bodies **520**, **520** for forming the ball circulation passage are separately formed from the block body **513**. Even when the movable block **504** has a larger size, there is no restriction of flow of molten resin by the block body **513**, unlike the case where the block body **513** is integrally formed with the resin-formed bodies **520**, **520**. Increase in number of gates formed on a die may ensure proper run of the molten resin, thus improving the formability. Especially, the ball passage forming portions **521**, **521** located at the opposite longitudinal sides of the ball running groove **508** are thin, with the result that molten resin may not reach every part of the space for forming the ball passage forming portions **521**, **521**. It is therefore effective to form the resin-formed bodies **520**, **520** separately from the block body **513** in accordance with the embodiment of the present invention.

In addition, since there are formed the right and left-hand resin-formed bodies **520**, **520** for forming the ball circulation passage, each of which has two endless circulation passages, a proper run of molten resin is ensured even when the movable block **513** has a larger width.

The continuous circulation passage is formed by the resin-formed body **520**, and it is therefore possible to make positional determination of the inner guide groove **510***a* for the direction changing passage relative to the ball passage forming portions **521**, **521**, as well as positional determination of the inner guide groove **510***a* for the direction changing passage relative to the ball returning passage **509**, thus ensuring continuity of the circulation passage so as to make smooth circulation of the balls **503**.

When the proper positional relationship of the inner guide groove **510***a* for the direction changing passage relative to the ball passage forming portions **521**, **521**, is maintained, the ball passage forming portions **521**, **521** are located at the longitudinal both sides of the ball running groove **508** so as to be aligned with the ends of the inner guide groove **510***a* for the direction changing passage.

When the proper positional relationship of the inner guide groove **510***a* for the direction changing passage relative to the ball returning passage **509** is maintained, the inner guide groove **510***a* for the direction changing passage can be aligned with the inner groove **523***a* of the ball returning passage **509**.

The connecting portion of the ball passage forming portions **521**, **521** and the direction changing passage-inner guide forming portion **522** is obtained by integral forming, thus permitting omission of an assembling step of the connecting portion. Although the running direction of the balls **503** is changed in such a connecting portion, the above-mentioned integral structure may ensure continuity of the circulation passage, without being affected by assembling accuracy. It is therefore possible to make smooth run of the balls **503** from the ball running passage between the ball running groove **505** and the ball running counter-groove **508** to the direction changing passage **510**, as well as from the direction changing passage **510** to the ball returning passage **509**.

According to the present invention as described in detail, since the resin-formed body for forming the rolling member circulation passage is separately formed from the block body, even when the movable block has a larger size, increase in number of gates formed on a die may ensure proper run of the molten resin, thus improving the formability. It is therefore effective to form the resin-formed body separately from the block body in accordance with the present invention, taking into consideration the fact that the rolling member passage forming portions located at the opposite longitudinal sides of the rolling member running track are thin, with the result that molten resin may not reach every part of the space for forming the rolling member passage forming portions.

The continuous circulation passage is formed by the resin-formed body, and it is therefore possible to make positional determination of the inner guide groove for the direction changing passage relative to the rolling member passage forming portions, as well as positional determination of the inner guide groove for the direction changing passage relative to the rolling member returning passage, thus ensuring continuity of the circulation passage so as to make smooth circulation of the rolling members.

When the connecting portion of the rolling member passage forming portions and the direction changing passage-inner guide forming portion or the connecting portion of the direction changing passage-inner guide forming portion and the returning passage forming portion, in which portion the running direction of the rolling members is changed is obtained by integral forming, it is possible to omit an assembling step of the connecting portion and to ensure continuity of the circulation passage, without being affected by assembling accuracy.

The integral formation of the connecting portion of the rolling member passage forming portion with the direction changing passage-inner guide forming portion may cause the smooth running of the rolling members between the rolling member running track in the loaded area and the direction changing passage-inner guide forming portion, even when the returning passage forming portion formed of resin is not used.

When the rolling member retainer is used, it is possible to maintain a proper continuity on the entire periphery of the circulation passage in the retainer guide portion for guiding the rolling member retainer.

The thin retainer guide portion is formed without insertion of the body of the movable member in a die, and position of gates in the die can freely be determined without being restricted by the body of the movable member, with the result that molten resin can reach, during formation of the guide portion, the entire space therefor, which is formed in the die.

In addition, the formation of the right and left-hand resin-formed bodies for forming the rolling member circulation passage, each of which has two endless circulation passages may ensure a proper run of molten resin even when the body of the movable member has a larger width.

The connection of the direction changing passage-inner guide forming portion with the rolling member passage forming portion through the thin sheet portion makes it possible to maintain, through deformation of the thin sheet portion, a proper positional relationship between the direction changing passage-inner guide forming portion and the rolling member passage forming portion or a proper positional relationship between the direction changing passage-inner guide forming portion and the rolling member returning passage forming portion, thus making an accurate positional determination of the end of the direction changing passage-inner guide forming portion relative to the rolling member returning passage forming portion as well as an accurate positional determination of the direction changing passage-inner guide forming portion relative to the rolling member returning passage forming portion.

The thin sheet portion is urged against the flat end face of the body of the movable member by a clamping force, which is applied to the side cover plate. It is therefore possible to correct the position of the direction changing passage-inner guide forming portion through deformation of the thin sheet portion, even when the direction changing passage-inner guide forming portion is not correctly positioned relative to the end face of the body of the movable member.

In addition, the thin sheet portion can firmly be secured between the side cover plate and the body of the movable member by the clamping force, which is applied to the side cover plate, and it is therefore possible to prevent the direction changing passage-inner guide forming portion from being incorrectly placed.

What is claimed is:

1. A linear motion guiding apparatus comprising:

a guide member provided with at least one rolling member running track, and

a movable member arranged so as to be movable along the guide member, said movable member being provided with (i) a rolling member running counter-track corresponding to each of the at least one rolling member running track of said guide member, (ii) a rolling member returning passage arranged in parallel with each said rolling member running counter-track and (iii) a direction changing passage for connecting each said rolling member running counter-track and the corresponding rolling member returning passage to permit circulation of a plurality of rolling members,

wherein:

said movable member comprises a movable main body and a separate resin-formed body for providing a rolling member circulation passage;

said resin-formed body comprises a pair of rolling member passage forming portions extending along both longitudinal sides of said rolling member running counter-track and a pair of direction changing passage-inner guide forming portions for providing inner peripheral guide portions of said direction changing passage; and

said resin-formed body is divided into a plurality of parts so that at least two of said pair of rolling member passage forming portions and said pair of direction changing passage-inner guide forming portions are integrally formed, and a remainder of said pair of rolling member passage forming portions and said pair of direction changing passage-inner guide forming portions is separated independently from said at least two, whereby said resin-formed body can be built in said movable main body;

said guide member comprises a guide rail provided with two said rolling member running tracks on each of right and left-hand side surfaces of the guide rail, so as to provide a total of four said rolling member running tracks;

said movable member comprises a movable block, said movable block comprising:

a pair of wing portions, between which the guide rail is held at the right and left-hand side surfaces thereof, each of said wing portions having on an inner surface thereof two said rolling member running counter-tracks corresponding to said two rolling member running tracks on each said side of the guide rail, so as to provide a total of four said rolling member running counter-tracks in the movable block;

four rolling member returning passages arranged in parallel with said four rolling member running counter-tracks, respectively; and direction changing passages for connecting both ends of each of said four rolling member running counter-tracks with ends of a respective one of said four rolling member returning passages;

said four rolling member running counter-tracks, said four rolling member returning passages and said direction changing passages providing four endless circulation passages;

said resin-formed body comprising, for each of said four endless circulation passages, the pair of rolling member passage forming portions, a returning passage forming portion for providing the rolling member returning passage and the pair of direction changing passage-inner guide forming portions;

said resin-formed body being divided into two body-parts, which are arranged on the wing portions of the movable block, respectively, so as to form the two endless circulation passages at an inner side of each of the wing portions; and

in each of the two body-parts, the pair of rolling member passage forming portions and the pair of direction changing passage-inner guide forming portions are provided as an integral body, and the returning passage forming portion is provided separate from said integral body.

2. An apparatus as claimed in claim **1**, wherein:

a rolling member retainer is provided, said rolling member retainer being able to retain the rolling members in a train with a prescribed distance kept between adjacent two of the rolling members, and said rolling member retainer having side edge portions projecting from both sides of each of the rolling members; and

guide grooves for guiding the side edge portions of the rolling member retainer are formed on an entire periphery of the rolling member circulation passage.

3. An apparatus as claimed in claim **1**, wherein:

each of said direction changing passage-inner guide forming portions has a thin sheet portion, which is to be brought into contact with an end face of the body of said movable member, and said each of said direction changing passage-inner guide forming portions is connected to the rolling member passage forming portions or the returning passage forming portion by means of said thin sheet portion.

* * * * *

US006116783A

United States Patent [19]

Shirai et al.

[11] **Patent Number: 6,116,783**

[45] **Date of Patent: Sep. 12, 2000**

[54] **BALL CHAIN**

[75] Inventors: **Takeki Shirai; Shigeru Ebina; Mitsuaki Honma; Tomozumi Murata,** all of Tokyo, Japan

[73] Assignee: **THK Co., Ltd.,** Tokyo, Japan

[21] Appl. No.: **09/142,139**

[22] PCT Filed: **Jan. 14, 1998**

[86] PCT No.: **PCT/JP98/00120**

§ 371 Date: **Sep. 2, 1998**

§ 102(e) Date: **Sep. 2, 1998**

[87] PCT Pub. No.: **WO98/31945**

PCT Pub. Date: **Jul. 23, 1998**

[30] **Foreign Application Priority Data**

Jan. 17, 1997	[JP]	Japan	9-006760
Feb. 28, 1997	[JP]	Japan	9-046179

[51] **Int. Cl.**[7] **F16C 29/06**

[52] **U.S. Cl.** **384/43**; 384/45; 384/51

[58] **Field of Search** 384/43, 44, 45, 384/49, 51

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,944,607	7/1990	Jacob	384/44

FOREIGN PATENT DOCUMENTS

2 655 099	5/1991	France .	
42 29 136 C1	3/1994	Germany .	
59-24226	2/1984	Japan .	
5-52215	3/1993	Japan .	
5-52217	3/1993	Japan .	
5-196037	8/1993	Japan .	
2 104 600	3/1983	United Kingdom .	
WO92/14070	8/1992	WIPO	384/51

OTHER PUBLICATIONS

Abstract of Japanese Patent Publication No. 05196037; dated Aug. 6, 1993.

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Nikaido, Marmelstein, Murray & Oram LLP

[57] **ABSTRACT**

The present invention relates to a ball chain used by being integrated to, for example, a ball endless track of a linear guide device for endless sliding in which a number of balls are arranged in one row and rollably held, particularly to a ball chain which is most pertinent to a linear guide device having a ball rolling groove in a shape of a Gothic arch. According to the ball chain, the number of balls are arranged in one row and the balls are held rollably, each of the balls is pinched by a pair of spherical seats and the spherical seats are connected to each other by flange portions to thereby constitute a ball holding unit and a plurality of the ball holding units are connected in a shape of a rosary by a flexible connecting portion. Further, the spherical seats and the flange portions are molded by a resin material whereas the connecting portion is formed by a material having a tensile strength larger than that of the resin material.

3 Claims, 12 Drawing Sheets

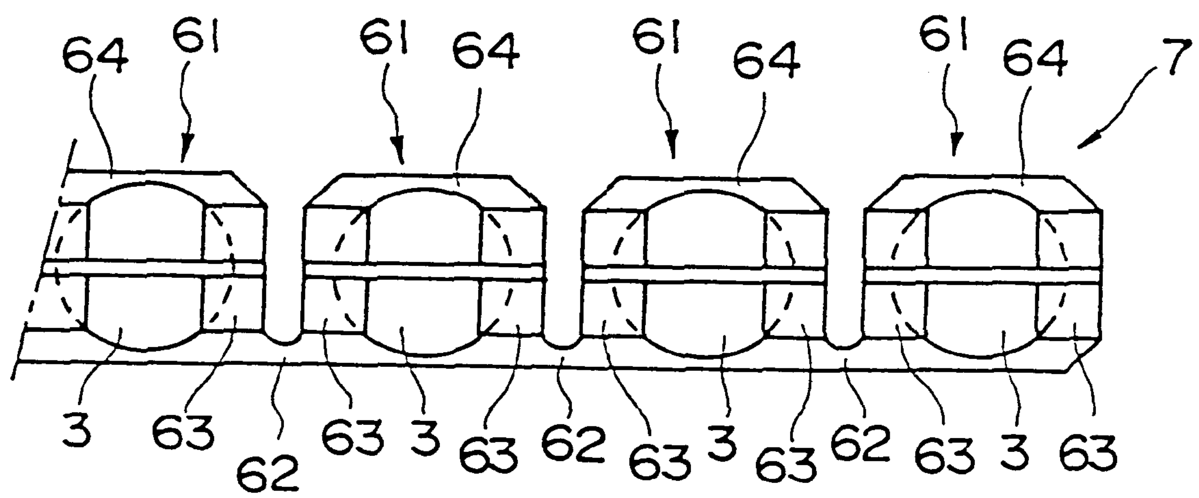


Fig. 1

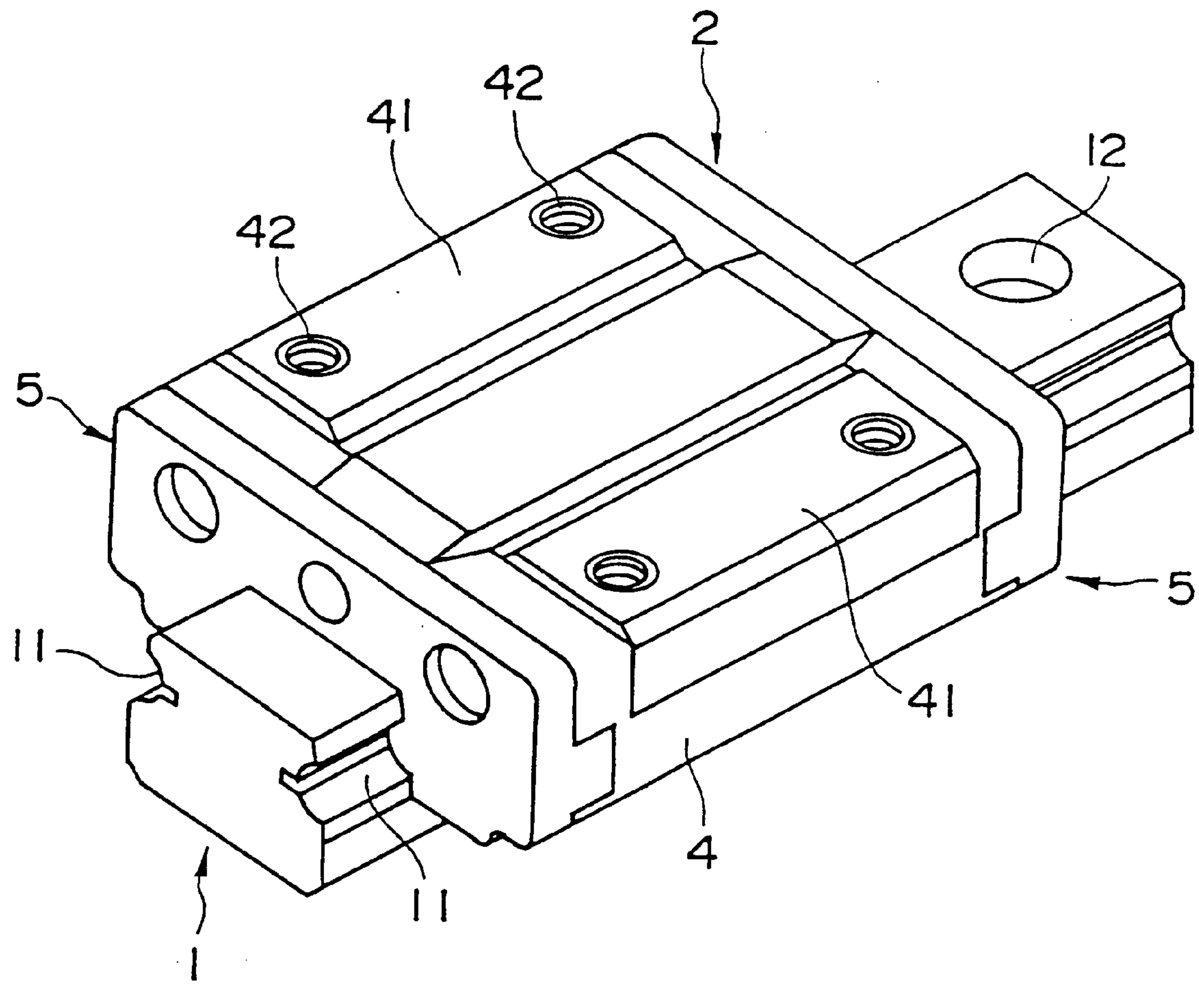


Fig. 2

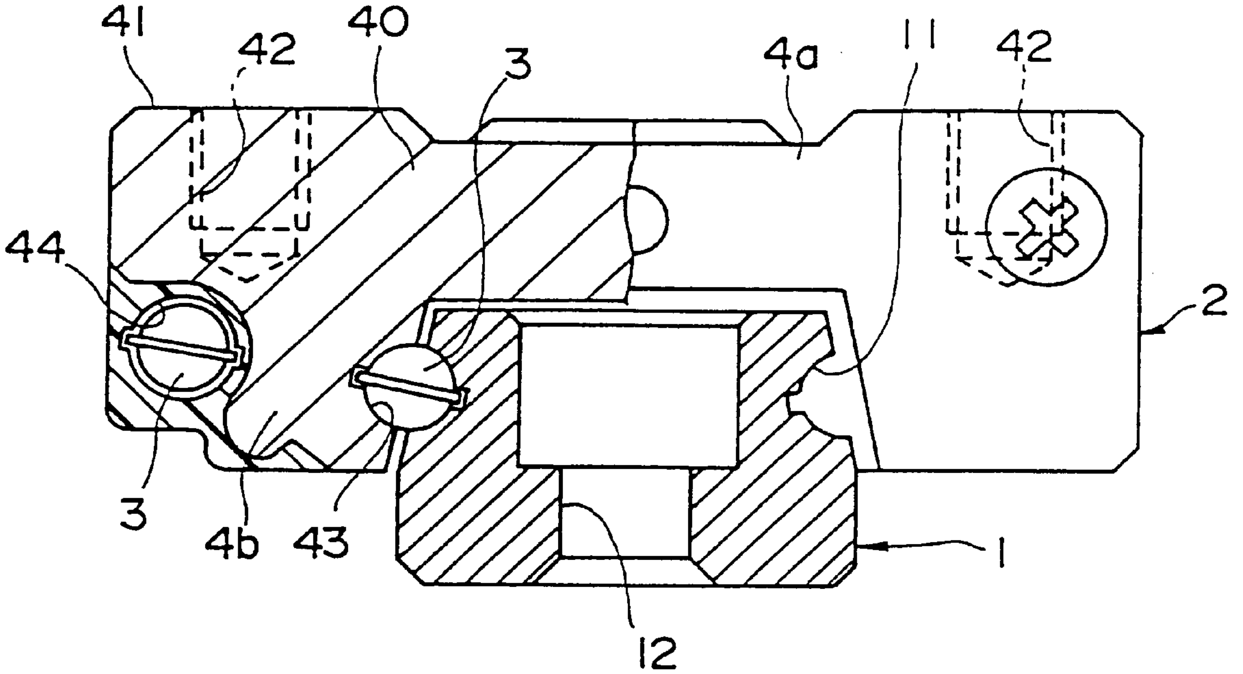


Fig. 3

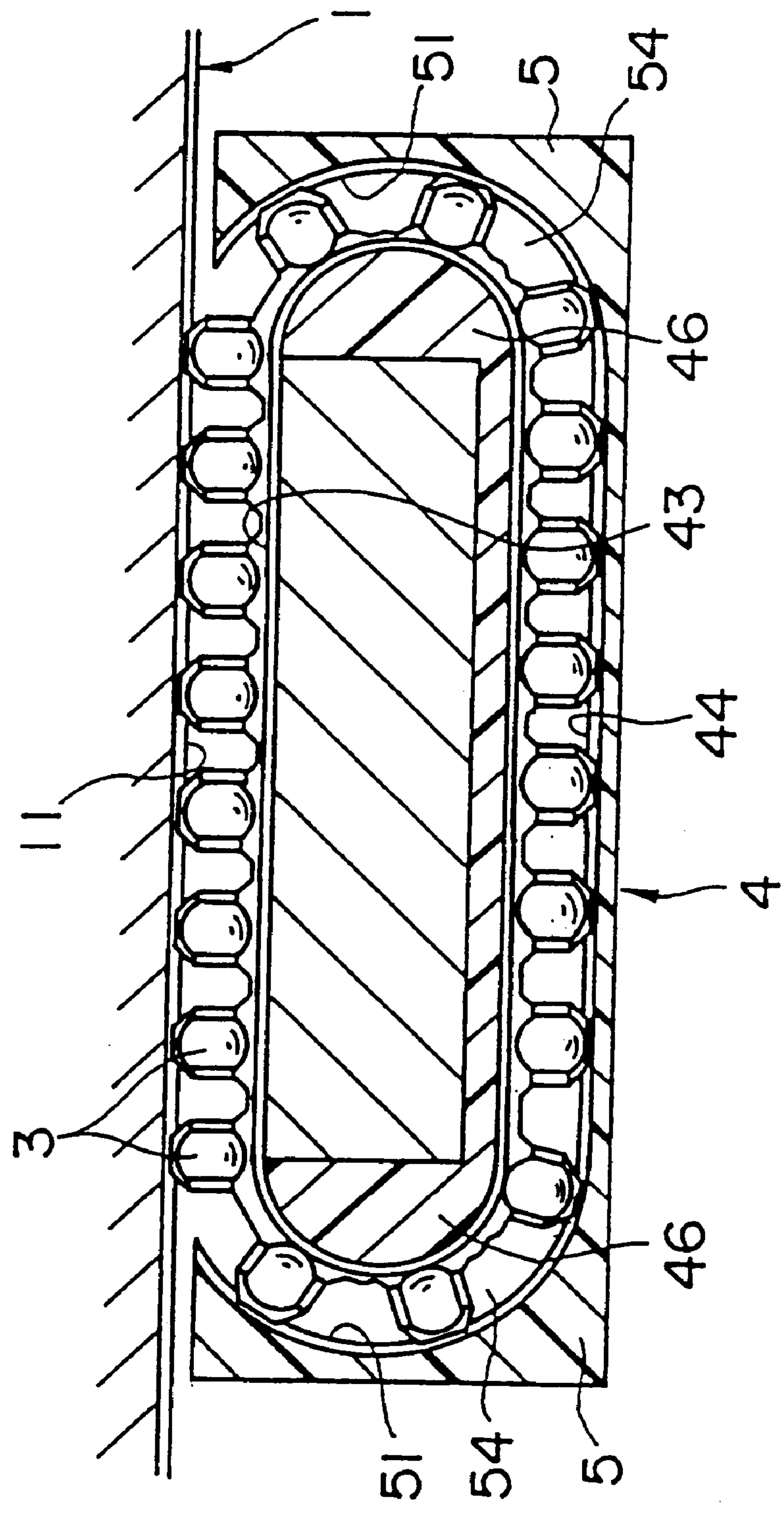
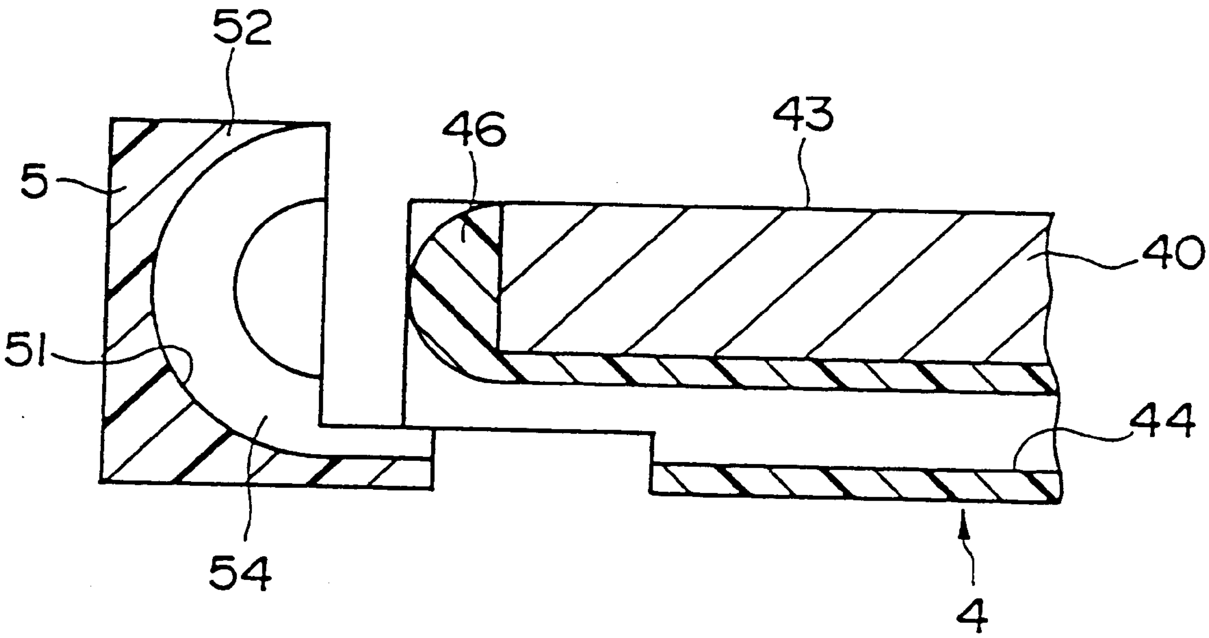


Fig. 4



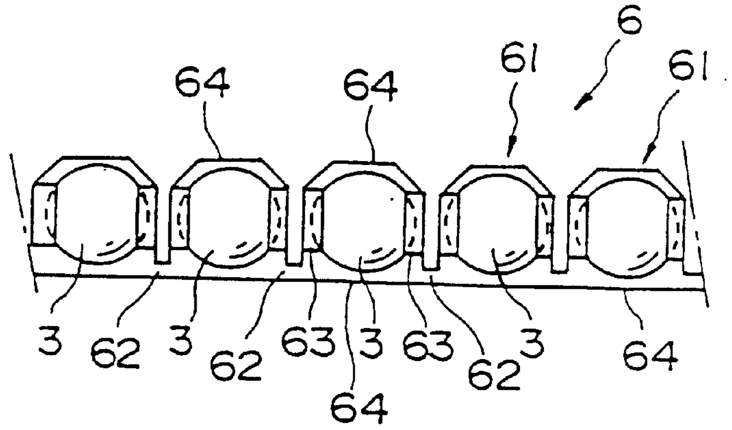


Fig. 5a

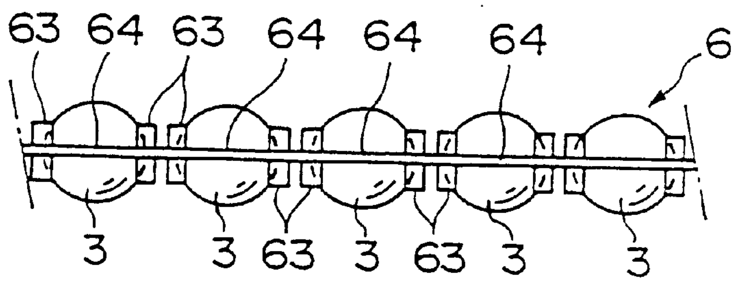
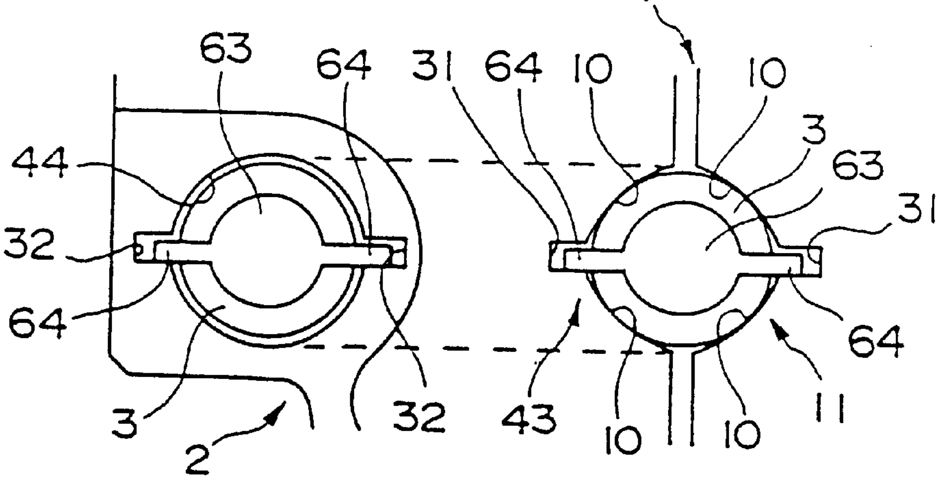


Fig. 5b

Fig. 6



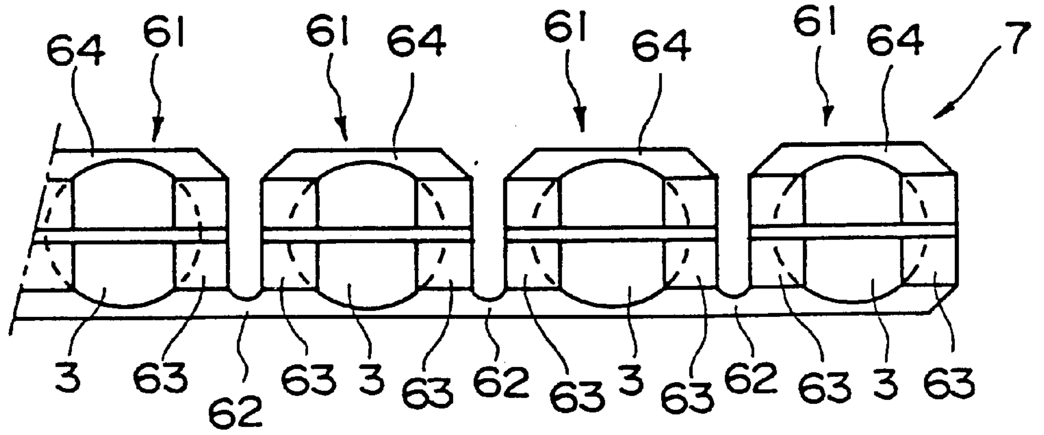

64
61
61
64
61
64
61
64
7
3
63
62
63
3
63
62
63
3
63
62
63
3
63

Fig. 8

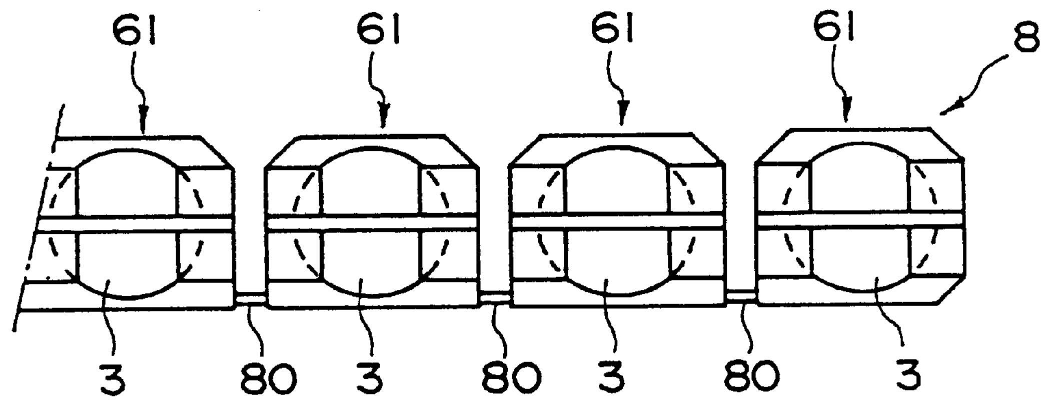

61
61
61
61
8
3
80
3
80
3
80
3

Fig. 9

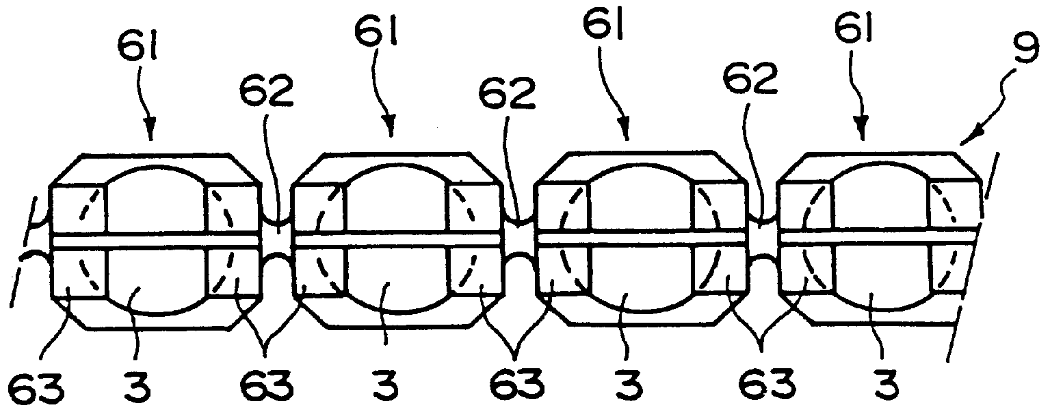

61
62
61
62
61
62
61
9
63
3
63
3
63
3
63
3

Fig. 10

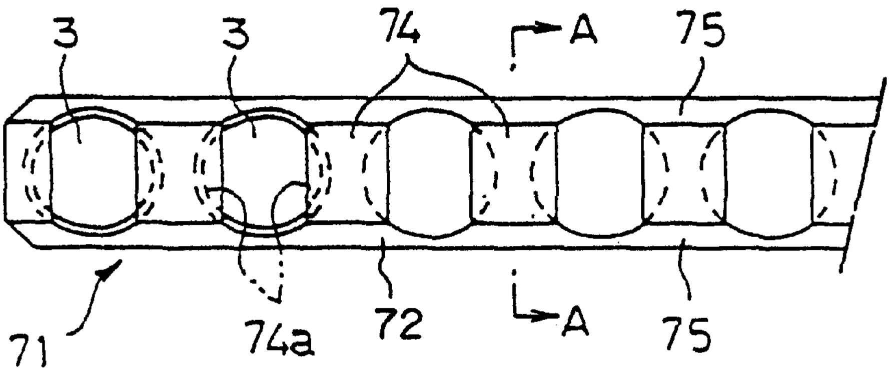


Fig. 10a

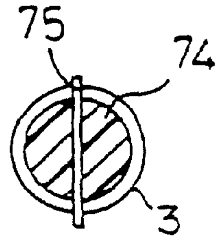


Fig. 11a

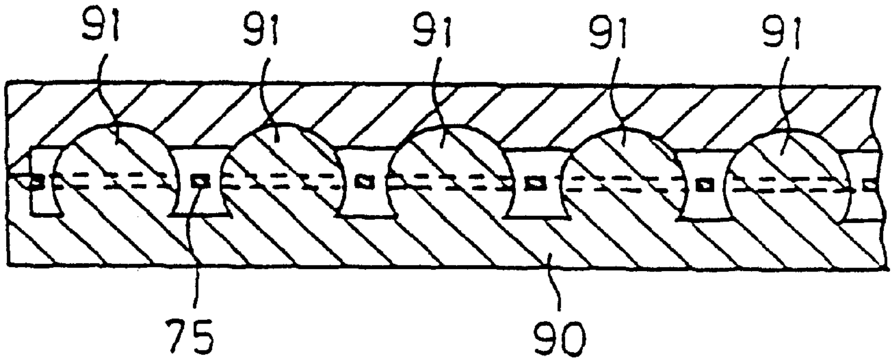


Fig. 11b

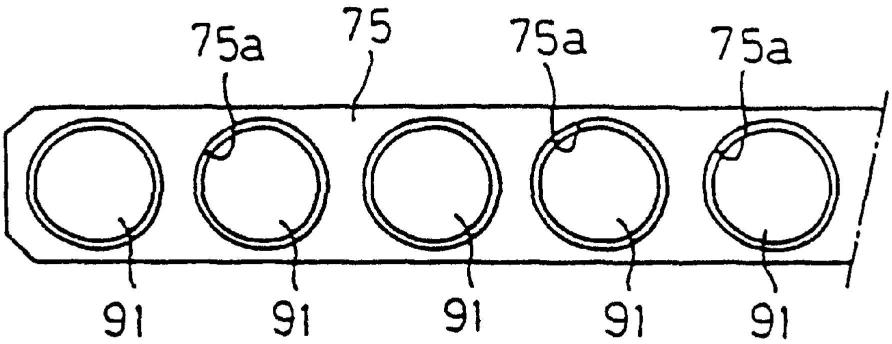


Fig. 12

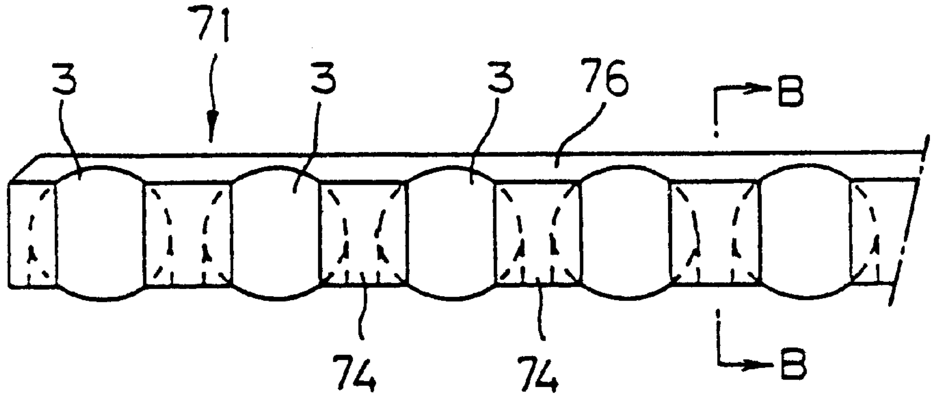


Fig. 12a

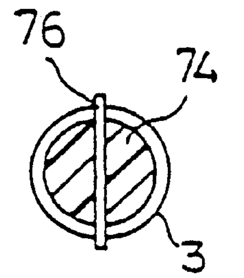


Fig. 13

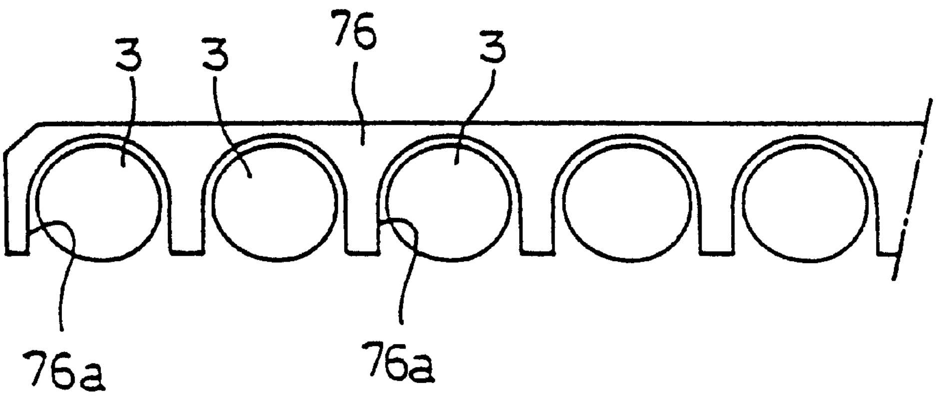


Fig.14

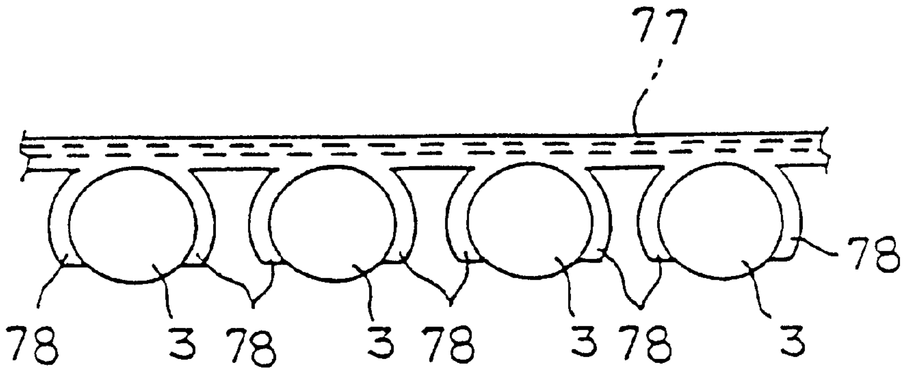


Fig. 15

Fig. 15 a

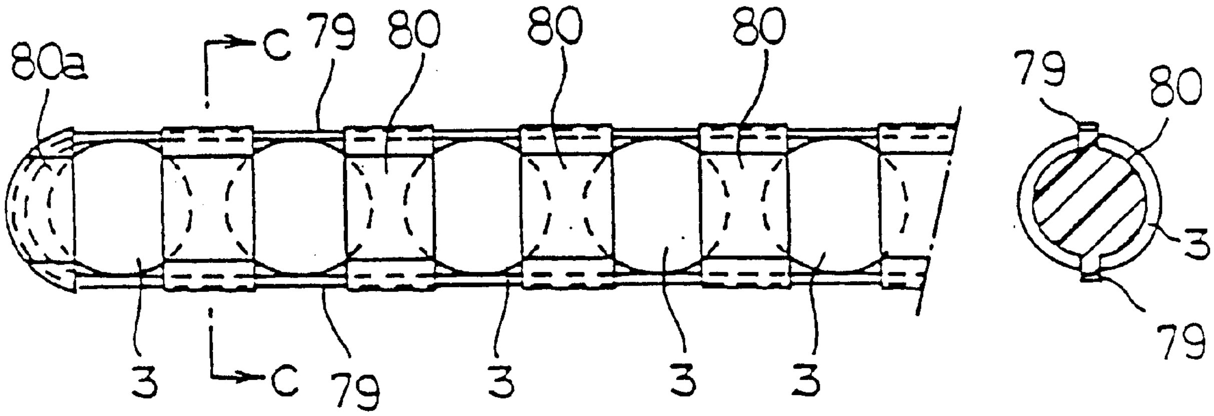


Fig. 16 PRIOR ART

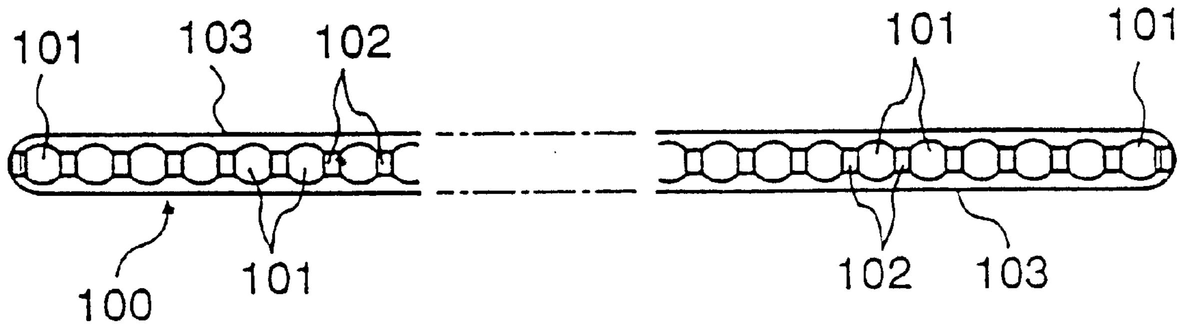
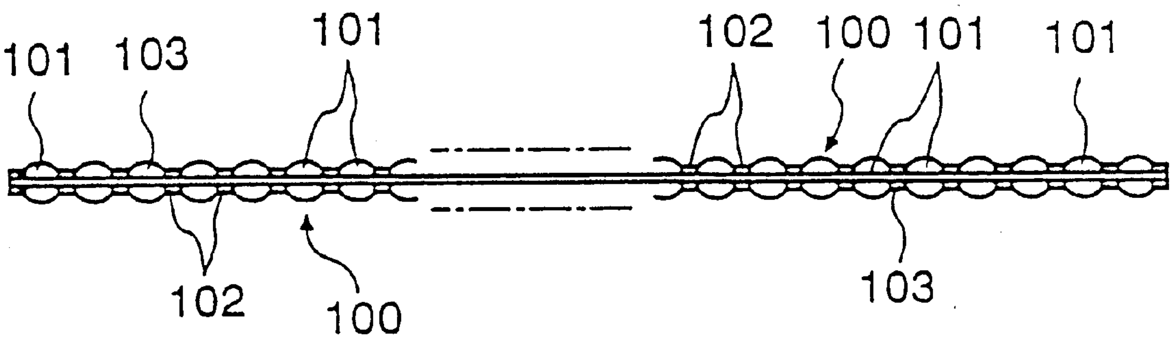


Fig. 17 PRIOR ART



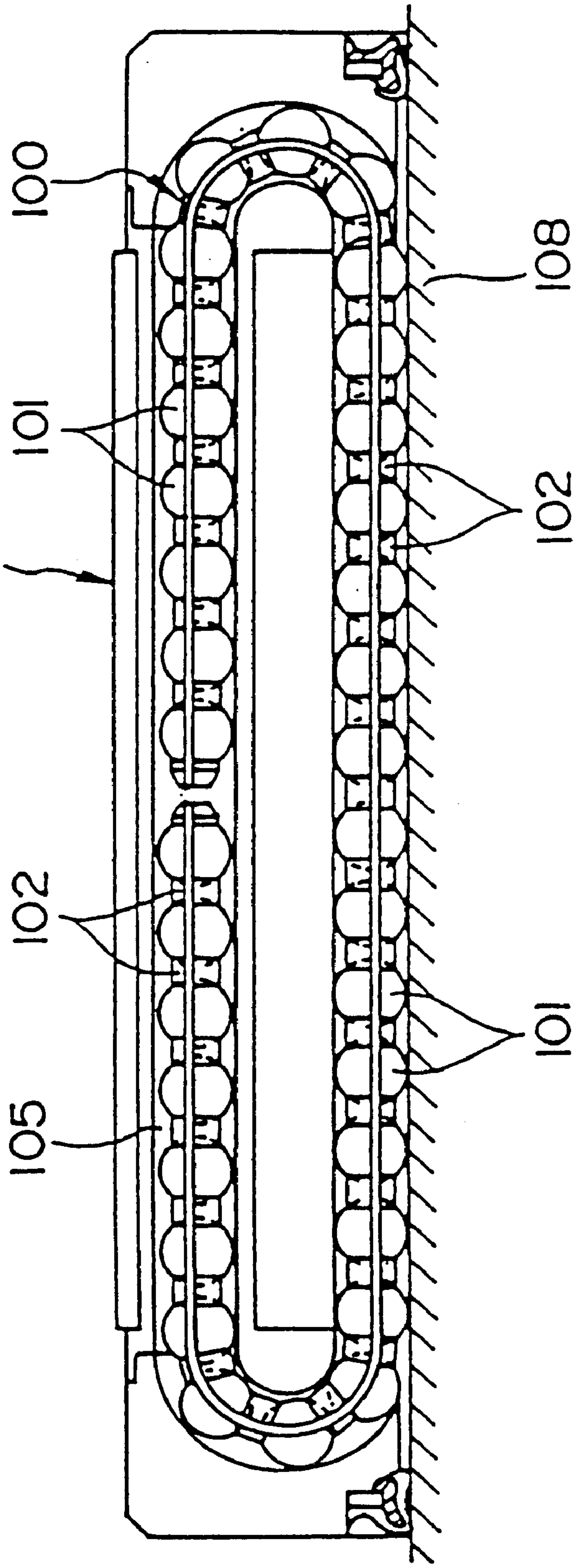


Fig. 18 PRIOR ART

Fig. 19 PRIOR ART

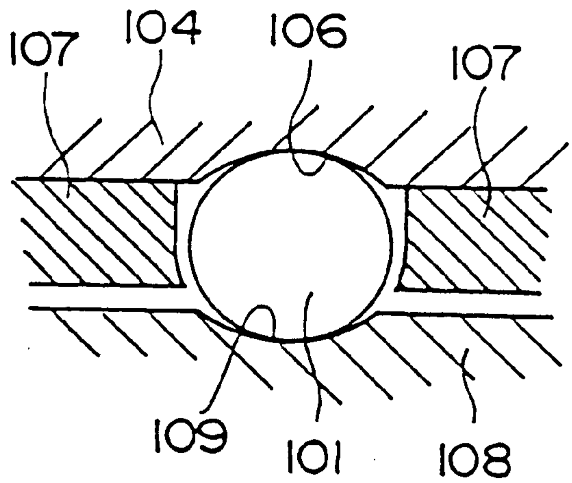
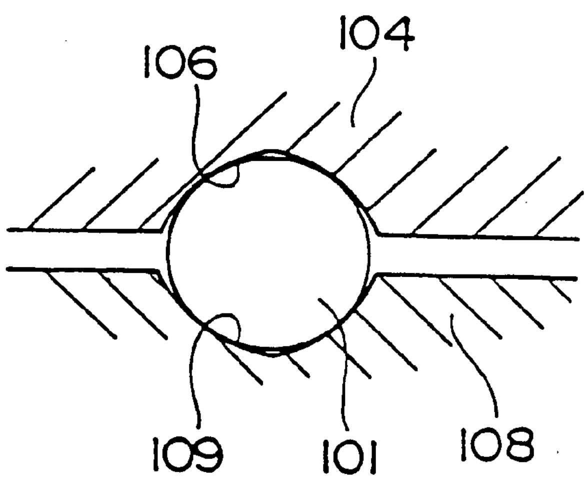


Fig. 20 PRIOR ART



BALL CHAIN

TECHNICAL FIELD

The present invention relates to a ball chain used by being integrated, for example, to a ball endless track of a linear guide device for endless sliding in which a number of balls are arranged in one row and are held rollably, particularly to a ball chain which is most pertinent in a linear guide device having a ball rolling groove in a shape of a Gothic arch.

BACKGROUND ART

There has conventionally been known a linear guide device for guiding a movable body of a table or the like along a fixed unit of a bed or the like, which is constituted by a track rail having a ball rolling groove, a slider having a load rolling groove opposed to the ball rolling groove, having a no load rolling path for circulating balls from one end to other end of the load rolling groove and moved along the track rail and a number of the balls rolling between the slider and the track rail while carrying a load and circulating an endless track constituted by the load rolling groove of the slider and the no load rolling path.

According to the conventional linear guide device constituted in this way, the endless track of the slider is filled with the balls and accordingly, when the slider is moved along the track rail, the balls contiguous to each other are circulated in the endless track while colliding or sliding with each other by which there poses a problem in which the balls are worn at an early stage and the life of the device is shortened.

Hence, in order to resolve such a problem, there has been proposed a linear guide device in which a ball chain aligning and holding a number of balls is integrated to the endless track (Japanese Unexamined Patent Publication No. JP-A-5-52217). As shown by FIG. **16** and FIG. **17**, according to such a ball chain **100**, spacers **102** are interposed among respective balls **101** contiguous to each other, the balls **101** are connected in a shape of a rosary (i.e., string of beads) by connecting the respective spacers **102** by connecting portions **103** in a strip-like shape and the balls **101** are fabricated by injection molding of flexible resin where balls **101** are arranged in a mold as cores.

The conventional ball chain **100** constituted in this way, is integrated in an endless track **105** of a slider **104** and circulated in the endless track as shown by FIG. **18**, in this case, the spacers **102** are interposed among the balls **101** contiguous to each other and therefore, mutual friction or collision among the balls is prevented and wear of the balls **101** can be minimized.

However, according to such a conventional ball chain **100**, one of the spacers **102** supports two of the balls **101** disposed on both sides thereof and therefore, when an angle of contact of the spacer **102** with respect to the ball **101** is changed by bending or twisting the ball chain **100**, there poses a problem in which the balls **101** drop off among the spacers **102**.

Accordingly, although the conventional ball chain sufficiently achieves a function as a ball retainer for preventing mutual contact of balls, a function thereof as a so-called ball case for preventing detachment of balls is not sufficient. Therefore, according to a conventional linear guide device integrated with such a ball chain, in order to completely prevent accident of detachment of balls when a slider is removed from a track rail, as shown by FIG. **19**, ball retainers **107** are installed on both sides of a load rolling groove **106** of a slider **104**.

However, when a ball rolling groove **109** of a track rail **108** and the load rolling groove **106** of the slider **104** are formed in the shape of a so-called circular arc comprising a single ball rolling face, the depths of the rolling grooves **106** and **109** are comparatively small relative to the radius of the ball **101** and therefore, although as shown by FIG. **19**, the ball retainers **107** can be formed on the both sides of the load rolling groove **106** of the slider **104**, when the ball rolling groove **109** and the load rolling groove **106** are formed in a shape of a Gothic arch, that is, in a shape where a pair of ball rolling faces are intersected with each other, as shown by FIG. **20**, the depths of the rolling grooves **106** and **109** are near to the radius of the ball **101** and accordingly, it is almost impossible to install the ball retainers **107** on the both sides of the load rolling groove **106**.

Therefore, in integrating a ball chain to a linear guide device having ball rolling grooves in the shape of a Gothic arch, it is necessary to ensure sufficiently the function of the ball chain for retaining the balls and it is problematic to integrate a conventional ball chain having such a weak function as it is.

Meanwhile, such a ball chain **100** is used by being circulated in an endless track and accordingly, it is preferable to make the connecting portion **103** for connecting the respective spacers **102** as thin as possible and make a sectional area thereof as small as possible to flexibly bend the ball chain **100** in the endless track.

Meanwhile, considering that the respective spacers **102** are brought into sliding contact with the balls **101**, the resin material used in molding the ball chain **100** needs to be provided with lubrication performance, wear resistance and the like with respect to rolling of the balls **101** and therefore, there is a constant restriction in selecting resin for molding the ball chain **100** and mechanical strength of the mold resin per se is difficult to provide.

Therefore, according to the conventional ball chain **100**, the tensile strength of the connecting portion **103** is lower and there results a problem in which the connecting portion **103** is broken between the respective spacers **102** when the ball chain is being used in an endless circulating path.

DISCLOSURE OF THE INVENTION

The present invention has been carried out in view of such a problem and it is a first object thereof to provide a ball chain capable of firmly holding balls even when the ball chain is bent or twisted or the like and which is most pertinent to a linear guide device having a ball rolling groove in a shape of a Gothic arch.

Further, it is a second object of the present invention to provide a ball chain in which lubrication performance and wear resistance with respect to rolling of balls are excellent, arranged balls are rolled excellently and which is provided with sufficient tensile strength and capable of preventing breaking of the ball chain while it is being used.

According to an aspect of the present invention achieving the first object, there is provided a ball chain arranged with a number of balls in one row and rollably holding the balls wherein each of the bails are pinched by a pair of spherical seats and the spherical seats are connected to each other by flange portions to thereby constitute a ball holding unit and a plurality of the ball holding units are connected in the shape of a string of beads by a flexible connecting portion.

According to such a technical means, each of the balls is pinched by the pair of spherical seats connected by the flange portions, the ball holding unit is constituted for each of the balls and the ball chain is constituted by connecting the ball holding units in a shape of a string of beads by the flexible connecting portion and accordingly, even when the ball chain is bent or twisted or the like, the angle of contact of the spherical seat with respect to the ball remains unchanged and the ball can be held at each of the ball holding unit with certainty.

In this case, the ball chain according to the present invention can be fabricated by injection molding of synthetic resin in which the balls are inserted into a mold as cores and in view of reducing the minimum radius in bending the ball chain in a shape of a circular arc, it is preferable that the connecting portion is softer and the sectional area is preferably small.

Further, according to another aspect of the present invention achieving the second object mentioned above, there is provided a ball chain comprising a number of balls arranged in one row, a plurality of ball holding members arranged among the balls contiguous to each other for rotatably holding the balls and a connecting portion for connecting the ball holding members wherein the tensile strength of the connecting portions is larger than a tensile strength of the ball holding members.

According to such a technical means, the ball holding members for rotatably holding the balls are interposed among the balls contiguous to each other, the ball holding members are connected to each other by the connecting portion having a tensile strength larger than a tensile strength of the ball holding member and accordingly, even when a material for molding the ball holding member which is provided with a low mechanical strength is used, a sufficient tensile strength can be ensured for the ball chain as a whole. Further, the mechanical strength of the material per se for molding the ball holding member does not pose any problem and the tensile strength of the ball chain as a whole can be ensured and accordingly, such a molding material can be selected only in view of lubrication performance, wear resistance or the like with respect to rolling of the balls and excellent rolling of the arranged balls can be expected.

In this case, although the ball chain according to the present invention can be integrated by penetrating the connecting portion such as wire or the like through the ball holding members molded by resin, the integrating operation is troublesome when the ball holding members are penetrated one by one by the connecting portion and in view of reducing time and labor of integration, it is preferable to pad the ball holding members to the connecting portion by injection molding of synthetic resin.

Further, in molding the ball holding members by such an injection molding, it is preferable to form recesses and protrusions at the connecting portion in correspondence with portions for molding the ball holding members such that the ball holding members do not drop off the connecting portion after molding.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view showing a first embodiment of a linear guide device using a ball chain according to the present invention;

FIG. **2** illustrates a front view and a sectional view showing the first embodiment of the linear guide device according to the present invention;

FIG. **3** is a sectional view showing an endless track of balls provided to a slider according to the first embodiment;

FIG. **4** is a view disassembling a moving block and a lid constituting the endless track of balls;

FIG. **5** illustrates a plane view and a front view showing the first embodiment of the ball chain according to the present invention;

FIG. **6** is an enlarged view showing a section of the endless track of balls according to the first embodiment of a linear guide device;

FIG. **7** is a plane view showing a second embodiment of a ball chain according to the present invention;

FIG. **8** is a plane view showing a third embodiment of a ball chain according to the present invention;

FIG. **9** is a plane view showing a fourth embodiment of a ball chain according to the present invention;

FIG. **10** illustrates a front view and a sectional view showing a fifth embodiment of a ball chain according to the present invention;

FIGS. **11***a* and *b* are front views showing connecting portions according to the fifth embodiment;

FIG. **12** illustrates a front view and a sectional view showing a sixth embodiment of a ball chain according to the present invention;

FIG. **13** is a front view showing connecting portions according to the sixth embodiment;

FIG. **14** illustrates a front view and a sectional view showing a seventh embodiment of a ball chain according to the present invention;

FIG. **15** illustrates a front view and a sectional view showing an eighth embodiment of a ball chain according to the present invention;

FIG. **16** is a front view showing a conventional ball chain;

FIG. **17** is a side view showing the conventional ball chain;

FIG. **18** is a sectional view showing a state in which the ball chain is integrated to an endless track of a slider of a linear guide device;

FIG. **19** is a sectional view showing a state of rolling balls in the case where a load rolling groove of a slider and a ball rolling groove of a track rail are formed in a shape of a circular arc; and

FIG. **20** is a sectional view showing a state of rolling balls in the case where a load rolling groove of the slider and a ball rolling groove of the track rail are formed in a shape of a Gothic arch.

[Description of Notation]

1 . . . Track rail **2** . . . slider **3** . . . ball b . . . ball chain **11** . . . ball rolling groove **31** . . . escape groove **43** . . . load rolling groove **61** . . . ball holding unit **62** . . . connecting portion **63** . . . spherical seat **64** . . . flange portion

BEST MODE FOR CARRYING OUT THE INVENTION

A detailed explanation will be given of a ball chain according to the present invention in reference to attached drawings as follows.

First Embodiment

FIG. **1** and FIG. **2** show an embodiment of a linear guide device integrated with a ball chain according to the present invention.

In the drawings, notation **1** designates a track rail arranged at a fixed unit of a bed of a machine tool or the like, notation **2** designates a slider for guiding a movable body of a table or the like along the track rail **1**, notation **3** designates a ball rolling between the track rail **1** and the slider **2** while carrying a load and is endlessly circulated in the slider **2**.

First, a section of the track rail **1** is formed substantially in a rectangular shape and a total of two streaks of ball rolling grooves **11** where the balls **3** roll are formed on both side faces thereof along a longitudinal direction (direction orthogonal to paper face of FIG. **2**). The track rail **1** is formed with bolt attaching holes **12** at pertinent intervals in the longitudinal direction and the track rail **1** is fixed to the fixed unit by fixing bolts, not illustrated, which are inserted into the bolt attaching holes **12**.

Further, the slider **2** is constituted by a moving block **4** having attaching faces **41** for a movable body of a table or the like and tap holes **42** into which fixing bolts of the movable body are screwed and a pair of lids **5** which are fixed to both front and rear end faces of the moving block **4** and endless tracks of the balls **3** are provided in the slider by fixing the lids **5** to the moving block **4**.

A section of the moving block **4** is formed substantially in the shape of a saddle having a horizontal portion **4***a* formed with the attaching faces **41** and a pair of skirt portions **4***b* hung from the horizontal portion **4***a* and a load rolling groove **43** opposed to the ball rolling groove **11** of the track rail **1** is formed on an inner face side of each of the skirt portions **4***b*. Further, a ball return hole **44** in correspondence with each of the load rolling grooves **43** is formed at each of the skirt portions **4***b* in which the balls **3** finished with rolling on the load rolling groove **43** and relieved of the load are rolled in the reverse direction to the direction of rolling on the load rolling groove **43**.

The moving block **4** is fabricated by utilizing injection molding of synthetic resin. That is, the moving block **4** is formed by padding synthetic resin by injection molding to a block main body **40** made of metal and formed by machining, portions requiring mechanical strength such as the movable body attaching face **41**, the load rolling face **43** of the ball **3** and the like mentioned above, are formed in the block main body **40** and in the meantime, portions where mechanical strength is not important, such as the ball return hole **44** and the like, are formed of synthetic resin and light weight formation of the moving block **4** is achieved as light as possible.

FIG. **3** is a sectional view showing an endless track of the balls **3** provided to the slider **2** and as shown by FIG. **4**, the endless track is completed by fixing the lids **5** to end faces of the moving block **4**. That is, when the lid **5** is fixed to the moving block **4**, a ball guide portion **46** on the side of the moving block **4** is fitted into a U-shape groove **51** on the side of the lid **5** by which a direction change path **54** in a U-like shape is completed and the load rolling face **43** of the moving block **4** is connected to the ball return hole **44** by the direction change path **54**.

Thereby, when the balls **3** carrying a load between the ball rolling groove **11** of the track rail **1** and a load rolling groove **43** of the moving block **4**, finishes rolling on the load rolling groove **43** in accordance with movement of the slider **2**, the balls are relieved of the load, enter the direction change path **54** of one of the lids **5** and are rolled in the ball return hole **44** of the moving block **4** in a no load state as they are in the reverse direction to the direction of rolling on the load rolling groove **43**. Further, the balls **3** which have finished rolling in the ball return hole **44**, enter again between the track rail **1** and the moving block **4** via the direction change path **54** of other of the lids **5** and roll on the load rolling groove **43** while carrying the load.

Meanwhile, the balls **3** are integrated to the endless track of the slider **2** in a state where they are held in one row by the ball chain **6** and the ball chain **6** is circulated in the endless track in accordance with rolling of the balls **3**. As shown by FIG. **5**, the ball chain **6** is formed by connecting a plurality of ball holding units **61** each holding a single ball **3** in a shape of a string of beads by a flexible connecting portion **62** and each of the ball holding units **61** is constituted by a pair of spherical seats **63** pinching the ball **3** from left and from right and flange portions **64** connecting the spherical seats **63** to each other.

The connecting portion **62** connects only side ends on one side of the ball holding units **61** arranged in one row to each other and when the connecting portion **62** is flexed as shown by FIG. **3**, slit-like spaces among the ball holding units **61** contiguous to each other are expanded and the ball chain **6** per se can be bent in a ring-like shape in a state where the flange portions **64** are disposed on an inner peripheral side or an outer peripheral side.

Further, the ball chain **6** is formed by injection molding of synthetic resin inserted with the balls **3** as cores in a mold and the connecting portions **62**, the spherical seats **63** and the flange portions **64** are integrally molded by such an injection molding and the balls **3** are incorporated by the spherical seats **63**.

FIG. **6** is an enlarged sectional view showing a state of rolling the balls **3** in the endless track.

The load rolling groove **43** of the slider **2** and the ball rolling groove **11** of the track rail **1** are formed in a shape of a Gothic arch formed by intersecting two of ball rolling faces **10** to each other and each of the balls **3** is brought into contact with two points of each of the load rolling groove **43** and the ball rolling groove **11**. Further, escape grooves **31** are respectively formed at deepest portions of the ball rolling groove **11** and the load rolling groove **43** which are formed in a shape of a Gothic arch, that is, positions in each of which the two ball rolling faces **10** are intersected with each other and the flange portions **64** of the ball chain **6** are contained in the escape grooves **31** while the balls **3** are rolling in the rolling grooves **43** and **11**.

Further, guide grooves **32** are formed in the ball return hole **44** of the slider **2** along the longitudinal direction, the flange portions **64** of the ball chain **6** under a no load state are guided by the guide grooves **32** and the ball chain **6** is prevented from meandering in the ball return hole **44**.

Further, according to the linear guide device of the embodiment constituted as described above, when the slider **2** is moved on the track rail **1**, the balls **3** roll on the load rolling groove **43** of the slider **2** and the ball rolling groove **11** of the track rail **1** and the ball chain **6** is circulated inside of the endless track formed in the slider **2**. In this case, according to the respective ball holding units **61** constituting the ball chain **6**, regardless of a state of flexing or extending the ball chain **6**, pairs of the spherical seats **63** always pinch the balls **3** with certainty and therefore, the balls **3** can be prevented from dropping off the ball chain **6** as less as possible.

Further, the ball chain **6** in the endless track is circulated while disposing the flange portions **64** on the outer peripheral side or the inner peripheral side and accordingly, for example, even when the slider **2** is drawn from the track rail **1** (state where track rail **1** is removed in FIG. **6**), the balls **3** are brought into a state where they are pinched from three directions by the load rolling groove **43** of the slider **2** and the flange portions **64** of the ball chain **6** and the balls **3** can be prevented from dropping off the endless track of the slider **2** with certainty.

Second Embodiment

FIG. **7** shows a second embodiment of a ball chain according to the present invention. Although the ball chain

7 is provided with a constitution substantially similar to that of the ball chain **6** of the first embodiment shown by FIG. **5**, the constitution is different therefrom only in that the flange portions **64** connecting pairs of the spherical seats **63** are arranged to divide in four the surroundings of the balls **3**. Therefore, according to the ball chain **7** of the second embodiment, the balls **3** are completely constrained at insides of the ball holding units **61** and the balls **3** can be completely prevented from dropping off the ball chain **7**.

Third Embodiment

FIG. **8** shows a third embodiment of a ball chain according to the present invention.

According to the ball chain **6** of the first embodiment, the connecting portion **62** for connecting the respective ball holding units **61** are also molded by resin and therefore, when the ball chain **6** is circulated in the endless track and flexing and extending thereof are repeated, there is a concern that the ball chain **6** is cut at the connecting portion **62**.

Hence, according to a ball chain **8** of the embodiment, a wire **80** penetrating the respective ball holding units **61** is installed and the connecting portion **62** is constituted by the wire **80**. Although a method of fabricating such a ball chain **8** is substantially the same as that of the ball chain **6** according to the first embodiment, a single piece of the wire **80** is inserted in a mold along with the balls **3** and the respective ball holding units **61** are molded to the wire **80** at an equal interval by injection molding of synthetic resin.

Further, according to the ball chain **8** of the embodiment where the connecting portion **62** is reinforced by the wire **80**, the connecting portion **62** is not broken even by repeated flexing and extending and trouble of breaking the ball chain **8** in the midst of use can be avoided.

Fourth Embodiment

FIG. **9** shows a fourth embodiment of a ball chain according to the present invention.

A ball chain **9** of the embodiment of constituted such that the connecting portion **62** for coupling the respective ball holding units **61** is formed at centers of the spherical seats **63** and a contiguous pair of the ball holding units **61** can be flexed in any direction centering on the connecting portion **62**. Therefore, different from the ball chains described above, there is no specific flexing direction in the ball chain **9** and the ball chain **9** can be integrated to the endless track without taking any special consideration in the flexing direction in the endless track of the slider **2**.

Further, although according to the linear guide devices mentioned above, the slider is provided with a total of two streaks of the ball endless tracks in which respective streaks are in correspondence with both left and right side faces of the track rail, the linear guide device according to the present invention is not limited thereto but the slider **2** may be provided with a total of four streaks of the ball endless tracks in which respective two streaks are in correspondence with each of both left and right side faces of the track rail **1**.

Fifth Embodiment

FIG. **10** shows a fifth embodiment of a ball chain according to the present invention.

According to a ball chain **71**, the plurality of balls **3** are arranged in a connector belt **72** in one row at a predetermined interval and the balls **3** are rotatable in a state where they are held by the connector belt **72**.

The connector belt **72** is constituted by a plurality of ball holding members **74** interposed among the respective balls **3** and a strip-like connecting portion **75** for connecting contiguous ball holding members **74** to each other and spherical seats **74***a* for embracing the spherical face of the ball **3** are formed at each of the ball holding members **74**. Thereby, the respective balls **3** are brought into a state where they are embraced from left and from right by the contiguous ball holding members **74** and are held by such a connector belt **72**.

As shown by FIGS. **11**(*a*) and **11**(*b*), according to the connecting portion **75**, through holes **75***a* each having a diameter slightly larger than the diameter of the ball, are formed in a stainless steel sheet (SUS 304 or the like) having a thickness of 0.05 through 0.2 mm which is formed in a strip-like shape and the balls **3** are contained in such through holes **75***a*. Meanwhile, the ball holding member **74** is molded by synthetic resin of polyamide-base elastomer, polyester-base elastomer or the like and is molded to the connecting portion **75** by injection molding. That is, as shown by FIG. **11**(*a*), ball dies **91** each having a diameter larger than the diameter of the ball **3** are projected at a predetermined interval in a forming mold **90** and as shown by FIG. **11**(*b*), the ball dies **91** are contained in the through holes **75***a* of the connecting portion **75** and under the state, the ball holding members **74** are molded to the connecting portion **75** by injection molding. Thereafter, the ball dies **91** are forcibly detached from among the ball holding members **74** and the balls **3** are pushed in portions detached from the ball dies **91** by which the ball chain **71** in which the balls **3** are contained in the through holes **75***a* of the connecting portion **75** by the ball holding members **74** is completed.

Further, the ball chain **71** of the embodiment constituted as described above, is used by being integrated to an endless track of a slider constituting a linear guide device or the like, the tensile strength of the connecting portion **75** formed by a stainless steel sheet is considerably larger than that of the ball holding member **74** made of synthetic resin and accordingly, even when large tensile force is exerted on the ball chain **71** during circulation in the endless track, the ball chain **71** is not broken between the ball holding members **74** contiguous to each other and smooth circulation of the ball chain **71** can always be expected.

Further, the tensile strength of the ball chain **71** per se is dependent on that of the connecting portion **75** and accordingly, it is not necessary to expect mechanical strength such as tensile strength or the like in resin material molding the ball holding members **74** and resin material used in injection molding can be selected only in view of lubrication performance, wear resistance or the like in respect of rolling of the balls **3**. Accordingly, smooth rolling of the balls **3** can also be expected.

Sixth Embodiment

FIG. **12** shows a sixth embodiment of a ball chain according to the present invention.

Although according to the above-described fifth embodiment, the connecting portion **75** is installed along both sides of a row of the balls which are arranged in one row, according to the embodiment, a connecting portion **76** is installed only on one side of the ball row. The other points as well as the constitution and the method of fabrication are the same as those in the fifth embodiment.

Accordingly, as shown in FIG. **13**, according to the connecting portion **76** of the embodiment, notched portions **76***a* each in a shape of an arch are arranged in the longitudinal direction at a predetermined interval and the balls **3** are contained in the notched portions **76***a*.

Seventh Embodiment

FIG. **14** shows a seventh embodiment of a ball chain according to the present invention.

Although according to the above-described fifth and sixth embodiments, a stainless steel sheet in a strip-like shape is used as the connecting portion, according to the embodiment, wires **77** each having a slender wire diameter are used as a connecting portion and ball holding members **78** are molded to the wires **77** by using injection molding of synthetic resin.

Each of the ball holding members **78** is arranged to be brought into contact with a single one of the ball and an independent ball holding unit is constituted by a pair of the ball holding members disposed on both sides of the ball. Therefore, even in the case where such a ball chain is used by being flexed extremely, according to each of the ball holding units, a pair of the ball holding members **78** hold the balls **3** with certainly and prevention of detachment of the ball **3** is achieved.

Eighth Embodiment

FIG. **15** shows an eighth embodiment of a ball chain according to the present invention.

Although according to the above-described ball chains of the respective embodiments, the ball holding members **74** interposed among the respective balls **3** are integrated with the connecting portion **75** (or **76**) in a strip-like shape by utilizing injection molding of synthetic resin, according to the embodiment, the connecting portion is constituted by a wire **79** having a slender wire diameter and ball holding members **80** previously formed by injection molding of synthetic resin which are penetrated by the wire **79** at a later stage.

That is, the ball holding members **80** are formed with through holes for inserting the wire **79** and by passing the wire **79** through the through holes, the respective ball holding members **80** are connected to each other. Such a wire **79** is folded back by a ball holding member **80***a* disposed at an end portion of the ball chain and is inserted through the respective ball holding members **80** at both sides of the ball row. Further, a stopper plate for fixedly engaging both end portions of the wire **79** is installed at an end portion of the ball chain, not illustrated, and a detachment preventive processing is carried out on the both end portions of the wire **79** which has passed through all of the ball holding members **80** after they are passed through the stopper plate.

Further, also in the ball chain of the eighth embodiment, the ball holding members **80** made of synthetic resin are connected by the wire **79** having large tensile strength by which the balls **3** are rotatably held and accordingly, even when large tensile force is exerted on the ball chain, the ball chain is not broken between the ball holding members **80** contiguous to each other and by using a resin material excellent in lubrication of the balls **3** for the ball holding members **80**, smooth formation of rolling of the balls **3** can be expected.

INDUSTRIAL APPLICABILITY

As has been explained, according to a ball chain of the present invention, a ball holding unit pinching a ball is formed by a pair of spherical seats, the ball chain is constituted by connecting a plurality of the ball holding units and accordingly, even when the ball chain is bent or twisted while it is being used, the balls do not drop off among the spherical seats and the balls can be held by the ball chain with certainty.

Further, according to a ball chain of the present invention, ball holding members interposed among balls contiguous to each other are connected to each other by a connecting portion having a tensile strength higher than that of the ball holding member and accordingly, even when a material for molding the ball holding member which is provided with a low mechanical strength is used, a sufficient tensile strength can be ensured for the ball chain as a whole and accordingly, occurrence of accident of breaking the ball chain while it is being used can be prevented beforehand.

Further, even in the case where the material for molding the ball holding member which is provided with low mechanical strength is used, the tensile strength of the ball chain can be ensured and occurrence of breaking the ball chain can be prevented and accordingly, in selecting a material for molding the ball holding member, consideration is given only in view of lubrication performance, wear resistance or the like in respect of rolling of the balls by which excellent rolling of the balls arranged thereby can be expected.

We claim:

1. A ball chain arranged with a number of balls in one row and rollably holding the balls:

wherein each of the balls are pinched by a pair of spherical seats and the spherical seats of each pair are connected to each other by flange portions to thereby constitute a ball holding unit and a plurality of the ball holding units are connected in series in the shape of a string of beads by a flexible connecting portion.

2. The ball chain according to claim **1**:

wherein the spherical seats and the flange portions are molded by a resin material and the connecting portion is formed by a material having a tensile strength larger than the tensile strength of the resin material.

3. A linear guide device comprising a track rail having ball rolling grooves each in a shape of a Gothic arch formed by intersecting a pair of ball rolling faces with each other, a slider having load rolling grooves each in a similar shape of a Gothic arch opposed to the ball rolling grooves and no load rolling paths for circulating the balls from one end to other end of each of the load rolling grooves for moving along the track rail and a number of balls rolling between the slider and the track rail while carrying a load and circulating endless tracks constituted by the load rolling grooves and the no load rolling paths of the slider:

wherein the ball chain according to claim **1** are integrated to each of the endless tracks of the slider such that the flange portions of the ball chain are disposed on an inner peripheral side or an outer peripheral side thereof and escape grooves by which the flange portions of the ball chains are contained and guided are formed at deepest portions of the ball rolling grooves of the track rail and the load rolling grooves of the slider both formed in the shape of the Gothic arch.

* * * * *

US006113272A

United States Patent [19]

Michioka et al.

[11] **Patent Number: 6,113,272**

[45] **Date of Patent: Sep. 5, 2000**

[54] **ROLLING MOTION GUIDE APPARATUS**

[75] Inventors: **Hidekazu Michioka; Tadashi Hirokawa**, both of Tokyo-to, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo-to, Japan

[21] Appl. No.: **09/317,185**

[22] Filed: **May 24, 1999**

[30] **Foreign Application Priority Data**

May 28, 1998 [JP] Japan P10-147417

[51] **Int. Cl.**[7] **F16C 29/06**

[52] **U.S. Cl.** **384/15**; 384/45

[58] **Field of Search** 384/45, 15

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,918,846 2/1999 Tsukada 384/15
5,011,300 4/1991 Teramachi .... 384/45 X
5,492,412 2/1996 Tsukada 384/15
5,588,750 12/1996 Osawa et al. 384/15
5,871,282 2/1999 Yuasa 384/15

Primary Examiner—Thomas R. Hannon

Attorney, Agent, or Firm—Young & Thompson

[57] **ABSTRACT**

A rolling motion guide apparatus comprises a track member having a rolling member rolling groove along a longitudinal direction of the track member, a plurality of rolling members rolling along the rolling member rolling groove of the track member, a movable member having a loaded rolling member rolling groove which constitutes a loaded rolling member rolling passage in association with the rolling member rolling groove of the track member. The movable member is movable along the track member through the rolling members rolling in the loaded rolling member rolling passage. A seal member is provided on a surface of the movable member facing the track member. The seal member is composed of a base plate portion disposed along the surface of the movable member facing the track member and sealing portions disposed to longitudinal side edge portions of the base plate portion so as to be contacted to the track member. The base plate portion is formed of resin material different from resin material of which the sealing portions are formed. The base plate portion and the sealing portions is integrally molded with each other through an extrusion process.

11 Claims, 7 Drawing Sheets

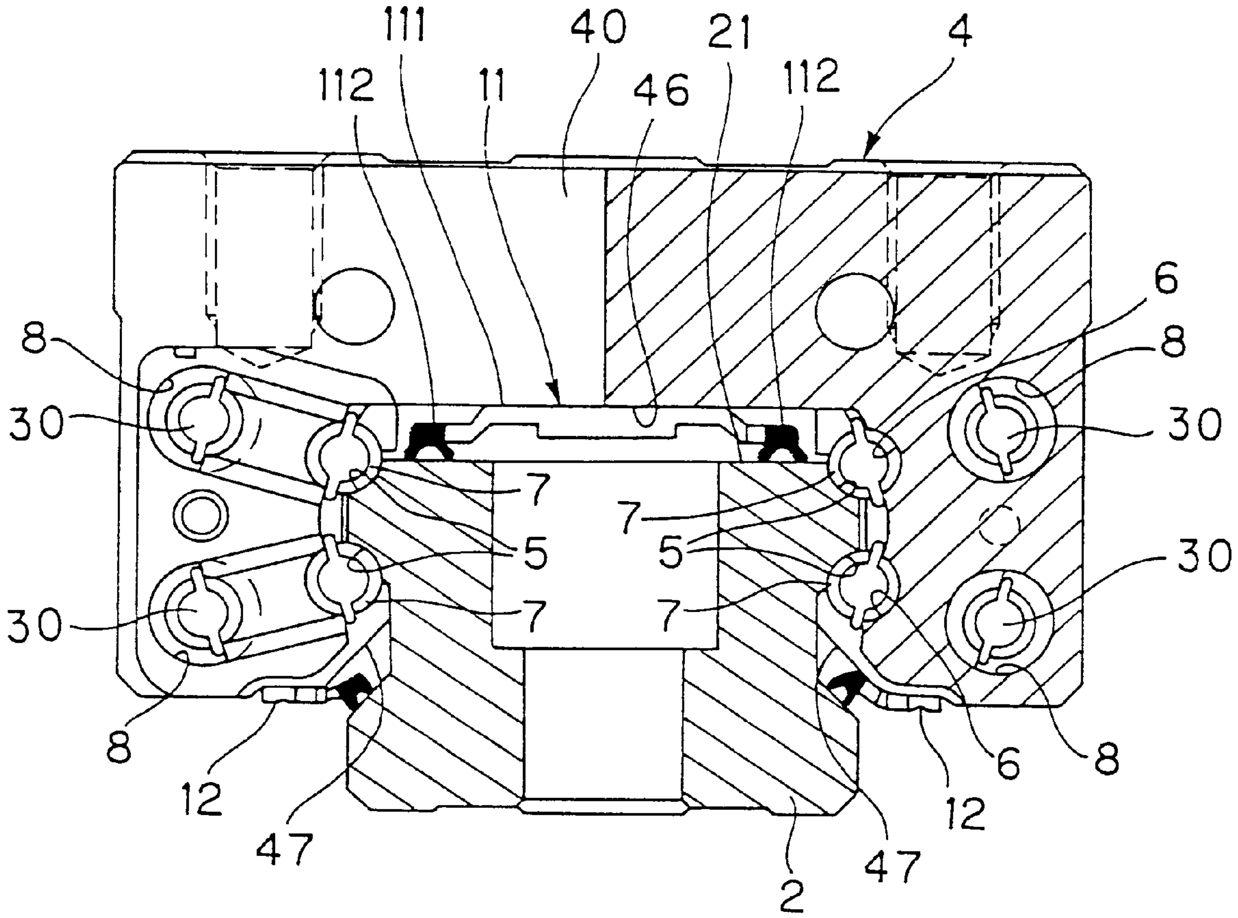


FIG. 1

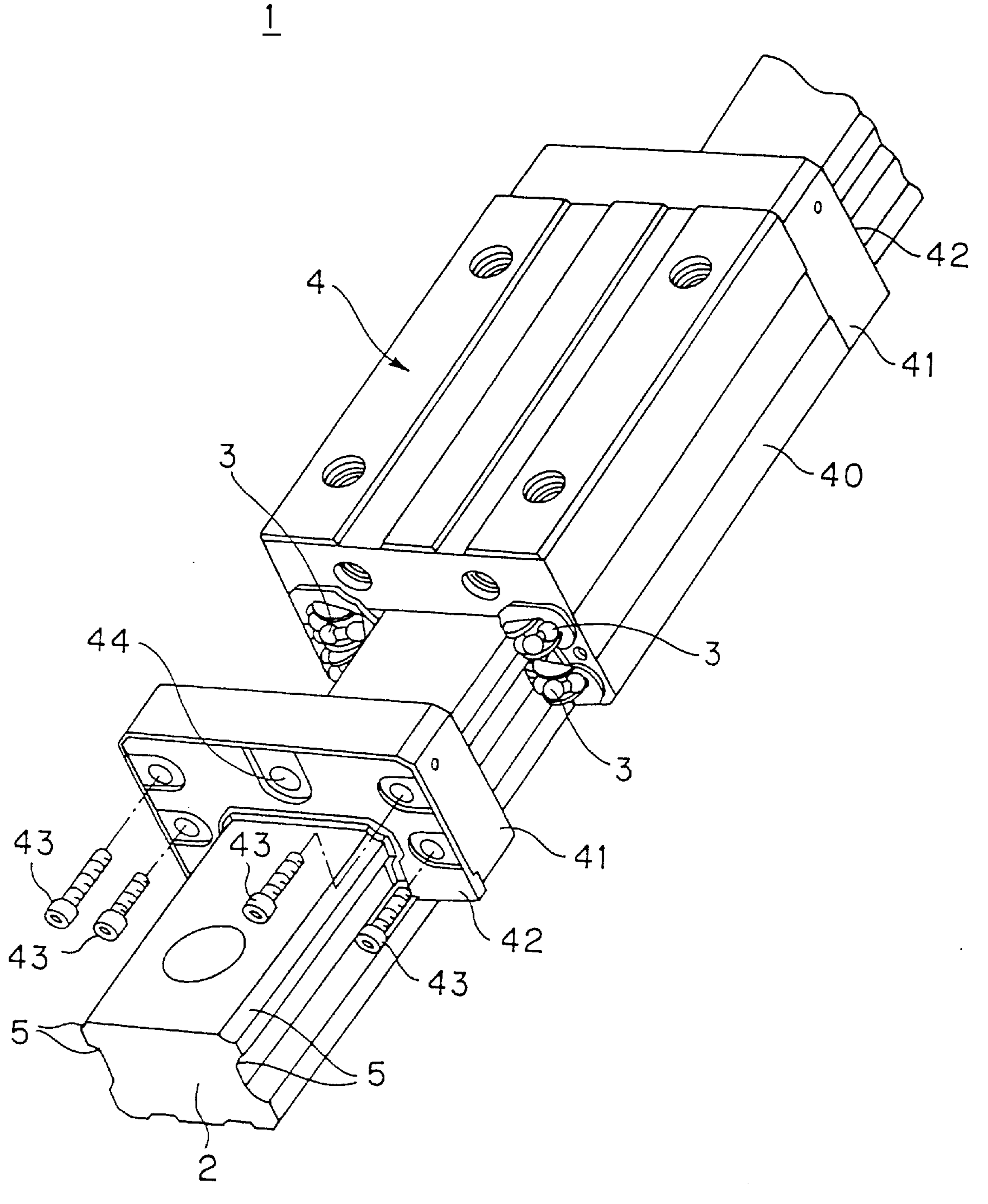


FIG. 2

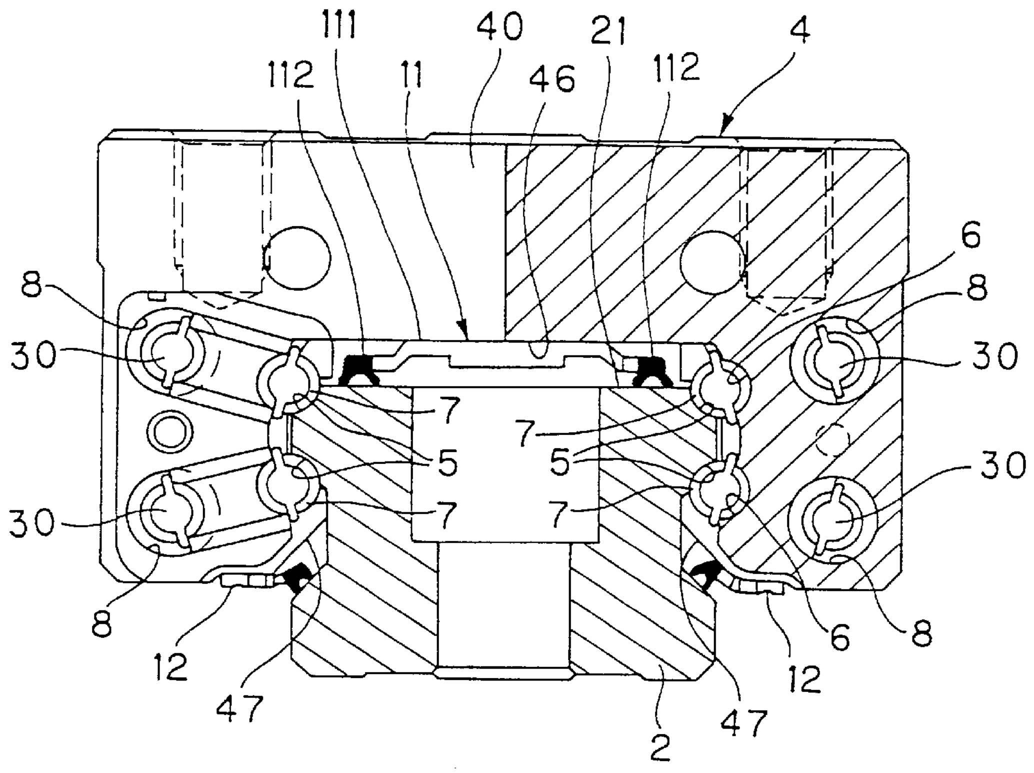

111
40
21
4
112
11
46
112
6
8
8
30
30
7
7
5
5
30
30
7
7
8
12
6
8
8
12
47
2
47

FIG. 3

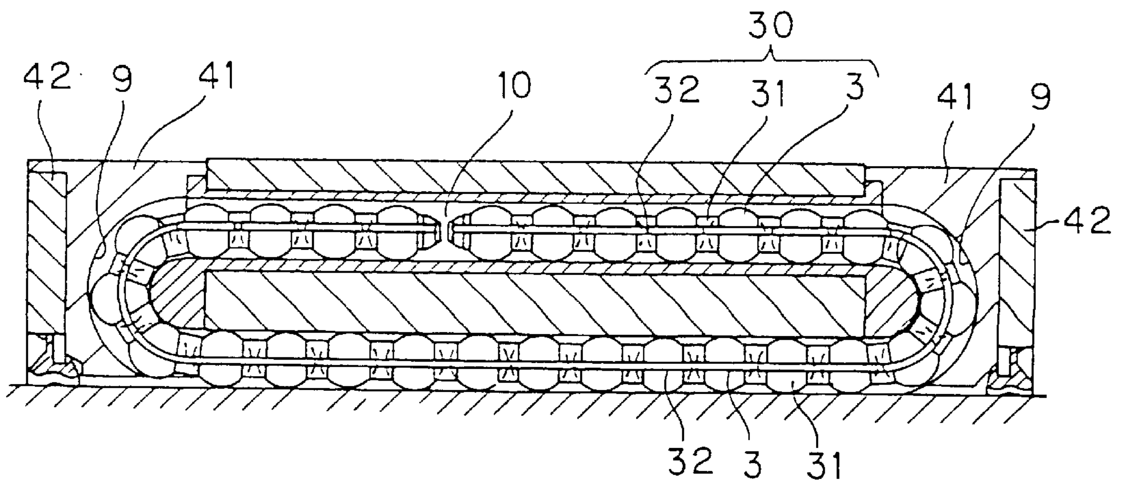

30
42
9
41
10
32
31
3
41
9
42
32
3
31

FIG. 4

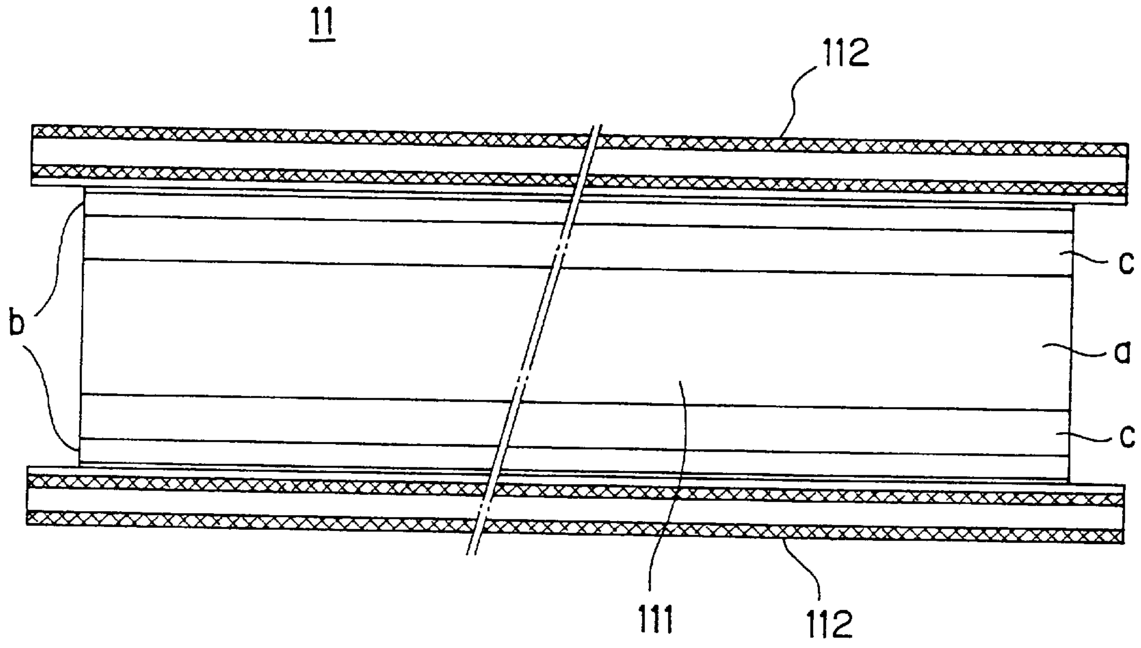


FIG. 5

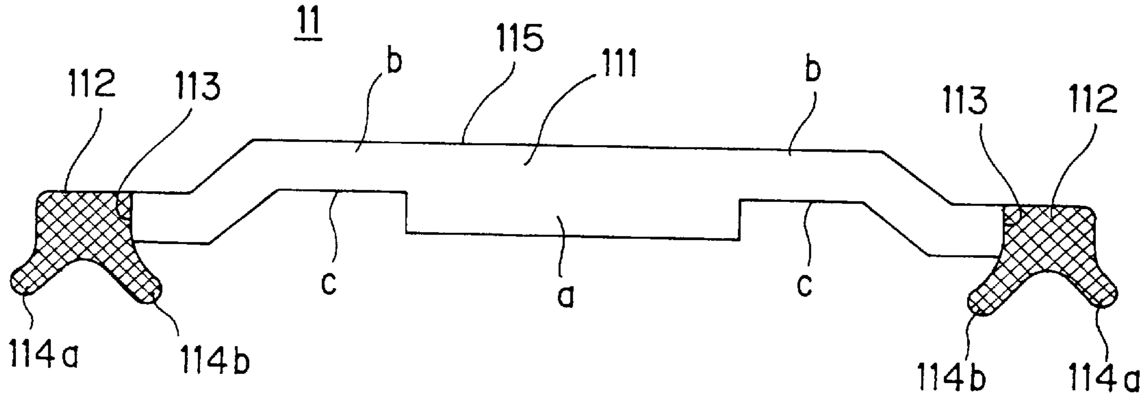


FIG. 6

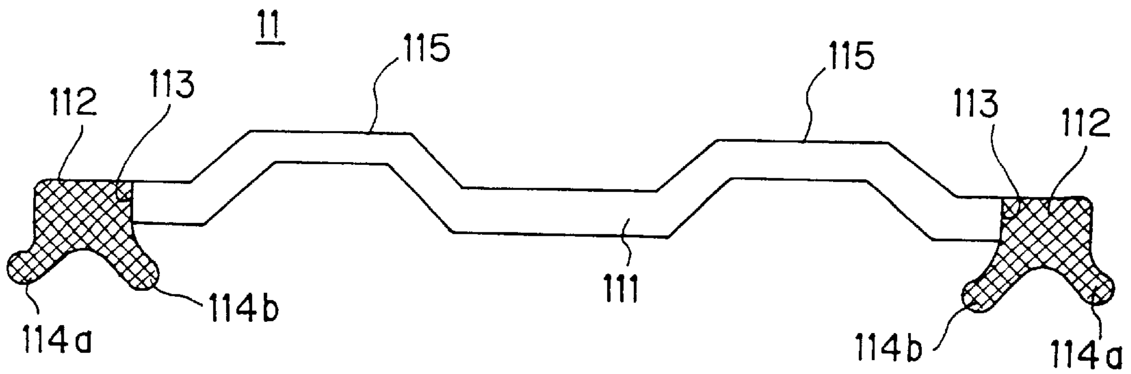


FIG. 7

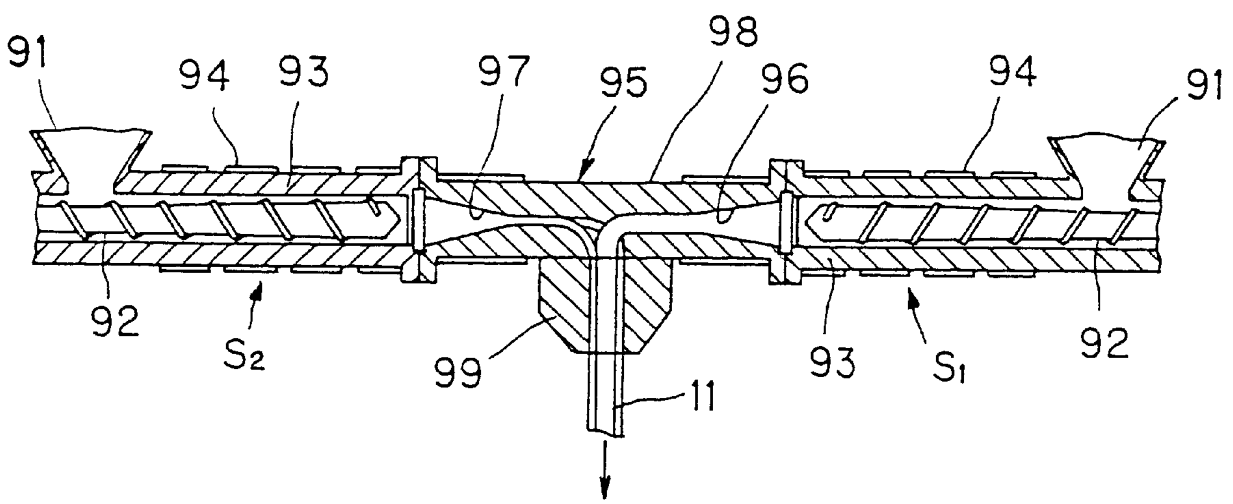


FIG. 8

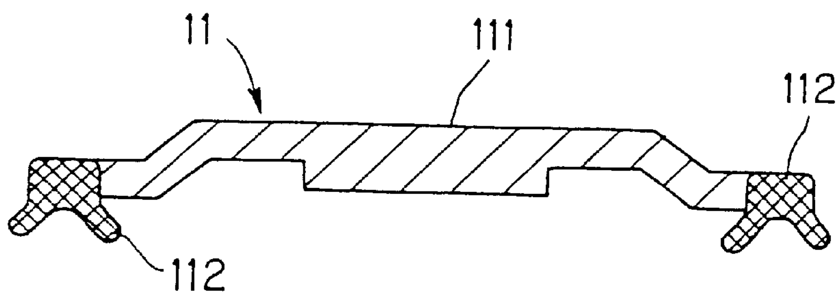


FIG. 9

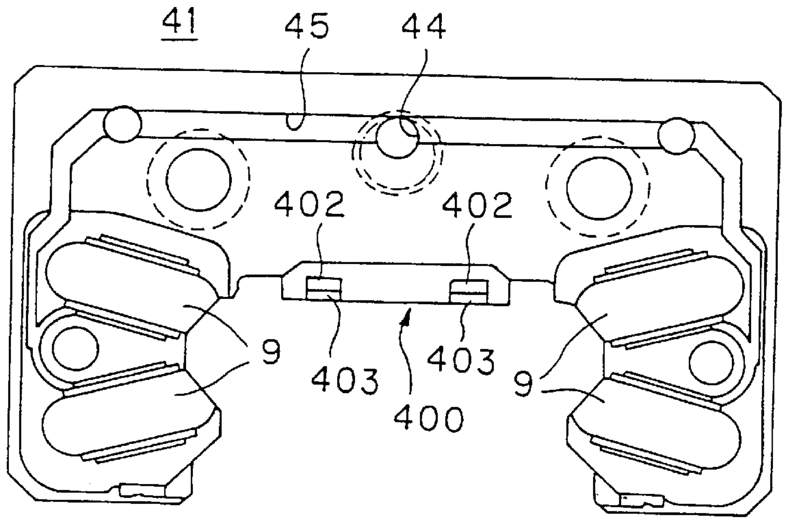


FIG. 10

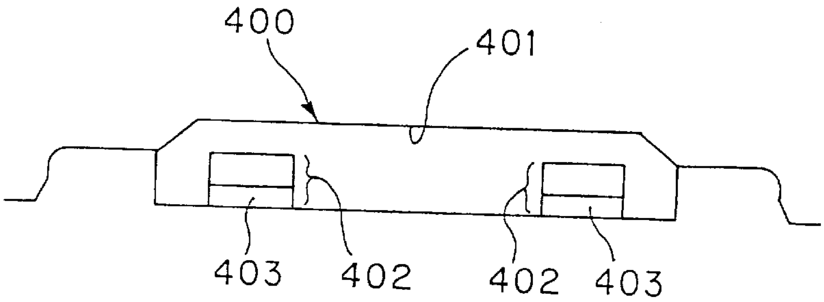


FIG. 11

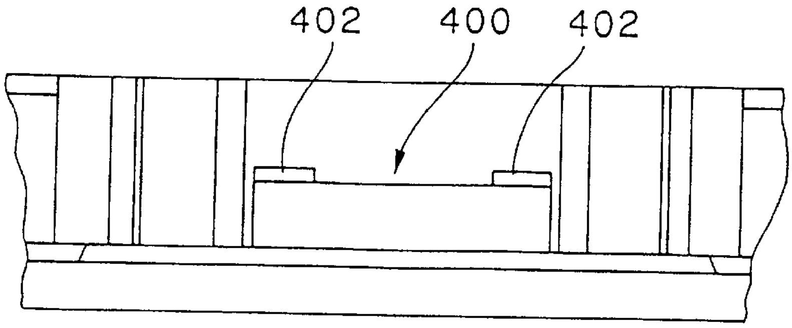


FIG. 12B

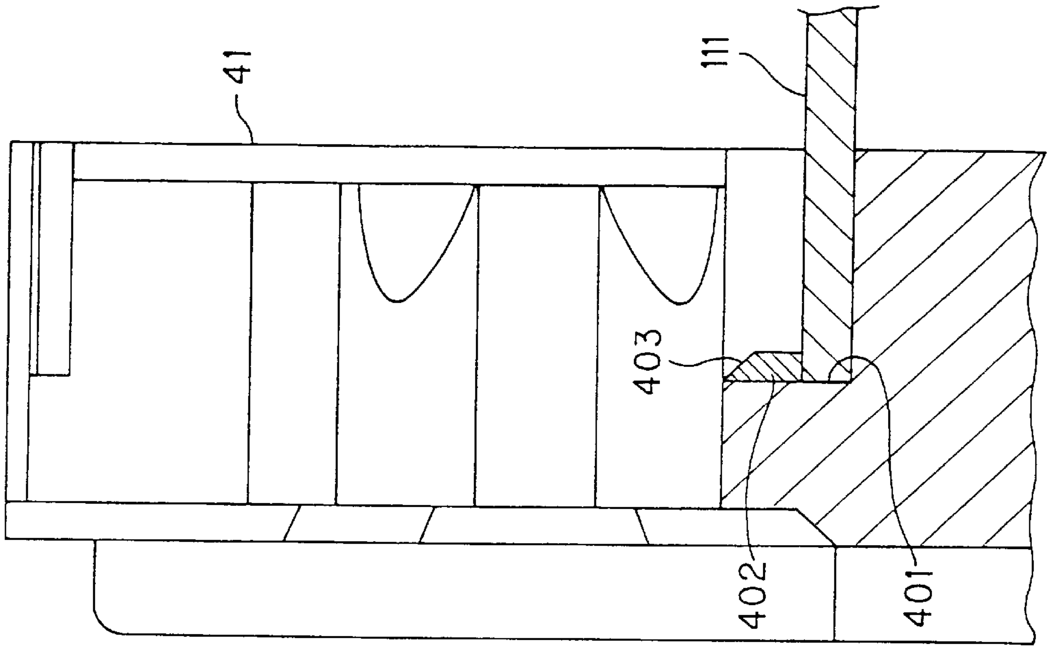


FIG. 12A

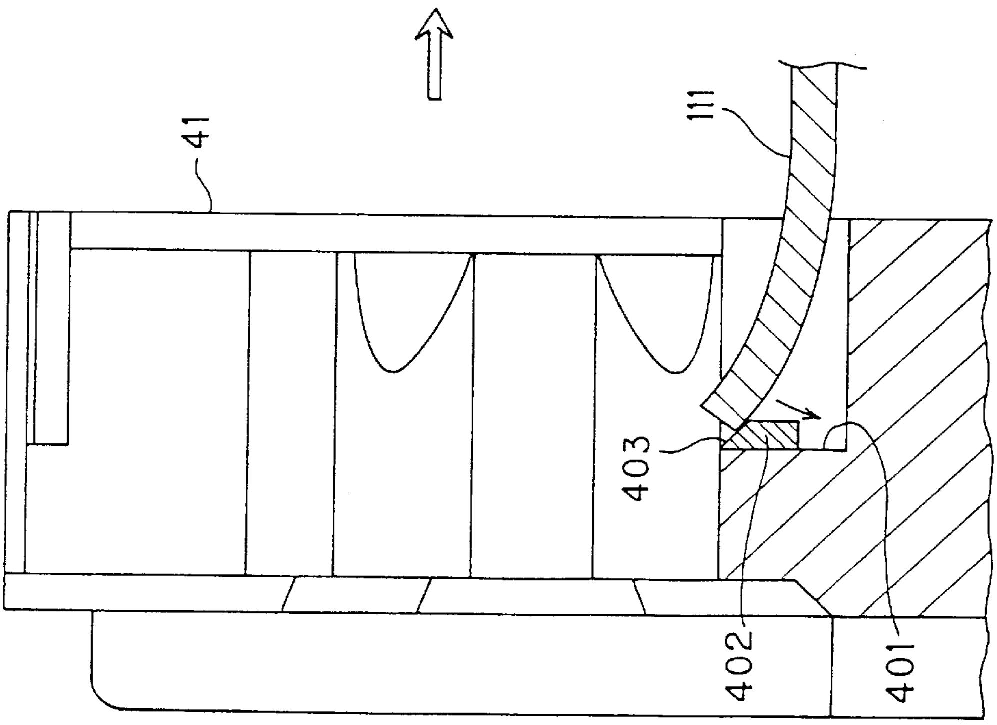
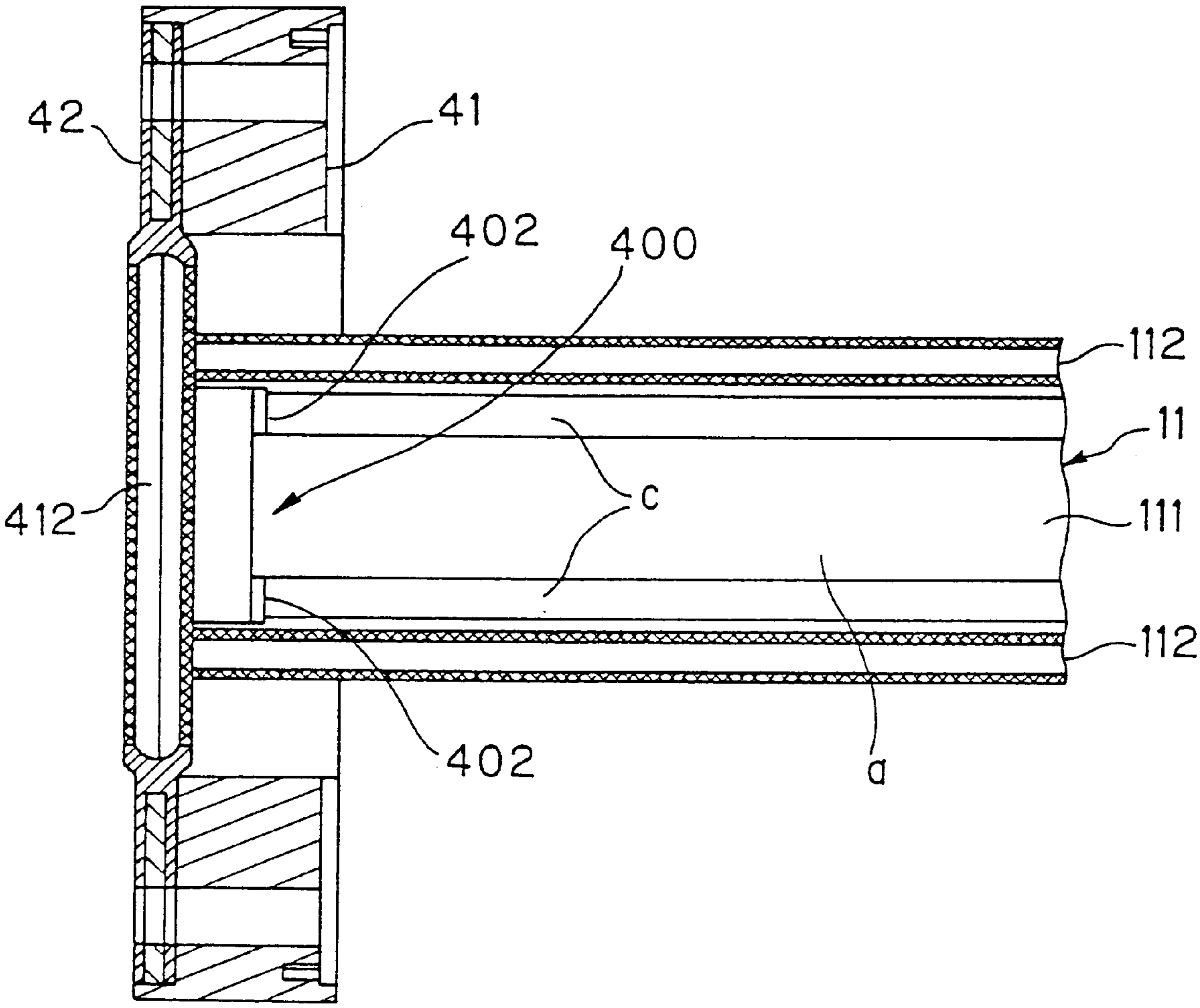


FIG. 13



ROLLING MOTION GUIDE APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a rolling motion guide apparatus having a seal member which is formed by integrally molding different parts or members with each other through an extrusion molding process and also relates to a rolling motion guide apparatus having such a seal member which is mounted on the apparatus by a new engaging or mounting method.

A rolling motion guide apparatus is well known as a means for conveying various machines or machinery. Such a rolling motion guide apparatus is provided with a track member and a movable member mounted on the track member in a straddle manner so as to be movable through a plurality of rolling members. When the movable member is moved along the track member, the machine or machinery mounted on the movable member is also moved. In such a rolling motion guide apparatus, the rolling members roll and circulate in an endless circulation passage formed by the combination of the rolling member rolling grooves formed on the movable member and the track member in accordance with the movement of the movable member.

In the known art, to such a rolling motion guide apparatus, a seal member is attached for protecting the rolling member and the endless circulation passage to prevent invasion of an external foreign material as well as leakage of a lubricant with which the endless circulation passage is filled. Particularly, in a case where it is desired to seal a gap formed between an upper surface of the track member and a surface of the movable member facing the upper surface of the track member, a plate-like seal member having sealing portions at its side edges is provided on the surface of the movable member facing the track member so as to seal the gap, as disclosed for example in Japanese Patent Laid-open (KOKAI) Publication No. HEI 7-286617.

A seal member utilized in the prior art is obtained by forming sealing portions of resin material, rubber material or the like and then joining the thus formed sealing portions on the peripheral edge portion of a base plate portion formed of a flat iron plate or the like, by a bonding method such as a thermal bonding method. Such a seal member is mounted on the movable member by fastening means such as screws prepared independently.

In the conventional method mentioned above, however, the seal member is formed by joining the base plate portion and the sealing portions after independently forming these portions, and accordingly, the number of parts or members to be used is increased and the manufacturing processes are also increased, which will require complicated manufacturing workings, in addition to a problem that the sealing portions may easily come off the base plate portion. In the above-mentioned prior art document of Japanese Patent Laid-open (KOKAI) Publication No. HEI 7-286617, there has been proposed one example for solving the problem. In that document, the base plate portion is formed so as to provide a stepped side edge portion for increasing a portion or area to be joined to the sealing portion. The formation of the base plate portion having such a stepped portion will make the manufacturing working further complicated.

Furthermore, in the conventional structure in which the base plate portion of the seal member has a flat shape, the seal member has a low rigidity and is easily plastically deformable. When the base plate portion is plastically deformed, the sealing portion is also deformed, and a gap will be hence caused between the front end of the sealing portion of the seal member and the track member, leading to reduction of the sealing function of the seal member.

On the other hand, in the conventional method in which the seal member is attached to the movable member by using the screw, parts to be used are increased and the manufacturing working and time are also increased and complicated, requiring much time, resulting in an increased production cost. Furthermore, in the method mentioned in the above Japanese Patent Publication in which the base plate portion and the sealing portion are joined without using any specific fastening means, it is required for the base plate portion to be formed into a specific shape.

SUMMARY OF THE INVENTION

An object of the present invention is to substantially eliminate defects or drawbacks encountered in the prior art mentioned above and to provide a rolling motion guide apparatus provided with a seal member capable of preventing a sealing portion from being detached or peeled off from a base plate portion so as to provide an improved rigidity and dimensional accuracy and also capable of having a mounting member for easily and surely mounting the seal member.

This and other objects can be achieved according to the present invention by providing, in one aspect, a rolling motion guide apparatus comprising:

a track member provided with a rolling member rolling groove along a longitudinal direction of the track member;

a plurality of rolling members rolling along the rolling member rolling groove formed on the track member;

a movable member provided with a loaded rolling member rolling groove which constitutes a loaded rolling member rolling passage in association with the rolling member rolling groove formed on the track member, the movable member being movable along the track member through the rolling members rolling in the loaded rolling member rolling passage; and

a seal member provided on a surface of the movable member facing the track member,

wherein the seal member comprises a base plate portion disposed along the surface of the movable member facing the track member and sealing portions disposed to longitudinal side edge portions of the base plate portion so as to be contacted to the track member, the base plate portion being formed of resin material different from resin material of which the sealing portions are formed, and the base plate portion and the sealing portions being integrally molded with each other through an extrusion process.

In a preferred embodiment in this aspect, the base plate portion is provided with an abutting portion having a surface which is perpendicular to the moving direction of the movable member and which has substantially a trapezoidal shape in section. The base plate portion may have a central portion in its sectional view which has a thickened portion and the side edge portions on which the sealing portions are disposed and which have thin thickness portions with respect to the thickened portion. The base plate portion and the sealing portions may be formed of different kinds of thermoplastic materials respectively.

According to this aspect of the present invention, the seal member is formed by integrally molding the base plate portion and the sealing portions with each other, and the formation and attachment of these portions can be carried out through a single extrusion molding process, which can reduce much time and labor for the manufacture thereof. The integral extrusion molding of the base plate portion with the sealing portions causes these portions to be formed into a single formed body. It is therefore possible to prevent the sealing portions from being separated from the base plate portion.

Furthermore, since the base plate portion can be held on the movable member by abutting the abutting portion against the movable member, the seal member can surely attached. The rigidity of the base plate portion can extremely be improved in comparison with a case in which the seal member is formed of a single plate member, and the deformation thereof can be also prevented, resulting in the realization of the improved sealing function.

Still furthermore, the formation of the thickened portion of the base plate portion can improve the strength and rigidity thereof and can prevent the deformation of the seal member at a time when the seal member is fitted to the engaging portion of the side cover.

In another aspect of the present invention, the above object can be achieved by providing a rolling motion guide apparatus comprising:

a track member provided with a rolling member rolling groove along a longitudinal direction of the track member;

a plurality of rolling members rolling along the rolling member rolling groove formed on the track member;

a movable member provided with a loaded rolling member rolling groove which constitutes a loaded rolling member rolling passage in association with the rolling member rolling groove formed on the track member, the movable member being movable along the track member through the rolling members rolling in the loaded rolling member rolling passage;

side covers fixed on both end surfaces of the movable member in the moving direction thereof; and

a seal member provided on a surface of the movable member facing the track member,

wherein the seal member comprises a base plate portion disposed along the surface of the movable member facing the track member and sealing portions disposed to longitudinal side edge portions of the base plate portion so as to be contacted to the track member, the side covers and the base plate portion are formed with engaging portions respectively, which are engaged with each other so as to hold the base plate portion of the seal member on the surface of the movable member facing the track member, and the base plate portion of the seal member is mountable on the end portions of the movable member through the engaging portions, with the side covers being fixed thereto.

In a preferred embodiment of this aspect, the base plate portion is provided with an abutting portion having a surface which is perpendicular to the moving direction of the movable member and which has substantially a trapezoidal shape in section.

In this aspect, also as mentioned in the above aspect, the base plate portion has a central portion in its sectional view which has a thickened portion and the side edge portions on which the sealing portions are disposed and which have thin thickness portions with respect to the thickened portion. The base plate portion may be formed of resin material different from resin material of which the sealing portions are formed, and the base plate portion and the sealing portions may integrally be molded with each other through an extrusion process. The base plate portion and the sealing portions may be formed of different kinds of thermoplastic materials respectively.

Furthermore, the engaging portion formed on each of the side covers at a portion facing a surface of the track member comprises a recessed fit portion having a size allowing the base plate portion to be fitted and engaging claw pieces engaged with engaging groove formed on the base plate portion, and each of the engaging claw pieces may have an inclined surface portion along which the base plate portion slides when fitted.

According to this aspect, in addition to the above one aspect, the seal member can be mounted on the movable member without using any other means, which results in the reduction of parts to be used and the manufacturing cost down, as well as the working time and labor. Furthermore, the seal member can easily be mounted without forming the base plate portion thereof so as to provide a specific shape. Since the seal member can be mounted merely by press-fitting the end portion of the seal member, it can be mounted on the movable member with the side covers being attached, improving the assembling working.

The nature and further characteristic features of the present invention can be made more clear from the following descriptions with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** is a perspective view of a rolling motion guide apparatus, partially cut away, according to one embodiment of the present invention;

FIG. **2** is a view, partially in section, viewed from a direction perpendicular to a guiding direction of the rolling motion guide apparatus shown in FIG. **1**;

FIG. **3** is a sectional side view showing an endless circulation passage for rolling members of the apparatus shown in FIG. **1**;

FIG. **4** is a back side view of a seal member to be mounted on the rolling motion guide apparatus of FIG. **1**;

FIG. **5** is an end view of the seal member;

FIG. **6** is an end view of another seal member to be utilized for the rolling motion guide apparatus of the present invention;

FIG. **7** is a sectional side view, partially cut away, of an apparatus for molding the seal member used for the rolling motion guide apparatus of the present invention;

FIG. **8** is an end view of a seal member formed by the molding apparatus of FIG. **7**;

FIG. **9** is a view showing a surface of a side cover facing a body of a movable member of the rolling motion guide apparatus;

FIG. **10** is an enlarged front view of an engaging portion shown in FIG. **9**;

FIG. **11** is an enlarged back side view of the engaging portion shown in FIG. **9**;

FIGS. **12**A and **12**B are views showing a process for mounting the seal member on the side cover; and

FIG. **13** a back side view showing a state of the seal member mounted on the side cover.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

One preferred embodiment of a rolling motion guide apparatus of the present invention will be described hereunder with reference to FIGS. **1** to **3**.

The rolling motion guide apparatus **1** of this embodiment is provided with a track member **2** and a movable member

4 which is mounted on the track member in a straddle manner through a plurality of spherical rolling members **3**—**3** such as balls so as to be freely movable on and along the track member **2**.

The track member **2** is a member having a surface, rectangular in cross section, perpendicular to the longitudinal direction thereof and formed with two rows of rolling member rolling grooves **5**, **5** on each side surface, totally four grooves, so as to extend throughout the entire longitudinal direction of the track member **2**. Each row of rolling member rolling grooves shows substantially a semi-circular shape. In the embodiment of FIG. **1**, although the track member **2** has a linear shape, it may be formed so as to provide a curved structure. Furthermore, the number of the rolling member rolling grooves is not limited to the described embodiment and other arrangements may be taken, for example, one row in each side, totally two rows. There may be taken further another arrangement having the total number of rows of three.

On the other hand, the movable member **4** has a cross sectional surface having an inverse U-shape, perpendicular to the moving direction of the movable member **4**. The movable member **4** is mounted on the track member **2** so as to straddle the same through a plurality of spherical rolling members **3**—**3** rolling in the passage composed of the groove formed on the inner surface of the movable member **4** and the groove formed on the outer surface of the track member **2**. The movable member **4** is composed of a movable member body **40**, side covers or lids **41**, **41** fixed on both the side ends in the longitudinal direction of the movable member body **40** and end plates **42**, **42** fixed on both the longitudinal ends thereof by means of screws **43**—**43**.

The inverse U-shaped movable member **4** has an inner space into which the track member **2** is located and has inner surfaces facing the outer surfaces of the track member, and two rows of loaded rolling member rolling grooves **6**, **6** are formed on each of the inner surface of the movable member **4** so as to correspond to or face on the rolling member rolling grooves **5**, **5** formed on the track member **2**, respectively. Each pair of these rolling member rolling grooves **5** and **6** form a loaded rolling member rolling passage **7** as a portion of a circulation passage of the rolling members **3**—**3**. The movable member body **40** is formed with return passages **8** each having a circular shape in cross section and extending along the entire longitudinal direction, i.e. moving direction thereof. The side covers **41**, **41** are formed with direction changing passages **9**, **9**, each connecting the loaded rolling member rolling passage **7** with the return passage **8**. In this manner, endless circulation passages **10** are formed by the continuous connection of the loaded rolling member rolling passages **7**, the return passages **8** and the direction changing passages **9** on both the sides of the track member **2** along the longitudinal moving direction thereof.

The rolling members **3**—**3** form a connection member **30** in association with spacers **31**—**31** disposed between adjacent rolling members **3**, **3** and belts, each in thin plate structure, supporting the rolling members **3**—**3** so as to be movable on both the sides thereof, and that is, in the connection member **30**, the rolling members **3**—**3** are connected by the spacers **31** and the belts in shape of a string of beads. The rolling members **3**—**3** circulate in the endless circulation passage **10** in the manner that when the movable member **4** is moved, the rolling members **3**—**3** are also moved in the loaded rolling member passage **7** and guided to one end side of the return passage **8** through the direction changing passage **9** on one end side, then moved along the return passage **8** toward the other one end side thereof, and then guided again to the loaded rolling member passage **7** through the other direction changing passage **9** on the other end side.

Seal members **11** and **12** are disposed on a horizontal surface **46** and both side surfaces **47**, **47** of the movable member **4** facing the track member **2** as shown in FIG. **2**. More specifically, the seal member **11** is disposed on the horizontal surface **46** of the movable member **4** facing the upper surface **21** of the track member **2** so as to extend in the movable member moving direction, i.e. the perpendicular direction to the drawing paper surface of FIG. **2**. On the other hand, the seal members **12**, **12** are disposed on the lower sides of the loaded rolling member passages **7**, **7** so as to seal the same.

FIGS. **4** to **6** show the detailed structure of the seal member **11**. The seal member **11** is composed of a base plate portion **111** and sealing portions **112**, **112** formed on both side edges **113**, **113** of the base plate portion **111** so as to entirely extend therealong.

The base plate portion **111** is formed so as to have a trapezoidal shape in an entire structure and has a contact portion **115** abutting against the movable member **4**. The base plate portion **111** includes a central thick portion having a large thickness sufficient for maintaining a proper rigidity of the base plate portion **111** and thin portions b, b having a small thickness on the sides of the side edge portions **113**, **113**. The back side surfaces, i.e., the lower side surfaces as viewed, of the thin portions b, b are formed with engaging grooves c, c to be engaged with engaging claws **402**, **402** of engaging portions (FIG. **9**) of the side covers **41**, **41**, respectively. The engaging groove c extends along the entire longitudinal direction of the base plate portion **111** and provides an inverse U-shaped cross section. However, this cross sectional shape is not limited to that shown in FIG. **5**, and the base plate portion **111** may be formed so as to provide a cross sectional shape shown in FIG. **6**, in which the contact portion **115** is partially formed. The base plate portion **111** may be formed of a resin material, preferably, a thermoplastic resin such as polyvinyl chloride, polyethylene, polystyrene, polypropylene, ABS resin, or the like.

The sealing portions **112**, **112** arranged on the both side edge portions **113**, **113** of the base plate portion **111** are formed of a resin material and have front end portions, each in shape of fork in section, so as to provide lip portions **114**, **114** (each being formed of lip portions **114***a*, **114***b*) having round distal end portions as shown in FIG. **5** or **6**. In a preferred embodiment, it is desired to make shorter the length of the lip portion **114***a* near the loaded rolling member rolling passage (FIG. **2**) than that of the other lip portion **114***b* positioned apart from the lip portion **114***a* with respect to the loaded rolling member passage **7** when assembled. Further, it may be preferred to form the sealing portions of a thermoplastic resin such as polyvinyl chloride, polyethylene or the like, but it is not limited to such resin material in the present invention and a rubber material may be utilized.

The base plate portion **111** and the sealing portions **112**, **112** are integrally formed with each other by an extrusion molding process so as to provide the seal member **11**. FIG. **7** shows one example of a molding apparatus D for molding the seal member **11**.

With reference to FIG. **7**, the molding apparatus D is provided with a first extrusion section S1 for forming the base plate portion **111** and a second extrusion section S2 for forming the sealing portions **112**, **112**. Each of these extrusion sections S1 and S2 is provided with a horn-shaped hopper **91** through which a raw material is fed, a barrel **93** into which the raw material is fed through the hopper **91**, a screw **92** disposed in the barrel **93** at substantially the central portion of the extrusion section for extruding the raw material, and a heater **94** disposed at the outer peripheral portion of the barrel **93** to heat the raw material in the barrel to a predetermined temperature. Both the extrusion sections S1 and S2 are connected to each other by means of a die **95** at the axial feed end portions of the screws **92**, **92**. The die **95** is a mold for molding the raw material so as to provide a desired shape and is provided with a material guide section **98** having a first supply passage **96** for supplying a raw material for the base plate portion **111** from the extrusion section S1 and a second supply passage **97** for supplying a raw material for the sealing portions **112** from the extrusion section S2 and a mixing section **99** for mixing these materials together.

The raw material for the base plate portion **111** is fed into a material feeding portion **98** of the die **95** through the first feeding passage **96** by the extrusion section S1. The raw material passes the material feeding portion **98** while being gradually formed into a shape of the base plate portion **111**. On the other hand, the raw material for the sealing portion **112** is extruded by the extrusion section S2, fed into the material feeding portion **98** of the die **95** through the second feeding passage **97** and, then, passes the material feeding portion **98** while being gradually formed into a shape of the sealing portion **112**. As shown in FIG. **7**, the second feeding passage **97** is positioned at each side of the first feeding passage **96** at the central portion of the material feeding portion **98**.

Thereafter, both the raw materials for the base plate portion **111** and the sealing portions **112** are supplied to the mixing portion **99**, and during the time when the raw materials pass through the mixing portion, both the raw materials are formed integrally into the seal member **11** of the rolling motion guide apparatus according to the embodiment of the present invention mentioned above.

FIGS. **9** to **12** show the various states of the side cover **41** to which the seal member **11** is attached. As shown in these figures, the side cover is formed with an engaging portion **400**, which is positioned at a portion of the side cover corresponding (opposing, when assembled,) to the upper surface **21** of the track member (see FIG. **2**). The engaging portion **400** is composed of a recessed fit portion **401** and engaging claws **402**, **402**. The base plate portion **111** is fitted into this recessed fit portion **401**, which has a cross sectional shape substantially equal to that of the base plate portion **112**. The engaging claws **402**, **402** can be engaged with the engaging grooves c, c formed on the base plate portion **111** as mentioned before. The engaging claw **402** projects toward the movable member body **40** (see FIG. **1**) and has an inclining surface **403**.

The seal member **11** is attached to the side cover **41** in the following manner. First, as shown in FIG. **12**, the base plate portion **111** is arranged so that the end surface in the longitudinal direction of the base plate portion **111** is positioned so that the upper side surface, as viewed in FIG. **5**, of the base plate portion **111** abuts against the inclining surface **403** of the engaging claw **402** (see FIG. **12**B) and then the end surface portion of the base plate portion **111** is pushed into the recessed fit portion **401** so as to establish the engaging state. FIG. **12**A shows a state that the base plate portion **111** of the seal member **11** is fitted into the engaging portion **400**. In this engagement, since the engaging claw **402** is formed with the inclining surface **403**, the base plate portion **111** can smoothly be fitted into the recessed fit portion **401** by sliding the end surface portion of the base plate portion along the inclining surface **403**. Further, the engaging grooves c, c, mentioned before with reference to FIGS. **4** and **5**, are arranged at portions at which they are engaged with the engaging claws **402**, **402** of the engaging portion **400**, whereby the seal member **11** can be prevented more surely from being disengaged from the side covers **41**, **41**.

FIG. **13** shows a seal member attaching state, in which the end surface of the sealing portion **112** is attached in an abutting state to the side surface of the sealing portion **412** of the end plate **42**. According to the construction of the seal member **11** in the manner mentioned above, the gap between the upper surface **21** of the track member **2** and the movable member **4** can be substantially completely sealed, and the invasion of the foreign material into the loaded rolling member rolling passage **7** from the central side of the guide apparatus **1** can be effectively prevented. Furthermore, though not shown, the sealing portions of the seal member **12** which seals the loaded rolling member rolling passage **7** from the lower side may also be constructed by abutting the longitudinal end portion thereof against the sealing portion **412** of the end plate **42**. According to the location of the sealing portions **112** and **412** of the respective seal members, the loaded rolling member rolling passage **7** can be sealed at its both the moving direction and the direction normal thereto of the movable member **4**, thus improving the dust proof effect. Furthermore, in order to ensure the smooth rolling of the rolling members **3**—**3** in the endless circulation passage **10**, lubricant such as grease may be applied to the endless circulation passage **10**. The lubricant is fed through the filling port **44** (FIG. **1**) and then supplied to the direction changing passage **9** through a lubricant guiding passage **45** formed on the side cover **41** as shown in FIG. **9**. In this viewpoint, the lubricant can also be prevented from leaking by locating the sealing portions **112** and **412** of the respective seal members in the manner mentioned above.

It is finally to be noted that the present invention is not limited to the described embodiment and many other changes or modifications may be made without departing from the scopes of the appended claims.

For example, in the described embodiment, although the rolling motion guide apparatus **1** provided with the endless circulation passage **10** is referred to, the present invention will be applicable to a rolling motion guide apparatus provided with a circulation passage having its ends.

What is claimed is:

1. A rolling motion guide apparatus comprising:

a track member provided with a rolling member rolling groove along a longitudinal direction of the track member;

a plurality of rolling members rolling along the rolling member rolling groove formed on the track member;

a movable member provided with a loaded rolling member rolling groove which constitutes a loaded rolling member rolling passage in association with the rolling member rolling groove formed on the track member, said movable member being movable along the track member through the rolling members rolling in the loaded rolling member rolling passage; and

a seal member provided on a surface of the movable member facing the track member,

wherein said seal member comprises a base plate portion disposed along the surface of the movable member facing the track member and sealing portions disposed to longitudinal side edge portions of the base plate portion so as to be contacted to the track member, said base plate portion being formed of resin material different from resin material of which said sealing portions are formed, and said base plate portion and said sealing portions being integrally molded with each other through an extrusion process.

2. The rolling motion guide apparatus according to claim **1**, wherein said base plate portion is provided with an abutting portion having a surface which is perpendicular to a moving direction of the movable member and which has substantially a trapezoidal shape in section.

3. The rolling motion guide apparatus according to claim **1**, wherein said base plate portion has a central portion in its sectional view which has a thickened portion and the side edge portions on which the sealing portions are disposed and which have thin thickness portions with respect to the thickened central portion.

4. The rolling motion guide apparatus according to claim **1**, wherein said base plate portion and said sealing portions are formed of different kinds of thermoplastic materials respectively.

5. A rolling motion guide apparatus comprising:

a track member provided with a rolling member rolling groove along a longitudinal direction of the track member;

a plurality of rolling members rolling along the rolling member rolling groove formed on the track member;

a movable member provided with a loaded rolling member rolling groove which constitutes a loaded rolling member rolling passage in association with the rolling member rolling groove formed on the track member, said movable member being movable along the track member through the rolling members rolling in the loaded rolling member rolling passage;

side covers fixed on both end surfaces of the movable member in the moving direction thereof; and

a seal member provided on a surface of the movable member facing the track member,

wherein said seal member comprises a base plate portion disposed along the surface of the movable member facing the track member and sealing portions disposed to longitudinal side edge portions of the base plate portion so as to be contacted to the track member, said side covers and said base plate portion are formed with engaging portions respectively, which are engaged with each other so as to hold the base plate portion of the seal member on the surface of the movable member facing the track member, and said base plate portion of the seal member is mountable on the end portions of the movable member through said engaging portions, with said side covers being fixed thereto.

6. The rolling motion guide apparatus according to claim **5**, wherein said base plate portion is provided with an abutting portion having a surface which is perpendicular to a moving direction of the movable member and which has substantially a trapezoidal shape in section.

7. The rolling motion guide apparatus according to claim **5**, wherein said base plate portion has a central portion in its sectional view which has a thickened portion and the side edge portions on which the sealing portions are disposed and which have thin thickness portions with respect to the thickened central portion.

8. The rolling motion guide apparatus according to claim **5**, wherein said base plate portion is formed of resin material different from resin material of which said sealing portions are formed, and said base plate portion and said sealing portions are integrally molded with each other through an extrusion process.

9. The rolling motion guide apparatus according to claim **8**, wherein said base plate portion and said sealing portions are formed of different kinds of thermoplastic materials respectively.

10. The rolling motion guide apparatus according to claim **5**, wherein said engaging portion formed on each of said side covers at a portion facing a surface of the track member comprises a recessed fit portion having a size allowing the base plate portion to be fitted and engaging claw pieces engaged with engaging grooves formed on the base plate portion.

11. The rolling motion guide apparatus according to claim **10**, wherein each of said engaging claw pieces has an inclined surface portion along which the base plate portion slides when fitted.

* * * * *

US006094819A

United States Patent [19]

Teramachi et al.

[11] **Patent Number: 6,094,819**

[45] **Date of Patent: *Aug. 1, 2000**

[54] **METHOD FOR MANUFACTURE OF RECTILINEAR GUIDE UNIT**

[75] Inventors: **Hiroshi Teramachi**; **Takeki Shirai**, both of Tokyo, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

[21] Appl. No.: **08/973,543**

[22] PCT Filed: **May 6, 1997**

[86] PCT No.: **PCT/JP97/01523**

§ 371 Date: **Jun. 10, 1998**

§ 102(e) Date: **Jun. 10, 1998**

[87] PCT Pub. No.: **WO97/42423**

PCT Pub. Date: **Nov. 13, 1997**

[30] **Foreign Application Priority Data**

May 7, 1996 [JP] Japan 8-112259

[51] **Int. Cl.**^{7} **B21D 53/10**; B21K 1/10

[52] **U.S. Cl.** **29/898.03**; 29/527.1; 29/898.15; 264/273; 384/43; 384/44; 384/45

[58] **Field of Search** 29/898.03, 898.049, 29/898.06, 898.12, 898.15, 527.1, 527.4; 384/43, 44, 45; 264/273, 274, 275

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,551,895	11/1985	Teramachi	29/148.4 R
4,869,600	9/1989	Tonogai	384/43
4,902,143	2/1990	Morita	384/43
5,277,498	1/1994	Kawaguchi	384/45
5,373,635	12/1994	Nonaka et al.	29/898.1
5,380,099	1/1995	Teramachi	384/45
5,431,498	7/1995	Lyon	384/45
5,640,768	6/1997	Teramachi	29/898.03
5,716,139	2/1998	Okamoto et al.	384/45
5,755,516	5/1998	Teramachi et al.	384/45
5,829,883	11/1998	Kawaguchi et al.	384/45
5,851,073	12/1998	Takeuchi	384/45
5,951,168	9/1999	Teramachi et al.	384/45
6,012,848	1/2000	Michioka et al.	384/43

FOREIGN PATENT DOCUMENTS

64-65325	3/1989	Japan .
2-142918	6/1990	Japan .
6-147222	5/1994	Japan .
7-317762	12/1995	Japan .

Primary Examiner—David P. Bryant
Assistant Examiner—Essama Omgba
Attorney, Agent, or Firm—Arent Fox Kintner Plotkin & Kahn

[57] **ABSTRACT**

The present invention relates to a method of manufacture of a slider of a rectilinear guide unit for guiding a movable body such as a work table of a machine tool, an industrial robot or the like by moving along an orbital rail arranged on a stationary section such as a bed, column or the like as it bears a load thereon. This method comprises a first step in which a metallic block main body as a core of the slider is machined to a predetermined shape and to form ball load rolling contact surfaces in the block main body and a second step in which the block main body machined in the previous step is inserted into a mold so as to allow a die-molding material to be padded thereon to thereby form an endless ball circulation path wherein in the first step, chamfered sections are formed on the corners of the block main body corresponding to a portion where the above-mentioned endless ball circulation path is formed.

3 Claims, 7 Drawing Sheets

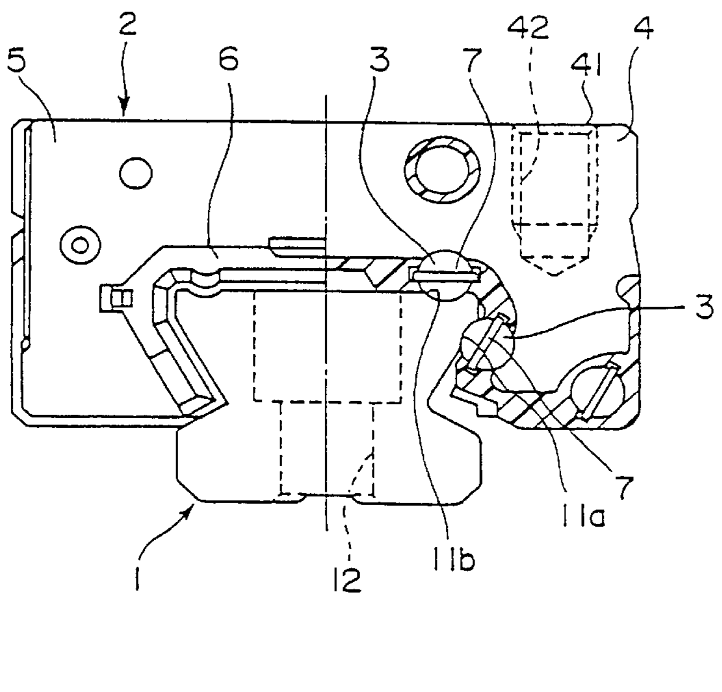


Fig. 1

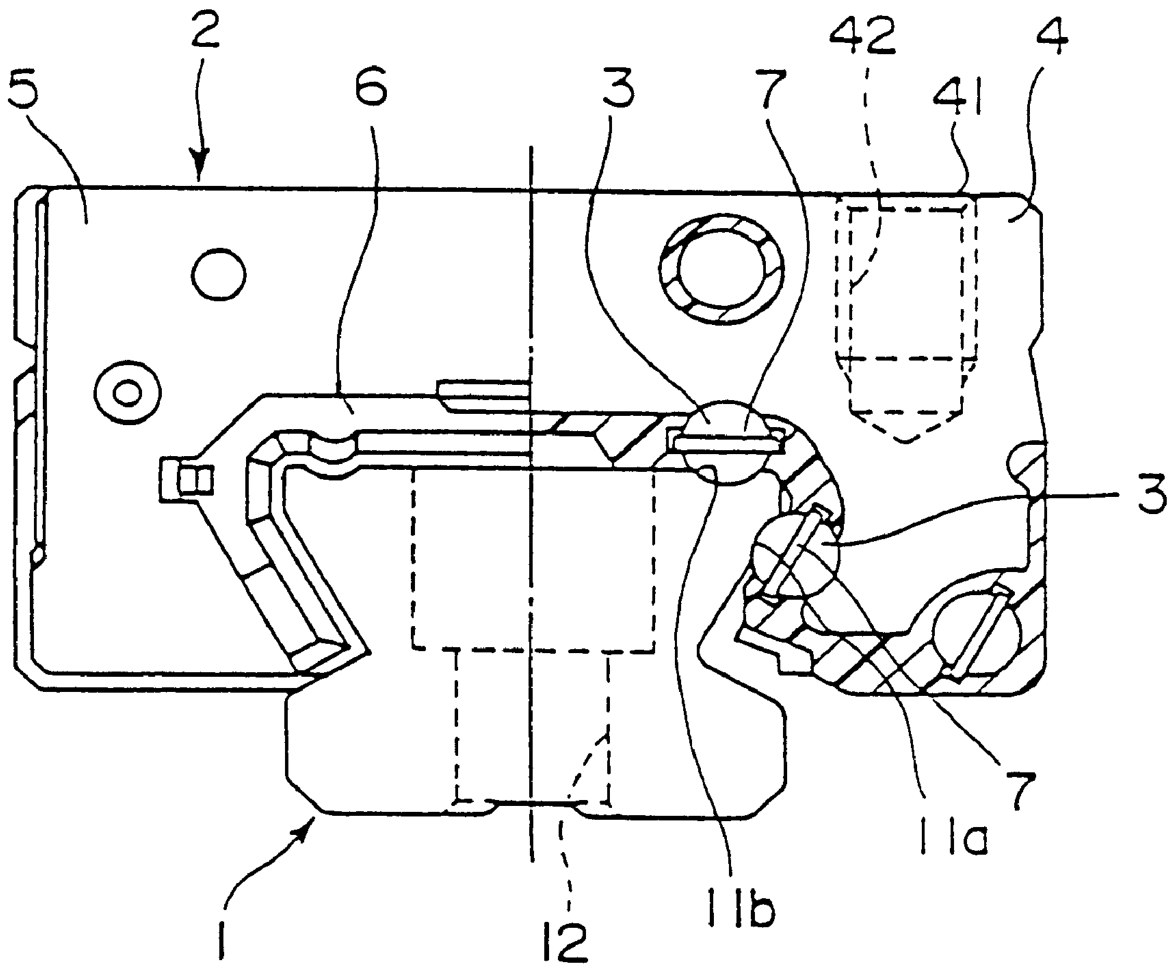


Fig. 2

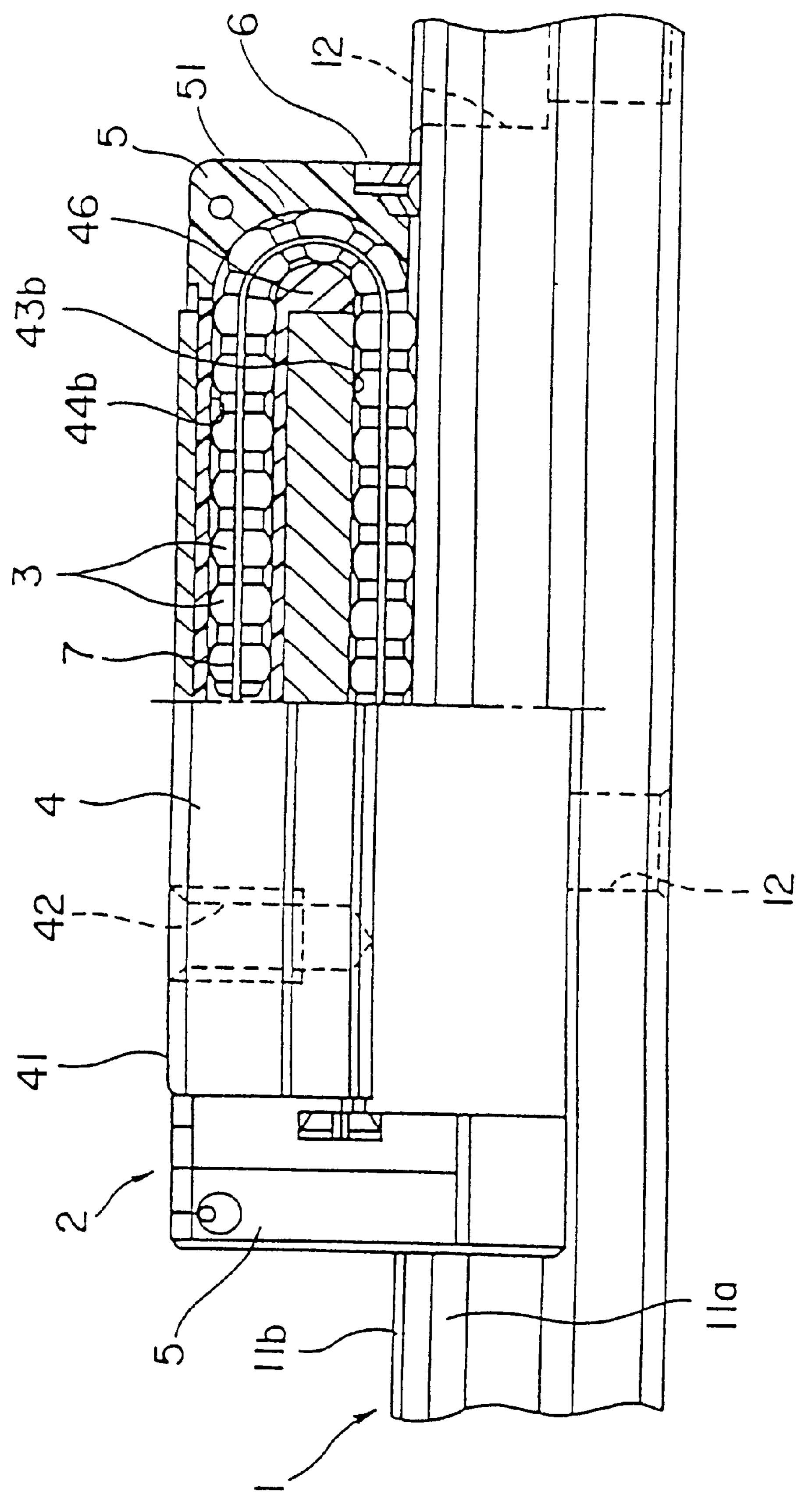


Fig. 3

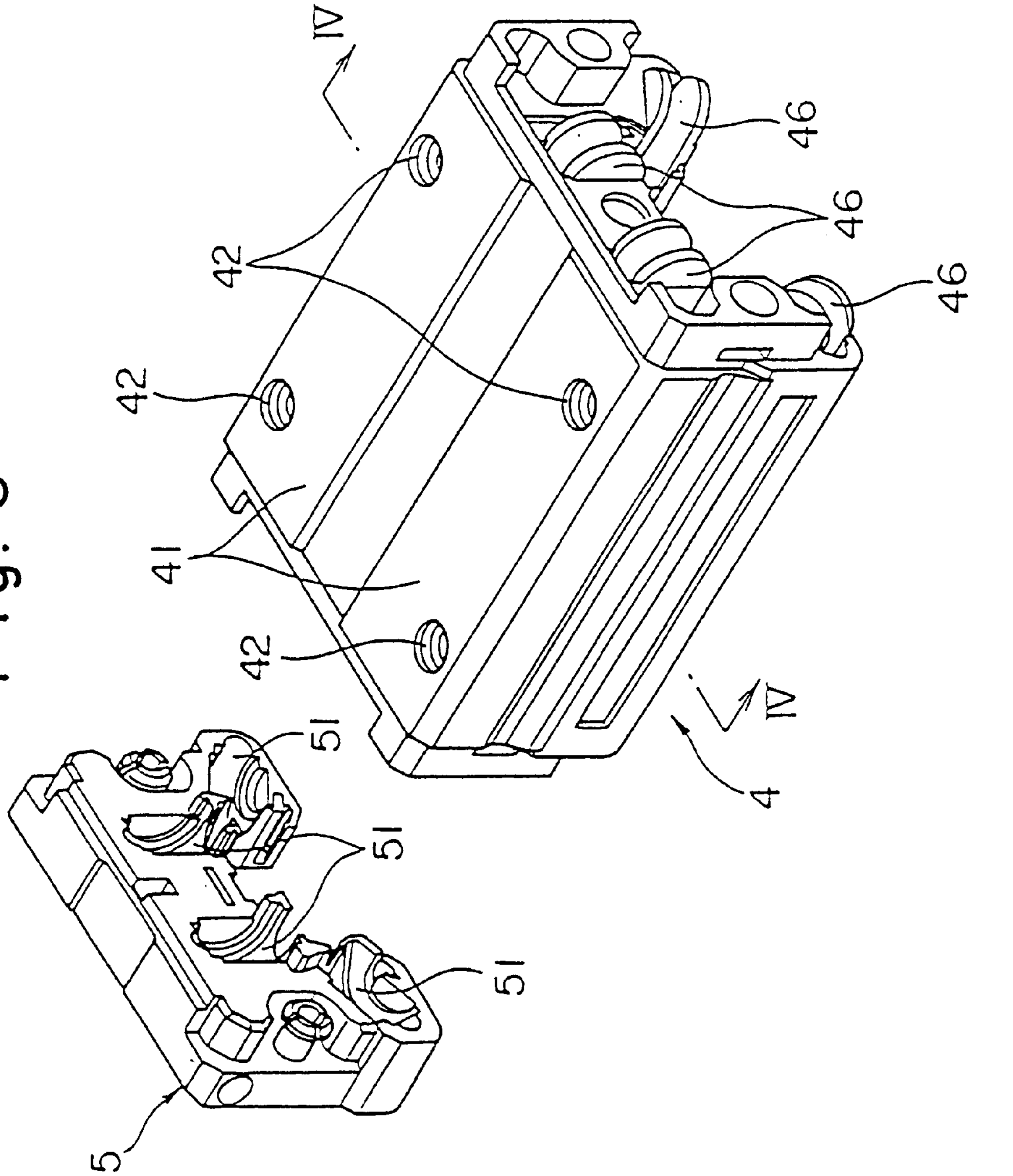


Fig. 4

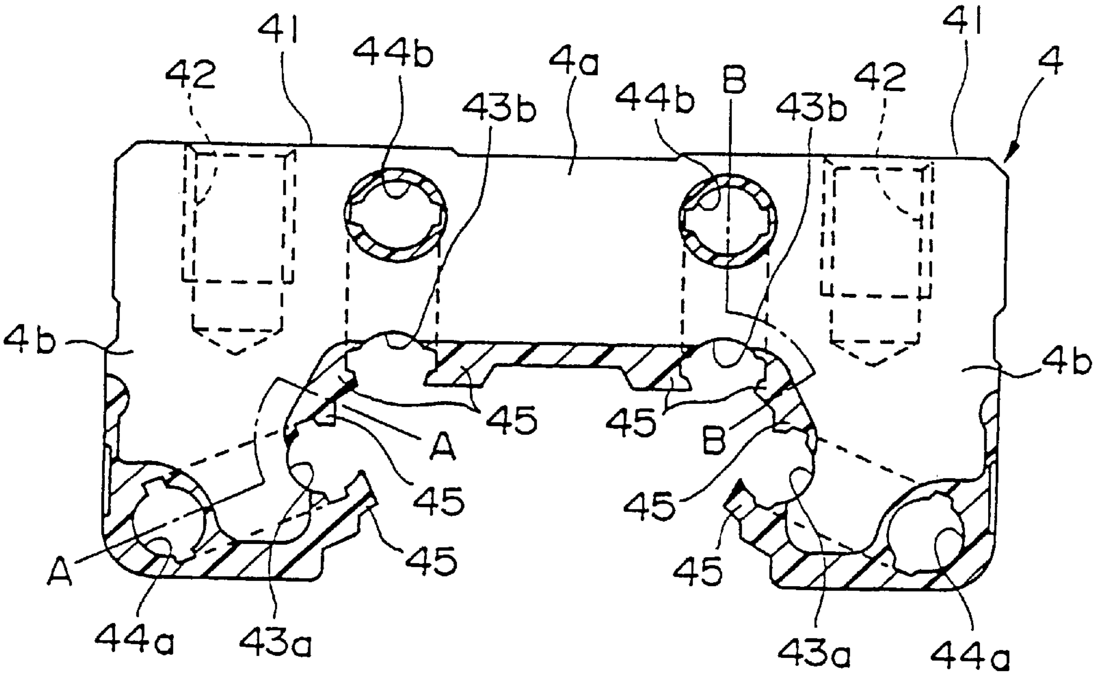

41
44b
4a
42
44b
B
43b
42
41
4
43b
4b
4b
45
45
A
B
45
45
A
45
45
44a
43a
43a
44a

Fig. 5

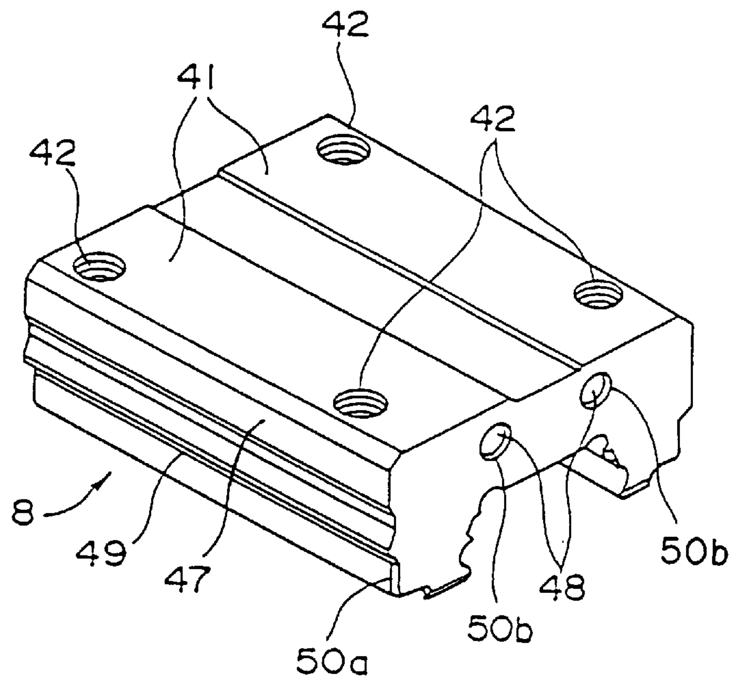
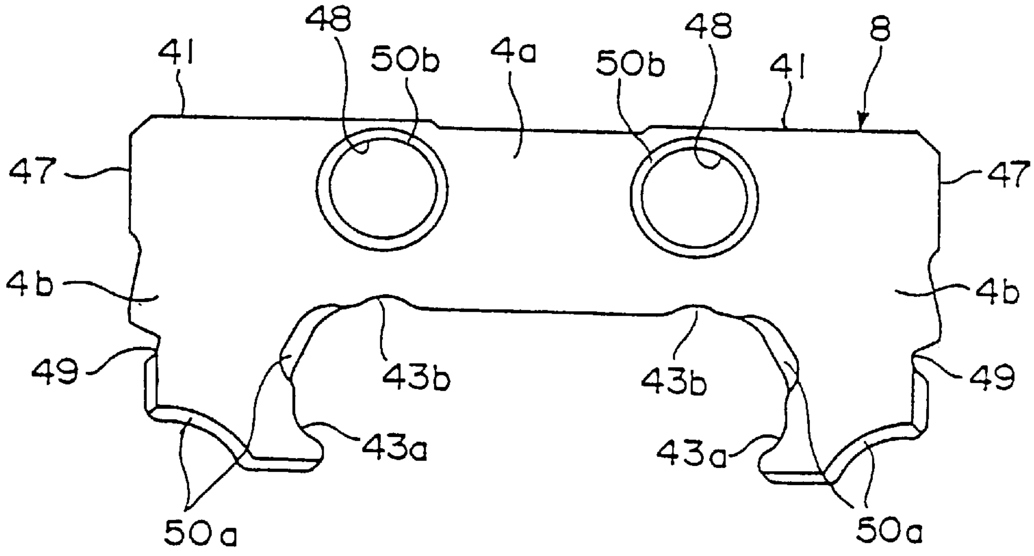

42
41
42
42
8
49
47
50a
50b
48
50b

Fig. 6


48
50b
4a
50b
48
8
41
41
47
47
4b
4b
49
49
43b
43b
43a
43a
50a
50a

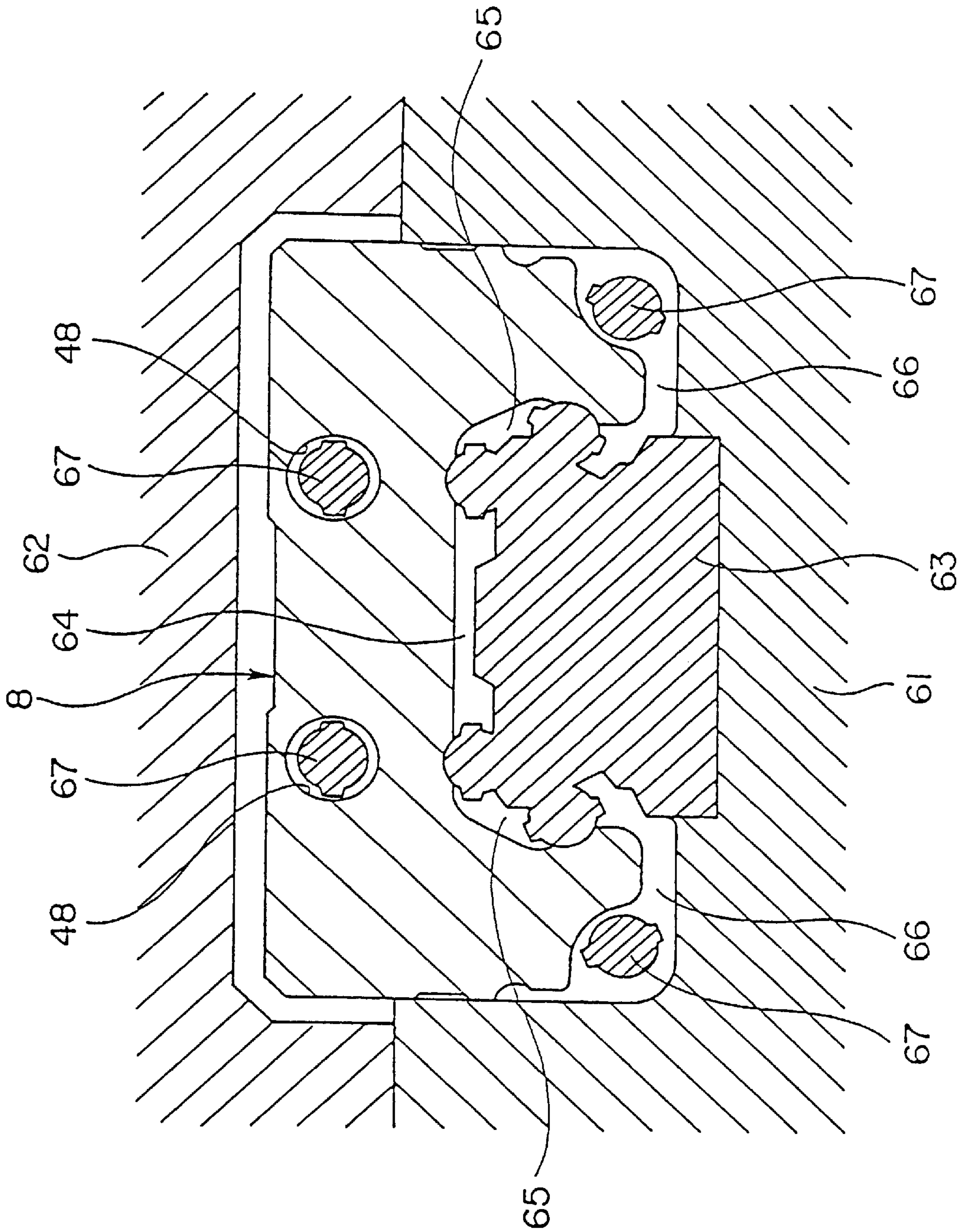


Fig. 7

Fig. 8(a)

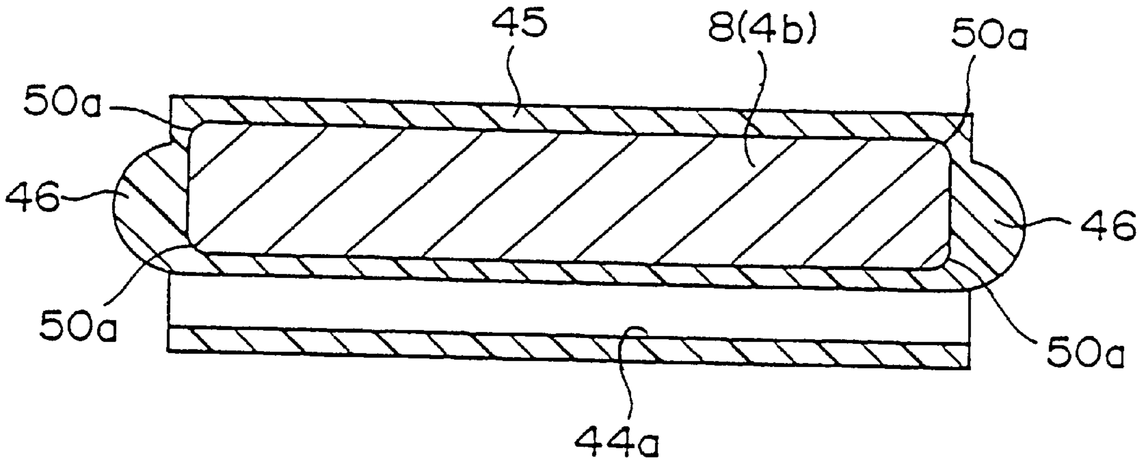
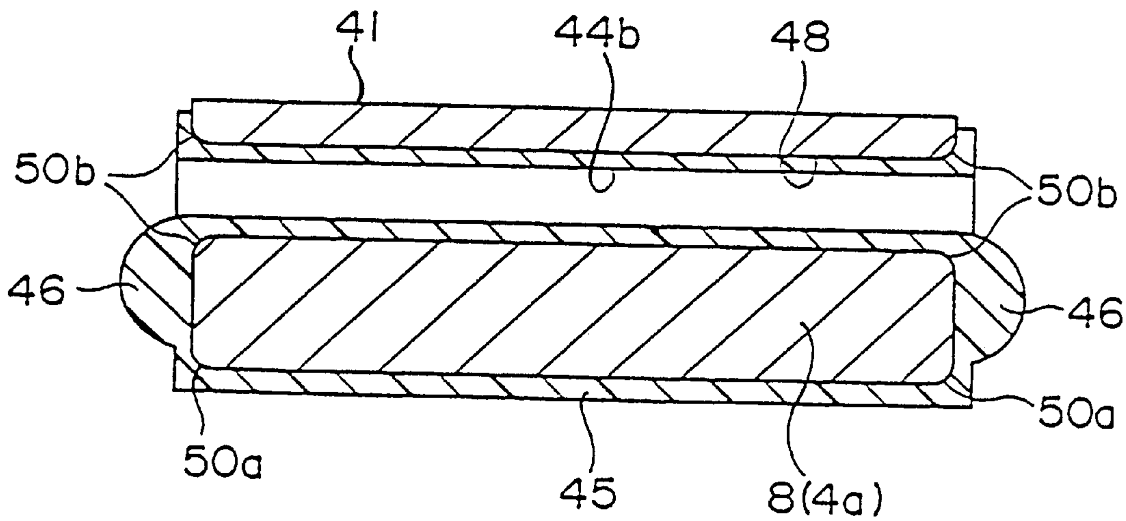

45
8(4b)
50a
50a
46
46
50a
50a
44a

Fig. 8(b)


41
44b
48
50b
50b
46
46
50a
50a
45
8(4a)

METHOD FOR MANUFACTURE OF RECTILINEAR GUIDE UNIT

TECHNICAL FIELD

The present invention relates to a method of manufacture of a slider for a rectilinear guide unit for guiding a movable body such as a work table of a machine tool, an industrial robot and etc. while moving along an orbital rail arranged on a bed, column or the like, and more particularly to an improvement in a method in which a slider is formed by padding a die-molding material such as a synthetic resin to a metallic block main body.

BACKGROUND TECHNOLOGY

Conventionally, as a linear guide unit of the above type, there is known the one that has a structure comprising a orbital rail arranged on a stationary portion such as a bed and having ball rolling contact surfaces and a slider fastened to the orbital rail through a number of balls and movable along the rail which supports a movable body such as a table.

Further, the slider comprises a mobile block having ball load rolling contact surfaces opposing to the ball rolling contact surface of the orbital rail through the balls and ball return holes parallel to the ball load rolling contact surfaces and capable of moving along the orbital rail following the rolling of the balls, a pair of covers having change-direction paths for establishing communication between the ball load rolling contact surfaces and the ball return holes and ball retainers attached to the mobile block so as to prevent the falling of the balls from the ball load rolling contact surfaces and the end portions of the ball return holes are connected by the change-direction path when the covers are fixed to the front and rear end surfaces of the mobile block, respectively, thereby completing an endless circulation path for the balls in the slider.

In the case of the slider of the conventional rectilinear guide unit of the above-described structure, the process of drilling the ball return holes and the fixing of the ball retainers to the mobile block becomes necessary resulting in taking much time and labor for its manufacture so that the present applicant proposed a method of manufacture of the slider by making use of extrusion molding of a synthetic resin (refer to Japanese Unexamined Patent Publication No. 317762/1995).

More concretely, the above-proposed method is such that a synthetic resin is padded onto the metallic block main body having the above-mentioned load rolling contact surfaces subjected to cutting so that the ball return holes and the ball retainers are molded integral with the block main body and the ball guide sections on the side of the inner peripheral surface of each of the change-direction paths which have hitherto been formed in the covers are also molded on the end surfaces of the block main body to thereby manufacture the movable block. Besides the advantage of being able to manufacture a mobile block of a complicated shape in a simple manner, this proposed method has also such advantage that an endless ball circulation path provided with ball return holes, inner peripheral side ball guide sections and ball retainers formed continuous with one another can be formed with a synthetic resin thereby smoothing the circulation of the balls.

Now, where such endless ball circulation path is continuously formed with the synthetic resin, it is usual that the molten resin immediately after injection-molding solidifies as it contracts toward a direction parallel to the ball return holes but since such endless circulation path itself is so

formed as to surround the block main body, in the case of the mobile block which has been subjected to molding, the synthetic resin forming the endless ball circulation path binds the block main body tightly and a tensile stress remains in the molded synthetic resin. Consequently, there has arisen the problem that when the block main body has front and rear corners near the boundary of the ball return holes and the inner peripheral side ball guide sections formed of the synthetic resin, the tensile stress concentrates on the corners causing the synthetic resin to crack thereby hindering the smooth rolling of the balls in the endless ball circulation path.

Further, there has also been the problem that when the block main body has corners formed of synthetic resin, the flow of the molten resin is hindered at the time of injection-molding and the fluidity of such molten synthetic resin becomes insufficient so that a weld line is generated in the synthetic resin forming the endless ball circulation path and the smooth rolling of the balls is hindered because of the presence of such weld line.

In addition, due to the fact that when the block main body has corners formed of synthetic resin, the flow of the molten resin is hindered due to the presence of these corners, the thickness of the synthetic resin at the ball return holes and the ball retaining sections tends to become non-uniform and it has not been able to avoid the generation of deformation of the ball return holes and the ball retaining sections in the cooling process after molding. Accordingly, there has been the problem that the smooth rolling of the balls is hindered because of this point, too.

Now, in order to allow the balls rolling in the endless ball circulation path to circulate smoothly along a predetermined track, it is necessary to prevent each of the balls rolling within the endless ball circulation path from unsteadily moving right and left by reducing the gap between the ball and the inner wall of the endless circulation path to a minimum. Accordingly, in order to secure the smooth movement of the slider with respect to the orbital rail, it is necessary to mold the endless ball circulation path to a predetermined dimensional accuracy without fail so that a special consideration has been required for padding a synthetic resin to the metallic block main body by injection-molding.

DISCLOSURE OF THE INVENTION

The present invention has been made to solve the above-described problems and an object of the invention is to provide a method of manufacture of a slider of a rectilinear guide unit in which when the slider of the rectilinear guide unit provided with ball return holes and ball retaining sections formed by padding a synthetic resin on a metallic block main body, no cracking generates in the synthetic resin forming an endless ball circulation path and ball return holes and ball retaining sections can be accurately formed.

In order to achieve the above-described object, a method of manufacture of a slider of a rectilinear guide unit according to the present invention comprises a first step in which a metallic block main body as a core of the slider is machined to a predetermined shape and ball load rolling contact surfaces are formed in the block main body and a second step in which the block main body formed in the first step is inserted into a mold to thereby mold a die-molding material to form an endless ball circulation path and characterized in that the first step includes forming chamfered sections at corners of the block main body at positions corresponding to the portion where the endless ball circulation path is formed.

According to the method of the present invention comprising the above-mentioned steps, since the first step includes the formation of the chamfered sections on the corners of the block main body at positions corresponding to the portion where the endless ball circulation path is formed, even when the die-molding material is padded to the block main body so as to surround the latter, the die-molding material forming the endless ball circulation path does not crack due to a tensile stress applied on the die-molding material after completion of molding to thereby secure the smoothness of rolling of the balls in the endless ball circulation path.

Further, by the formation of the chamfered sections on the corners of the block main body at a position corresponding to the endless ball circulation path, the molten die-molding material injected into the mold quickly spreads in the longitudinal direction of the block main body so that the thickness of the ball return holes and the ball retaining sections forming parts of the endless ball circulation path can be equalized with ease, the generation of deformation or distortion of these portions after the completion of molding can be controlled and the formation of a welding line of the die-molding material such as a synthetic resin in the endless ball circulation path can be prevented. Accordingly, it is possible to secure the smooth rolling of the balls within the endless ball circulation path from this point, too.

In the above case, the chamfered sections to be formed at the corners of the block main body may be planar or curved.

Further, according to the method of the present invention, when the molten die-molding material is injected into the mold in the second step, it is preferable that the molten die-molding material be injected from a direction parallel to the load rolling contact surface of the block main body because by so doing, the flow velocity of the molten die-molding material in the longitudinal direction of the block main body is improved to form the ball return holes and the ball retaining sections more accurately thereby smoothing the rolling of the balls.

It should be noted that in the inventions described in claims **1** through **3**, whether or not the die-molding material is padded to the block main body to form ball retainers along both edges of the load rolling contact surface is a matter of design. In other word, the endless ball circulation path according to the present invention does not always include the ball retainers.

Further, the die-molding material referred to in the present invention also includes die-casting alloys and the like besides a synthetic resin material.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front view (partly in section) of one embodiment of a rectilinear guide unit to be manufactured by a method of the present invention;

FIG. **2** is a side view (partly in section) of one embodiment of the linear guide shown in FIG. **1**;

FIG. **3** is an exploded perspective view of a slider according to one embodiment of the present invention;

FIG. **4** is a sectional view of a mobile block forming a slider shown in FIG. **3**;

FIG. **5** is a perspective view of a block main body as a core of the mobile block according to one embodiment of the present invention;

FIG. **6** is a front view of the block main body shown in FIG. **5**;

FIG. **7** is a sectional view of the block main body when the block main body is inserted into a mold; and

FIG. **8** is a sectional view of the mobile block according to one embodiment of the present invention especially when a synthetic resin material is padded onto the block wherein FIG. **8**(*a*) is a sectional view taken along the A—A line of FIG. **4** and FIG. **8**(*b*) is a sectional view taken along the B—B line of FIG. **4**.

DESCRIPTION OF REFERENCE SYMBOLS

Reference numeral **1** designates an orbital rail, reference numeral **2** designates a slider; reference numeral **3** designates a ball, reference numeral **8** designates a block main body, reference numerals **43***a* and **43***b* designate ball load rolling surfaces, reference numerals **44***a* and **44***b* designate ball return holes, reference numeral **45** designates a ball retaining section; reference numerals **50***a*, **50***b* designate chamfered sections and reference numerals **61** and **62** designate dies.

BEST MODE FOR CARRYING OUT THE INVENTION

The method of manufacture of a slider of a rectilinear guide unit according to the present invention will now be described by referring to the accompanying drawings.

FIGS. **1** and **2** show one embodiment of the rectilinear guide unit in which the slider manufactured by the method of the present invention is combined with an orbital rail. In these figures, reference numeral **1** designates an orbital rail arranged on a stationary portion such as a bed of a rectilinear guide unit, reference numeral **2** designates the slider for guiding a movable body such as a table and reference numeral **3** designates balls endlessly circulating within the slider **2** while rolling between the orbital rail **1** and the slider **2** as it bears a load thereon.

First, the orbital rail **1** is substantially rectangular in section and a total of four (4) lines of ball rolling contact surfaces **11***a* and **11***b* on which the balls **3** roll are formed along the longitudinal direction. These ball rolling contact surfaces **11***a* and **11***b* are formed on both side surfaces and both edges of the upper surface of the orbital rail **1**, respectively, such that the ball rolling contact surface **11***a* is formed downward at an angle of 30° with respect to the horizontal direction in FIG. **1** and the ball rolling contact surface **11***b* is formed upright. Further, the orbital rail **1** is provided with a plurality of bolt fitting holes **12** at suitable intervals in the longitudinal direction thereof so that the orbital rail **1** is fixed to the stationary portion of the machine tool or the like by means of fixing bolts (not shown) to be inserted into these holes **12**, respectively.

On the other hand, the above-mentioned slider **2** comprises a mobile block **4** having a fitting surface **41** for a movable body such as a table and a plurality of tap holes **42** into which movable body fixing bolts are inserted and a pair of covers **5** which are fixed to front and rear end surfaces of the mobile block **4** whereby when the covers **5** are fixed to the mobile block **4**, the slider can be provided therein with an endless circulation path for the balls **3**. Further, to each of the covers **5**, there is attached a seal member **6** coming into sliding contact with the orbital rail **1** so that dust and the like adhered to the orbital rail **1** are prevented from entering into the slider **2** following the movement of the slider **2**.

As shown in FIGS. **3** and **4**, the mobile block **4** is substantially in the shape of a saddle having a horizontal section **4***a* on which the fitting surface **41** is formed and a pair of skirts **4***b* drooping from the horizontal section **4***a* and on the lower surface of the horizontal section **4***a* and the inner surface of each of the skirts **4***b* there are formed a total of four load rolling contact surfaces **43***a* and **43***b*, respectively. Further, on the horizontal section **4***a* and each of the skirts **4***b*, there are provided ball return holes **44***a* and **44***b*, respectively, in correspondence to the load rolling contact surfaces **43***a* and **43***b* so that the load rolling contact surfaces **43***a* and **43***b* and the ball return holes **44***a* and **44***b* corresponding thereto are connected by ball change-direction paths **51** formed in each of the covers **5** resulting in the formation of an endless circulation path for the balls **3**.

With the above structure, each of the balls **3** which have borne a load between the ball rolling contact surfaces **11***a* and **11***b* of the orbital rail **1** and the load rolling contact surfaces **43***a* and **43***b* of the mobile block **4** is released from the load when it has rolled on the load rolling contact surfaces **43***a* and **43***b* following the movement of the slider **2**, so that the ball **3** enters the change-direction path **51** of one of the pair of the covers **5** and moves toward a direction reverse to the direction of rolling of the ball on the load rolling contact surfaces **43***a* and **43***b* in a no-load condition so as to roll through the ball return holes **44***a* and **44***b* of the mobile block **4**. Further, each of the balls **3** which has rolled through the ball return holes **44***a* and **44***b* enters again between the orbital rail **1** and the mobile block **4** through the change-direction path **51** of the other cover **5** and rolls on the load rolling contact surfaces **43***a* and **43***b* while it bears a load.

Further, on both sides of each of the load rolling contact surfaces **43***a* and **43***b* there are formed ball retaining sections **45** so as to hang over the load rolling contact surfaces **43***a* and **43***b* and when the slider **2** is removed from the orbital rail **1**, the balls **3** on the load rolling contact surfaces **43***a* and **43***b* are prevented from falling down from the slider **2**.

Further, in the instant embodiment, from the point of view of preventing as much as possible the abrasion of the balls by keeping the balls out of contact with one another within the endless ball circulation path, the balls **3** are fitted into a belt-like cage **7** made of a synthetic resin to thereby form a ball chain and such ball chain is assembled into the endless ball circulation path. For this purpose, each of the ball return holes **44***a* and **44***b* and each of the ball retaining sections **45** are provided with grooves for supporting both edges of the above-mentioned belt-like cage **7** which circulates through the endless ball circulating path together with the balls **3**.

In addition, as shown in FIG. **3**, on the front and rear end surfaces of the mobile block **4** there are provided semicircular ball guides **46**, respectively, so as to guide each of the balls **3** coming into, and getting away from, the ball return holes **44***a* and **44***b*, side by side with the change-direction paths **51** of the pair of covers **5**.

The mobile block **4** is formed by padding a synthetic resin to the metallic block main body **8** by an injection-molding process such that the portions such as the movable body fitting surface **41** and the load rolling contact surfaces **43***a* and **43***b* for the balls **3** where a mechanical strength is required are formed in the block main body **8** while the portions such as the ball return holes **44***a*, **44***b*, the ball retaining sections **45** and the ball guide sections **46** where the mechanical strength is not deemed important are made of a synthetic resin so as to make the weight of the mobile block **4** as small as possible.

FIG. **5** is a front view of the block main body **8** before it is padded with a synthetic resin. Such block main body **8** is finished in such a manner that the horizontal section **4***a* and the skirts **4***b* are roughly formed by drawing, then the movable body fitting surfaces **41**, reference side surfaces **47** and the load rolling contact surfaces **43***a* and **43***b* are formed

to have a predetermined degree of accuracy and through holes **48** as prepared holes for the ball return holes **44***b* are formed by drilling. Further, in the above-mentioned drawing process, in order to improve the adhesion of the synthetic resin to be padded to the block main body **8**, concave portions **49** serving as resin reservoirs are formed on the outer sides of the skirts **4***b*, respectively.

In the above case, in view of the fact that the synthetic resin is padded around the skirts **4***b* of the block main body **8** at the time of injection molding to be performed later, substantially curved chamfered sections **50***a* are formed at the corners of the front and rear end surfaces of each of the skirts **4***b* with the exception of the portions where the load rolling contact surfaces **43***a* and **43***b* are formed so that the molten synthetic resin at the time of injection molding is made to flow smoothly.

Next, the process of padding a synthetic resin, by injection-molding, to the block main body **8** finished to a predetermined shape as described above will be explained.

This injection molding is performed by the so called insert molding in which the finished block main body **8** is arranged within a mold so as to act as a core whereby the synthetic resin is padded only to a predetermined portion of the block main body **8** to thereby form the above-mentioned ball return holes **44***a* and **44***b*, the ball retaining sections **45**, the ball guide sections **46** and etc.

FIG. **7** is a sectional view of the block main body **8** inserted into a mold comprising dies **61** and **62**. The die **61** has a support **63** erected thereon so as to fix the block main body **8** thereto and when the block main body **8** is caused to fit about the support **63** from the direction of axis of the block main body **8** (i.e., the vertical direction in FIG. **7**), the block main body **8** is positioned between the dies **61** and **62** so that cavities **64** and **65** corresponding to the ball retaining sections **45** of the mobile body **4** are formed between the block main body **8** and the support **63** and at the same time, cavities **66** for forming the ball return holes **44***a* are formed between the skirts **4***b* and the die **61**. Further, into the through holes **48** of the block main body **8** and into the cavities **66** there are inserted rod-shaped die members **67** each having a sectional configuration coinciding with the shape of the ball return holes **44***a* and **44***b* so that when the molten synthetic resin is filled into these through holes **48** and the cavities **66**, the ball return holes **44***a* and **44***b* are formed.

Further, the die **61** is in contact with the lower edges of the reference side surfaces **47** of the block main body **8** whereby the molten synthetic resin to be filled into the cavities **66** is cut well to thereby prevent the synthetic resin from covering the reference side surfaces **47**.

In the instant embodiment, the filling of the molten synthetic resin into the cavities **64**, **65** and **66** is performed from a direction parallel to the load rolling contact surfaces **43***a* and **43***b* formed in the block main body **8** so that the molten synthetic resin flows quickly up to the innermost portions of the cavities **64**, **65** and **66** which extend long toward that direction.

Thus, after the block main body **8** has been inserted between the dies **61** and **62**, when the molten synthetic resin is filled into the cavities **64**, **65** and **66** so as to be padded on the block main body **8**, the mobile block **4** shown in FIG. **3** is completed.

FIG. **8** is a sectional view of the mobile block **4** finished by the above-described process especially in a state in which the mobile block **4** is padded with a synthetic resin wherein FIG. **8**(*a*) is a sectional view of the skirt **4***b* when taken along the A—A line of FIG. **4** and FIG. **8**(*b*) is a sectional view of the horizontal section **4***a* when taken along the B—B line of FIG. **4**. As will be clear from these figures, chamfered sections **50***a* are formed on the front and rear end surfaces of the skirt **4***b* of the block main body **8** and chamfered sections **50***b* are formed also at the opening edges of the through holes **48** formed in the horizontal section **4***a* so that when the molten synthetic resin is filled into the mold in the above-described insert-molding process, the molten synthetic resin spreads quickly around the skirts **4***b* and flows inside the through holes **48**.

Consequently, the equalization of thickness of the synthetic resin forming the ball return holes **44***a*, **44***b* and the ball retaining sections **45** is promoted so that it is possible to prevent as much as possible the deformation or distortion of the ball return holes **44***a* and **44***b* and the ball retaining sections **45** at the time of solidification of the contracted synthetic resin thereby increasing the dimensional accuracy of the endless ball circulation path formed by these elements. Further, it is also possible to prevent the generation of a weld line of the synthetic resin within such endless circulation path. As a result, the slider **2** assembled by using the mobile block **4** manufactured by the above-described process allows the balls **3** to smoothly roll within the endless ball circulation path and the slider **2** itself can smoothly move on the orbital rail **1**.

Further, since the chamfered sections **50***a* are formed on the front and rear end surfaces of the skirts **4***b* of the block main body **8**, respectively, even when the synthetic resin which forms the endless ball circulation path by being padded around each of the skirts **4***b* contracts after the completion of the injection-molding process, there is no possibility of the synthetic resin getting cracked and also due to this advantage, the rolling of the balls **3** in the endless ball circulation path can be made smooth.

INDUSTRIAL APPLICABILITY

As described above, according to the method of manufacture of the slider of the rectilinear guide unit of the present invention, even when the endless circulation path for the balls is formed by padding a die-molding material around the block main body, since the corners of the block main body corresponding to the endless ball circulation path are substantially curved, the endless ball circulation path made of the die-molding material does not crack so that it is possible to secure the smooth endless circulation of the balls and hence the smooth movement of the slider.

Further, by making the corners of the block main body substantially curved, the molten die-molding material flows quickly around the block main body at the time of molding and the equalization of thickness of the ball return holes and the ball retaining sections forming the endless ball circulation path is promoted. Consequently, the deformation or distortion of the ball return holes or the ball retaining sections is prevented to thereby increase the dimensional accuracy of the endless ball circulation path so that it is possible to secure the smooth circulation of the balls and hence the smooth movement of the slider with respect to this point, too.

What is claimed is:

1. A method of manufacture of a slider of a rectilinear guide unit, which method comprising:

machining a metallic block main body as a core of the slider to a predetermined shape having ball load rolling contact surfaces in the block main body:

positioning the block main body into a mold; and

molding a body portion onto the block main body for forming an endless ball circulation path using a die-molding material;

further comprising during said machining, forming chamfered sections on front and rear edge corners of the block main body corresponding to a portion where the endless ball circulation path is formed during the molding, said chamfered sections being covered by the die-molding material following the molding, whereby smooth flow of the die-molding material occurs during the molding.

2. The method according to claim **1**, wherein, in said molding, a molten die-molding material is injected from a direction parallel to the ball load rolling contact surfaces of the block main body inserted into a mold.

3. In a slider for a rectilinear guide unit including a metallic block main body having ball load rolling contact surfaces and a molded body portion on the block main body for endlessly circulating balls so that an endless ball circulation path is formed by said molding, the improvement wherein molding-flow-smoothing chamfered sections are formed on front and rear corners of the block main body corresponding to a portion where the endless ball circulation path is formed and are covered by said molded body portion.

* * * * *

US006085420A

United States Patent [19]
Konomoto

[11] **Patent Number: 6,085,420**

[45] **Date of Patent: Jul. 11, 2000**

[54] **METHOD OF MAKING A SLIDER OF A LINEAR GUIDE DEVICE**

[75] Inventor: **Masashi Konomoto**, Tokyo, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **08/845,151**

[22] Filed: **Apr. 21, 1997**

[30] **Foreign Application Priority Data**

Apr. 25, 1996 [JP] Japan 8-105856

[51] **Int. Cl.**^{7} **B23P 15/00**; F16C 33/00

[52] **U.S. Cl.** **29/898.03**; 29/527.3; 29/434; 264/318; 264/296; 384/45

[58] **Field of Search** .... 29/527.2, 527.3, 29/434, 898.03 OR, 898.047, 898.049, 898.05; 264/242, 250, 255, 259, 267, 268, 269, 274, 275, 279, 318, 336, 248, 296; 384/45

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,380,099	1/1995	Teramachi	384/45
5,477,614	12/1995	Watanabe	29/898.045
5,551,141	9/1996	De'Ath et al.	29/527.3
5,582,487	12/1996	Teramachi	384/45
5,596,805	1/1997	Kunze et al.	29/898.055
5,640,768	6/1997	Teramachi	29/898.03

FOREIGN PATENT DOCUMENTS

7-317762 12/1995 Japan .

Primary Examiner—Larry I. Schwartz
Assistant Examiner—Marc W. Butler
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

The present invention relates to a method of making a slider of a linear guide device for guiding a movable body such as a work table or an industrial robot of a machine tool under load which moves along a track rail arranged at a fixed portion such as a bed, a column or the like, the method is comprising a first step of forming a block main body made of a metal which becomes a core part of the slider in a predetermined shape and forming load rolling faces of balls on the block main body by machine, and a second step of inserting the block main body formed in the first step into a mold and executing an injection molding of a synthetic resin by which ball retaining portions are built on both sides of the load rolling faces of block main body, and according to the first step pairs of smooth faces for shielding the molten synthetic resin are formed along the both edges in the longitudinal direction of the load rolling faces formed on block main body whereas according to the second step the block main body is fixed at a predetermined position in the mold by bringing a projected support portion on the side of the mold into contact with the smooth faces for shielding the molten synthetic resin.

2 Claims, 8 Drawing Sheets

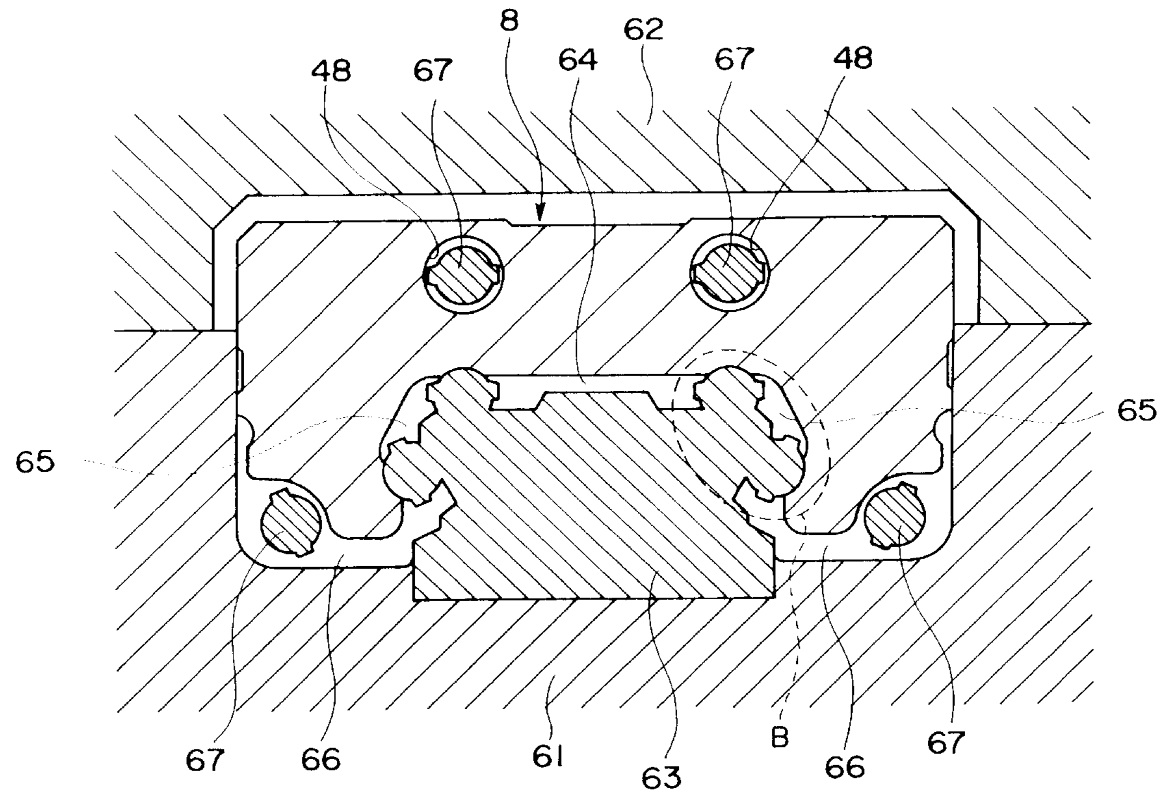
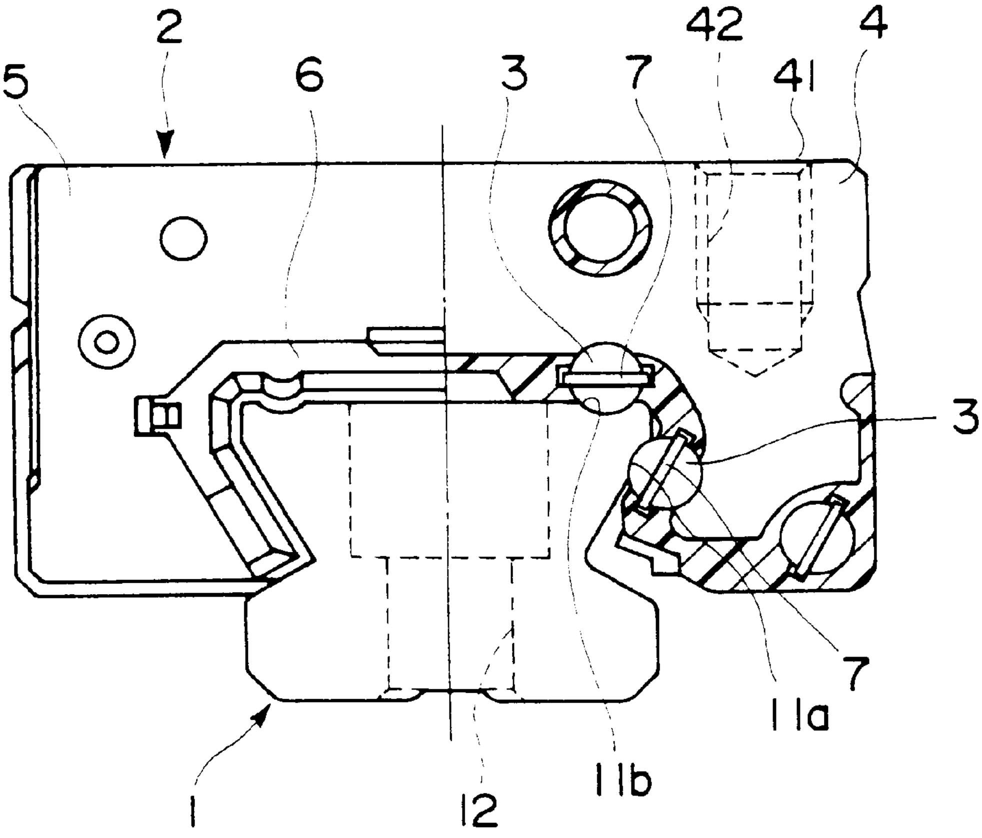


Fig.1



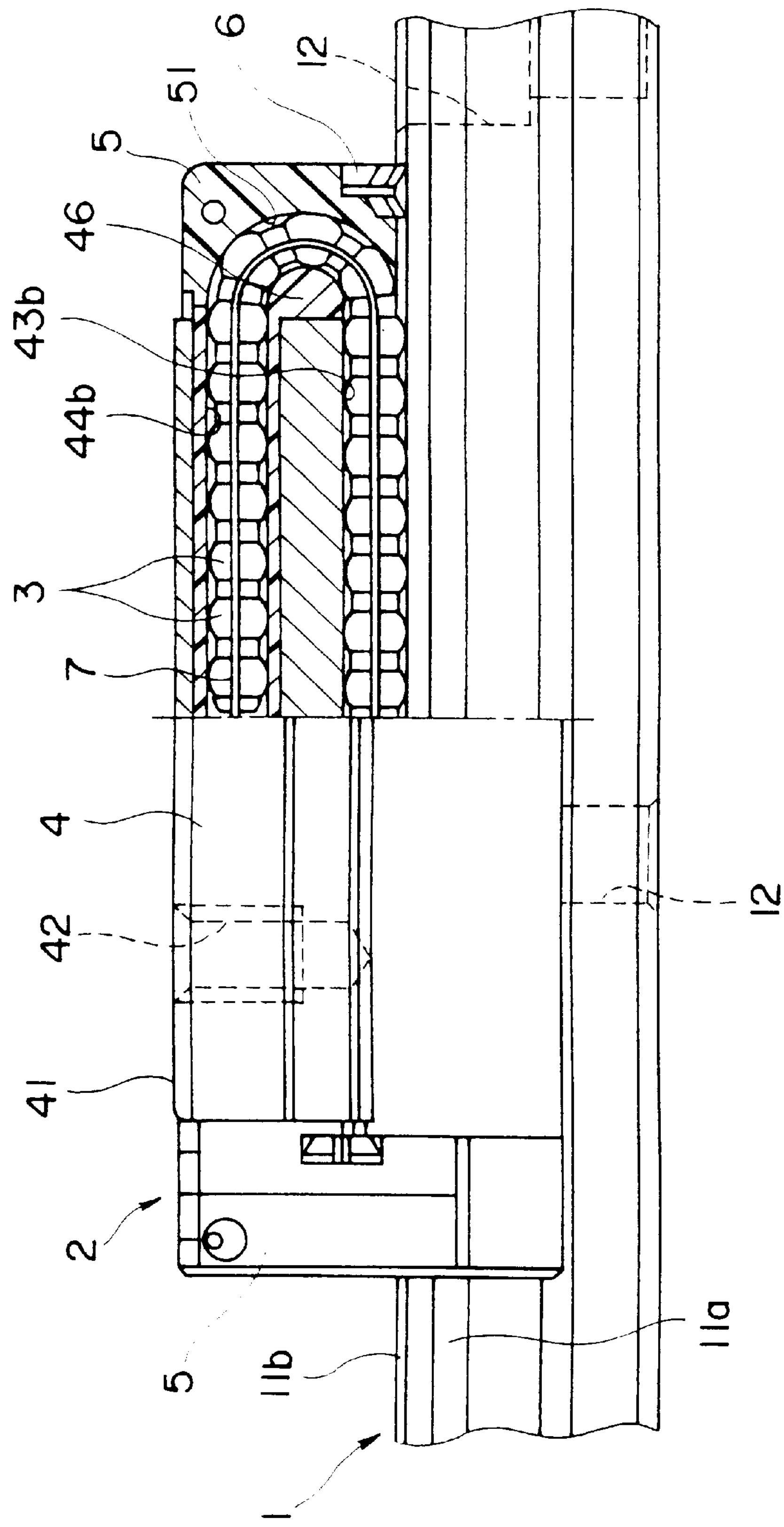


Fig.2

Fig.3

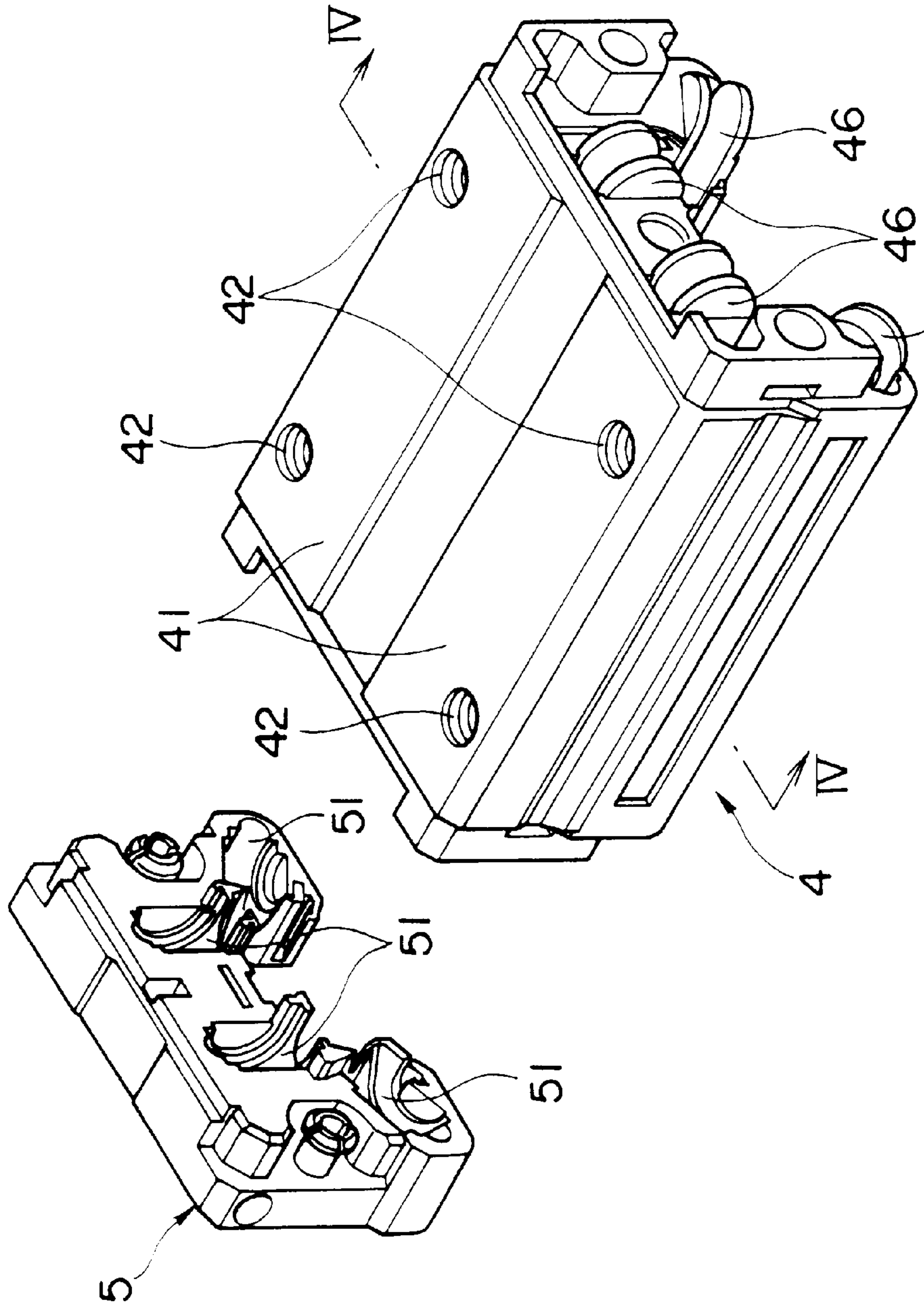


Fig.4

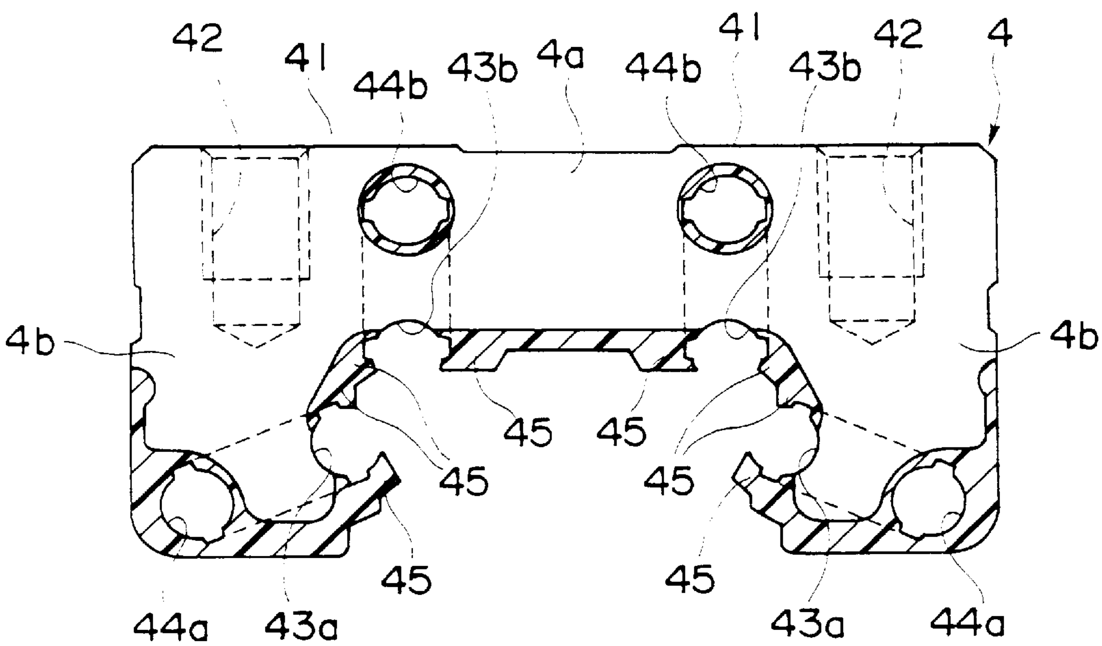

42
41
44b
43b
4a
44b
41
43b
42
4
4b
4b
45
45
45
45
45
45
44a
43a
43a
44a

Fig.5

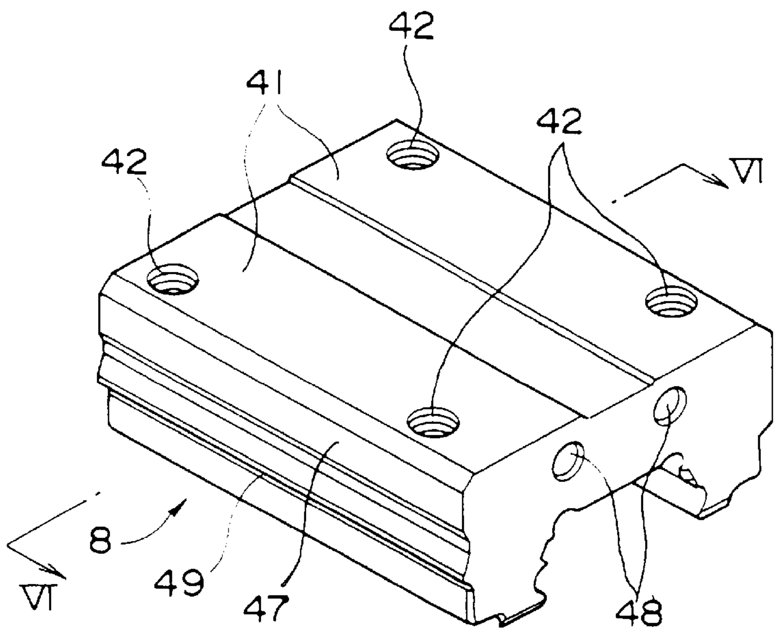

42
41
42
42
VI
8
49
47
48
VI

Fig.6

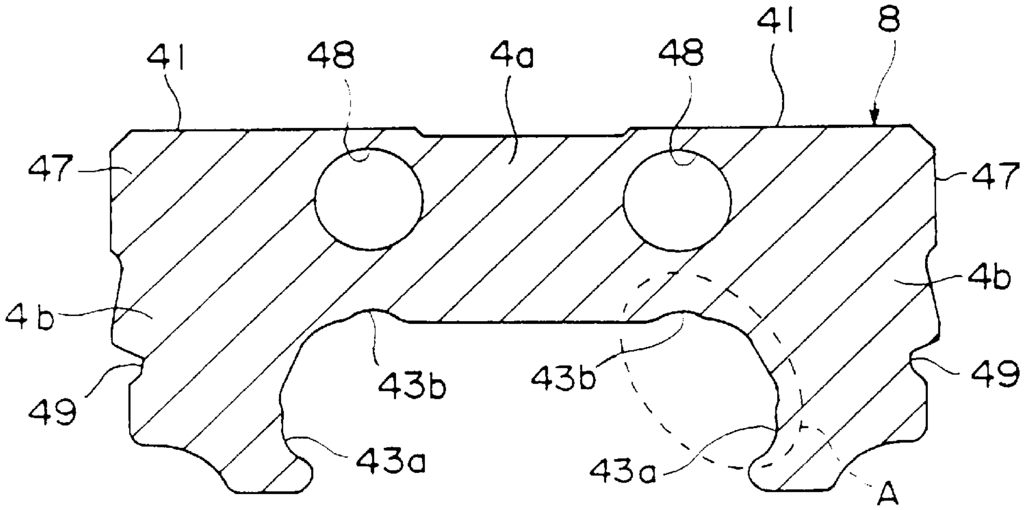

41
48
4a
48
41
8
47
47
4b
4b
43b
43b
49
49
43a
43a
A

Fig.7

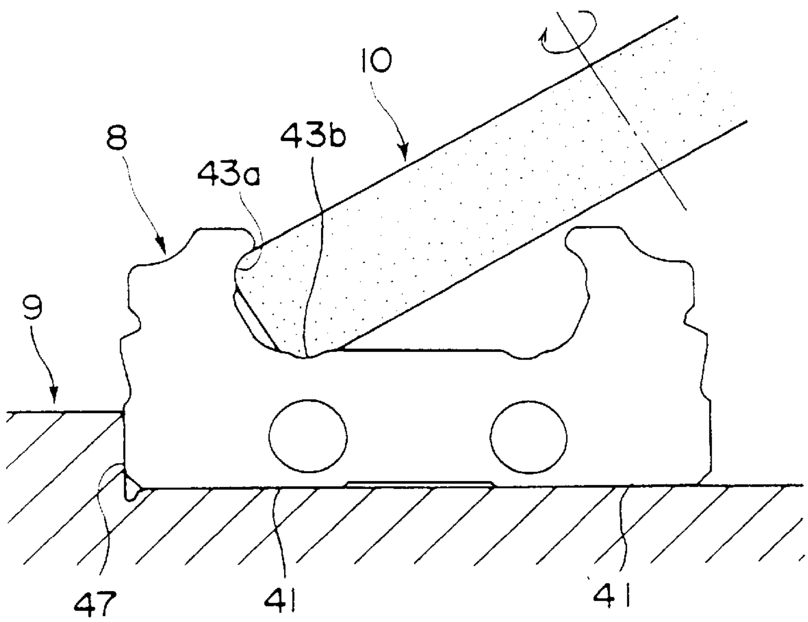


Fig.8

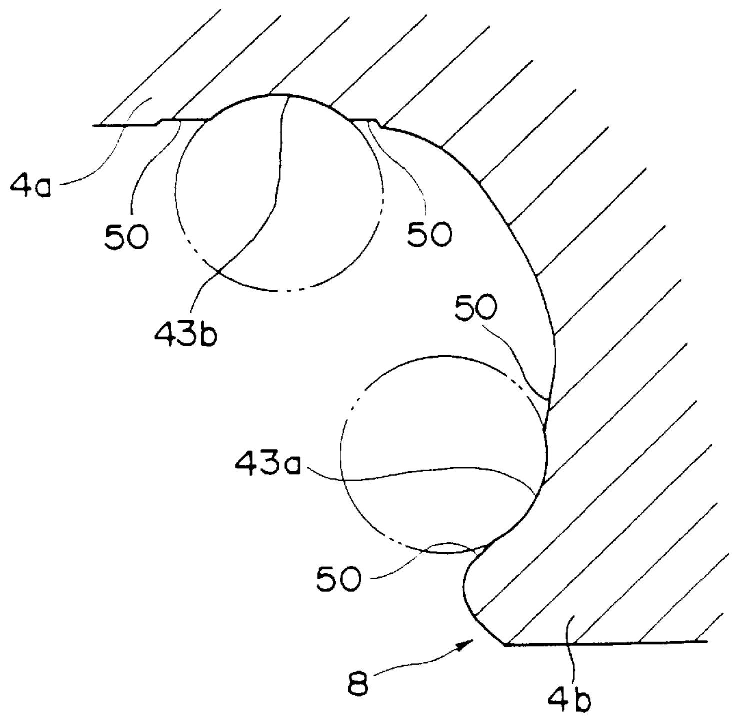


Fig.9

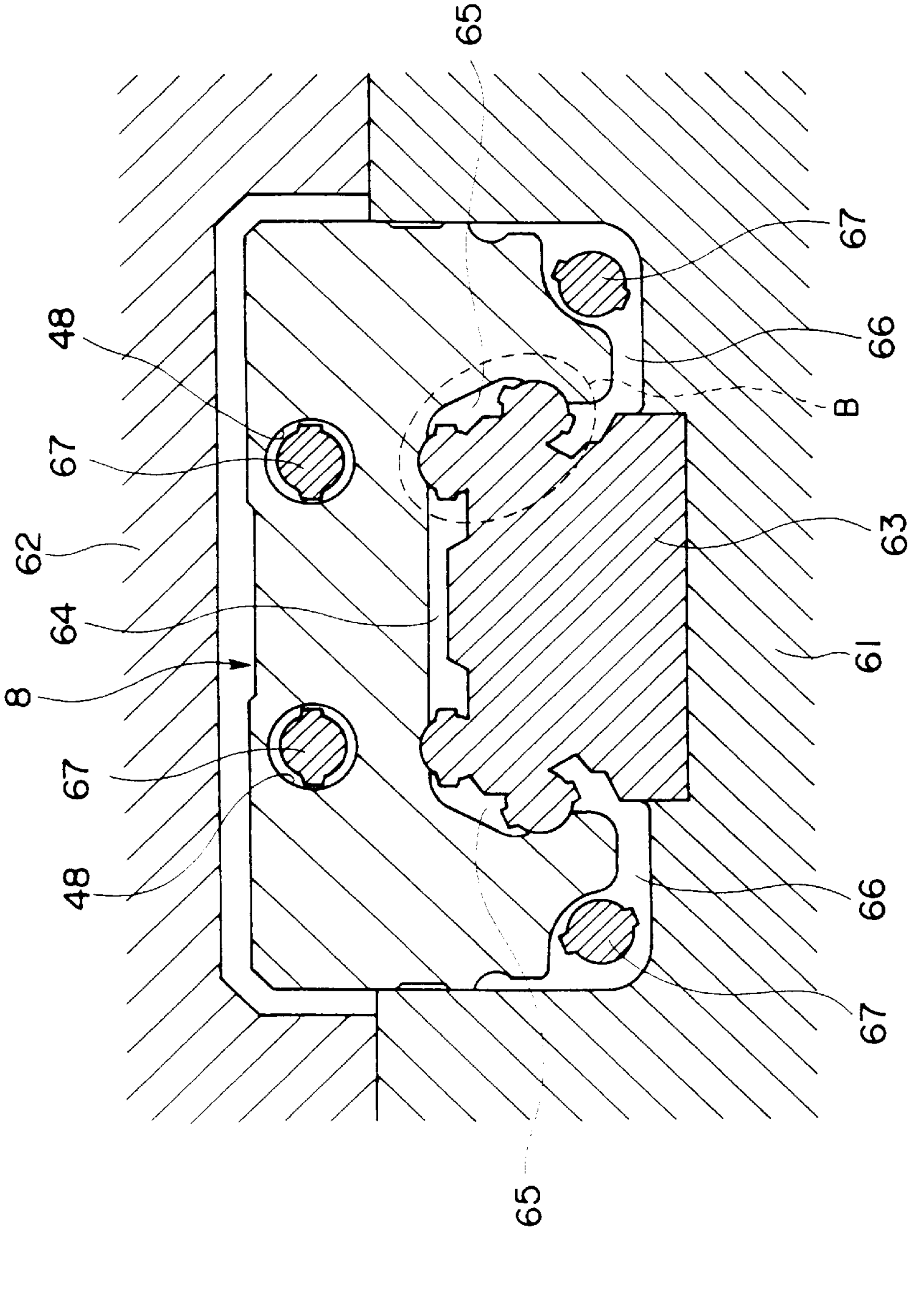
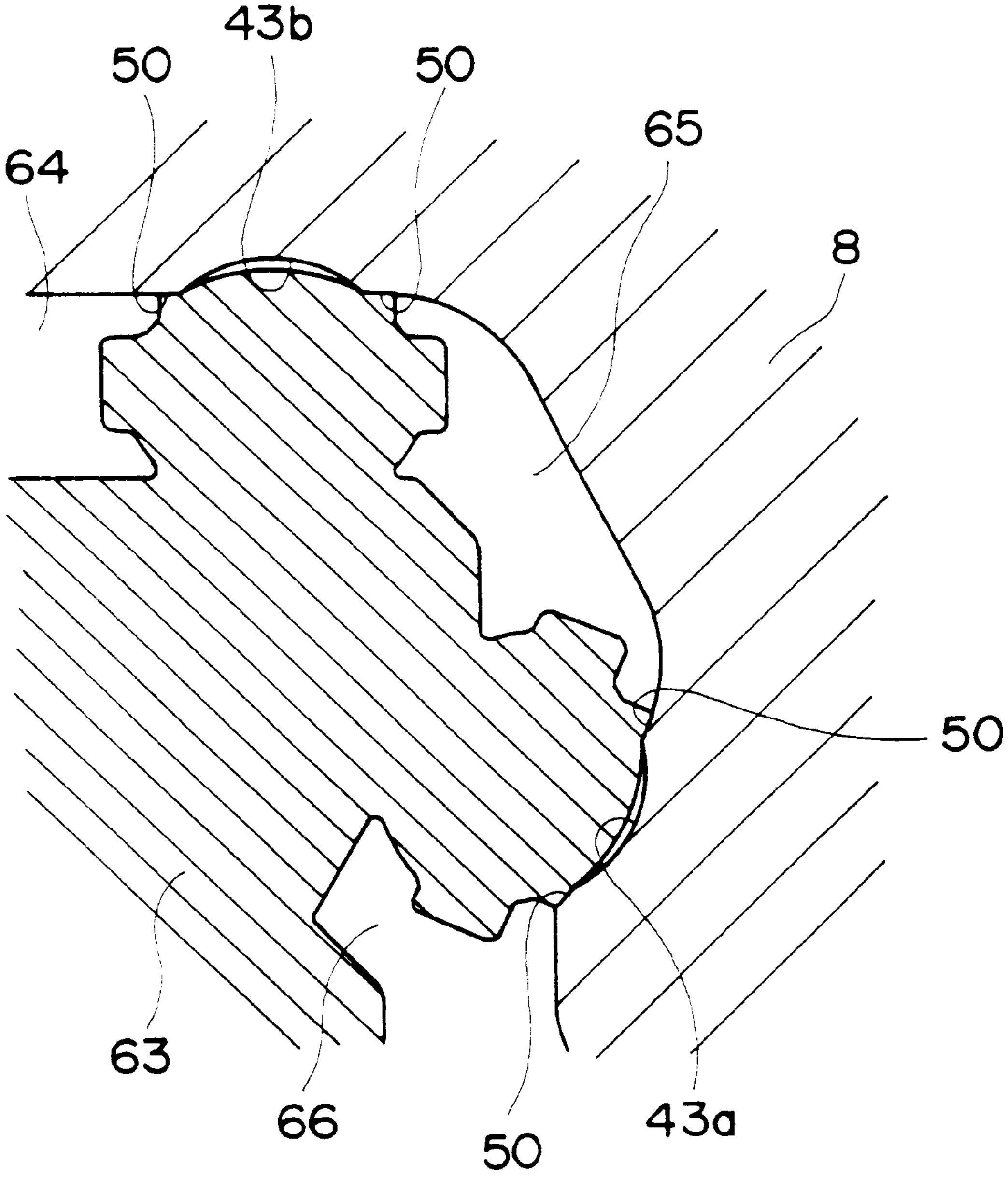


Fig.10



METHOD OF MAKING A SLIDER OF A LINEAR GUIDE DEVICE

FIELD OF THE INVENTION AND RELATED ART STATEMENT

The present invention relates to a method of making a slider of a linear guide device for guiding a movable body such as a work table of a machine tool or an industrial robot or the like moving along a track rail arranged at a fixed portion such as a bed, a column or the like while applying load on the track rail, particularly to a method of forming a slider by building up a synthetic resin onto a block main body mace of a metal.

There has been known a conventional linear guide device of such a kind constituted by a track rail that is arranged at a fixed portion such as a bed or the like and on which rolling faces of balls are formed and a slider integrated to the track rail via a number of balls for moving along the track rail while supporting a movable body such as a table or the like.

Further, the above-described slider is constituted by a movable block having load rolling faces opposed to the rolling faces of the track rail via balls and ball return holes in parallel to the load rolling faces, which is movable along the track rail by rolling the balls, a pair of end caps respectively fixed to forward and backward end faces of the moving block and having direction change paths of the balls for communicating and connecting the load rolling faces with the ball return holes and ball retainers attached to the moving block for preventing the balls from coming off from the load rolling faces when the slider is removed from the track rail. Also, end portions of the load rolling faces and the ball return holes are connected by the direction change paths by fixing the end caps to the forward and rearward end faces of the moving block whereby infinite circulation paths of balls are completed in the slider.

Meanwhile, according to the conventional slider for the linear guide device constituted as described above, boring of the ball return hole, attaching operation of the ball retainers and the like are needed with respect to the moving block and considerable time and labor is required in manufacturing the slider. Therefore, the applicants have proposed to manufacture the slider by utilizing an injection molding process of a synthetic resin (Japanese Unexamined Patent Publication No. JP-7-317762).

Specifically, a synthetic resin is built up by injection molding onto a block main body made of a metal where the above-described load rolling faces have been ground and the ball return holes and the ball retainers are integrally formed with the block main body in the injection molding by which the moving block is manufactured, which is provided with an advantage whereby a moving block having a complicated shape can easily he manufactured.

Meanwhile, in building up a synthetic resin onto the block main body made of a metal, the ball retaining portions are formed on the both sides of the load rolling faces of the block main body as described above, where it is necessary to expose the load rolling faces per se on which the balls run without putting the synthetic resin on the load rolling faces. Therefore, it is necessary to cover the load rolling faces against the molten synthetic resin in the injection molding.

Accordingly, conventionally, in fixing the block main body in the mold of the injection molding, a projected support portion provided on the side of the mold is brought into contact with the load rolling faces of the block main body and the load rolling faces are covered against the molten synthetic resin by the projected support portion.

However, when the load rolling faces are covered by bringing the projected support portion of the mold into direct contact with the load rolling faces, since the load rolling faces are formed in a curved face corresponding to the curvature of the ball, it is necessary to form the projected support portion in contact with the load rolling faces also in a curved face in compliance with the curvature of the load rolling faces and if the curved faces of both are not brought into accurate alignment, the molten synthetic resin forming the retainers invades a clearance therebetween.

Furthermore, when the molten synthetic resin invades the clearance between the load rolling faces and the projected support portion of the mold, the molten synthetic resin constitutes burrs of the synthetic resin covering the load rolling faces and the smooth running of the balls is significantly hampered under such a state. Also, once the ball retainers are formed on the both sides of the load rolling faces, the load rolling faces cannot be polished since the ball retainer becomes a hazard for the polishing operation and therefore, the constituted burrs cannot be removed. Accordingly, in the method of manufacturing the moving block utilizing the injection molding, a countermeasure for preventing the occurrence per se of burrs covering the load rolling face is indispensable.

Meanwhile, it is preferable to set the block main body to the mold with the load rolling faces which have been formed, as positioning references in fixing the block main body in injection molding, since the ball retaining portions are needed to form accurately in the positional relationship thereof with the load rolling faces.

However, it is difficult to position the block main body by bringing the load rolling faces in contact with the projected support portion on the side of the mold, which is also formed in a curved face since the load rolling faces are formed in a curved face as described above. Especially, when the load rolling faces face in different four directions, it is extremely difficult to accurately position the block main body in the mold.

Also, when the projected support portion of the mold is brought into contact with the load rolling faces, the load rolling faces which have been grounded in the finishing operation may be damaged with high probability and the grinding operation of the block main body prior to the injection molding operation may completely be spoilt.

OBJECT AND SUMMARY OF INVENTION

The present invention has been carried out in view of such a problem and it is an object of the present invention to provide a method of making a slider of a linear guide device in which in forming the slider of the linear guide device installed with ball return holes and ball retaining portions by building up a synthetic resin onto a block main body made of a metal, the synthetic resin does not bring about burrs on load rolling faces of the block main body and the ball return holes and the retainers can be formed accurately.

In order to achieve the above-described object, a method of making a slider according to the present invention is comprising a first step of forming a block main body made of a metal which becomes a core part of the slider in a predetermined shape by machining and forming load rolling faces of balls on the block main body, and a second step of inserting the block main body formed in the first step into a mold and executing an injection molding of a synthetic resin whereby ball retaining portions are built on both sides of the load rolling faces of the block main body, wherein according to the first step pairs of smooth faces for shielding the molten synthetic resin are formed on both edges in the longitudinal direction of the load rolling faces formed on the block main body, whereas according to the second step the block main body is fixed at a predetermined position in the mold by bringing a projected support portion erected on the mold into contact with the smooth faces for shielding the molten synthetic resin.

As describe above, in forming the ball retaining portions on the both sides of the load rolling faces by utilizing the injection molding of a synthetic resin, it is necessary to prevent the molten synthetic resin from invading the load rolling faces. According to the invented method having the above-described steps, with respect to the main body fixed in the mold the pairs of faces for shielding the synthetic resin formed along the both edges of the load rolling faces are brought into contact with the projected support portion erected on the mold and therefore, the molten synthetic resin for forming the ball retaining portions can be prevented from flowing to the load rolling faces by the smooth faces for shielding the molten synthetic resin. Moreover, the smooth faces for shielding a molten synthetic resin are not formed in a curved face as in the load rolling faces but in a smooth face and therefore, no clearance is formed between the smooth faces for shielding the molten synthetic resin and the projected support portion of the mold which are brought into contact with each other and the molten synthetic resin can firmly be prevented from invading the load rolling faces. Therefore, according to the invented method formation of burr of the synthetic resin on the load rolling faces can firmly be prevented.

Meanwhile, when the slider made by this method is observed, it is recognized that the pairs of smooth faces for shielding the molten synthetic resin mold which become positioning references for fixing the main body in the injection molding and which are disposed between the load rolling faces and the ball retaining portions on the both sides of the load rolling faces, are exposed without being covered by the ball retaining portions. Accordingly, whether a slider is made by the invented method, can be determined by whether the pairs of faces for shielding the molten synthetic resin, which has been finished smoothly to a degree whereby they can be utilized as positioning references, are exposed on the both edges along the longitudinal direction of the load rolling faces. That is, according to another aspect of the present invention, there is provided a slider of a linear guide device wherein pairs of faces for shielding a molten synthetic resin which become references for fixing a block main body in injection molding, are exposed on both edges along the longitudinal direction of load rolling faces.

Also, according to the invented method, in the second step the block main body is positioned and fixed in the mold by bringing the projected support portion of the mold into contact with the smooth faces for shielding the synthetic resin and therefore, the positioning accuracy of the block main body in the mold is promoted in comparison with the conventional case in which the positioning is carried out by using the load rolling faces in a curved face whereby the positioning relationship between the ball retaining portions built up on the block main body by injection molding and the load rolling faces can be made accurate. Thereby, it can be prevented that noise is caused due to contact of the balls running on the load rolling faces with the ball retaining portions or the circulation of the balls becomes unstable in using the linear guide device.

Further, according to the invented method the block main body is fixed in the mold by bringing the projected support portion of the mold into contact with the faces for shielding the synthetic resin. It is preferable in this procedure that the projected support portion is brought into contact with the faces for shielding the molten synthetic resin which are formed on the both edges to span across the load rolling faces whereby spaces are formed between the projected support portion and the load rolling faces. The reason is that according to the invented method the machining of the load rolling faces are completed in the first step prior to the injection molding and therefore, if the projected support portion in the mold is brought into contact with the load rolling faces in the second step, the load rolling faces which have been finished with a predetermined face accuracy will be roughened.

As described above, according to the invented method the both edges of load rolling faces of the block main body which becomes a core part of a slider, are formed with the pairs of smooth faces for shielding the molten synthetic resin and in the step of the insert molding for building the synthetic resin on the block main body the faces for shielding the molten synthetic resin and the projected support portion erected on the mold are brought into contact. Therefore, the formation of burrs of the synthetic resin on the load rolling faces through the process of the insert molding can be prevented and the ball retaining portions can be formed accurately on the block main body whereby the slider of a linear guide device on which the balls run smoothly and in which generation of noise accompanied by the circulation of the balls is restrained as less as possible, can be manufactured.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a partially cut front view showing an embodiment of a linear guide device manufactured by the invented method;

FIG. **2** is a partially cut side view showing the embodiment of the linear guide device manufactured by the invented method;

FIG. **3** is an exploded perspective view of a slider in accordance with the embodiment;

FIG. **4** is a sectional view taken along a line IV—IV of FIG. **3**;

FIG. **5** is a perspective view showing a block main body constituting a core part of a moving block according to the embodiment;

FIG. **6** is a sectional view taken along a line VI—VI of FIG. **5**;

FIG. **7** is a front view showing a behavior of grinding operation on load rolling faces and smooth faces with respect to the block main body;

FIG. **8** is an enlarged view showing details of a region encircled by a circle A described by a broken line in FIG. **6**;

FIG. **9** is a sectional view showing the block main body inserted into a mold; and

FIG. **10** is an enlarged view showing details of a region encircled by a circle B drawn by a broken line in FIG. **9**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A detailed explanation will be given of a method of making a slider of a linear guide device according to the present invention in reference to the attached drawings as follows.

FIG. **1** and FIG. **2** illustrate an embodiment of a linear guide device in which a slider manufactured by the invented method is integrated with a track rail. In FIGS. **1** and **2**, numeral **1** designates a track rail arranged to a fixed portion such as a bed or the like of a machine tool, numeral **2** designates a slider for guiding a movable body such as a table or the like along the track rail **1** and numeral **3** designates a ball rolling under load between the track rail **1** and the slider **2** and infinitely circulated in the slider **2**.

Firstly, the section of the track rail **1** is formed in substantially a square shape in which a total of four tracks of ball rolling face **11***a* and **11***b* on which the balls **3** run, are formed along the longitudinal direction (orthogonal to the paper face of FIG. **1**). These ball rolling faces **11***a* and **11***b* are formed on the both side faces and the both edge portions of the upper face of the track rail **1** in which the ball rolling faces **11***a* on the both side faces are formed **30** downwardly from the left and right direction of the paper face whereas the ball rolling faces **11***b* on the upper face are formed upwardly in the vertical direction. Further, bolt attaching holes **12** are formed in the track rail **1** at pertinent intervals in the longitudinal direction and the track rail **1** is fixed to a fixed portion by fixing bolts, not illustrated, which are inserted into the bolt attaching holes **12**.

Meanwhile, the slider **2** is constituted by a moving block **4** having an attaching face **41** for attaching a movable body such as a table or the like and tap holes **42** for screwing fixing bolts of the movable body and a pair of end caps **5** fixed to the foreword and rearward end faces of the moving block **4** and infinite circulation paths of the balls **3** are provided in the slider by fixing the end caps **5** to the moving block **4**. Further, seal members **6** which are brought into abrasive contact with the track rail **1** are attached to the end caps **5** for preventing dust or dirt attached onto the track rail **1** from invading the inside of the slider **2** accompanied by the movement of the slider **2**.

As illustrated in FIG. **3** and FIG. **4**, the moving block **4** is provided with a horizontal portion **4***a* where the attaching face **41** is formed and a pair of skirt portions **4***b* hanging down from the horizontal portion **4***a* and the section thereof is formed in substantially a saddle form and four tracks of load rolling faces **43***a* and **43***b* are formed on the lower face of the horizontal portion **4***a* and on the inner faces of the respective skirt portions **4***b* opposingly to the ball rolling faces **11***a* and **11***b* of the track rail **1**. Also, ball return holes **44***a* and **44***b* respectively corresponding to the load rolling faces **43***a* and **43***b* are formed at the horizontal portion **4***a* and the skirt portions **4***b* and the respective load rolling faces **43***a* and **43***b* and the corresponding ball return holes **44***a* and **44***b* are connected by direction change paths **51** of the balls **3** formed in the end caps **5** thereby forming the infinite circulation paths of the balls.

Thereby, when the balls **3** which have been under load between the rolling faces **11***a* and **11***b* of the track rail **1** and the load rolling faces **43***a* and **43***b* of the moving block **4**, finish running on the load rolling faces **43***a* and **43***b* with the movement of slider **2**, they are relieved from the load and enter the direction change paths **51** of one of the end caps **5**, and run under no load in the ball return holes **44***a* and **44***b* of the moving block **4** toward a direction reverse to the running direction at the load rolling faces **43***a* and **43***b*. Further, the balls **3** which have finished running in the ball return holes **44***a* and **44***b*, enter again between the track rail **1** and the moving block **4** via the direction change paths **51** of the other one of the end caps **5** and run on the load rolling faces **43***a* and **43***b* under load.

Further, ball retaining portions **45** are formed on the both sides of the respective load rolling faces **43***a* and **43***b* as if covering the load rolling faces **43***a* and **43***b* thereby preventing the balls **3** which are disposed on the load rolling faces **43***a* and **43***b* from rolling down from the slider **2** when the slider **2** is removed from the track rail **1**.

Further, according to the embodiment, in view of avoiding contact among balls in the infinite circulation paths and preventing as less as possible the wear of the balls **3**, ball chains are constituted by rotatably fitting the balls **3** in belt-like cages **7** made of a synthetic resin and the ball chains are integrated to the infinite circulation paths. Therefore, recessed grooves for supporting the both edge portions of the belt-like cages **7** circulating in the infinite circulation paths along with the balls **3**, are formed in the hall return holes **44***a* and **44***b* and the ball retaining portions **45**.

Furthermore, as illustrated in FIG. **3**, ball guide portions **46** in a semicircular shape are projected at the foreword and rearward end faces of the moving block **4** for guiding the balls **3** entering and leaving the ball return holes **44***a* and **44***b* in cooperation with the direction change paths **51** of the end caps **5**.

The moving block **4** is formed by building by injection molding a synthetic resin onto the block main body **8** made of a metal which is formed by mechanical working. Portions requiring mechanical strength such as the movable body attaching face **41**, the load rolling faces **43***a* and **43***b* of the balls **3** and the like, are formed in the block main body **8**, whereas portions with no significance in mechanical strength such as the ball return holes **44***a* and **44***b*, the ball retaining portions **45** and the hall guide portions **46** and the like, are formed by a synthetic resin whereby light weight formation of the moving block **4** is achieved as light as possible. FIG. **5** and FIG. **6** show the block main body **8** before building a synthetic resin thereon. According to the block main body **8**, after the outline shape of the horizontal portion **4***a* and the skirt portions **4***b* has been formed by drawing, the movable body attaching face **41** and reference side faces **47** are formed with a predetermined accuracy by polishing and through holes **48** which become base holes for the ball return holes **44***b*, are formed by boring. Further, in the drawing process, recessed portions **49** which become resin storages are formed on the outer side of the skirt portions **4***b* with a purpose of promoting adherence of a synthetic resin which is to be built in later steps with respect to the block main body **8**.

The load rolling faces **43***a* and **43***b* are needed to form on the block main body **8** and the load rolling faces **43***a* and **43***b* are formed as illustrated in FIG. **7** after forming the movable body attaching face **41** and the reference side faces **47**. That is, the movable body attaching face **41** and the reference side faces **47** which have already been formed, are brought into contact with attaching reference faces of a polishing stage **9** thereby fixing the block main body **8**, under which the grindstone **10** is brought into contact with the block main body **8** whereby the load rolling faces **43***a* and **43***b* are polished. At this occasion the load rolling faces **43***a* and **43***b* are polished in one machining operation by using the same grindstone **10** in order to render accurate the positional relationship among the load rolling faces **43***a* formed at the skirt portions and the load rolling faces **43***b* formed at the horizontal portion.

FIG. **8** is an enlarged view showing the surroundings of the load rolling faces **43***a* and **43***b* which have been polished. According to the polishing operation using the grindstone **10** not only the load rolling faces **43***a* and **43***b* are formed but pairs of smooth faces **50** are formed along both edges in the longitudinal direction of the respective load rolling faces.

That is, the grindstone **10** is a formed polishing grindstone having a shape reverse to the shape of the load rolling faces **43***a* and **43***b* and the smooth faces **50** and the smooth faces **50** are formed with a constant positional accuracy in respect of the load rolling faces **43***a* and **43***b* which are disposed contiguously to the smooth faces **50**.

In steps of injection molding of a synthetic resin, mentioned later, the smooth faces **50** function as positioning reference faces of the block main body **8** in the mold and are used as measuring reference faces in measuring whether the load rolling face **43***a* and **43***b* are formed with a predetermined dimensional accuracy.

Next, an explanation will be given of a step of building a synthetic resin by injection molding onto the block main body **8** which has been finished in a predetermined shape in this way.

The injection molding is executed by a process in which the block main body **8** all the machining of which has been finished, is arranged in a mold as a core, which is referred to as insert molding, whereby a synthetic resin is built only at predetermined positions of the block main body **8** by which the ball return holes **44***a* and **44***b*, the ball retaining portions **45** and the like, are formed.

FIG. **9** is a sectional view showing the block main body **8** which is inserted into molds **61** and **62**. A projected support portion **63** for fixing the block main body **8** is erected on the mold **61** and positioning of the block main body **8** in the molds **61** and **62** is carried out by fitting the block main body **8** in respect of the projected support portion **63** from the axial direction (orthogonal to paper face) and cavities **64** and **65** corresponding to the ball retaining portion **45** of the moving block **4** are formed between the block main body **8** and the projected support portion **63** whereas cavities **66** for forming the ball return holes **44***a* are formed between the skirt portions **4***b* of the block main body **8** and the mold **61**. Further, rod-like mold bodies **67** having a sectional shape in agreement with the shape of the ball return holes **44***a* and **44***b*, are inserted into the through holes **48** of the block main body **8** and the cavities **66** by which the ball return holes **44***a* and **44***b* are formed when the molten synthetic resin is filled in the through holes **48** and the cavities **66**.

Also, the mold **61** is brought into contact with the lower end edges of the reference side faces **47** of the block main body **8** by which the shielding of the molten synthetic resin filled in the cavities **66** is carried out and the synthetic resin is prevented from covering the reference side faces **47**.

Meanwhile, FIG. **10** is an enlarged view showing details of a state of contact between the projected support portion **63** and block main body **8**. When the synthetic resin is put on the load rolling faces **43***a* and **43***b* formed on the block main body **8**, it becomes a hazard against the running of the balls **3** and therefore, it is required in such an insert molding that shielding of the molten synthetic resin is firmly carried out between the load rolling faces **43***a* and **43***b* and the contiguous cavities **64, 65** and **66**. Accordingly, in fitting the block main body **8** to the projected support portion **63**, the projected support portion **63** is brought into contact with the smooth faces **50** which are formed on the both edges of the load rolling faces **43***a* and **43***b* whereby the shielding the molten synthetic resin filled in the cavities **64, 65** and **66** is carried out. Further, the projected support portion **63** is brought into contact with the smooth faces **50** to span across the load rolling faces **43***a* and **43***b* to prevent the load rolling faces **43***a* and **43***b* which have been finished in a predetermined accuracy from damaging by the contact with the projected support portion **63**.

Further, after inserting the block main body **8** into the molds **61** and **62**, the molten synthetic resin is filled in the cavities **64, 65** and **66** formed by the block main body **8** and the mold **61** and the synthetic resin is built on the main body **8** whereby the moving block as illustrated by FIG. **3** and FIG. **4** is completed.

According to the step of the insert molding which is carried out as has been described above, in positioning the block main body **8** in the mold **61** in this embodiment, the projected support portion **63** erected on the mold **61** for fitting to the block main body **8**, is brought into contact with the pairs of smooth faces **50** which are formed along the both edges of the load rolling faces. Therefore, the following advantages is achieved in comparison with the conventional manufacturing method in which the positioning of the block main body is carried out by bringing the projected support portion in direct contact with the load rolling faces.

That is, the smooth faces **50** are formed by polishing them simultaneously with the load rolling faces **43***a* and **43***b* and therefore, the accuracy of the formed positions and the smoothness are significantly excellent and by bringing the projected support portion **63** into contact with the smooth faces **50** which have been formed with such a high accuracy, the projected support portion **63** and the smooth faces **50** are brought into close contact with each other whereby the molten synthetic resin can be shielded with certainty by the smooth faces **50**. Therefore, according to the moving block **4** manufactured by the method of this embodiment, no burr of synthetic resin is caused on the load rolling faces **43***a* and **43***b* whereby smooth running of hall can be guaranteed.

Also, it is possible to promote the positioning accuracy of the block main body **8** inserted into the molds **61** and **62** by bringing the projected support portion **63** into contact with the smooth faces **50** which have been formed with high accuracy, whereby the locations of forming the ball retaining portions **45** in respect of the load rolling faces **43***a* and **43***b* of the block main body **8** are made accurate. Therefore, the balls **3** running on the load rolling faces **43***a* and **43***b* can be prevented from being brought into contact with the ball retaining portions **45** and generation of noise can be avoided as less as possible in circulating the balls **3**.

Incidentally, according to the embodiment, when the block main body **8** is inserted into the molds **61** and **62**, the load rolling faces **43***a* and **43***b* with a predetermined accuracy prior to the insert molding, are not damaged by the step of the insert molding since spaces are formed between the load rolling faces **43***a* and **43***b* and the projected support portion **63** whereby the smooth running of the balls **3** can be guaranteed.

What is claimed is:

1. A method of making a slider of a linear guide device comprising:

a first step of forming a block main body made of a metal which becomes a core part of the slider in a predetermined shape by machining and forming load rolling faces of balls on the block main body;

a second step of inserting the block main body formed by the first step into a mold and executing an injection molding of a synthetic resin by which ball retaining portions are built up on both sides of the load rolling faces of the block main body;

wherein pairs of smooth faces for shielding the molten synthetic resin are formed along both edges in a longitudinal direction of the load rolling faces formed in the block main body in the first step; and

wherein the block main body is fixed at a predetermined position in the mold by bringing a projected support portion erected on the mold into contact with the smooth faces for shielding the molten synthetic resin in the second step.

2. The method of making a slider of a linear guide device according to claim **1**, wherein spaces are formed between the load rolling faces of the block main body and the projected support portion of the mold when the block main body is fixed into the mold in the second step.

* * * * *

US006082210A

United States Patent [19]

Ise

[11] **Patent Number: 6,082,210**

[45] **Date of Patent: Jul. 4, 2000**

[54] **BALL CONNECTING BODY AND BALL SCREW APPARATUS USING THE SAME**

[75] Inventor: **Genjiro Ise**, Tokyo, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **09/114,965**

[22] Filed: **Jul. 14, 1998**

[30] **Foreign Application Priority Data**

Jul. 18, 1997 [JP] Japan 9-194458

[51] **Int. Cl.**^{7} **F16H 55/17**; F16C 29/06

[52] **U.S. Cl.** .... **74/459**; 74/89.15; 74/424.8 R; 384/45; 384/49; 384/51

[58] **Field of Search** .... 74/89.15, 424.8 R, 74/459; 384/43, 44, 49, 45, 51

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,841,796	6/1989	Teramachi	74/459
5,156,462	10/1992	Jacob et al.	384/49
5,295,407	3/1994	Hirose et al.	74/459
5,622,082	4/1997	Machelski	74/459
5,755,516	5/1998	Teramachi et al.	384/45

FOREIGN PATENT DOCUMENTS

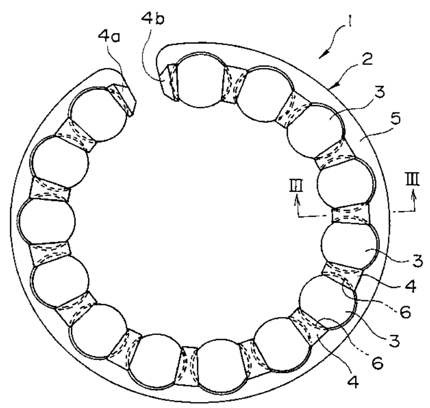
52217	3/1993	Japan .
5-27408	4/1993	Japan .
89360	4/1998	Japan .

Primary Examiner—David A. Bucci
Assistant Examiner—Marcus Charles
Attorney, Agent, or Firm—Arent Fox Kintner Plotkin & Kahn, PLLC

[57] **ABSTRACT**

A ball connecting body in which a multiplicity of balls are arranged in a line at a predetermined interval and in a freely rotating manner. The ball connecting body is installed and used in a ball endless track of a ball screw apparatus in which a screw shaft and a nut member are meshed with each other through a multiplicity of balls. The ball connecting body is constituted by a multiplicity of balls circulating on a substantially circular ring-like ball endless track provided in a bearing apparatus, and a flexible connecting body belt arranging the balls in a line at a predetermined interval and holding each of the balls in a freely rotating manner. Further, the connecting body belt is constituted by a plurality of spacer portions inserted between the mutually adjacent balls and having a spherical seat for bringing the balls into contact therewith formed, and a flange-like connecting band portion mutually connecting the spacer portions so as to outwardly surround the spacer portions, and is formed in a substantially circular ring shape at a time of arranging the balls.

3 Claims, 7 Drawing Sheets



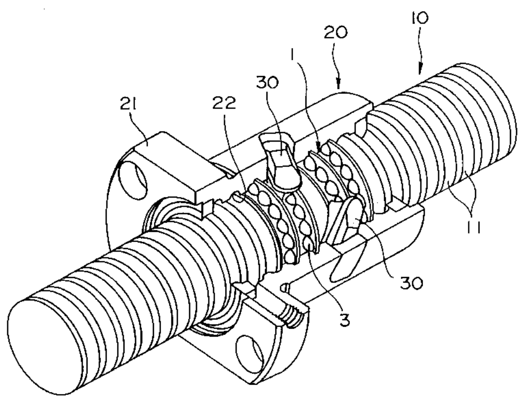


Fig. 1

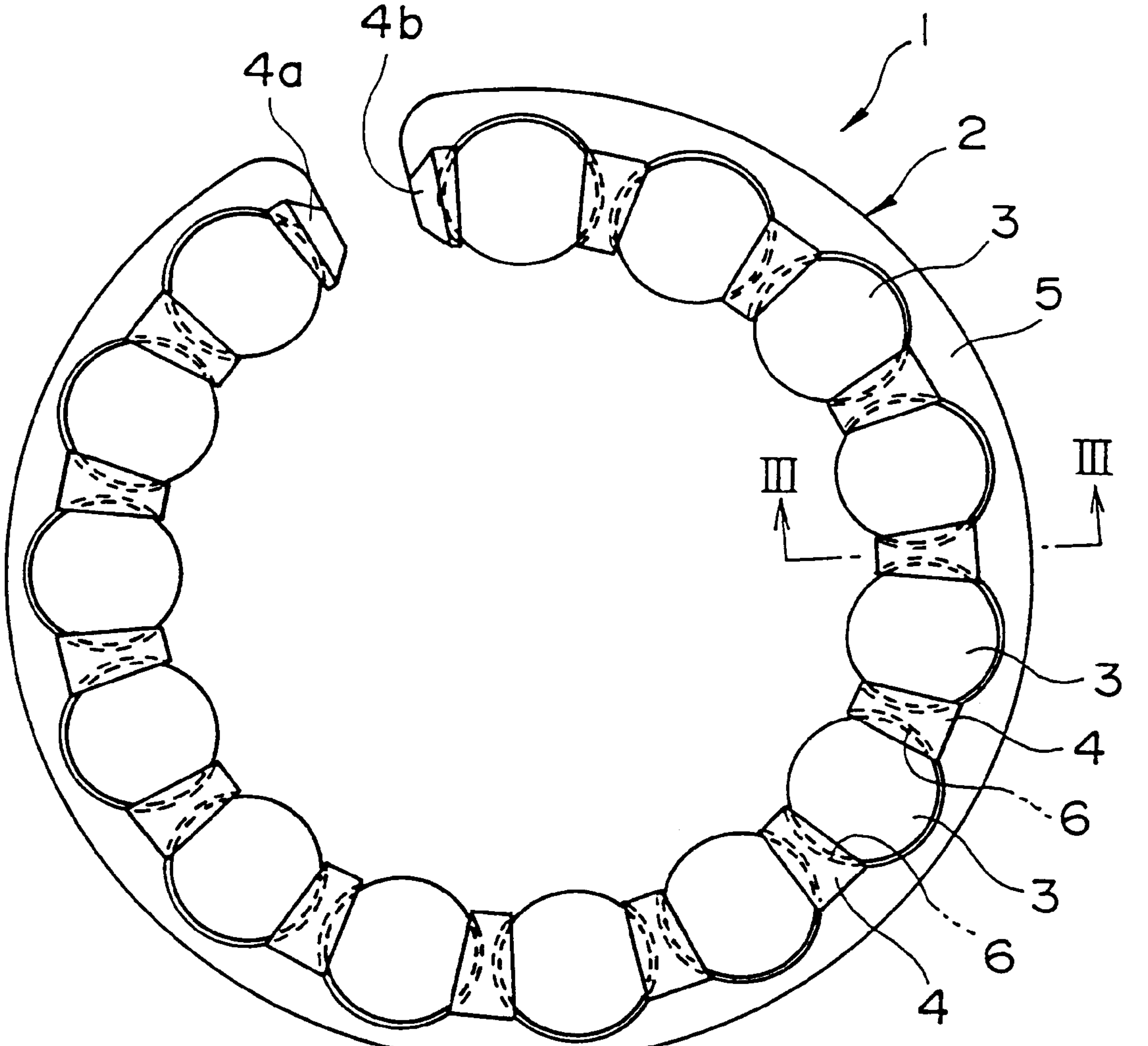


Fig. 2

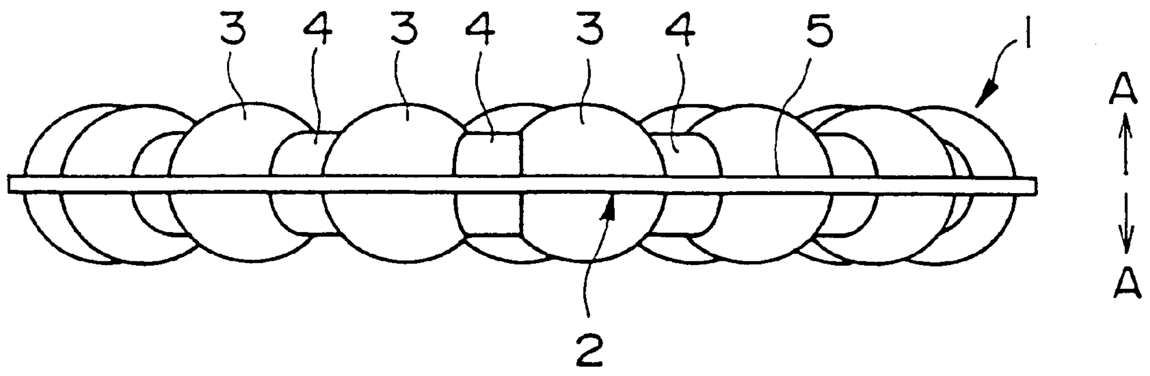
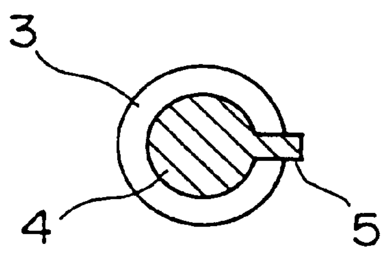


Fig. 3



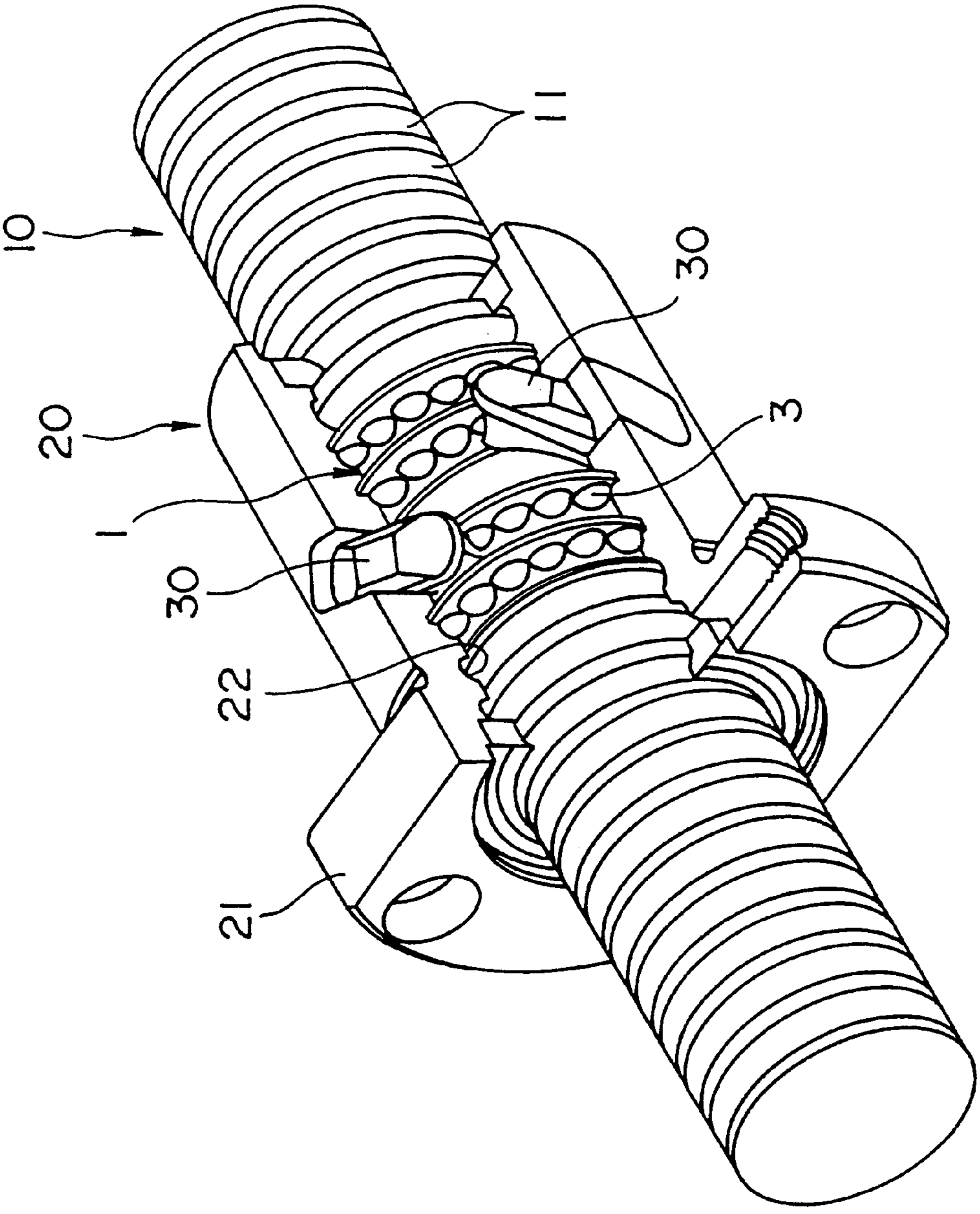


Fig. 4

Fig. 5

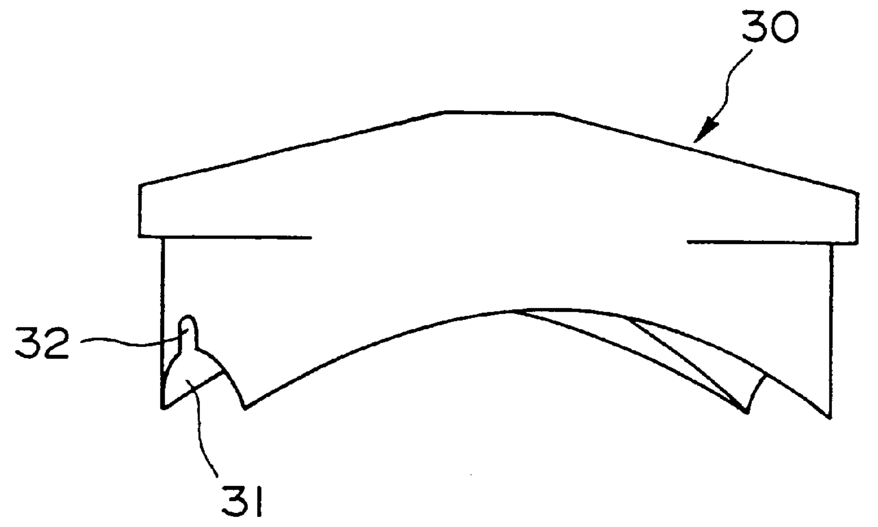


Fig. 6

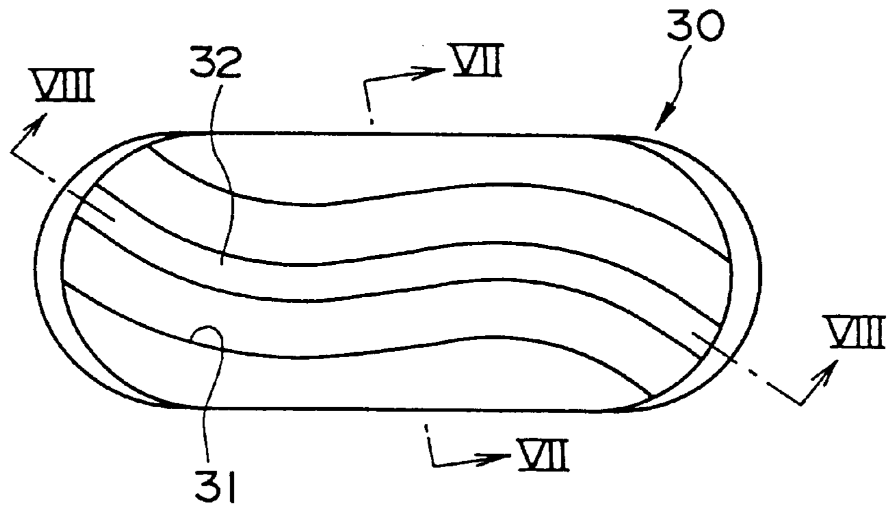


Fig. 7

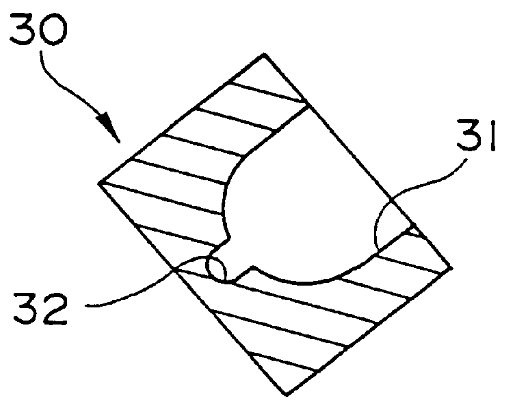


Fig. 8

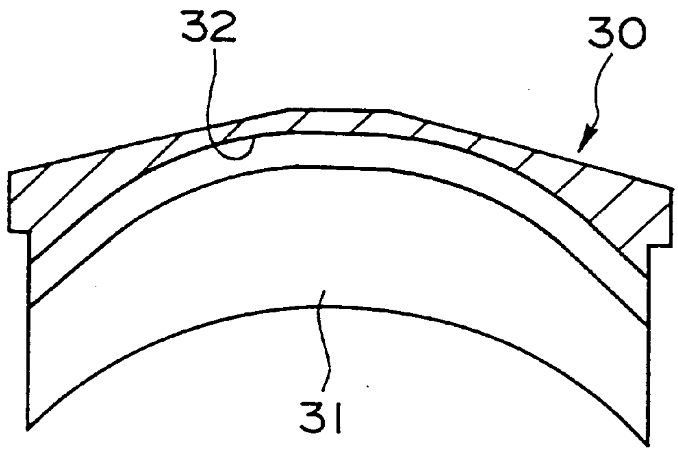


Fig. 9

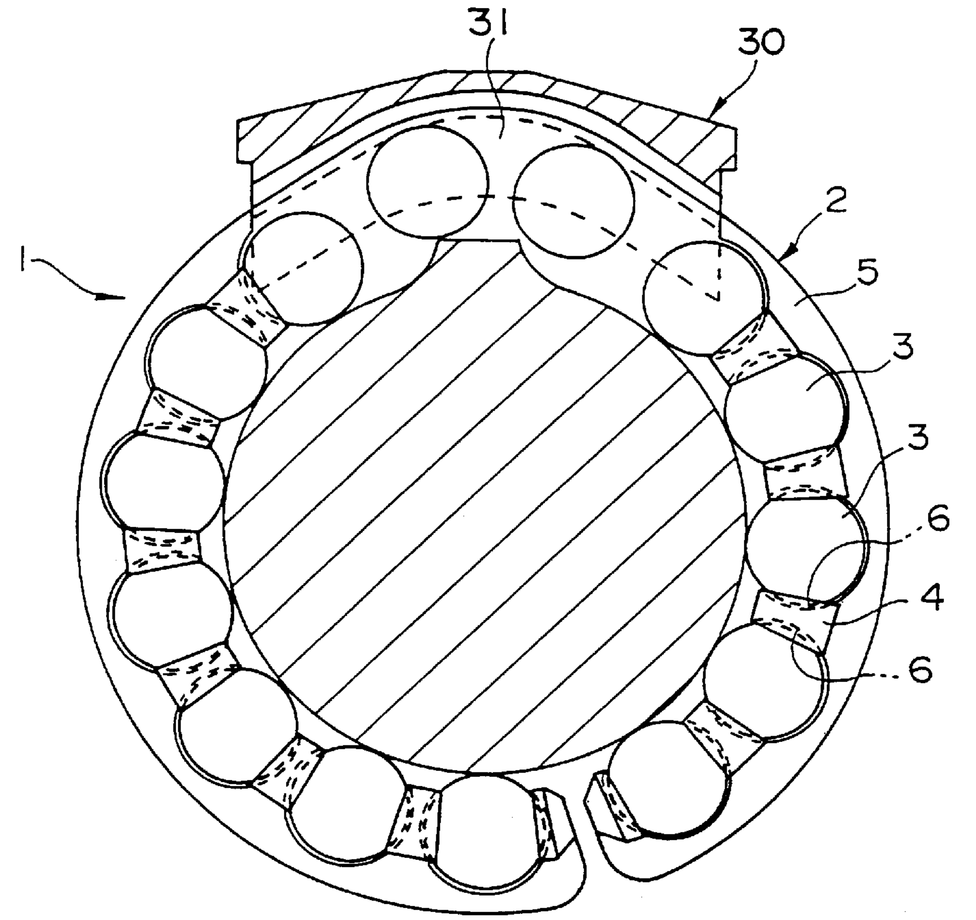


Fig. 10

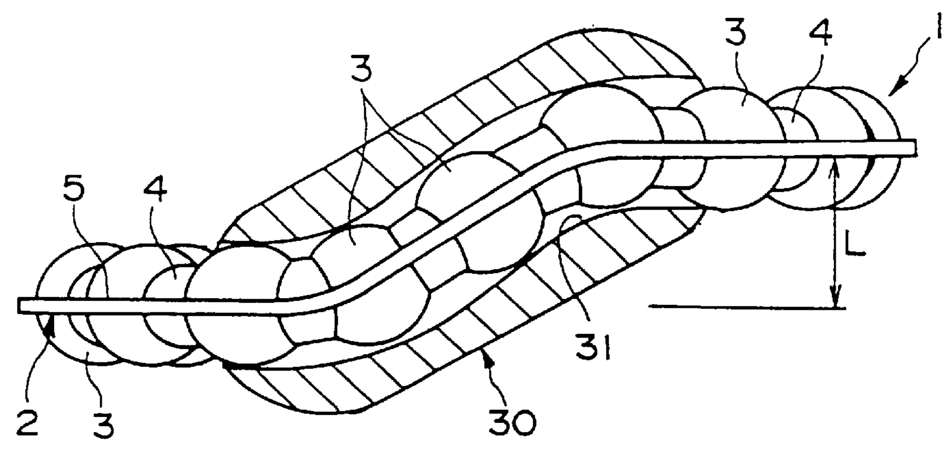
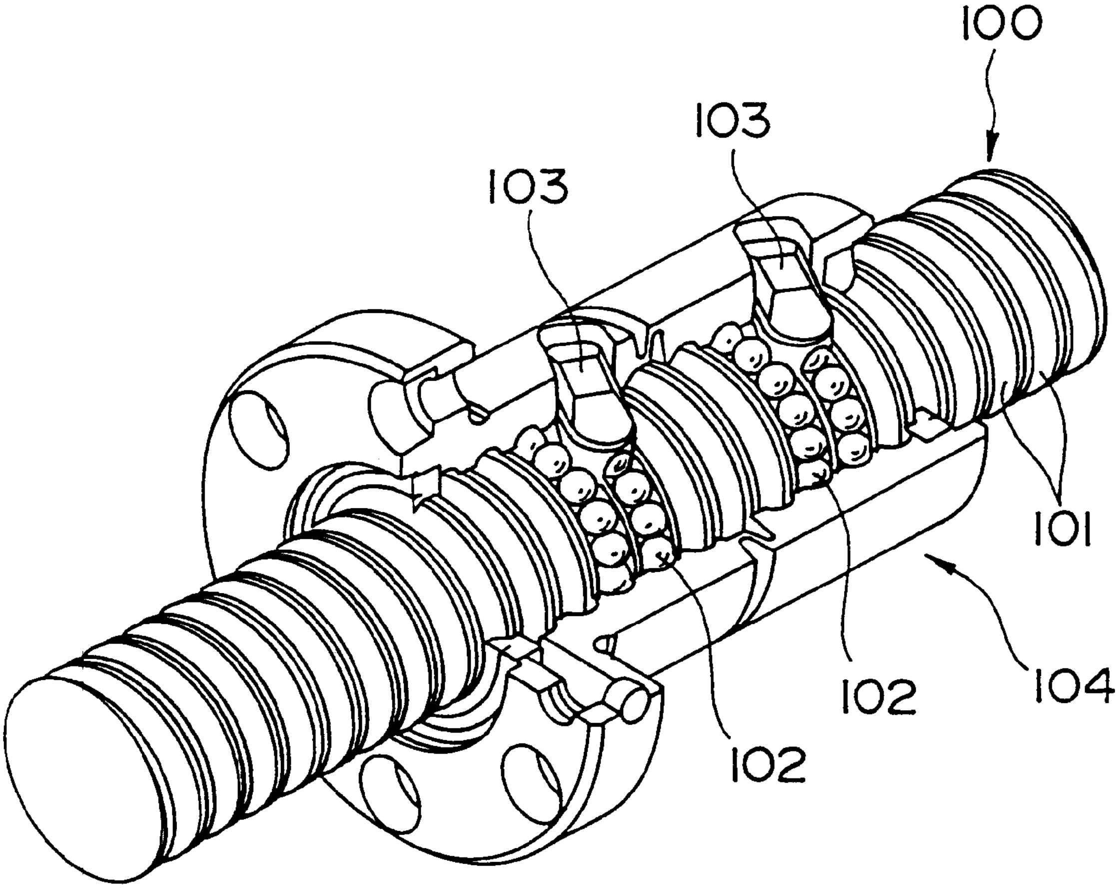


Fig. 11



BALL CONNECTING BODY AND BALL SCREW APPARATUS USING THE SAME

TECHNICAL FIELD

The present invention relates to a ball connecting body in which a multiplicity of balls are arranged in a line at a predetermined interval and in a freely rotating manner, and more particularly to a ball connecting body installed and used in a ball endless track of a ball screw apparatus in which a screw shaft and a nut member are meshed with each other through a multiplicity of balls and a ball screw apparatus using the same.

BACKGROUND OF THE INVENTION

A ball screw apparatus is frequently used in a straight sliding portion of an industrial robot, and is mainly used for a purpose of giving a straight moving amount in accordance with a rotating amount of a motor to a movable body such as a table. Such a ball screw apparatus is generally constituted by a screw shaft having a spiral ball rolling groove formed on an outer peripheral surface, and a nut member meshed with the screw shaft through a multiplicity of balls and provided with an endless track on which the balls circulate, and is structured such that when the screw shaft is connected to the motor and is rotated, a multiplicity of balls interposed between the screw shaft and the nut member circulate within the endless track provided in the nut member, and the nut member lightly performs a straight movement in an axial direction of the screw shaft in order to this.

On the contrary, in this kind of ball screw apparatus, each of the balls circulating within the ball endless track is mutually brought into contact with the balls positioned in front of and at the rear of the ball, whereby there are disadvantages such that the ball is prevented from smoothly circulating and a contact noise between the balls is rasping at a high rotation of the screw shaft, and as a structure for solving the disadvantages, a ball screw apparatus disclosed in Japanese Unexamined Utility Model Publication No. 5-27408 is suggested.

In the ball screw apparatus disclosed in the publication, a band-like retainer having a flexibility is provided within a ball endless track of a nut member in such a manner as to be capable of circulating and moving, and a ball pocket for receiving a ball is arranged in such a band-like retainer at a predetermined interval. Accordingly, the balls are received in the ball endless track of the nut member in a state of being arranged in the band-like retainer at a predetermined interval, whereby in the ball screw apparatus, the balls circulating within the endless track are prevented from being mutually brought into contact with each other.

In this case, as a structure of forming the ball endless track in the nut member of the ball screw apparatus, as shown in Japanese Unexamined Utility Model Publication No. 5-27408 mentioned above, a structure in which a ball circulating pipe for jumping over some winds of ball rolling grooves in the screw shaft is provided and a ball endless track is constructed with including some winds of ball rolling grooves, and as shown in FIG. **11**, a deflector **103** for scooping up a ball **102** from a ball rolling groove **101** in the screw shaft **100** is fitted to an inner peripheral surface of a nut member **104** and the ball **102** rolling on the ball rolling groove **101** of the screw shaft **100** is returned only for a wind of the ball rolling groove **101** through the deflector **103** have been known.

In the former structure using the ball circulating pipe, since the pipe is formed to have a length such as to jump over some winds of ball rolling grooves and is relatively gently curved, even when the band-like retainer mentioned above is assembled in the ball endless track and circulated, the band-like retainer can be smoothly inserted to the ball circulating pipe by curbing the band-like retainer after bending it within the pipe in a proper direction.

However, in the structure using the latter deflector, although the ball endless track is formed in a substantially circular ring shape corresponding to a wind of the ball rolling groove, the ball rolling in an inner portion of the deflector suddenly displaces in an axial direction of the screw shaft only for a lead of the ball rolling groove, so that in the case of assembling the band-like retainer of Japanese Unexamined Utility Model Publication No. 5-27408 formed in a band plate shape in the ball endless track as it is, the band-like retainer is forcibly curbed in the inner portion of the deflector. Accordingly, there is a risk that the band-like retainer can not smoothly circulate in the inner portion of the ball endless track.

DISCLOSURE OF THE INVENTION

The present invention is made by taking the problems mentioned above into consideration, and an object of the invention is to provide a ball connecting body applicable to a ball screw apparatus in which a screw shaft and a nut member are meshed with each other through a multiplicity of balls, and a substantially circular ring-like ball endless track is constructed by using a deflector, and capable of smoothly circulating within the ball endless track.

Further, another object of the invention is to provide a ball screw apparatus which can achieve a smooth ball circulation by assembling such a ball connecting body.

Accordingly, in accordance with the invention, there is provided a ball connecting body comprising a multiplicity of balls circulating on a substantially circular ring-like ball endless track provided in a bearing apparatus; and a flexible connecting body belt arranging the balls in a line at a predetermined interval and holding each of the balls in a freely rotating manner; wherein the connecting body belt is constituted by a plurality of spacer portions inserted between the mutually adjacent balls and having a spherical seat for bringing the balls into contact therewith formed; and a flange-like connecting band portion mutually connecting the spacer portions in such a manner as to outwardly surround the spacer portions; and the connecting body belt is formed in a substantially circular ring shape at a time of arranging the balls in the connecting body belt.

Further, the ball connecting body of the invention as structured in the above manner is approximately applied to, for example, a ball screw apparatus comprising a screw shaft having a spiral ball rolling groove formed on an outer peripheral surface; a nut member having a load rolling groove opposite to the ball rolling groove of the screw shaft on an inner surface and meshed with the screw shaft through a multiplicity of balls rolling with applying a load between the ball rolling groove and the load rolling groove; a deflector fitted to the inner peripheral surface of the nut, having a ball returning groove to return a ball rolling on said load rolling groove for a wind of the load rolling groove and forming a substantially circular ring-like ball endless track on which the balls circulate in an endless manner; and which is used in such a manner as to be assembled within the ball endless track and such that the ball applies a load between the load rolling groove of the nut member and the ball rolling groove of the screw shaft.

Since the ball connecting body in accordance with the invention is formed in a substantially circular ring shape at a time of arranging the ball in the connecting body belt, it is not necessary to circulate with forcibly curbing the connecting body belt even in the case of assembling it within the substantially circular ring-like ball endless track provided in the ball screw apparatus, so that the ball connecting body can be smoothly circulated and the ball held by the connecting body belt can be smoothly circulated.

Further, since the connecting band portion of the a connecting body belt is formed in a flange shape outwardly surrounding each of the spacer portions, it can be flexibly bent in a direction perpendicular to a plane on which each of the spacer portions is arranged. Accordingly, even in the case that the ball rolling on the ball endless track is taken out from the ball rolling groove in the screw shaft through the deflector and jumps over the outer diameter portion of the screw shaft so as to move to the ball rolling groove before a lead, the connecting body belt can flexibly follow this, and can smoothly circulate in the inner portion of the ball endless track.

On the contrary, since the ball rolling on the ball endless track jumps over the outer diameter portion of the screw shaft at a time of passing through the ball returning groove formed in the deflector, it is desirable that the connecting body belt can be flexibly bent also with respect to a radial direction of the nut member so as to prevent the ball from moving in this manner. Accordingly, in view of this, it is preferable that the spherical seat formed in the spacer portions of the connecting body belt is formed in a recessed spherical surface having a curvature larger than a spherical surface of the ball so as to freely change a contact angel between each of the spacer portions and the ball.

Further, the ball connecting body in accordance with the invention can be connected in an endless manner after assembled in the ball endless track of the ball screw apparatus, however, in the case of taking an extension of the connecting body belt in a periodical use into consideration, it is preferable to use both end portions as a shape having an end in place of connecting them.

As mentioned above, since the ball connecting body in accordance with the invention can be formed in a substantially circular ring shape at a time of arranging the ball in the connecting body belt and can be flexibly bent with respect to a direction perpendicular to the plane on which each of the spacer portions is arranged, it is optimum to the ball screw apparatus in which the screw shaft and the nut member are meshed with each other through a multiplicity of balls and a substantially circular ring-like ball endless track is constructed by using the deflector, so that it can smoothly circulate therewithin at a time of being used by assembling in the ball endless track, thereby making it possible to smoothly circulate the ball and to smoothly perform a relative rotation between the screw shaft and the nut member.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front elevational view which shows an embodiment of a ball connecting body in accordance with the invention;

FIG. **2** is a side elevational view of a ball connecting body in accordance with an embodiment;

FIG. **3** is a cross sectional view along a line III—III in FIG. **1**;

FIG. **4** is a partly cut-away perspective view showing an embodiment of a ball screw apparatus in which a ball connecting body shown in FIG. **1** is assembled;

FIG. **5** is a front elevational view which shows a deflector in accordance with a ball screw apparatus of an embodiment;

FIG. **6** is a bottom elevational view which shows a deflector in accordance with a ball screw apparatus of an embodiment;

FIG. **7** is a cross sectional view along a line VII—VII in FIG. **6**;

FIG. **8** is a cross sectional view along a line VIII—VIII in FIG. **6**;

FIG. **9** is a front cross sectional view showing a state in which a ball connecting body of an embodiment circulates on a ball endless track of a ball screw apparatus;

FIG. **10** is a plan view showing a state in which a ball connecting body of an embodiment circulates on a ball endless track of a ball screw apparatus; and

FIG. **11** is a partly cut-away perspective view which shows a conventional ball screw apparatus.

BEST MODE FOR CARRYING OUT THE INVENTION

A ball connecting body in accordance with the invention will be described in detail below with reference to the accompanying drawings.

FIGS. **1** and **2** show a first embodiment of a ball connecting body in accordance with the invention. The ball connecting body **1** is structured such as to be formed in a substantially circular ring-like by arranging a plurality of balls **3** in a synthetic resin connecting body belt **2** in a line at a predetermined interval, and the balls **3** can be freely rotated in a state of being held in the connecting body belt **2**.

The connecting body belt **2** is constituted by a plurality of spacer portions **4** interposed between the mutually adjacent balls **3** so as to prevent the balls from being in contact with each other, and a flange-like connecting band portion **5** mutually connecting the spacer portions **4** in such a manner as to outwardly surround the spacer portions **4**, in this embodiment, it is formed in a substantially C shape in which a part of the circular ring is cut away. Further, each of the spacer portions **4** is formed in a thin shape at an inner diameter end of the ball connecting body **1**, and on the contrary, is formed in a thick shape at an outer diameter end, thereby smoothly arranging the balls **3** in a circular ring-like manner at a time of arranging the ball **3** between the spacer portions **4**.

A recessed spherical seat **6** with which the ball is brought into contact is formed in each of the spacer portions **4**, and the ball **3** is held in the connecting body belt **2** by being held between a pair of spherical seats **6**. Further, a curvature of the spherical seat **6** is set to be slightly larger than a curvature of a spherical surface of the ball **3**, whereby a contact angle between the ball **3** and the spherical seat **6** can be freely changed at a certain degree. As a result, the ball connecting body **1** can be freely deformed at a certain degree with respect to a radial direction thereof.

As shown in FIGS. **2** and **3**, the connecting band portion **5** is formed in such a manner as to project outside the ball row arranged in a circular ring manner, as a result, the ball connecting body **1** can be freely bent to a direction (a direction shown by an arrow A in FIG. **2**) perpendicular to the plane on which the balls **3** are arranged.

Further, spacer portions **4*a*** and **4*b*** positioned at both ends of the connecting body belt **2** are formed in a steeple manner, and on the contrary, a front end of the connecting band portion **5** connected to these spacer portions **4*a*** and **4*b*** is also formed in a circular arc shape, thereby preventing the front end of the connecting body belt **2** from generating a hook portion within the ball endless track at a time when the ball connecting body **1** circulates the ball endless track of the ball screw apparatus.

The connecting body belt **2** is manufactured by an injection molding of a synthetic resin. In such an injection molding, a plurality of dummy balls having a diameter slightly larger than the ball **3** to be arranged in the connecting body belt **2** are inserted into a molding metal mold as a core, and they are arranged within the metal mold in the same manner as the arranging state of the ball **3** with respect to the connecting body belt **2**. Then, the connecting body belt **2** holding the dummy ball between the spacer portions **4** is formed by injecting the synthetic resin into the metal mold from this state. After the formed connecting body belt **2** is taken out from the metal mold, the dummy ball is removed, and in place of this, the ball **3** is inserted between the spacer portions **4**, so that the ball connecting body **1** in accordance with this embodiment is completed.

As mentioned above, when the connecting body belt **2** is formed by using the dummy ball having a diameter larger than the ball **3** as a core, the spherical seat **6** of each of the spacer portions **4** is formed in a recessed spherical surface following the spherical surface of the dummy ball, so that the spherical seat **6** having a curvature larger than a curvature of the spherical surface of the ball **3** can be easily formed. Further, since the ball **3** finally arranged, in the connecting body belt **2** has a diameter smaller than the dummy ball, a significantly small gap is formed between the spacer portions **4** and the ball **3**, so that it is possible to secure a free rotation of the ball with respect to the spacer portions **4**.

On the contrary, it is possible to form the connecting body belt **2** holding the ball **3** between the spacer portions **4** by inserting the ball **3** within the forming metal mold as a core without using the dummy ball, and in accordance with this method, a replacing operation between the dummy ball and the ball **3** is not required, so that the ball connecting body **1** can be further easily manufactured. In this case, since the ball **3** and the spacer portions **4** of the connecting body belt **2** are in close contact with each other, the ball connecting body **1** taken out from the metal mold is immersed into a mineral oil type lubricating oil as it is and the synthetic resin connecting body belt **2** is swelled by the lubricating oil. Accordingly, the spherical seat **6** of each of the spacer portions **4** becomes a recessed spherical surface having a curvature larger than a curvature of the spherical surface of the ball **3**, a gap is formed between the ball **3** and the spacer portions **4**, and it is also possible to secure a free rotation of the ball **3** with respect to the spacer portions **4**.

FIG. **4** shows an embodiment of the ball screw apparatus in which the ball connecting body **1** is assembled.

In the drawing, reference numeral **10** denotes a screw shaft on which a spiral ball rolling groove **11** is formed at a predetermined lead, and reference numeral **20** denotes a nut member having an endless track in which the ball connecting body **1** mentioned above is assembled and being meshed with the screw shaft **10** through the ball **3**, and the structure is made such that the nut member **20** moves in an axial direction of the screw shaft **10** by a relative rotation between the screw shaft **10** and the nut member **20**.

The nut member **20** mentioned above is formed in a cylindrical shape through which the screw shaft **10** extends, and a flange portion **21** for fixing the nut member **20** to a movable body such as a table is provided on an outer peripheral surface thereof in a projecting manner. Further, a spiral load rolling groove **22** opposing to the ball rolling groove **11** of the screw shaft **10** is formed on an inner peripheral surface of the nut member **20**, so that the ball **3** rolls between the ball rolling groove **11** and the load rolling groove **22** with applying the load. The load rolling groove **22** is formed in a so-called Gothic arch shape in which two ball rolling surfaces are crossed, and an escape groove for receiving the connecting band portion **5** of the ball connecting body **1** mentioned above is formed at a deepest portion of the groove.

On the contrary, a deflector **30** for circulating the ball **3** between the screw shaft **10** and the nut member **20** in an endless manner is fitted on the inner peripheral surface of the nut member **20**. As shown in FIG. **4**, the deflector **30** is fixed to the nut member **20** in such a manner as to jump over the ball rolling groove **11** of the screw shaft **10** for only a wind, so that the ball **3** rolling on the ball rolling groove **11** of the screw shaft **10** is changed a progressing direction thereof by the deflector **30** and returned to the ball rolling groove **11** a wind before by jumping over the outer diameter of the screw shaft **10**, whereby it is structured such that the ball **3** circulates within the nut member **20** in an endless manner. Further, in the nut member **20** in accordance with this embodiment, four deflectors **30** are fixed in such a manner as to uniformly separate the circumference of the nut member **20** into four portions, so that all four endless tracks are formed on the ball **3**. Accordingly, four ball connecting bodies **1** are assembled in the nut member **20** mentioned above.

FIGS. **5** to **8** show a detailed structure of the deflector **30** mentioned above.

A substantially S-shaped ball returning groove **31** is formed on the deflector **30**, and a guide groove **32** for guiding the connecting band portion **5** of the ball connecting body **1** is formed in a center portion of the ball returning groove **31**. Further, the ball returning groove **31** is formed in a most recessed shape at a center position of the deflector **30** so that the ball **3** entering to the ball returning groove **31** can jump over the outer diameter of the screw shaft **10**.

In accordance with the ball screw apparatus of this embodiment structured in the above manner, when the screw shaft **10** and the nut member **20** are relatively rotated, the ball **3** assembled in the ball connecting body **1** rolls on the load rolling groove **22** of the nut member **20** and the ball rolling groove **11** of the screw shaft **10**, and the ball connecting body **1** circulates in the inner portion of the endless track formed on the nut member **20**.

FIGS. **9** and **10** show a state in which the ball connecting body **1** in accordance with this embodiment circulates in the inner portion of the ball endless track. The ball endless track is formed in a substantially circular ring shape surrounding a periphery of the screw shaft **10**, however, is expanded outward in a radial direction of the screw shaft **10** at a position where the deflector **30** is mounted. Accordingly, the ball connecting body **1** is expanded toward an outer side in a radial direction of the endless track at a time of passing through the ball returning groove **31** of the deflector **30**, and is come out from the ball rolling groove **11** of the screw shaft **10** so as to jump over the outer diameter portion of the screw shaft **10**, on the contrary, goes along the ball returning groove **31** in a zigzag manner and moves along the axial direction of the screw shaft **10** for a lead of the ball rolling groove **11** (for a distance L in FIG. **10**). Therefore, the ball **3** jumps over the outer diameter of the screw shaft **10** together with the connecting body belt **2** so as to be returned to the ball rolling groove **11** a wind before, and circulates on the periphery of the screw shaft **10** in an endless manner.

At this time, since the ball connecting body **1** in accordance with this embodiment is formed in a substantially circular ring shape in a state of arranging the ball **3** on the connecting body belt **2**, a unreasonable force intending to forcibly bend it against the connecting body belt **2** does not act even when it is assembled within the ball endless track also formed in a substantially circular ring shape, so that it is possible to smoothly circulate within the ball endless track.

Further, in the connecting body belt **2**, the connecting band portion **5** is formed in a flange shape outwardly surrounding each of the spacer portions **4**, and is softly bent with respect to a direction shown by an arrow A (refer to FIG. **2**) perpendicular to the plane on which the balls **3** are arranged, so that even in the case of being guided in the inner portion of the deflector **30** in an S-shaped manner as shown in FIG. **10**, it can smoothly pass through the inner portion of the ball returning groove **31** in the deflector **30**. Accordingly, also in this point, the ball connecting body **1** in accordance with this embodiment can smoothly circulate in the inner portion of the ball endless track.

In addition, since the spherical seat **6** formed in each of the spacer portions **4** of the connecting body belt **2** is formed in a recessed spherical surface having a curvature larger than the spherical surface of the ball **3**, a slight gap is formed between the spherical seat **6** and the ball **3**, and both can freely change a contact angle thereof at a certain degree. Accordingly, as shown in FIG. **9**, even in the case that only a part of the peripheral direction of the ball connecting body **1** expands outward in a radial direction at a position of arranging the deflector **30**, no external force intending to forcibly bend this against the ball connecting body **1** acts, so that the ball connecting body **1** can be smoothly circulated within the ball endless track.

Accordingly, in the case of using the ball connecting body **1** in accordance with this embodiment in a state of being assembled in the ball endless track of the ball screw apparatus shown in FIG. **4**, the ball connecting body **1** can significantly smoothly circulate within the ball endless track, so that a relative rotation between the screw shaft **10** and the nut member **20** can be smoothly performed.

What is claimed is:

1. A ball connecting body comprising:

a multiplicity of balls circulating on a substantially circular ring-like ball endless track provided in a bearing apparatus; and

a flexible connecting body belt arranging the balls in a line at a predetermined interval and holding each of the balls in a freely rotating manner; wherein

said connecting body belt is constituted by a plurality of spacer portions inserted between mutually adjacent balls and having a spherical seat for bringing the balls into contact therewith, and a flange-like connecting band portion mutually connecting on only one side of the spacer portions; and

said connecting body belt is formed in a substantially circular ring shape at a time of arranging the balls in the connecting body belt so as to radially outwardly surround the spacer portions and the balls.

2. A ball connecting body as recited in claim **1**, wherein said connecting body belt is formed so as to have an end, and a length thereof is substantially equal to a length of a periphery of said ball endless track.

3. A ball screw apparatus comprising:

a screw shaft having a spiral ball rolling groove formed on an outer peripheral surface;

a nut member having a load rolling groove opposite to the ball rolling groove of the screw shaft on an inner surface and meshed with said screw shaft through a multiplicity of balls rolling with applying a load between the ball rolling groove and the load rolling groove;

a deflector fitted to an inner peripheral surface of the nut, having a ball returning groove to return a ball rolling on said load rolling groove for a wind of the load rolling groove and forming a substantially circular ring-like ball endless track on which the balls circulate in an endless manner; and

wherein a ball connecting body is assembled within said ball endless track, said ball connecting body comprising a ball connecting body comprising:

a multiplicity of balls circulating on a substantially circular ring-like ball endless track provided in a bearing apparatus; and

a flexible connecting body belt arranging the balls in a line at a predetermined interval and holding each of the balls in a freely rotating manner; wherein

said connecting body belt is constituted by a plurality of spacer portions inserted between mutually adjacent balls and having a spherical seat for bringing the balls into contact therewith and a flange-like connecting band portion mutually connecting on only one side of the spacer portions; and

said connecting body belt is formed in a substantially circular ring shape at a time of arranging the balls in the connecting body belt so as to radially outwardly surround the spacer portions and the balls, and said ball is structured such as to apply a load between the load rolling groove of the nut member and the ball rolling groove of the screw shaft.

* * * * *

US006080351A

United States Patent [19]

Shirai

[11] **Patent Number: 6,080,351**

[45] **Date of Patent: Jun. 27, 2000**

[54] **METHOD OF FORMING A MOVING BLOCK OF A ROLLING MOTION GUIDING DEVICE**

[75] Inventor: **Takeki Shirai**, Tokyo, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **09/077,755**

[22] PCT Filed: **Oct. 14, 1997**

[86] PCT No.: **PCT/JP97/03666**

§ 371 Date: **Jun. 11, 1998**

§ 102(e) Date: **Jun. 11, 1998**

[87] PCT Pub. No.: **WO98/16755**

PCT Pub. Date: **Apr. 23, 1998**

[30] **Foreign Application Priority Data**

Oct. 14, 1996 [JP] Japan 8-291161

[51] **Int. Cl.**[7] **B29C 45/14**

[52] **U.S. Cl.** **264/267**; 29/898.12; 164/137; 164/340; 264/242; 264/275; 264/279

[58] **Field of Search** 264/242, 328.1, 264/318, 267, 269, 275, 276, 279; 425/577, 468; 29/898.12; 384/45

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,564,188	10/1996	Akasako et al.	29/898.03
5,640,768	6/1997	Teramachi	29/898.03
5,728,343	3/1998	Ueno	264/275
5,755,516	5/1998	Teramachi et al.	384/45
5,911,509	2/1999	Kawaguchi et al.	384/45

Primary Examiner—Jan H. Silbaugh
Assistant Examiner—Dae Young Lee
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

A method of molding a movable block for a rolling motion guide device can effectively prevent the formation of burrs in the rolling member rolling groove and accurately positioning the movable block body in a molding die.

The positioning of the movable block body in width, vertical and longitudinal directions is performed at plain surfaces that are different from the rolling member rolling groove, so that damage or injury of the rolling member rolling groove can be prevented. Further, the molding material is shut off at either both end portions or both side peripheries of the rolling member rolling grooves, so that the molding material can be prevented from invading into the rolling member rolling grooves.

7 Claims, 14 Drawing Sheets

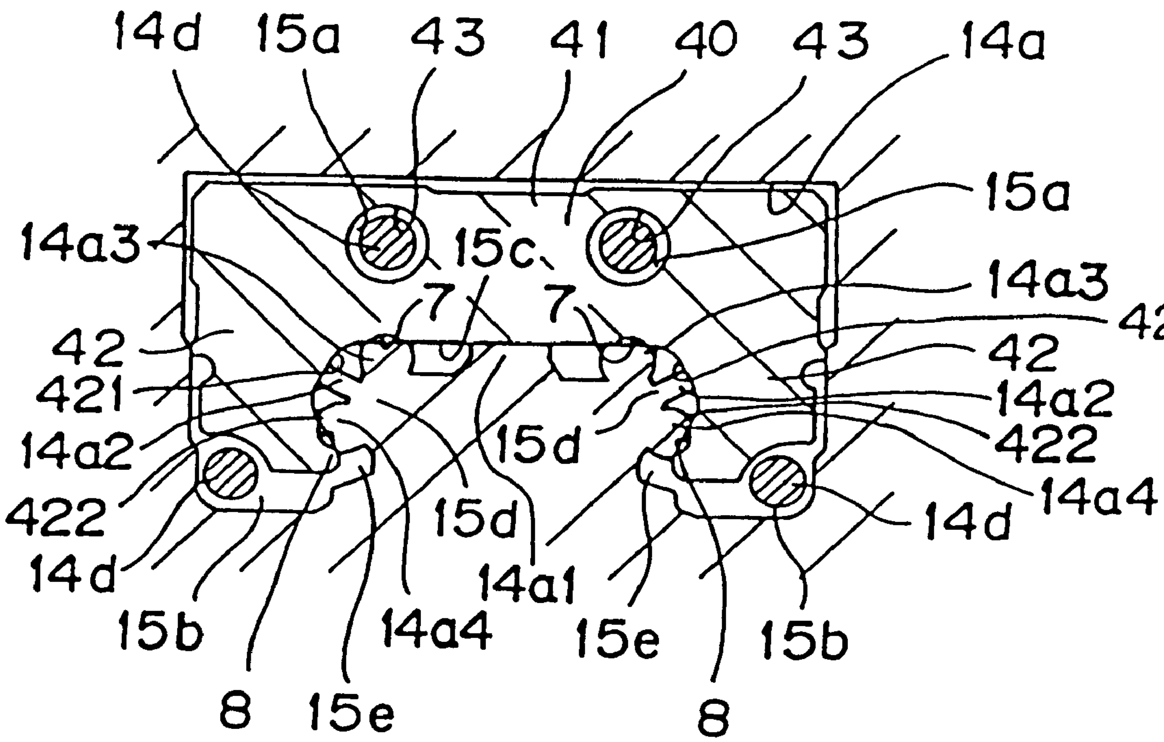


FIG. 1(a)

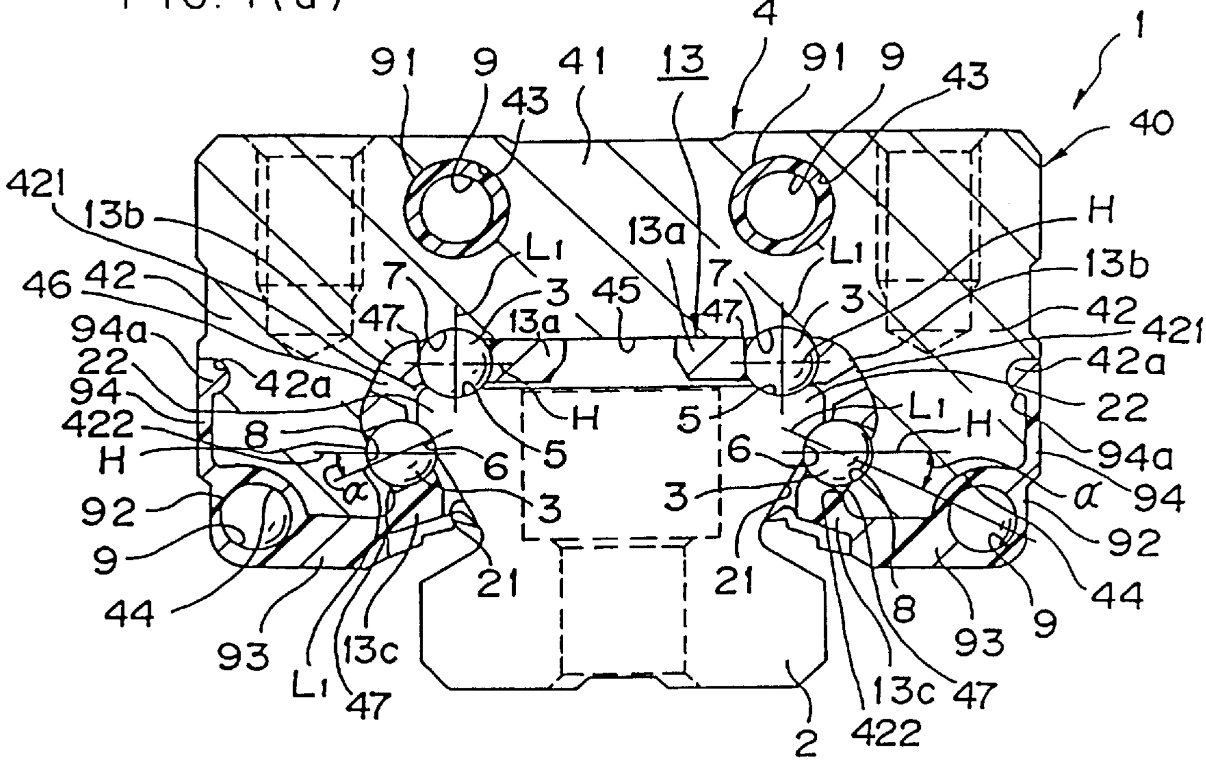


FIG. 1(b)

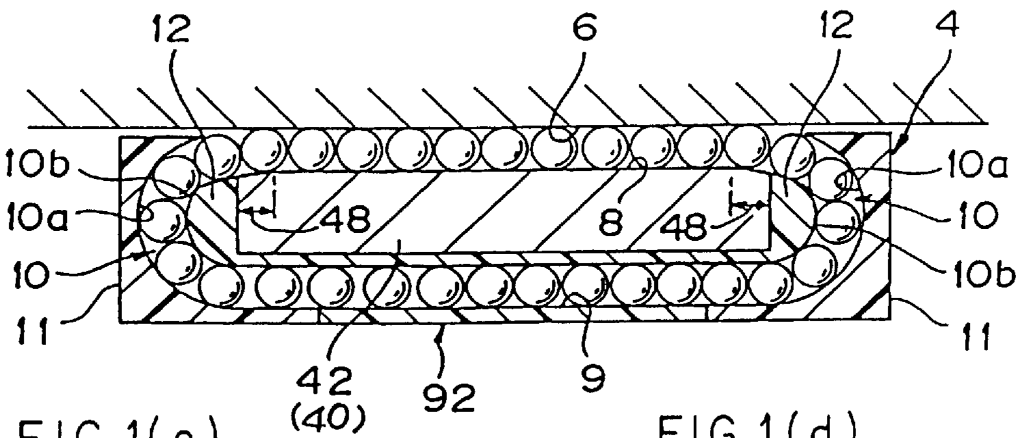


FIG. 1(c)

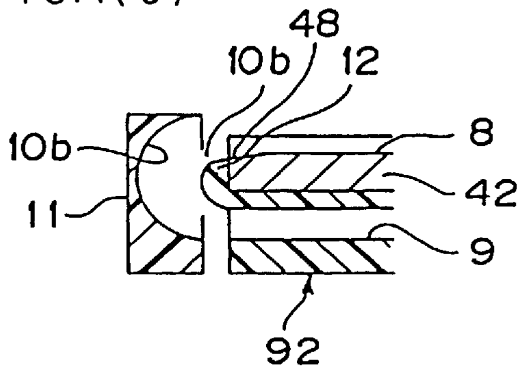


FIG. 1(d)

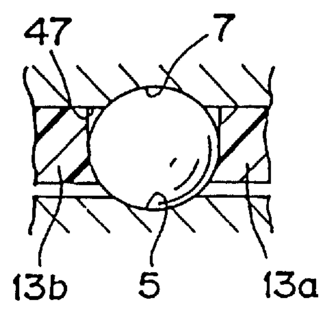


FIG.2(a)

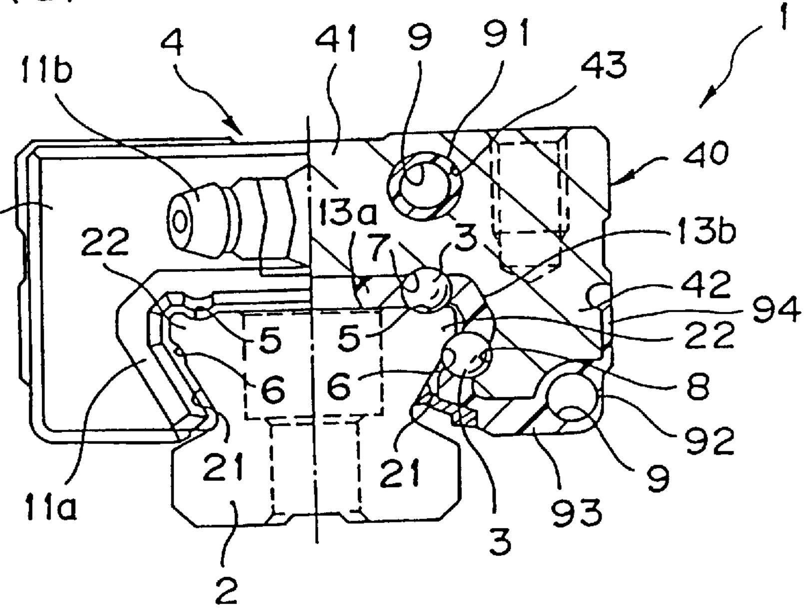

1
4
11b
41
9
91
43
40
11
13a
7
3
13b
22
42
94
5
5
22
6
6
8
92
21
21
9
11a
93
3
2

FIG.2(b)

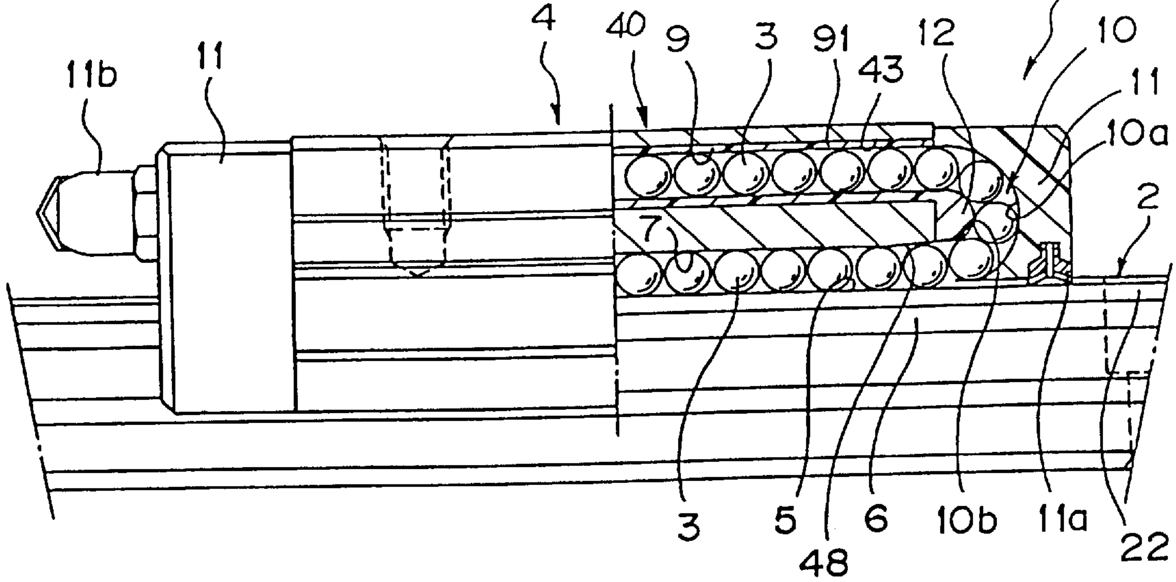

11b
11
4
40
9
3
91
43
12
1
10
11
10a
2
7
3
5
48
6
10b
11a
22

FIG. 3(a)

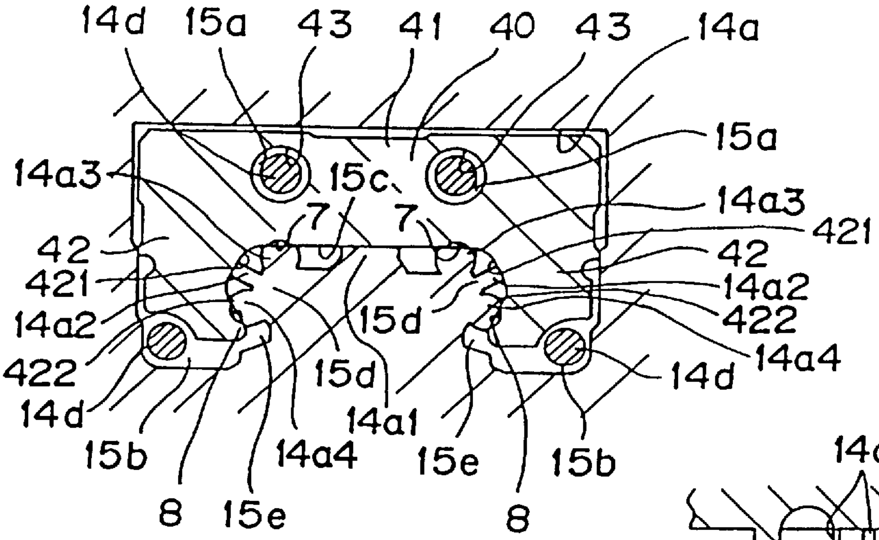


FIG. 3(b)

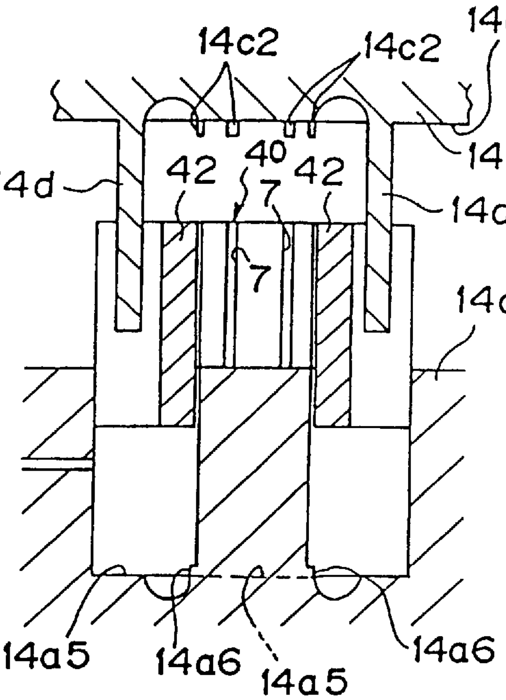


FIG. 3(e)

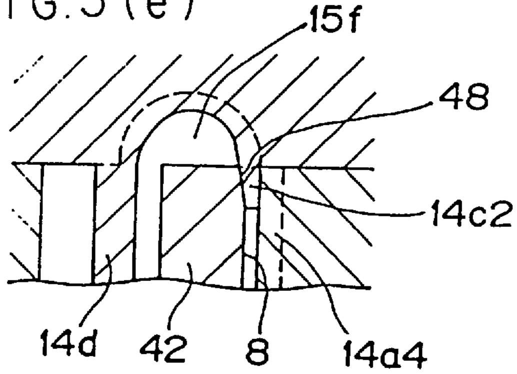


FIG. 3(c)

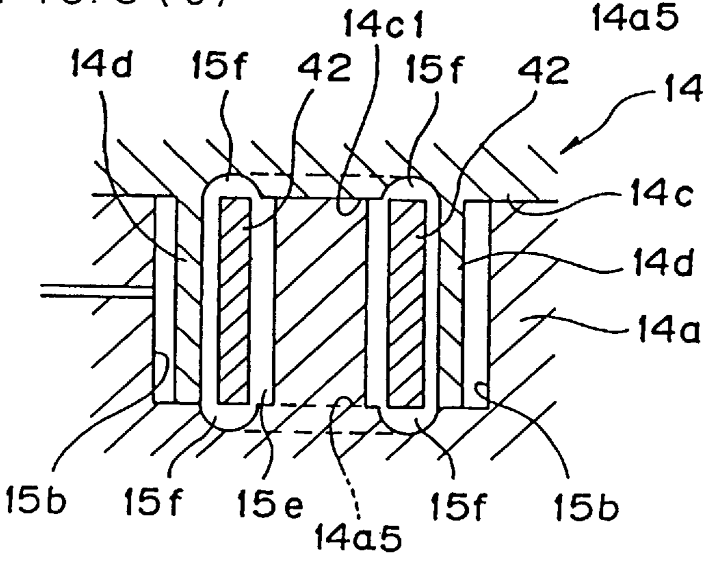


FIG. 3(d)

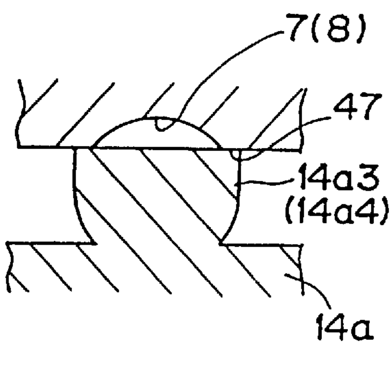


FIG. 4(a)

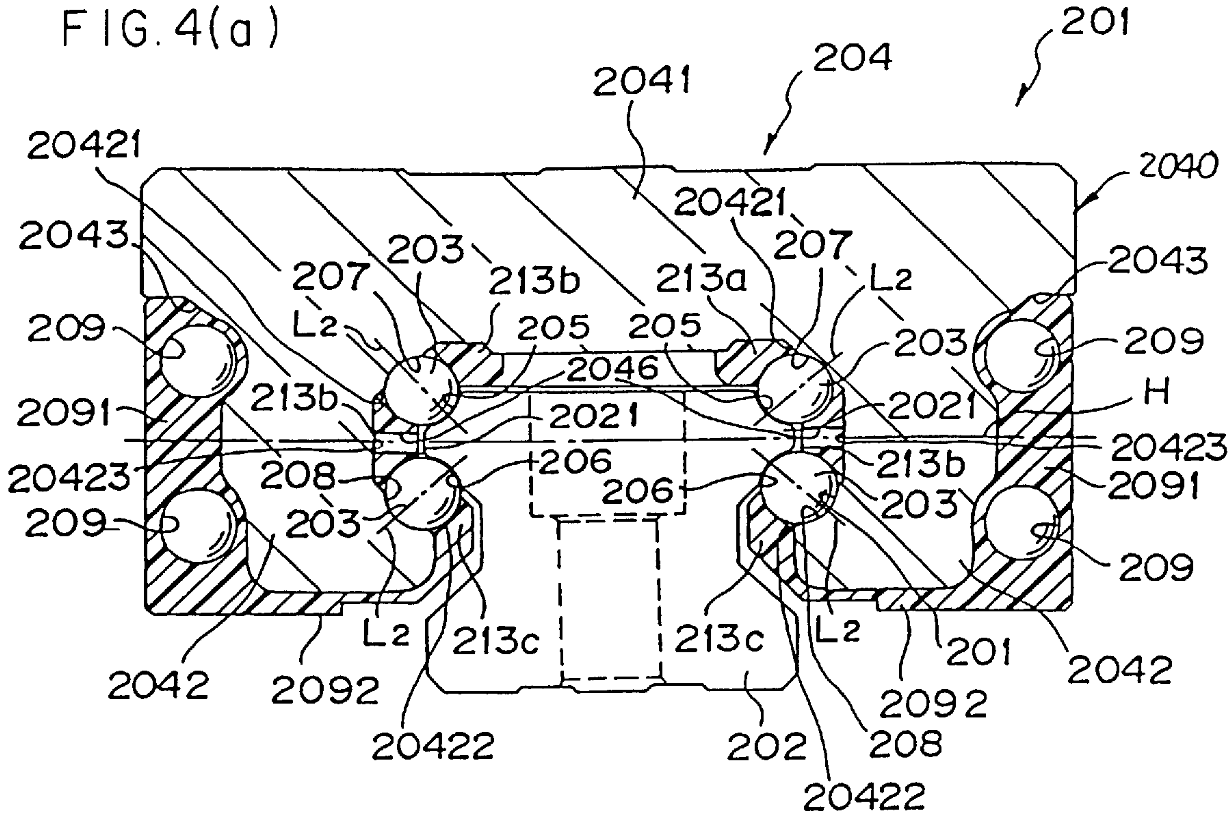
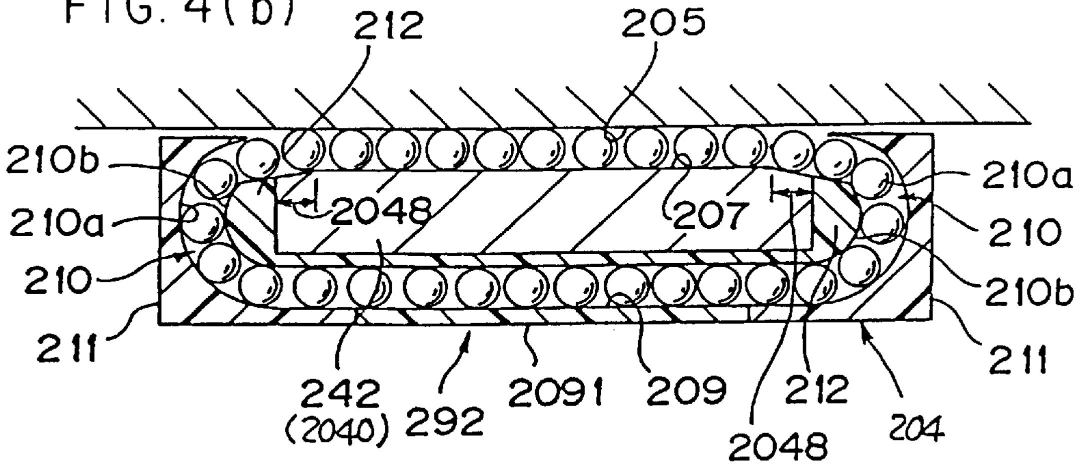


FIG. 4(b)



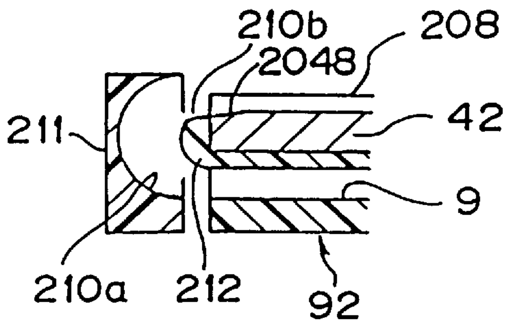


FIG. 4(c)

FIG. 5(a)

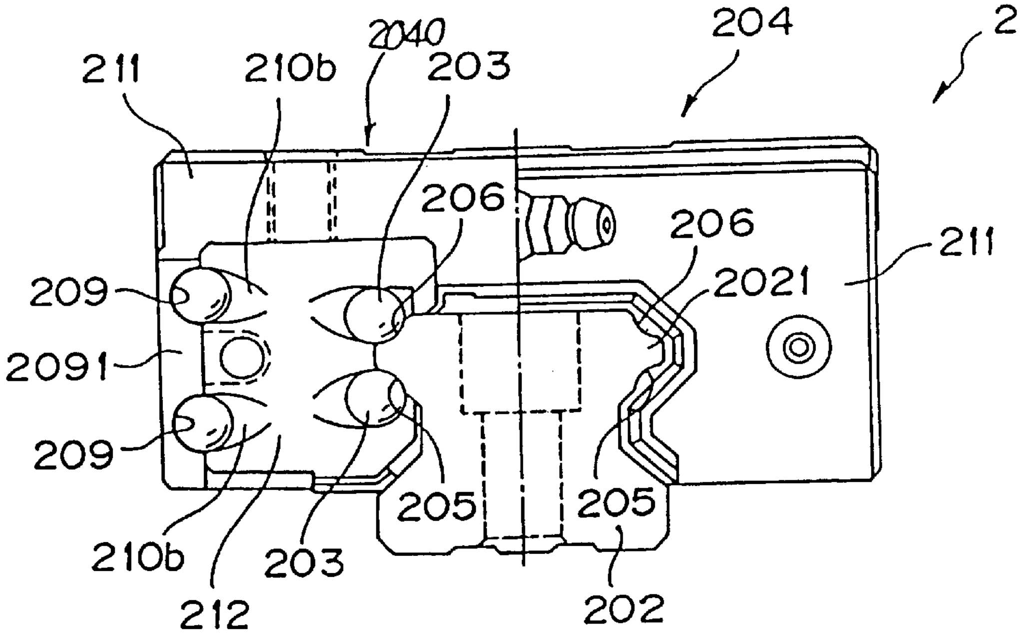

2040
204
201
211
210b
203
206
206
211
209
2021
2091
209
205
205
210b
203
202
212

FIG. 5(b)

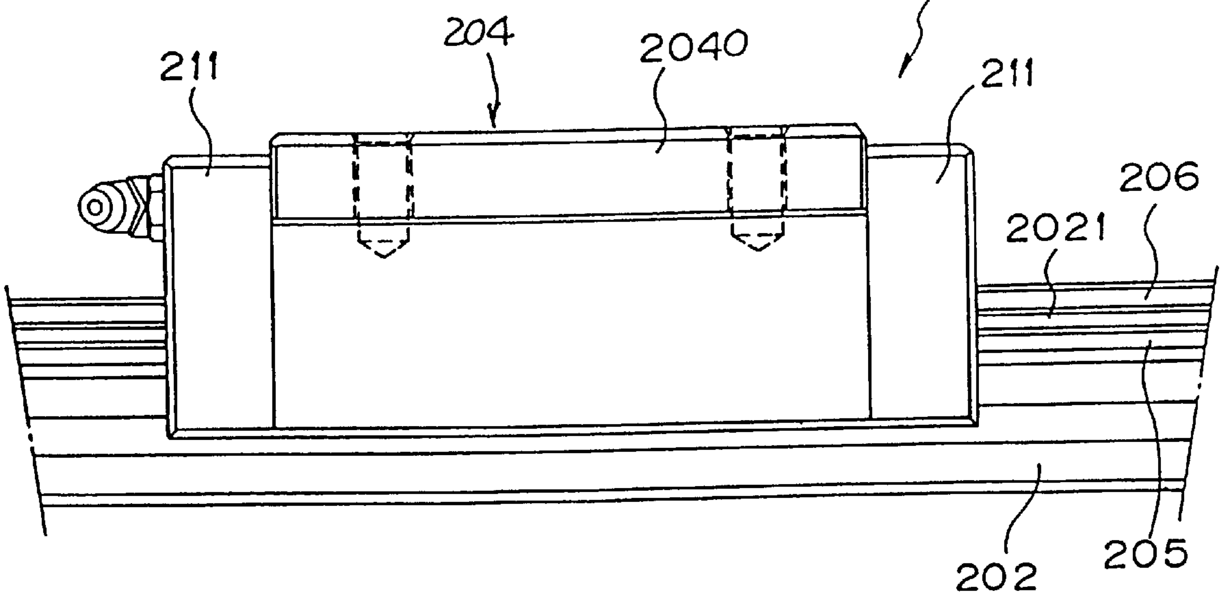

201
204
2040
211
211
206
2021
202
205

FIG. 6(a)

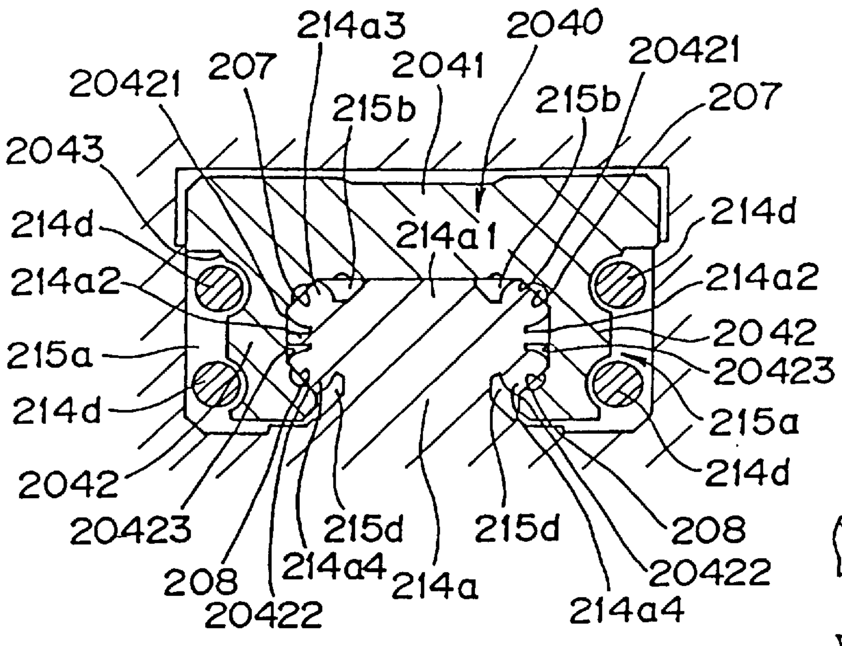


FIG. 6(d)

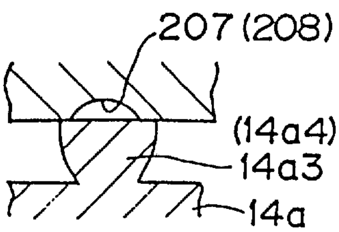


FIG. 6(b)

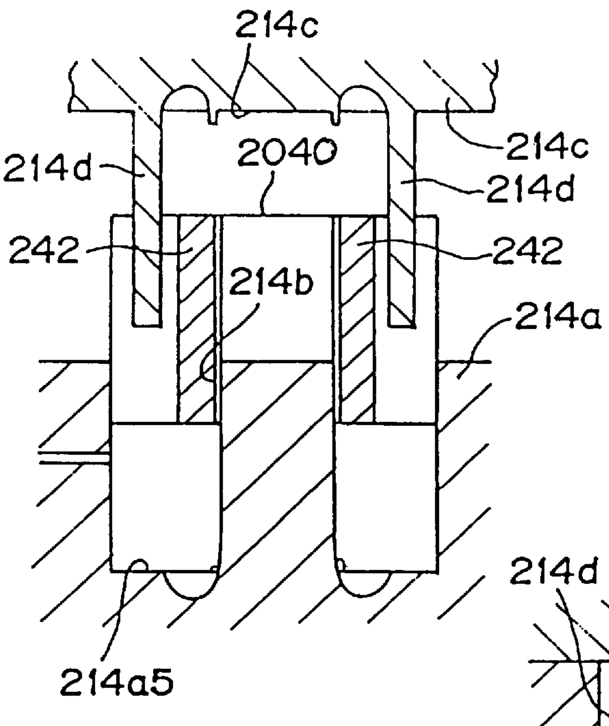


FIG. 6(e)

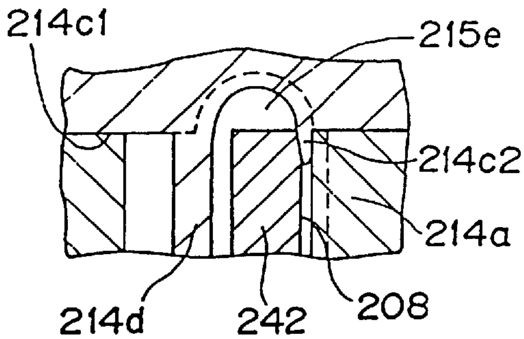


FIG. 6(c)

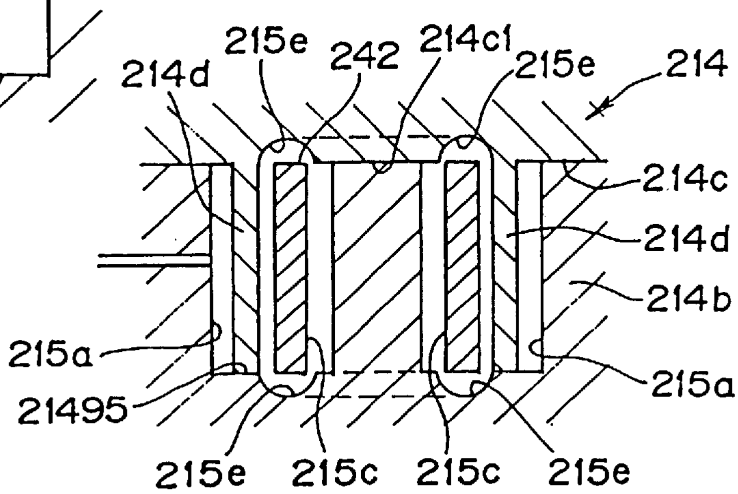


FIG. 7(a)

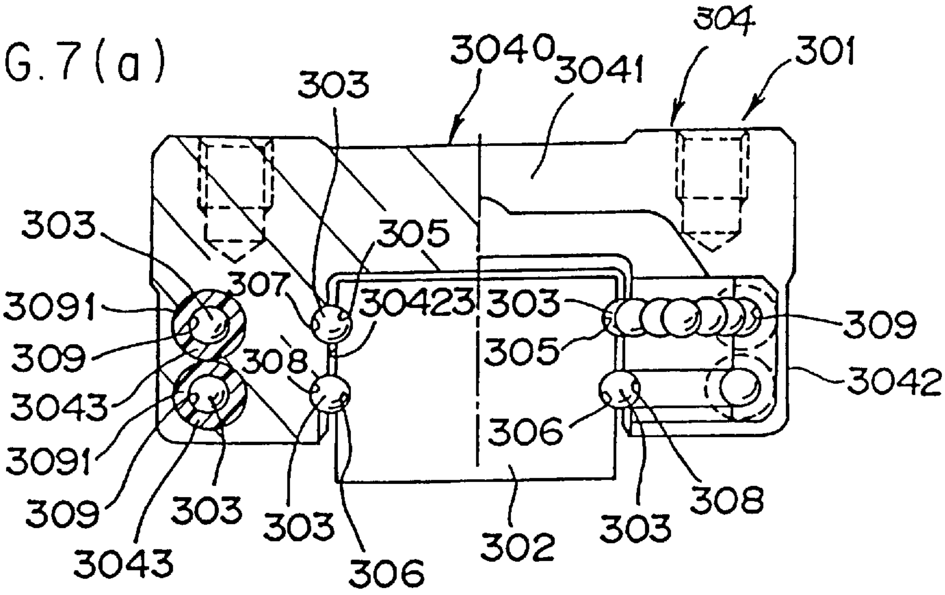


FIG. 7(b)

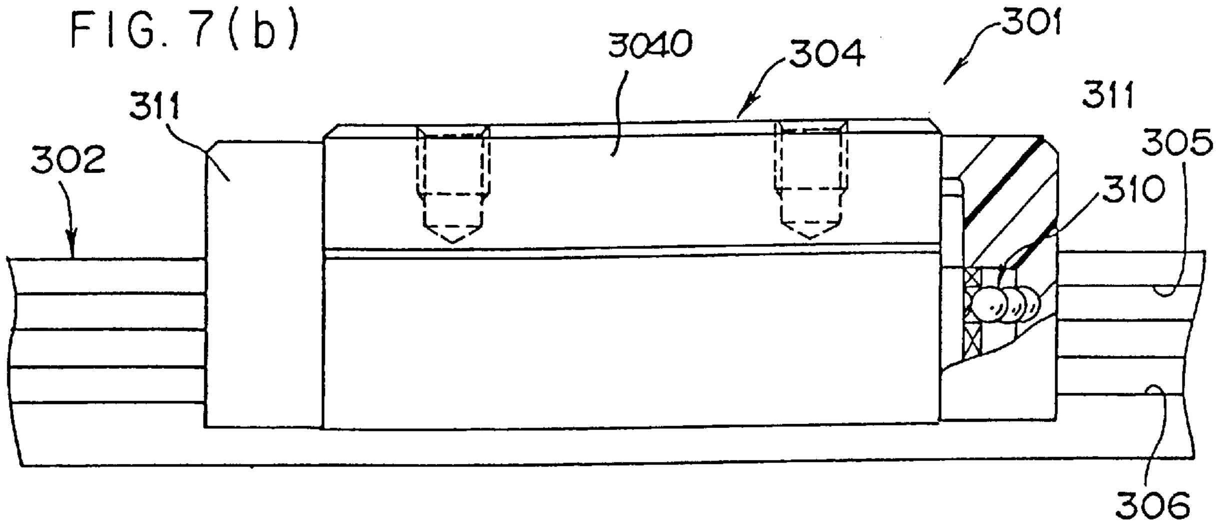


FIG. 7(c)

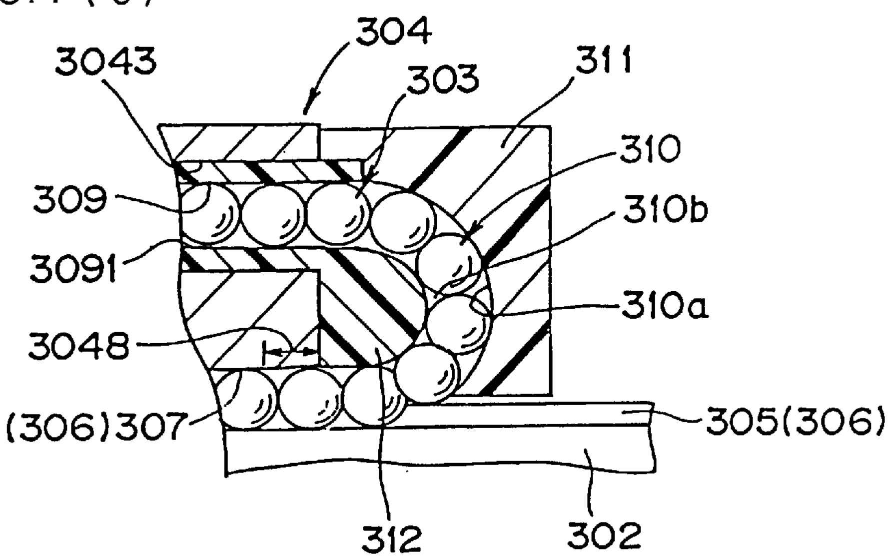


FIG. 8(a)

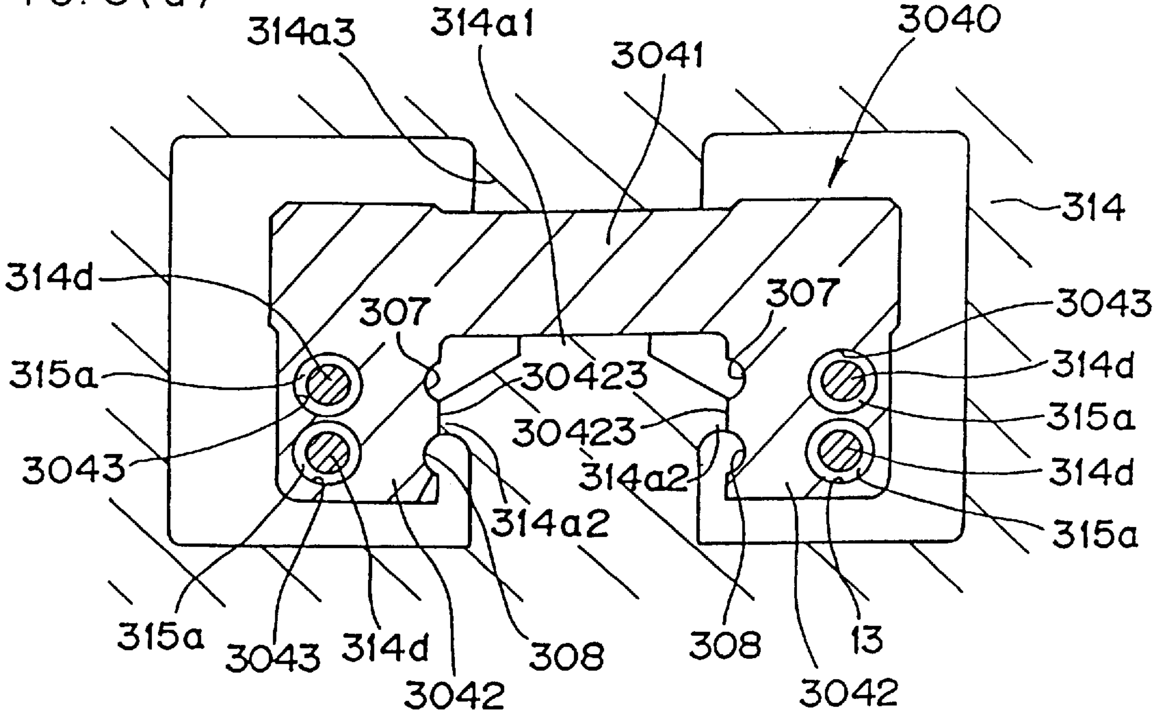

314a3
314a1
3040
3041
314
314d
307
307
3043
315a
30423
314d
315a
30423
3043
314a2
314d
314a2
315a
315a
3043
314d
308
308
13
3042
3042

FIG. 8(b)

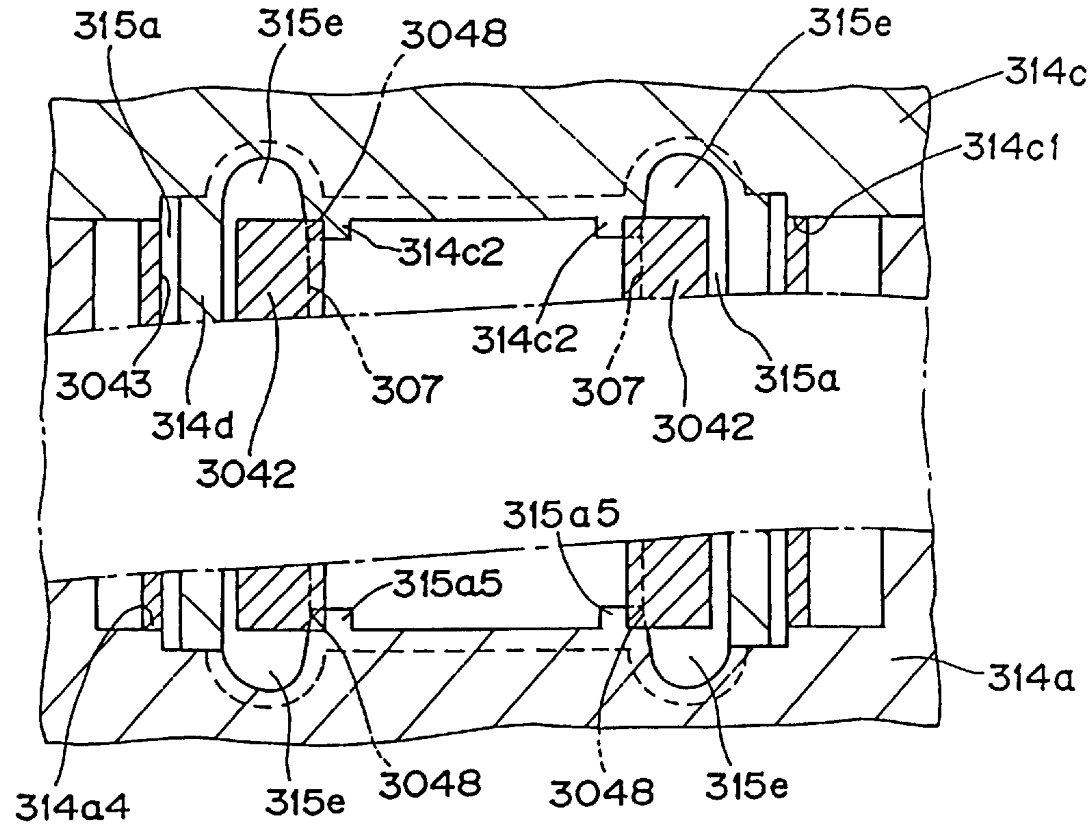

315a
315e
3048
315e
314c
314c1
314c2
314c2
3043
307
307
315a
314d
3042
3042
315a5
315a5
314a
314a4
315e
3048
3048
315e

FIG. 9(a)

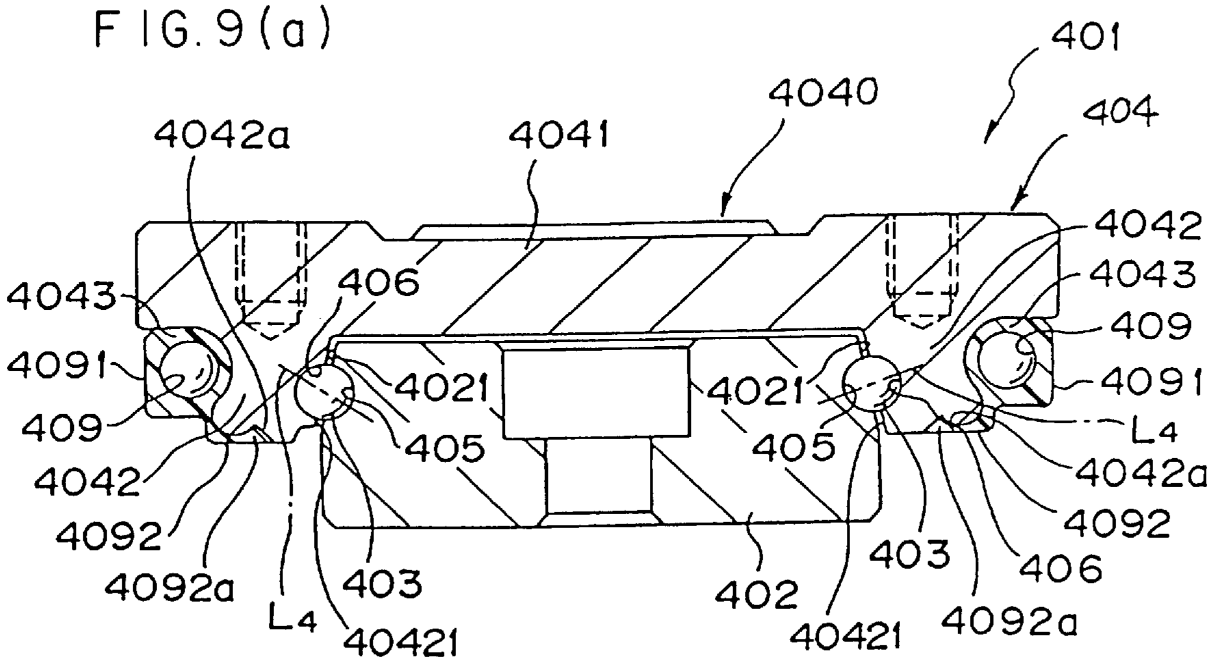


FIG. 9(b)

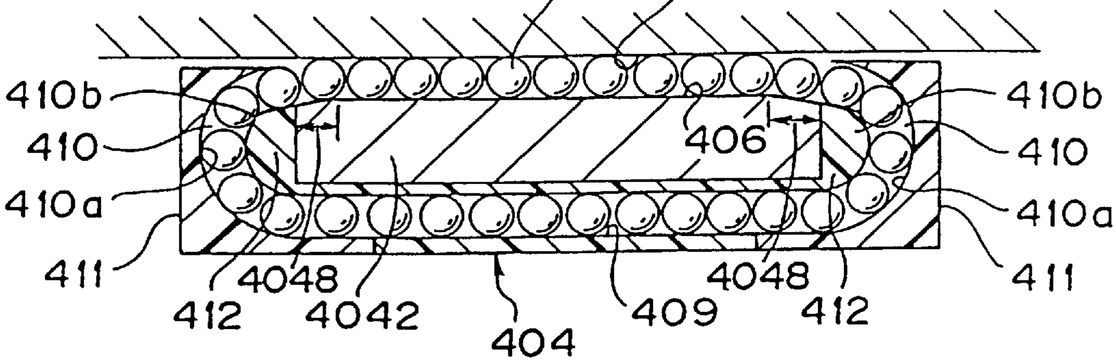


FIG. 9(c)

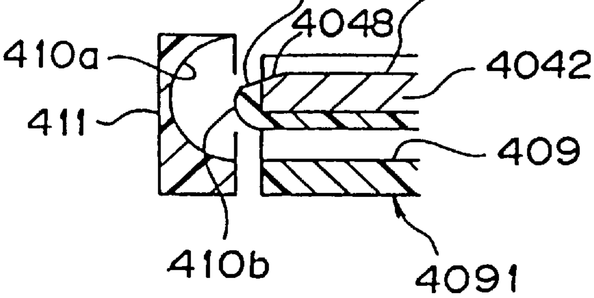


FIG.10(a)

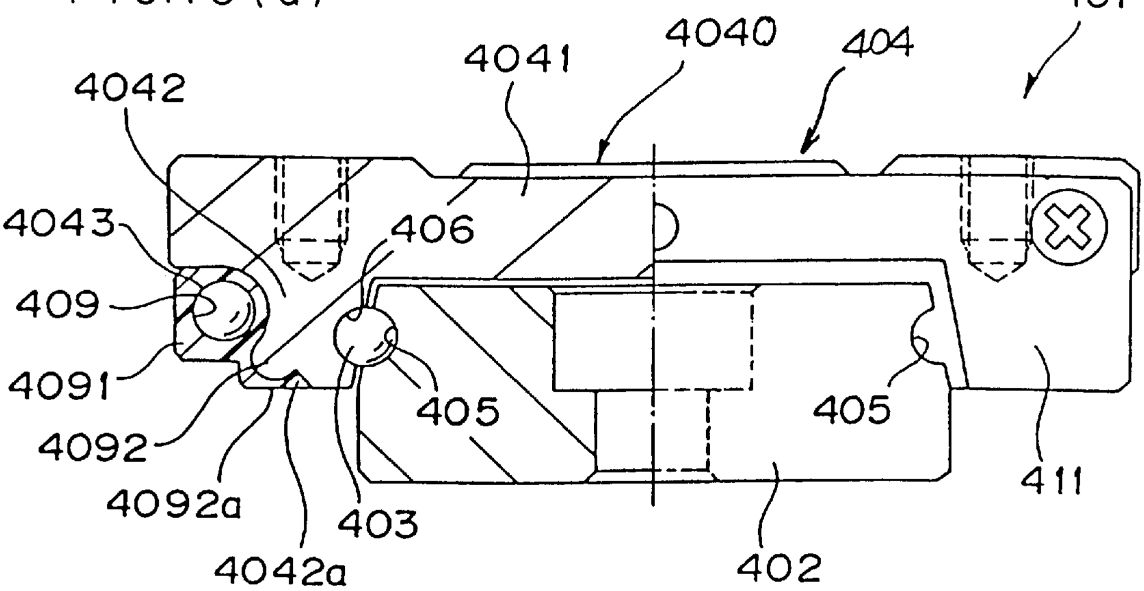


FIG.10(b)

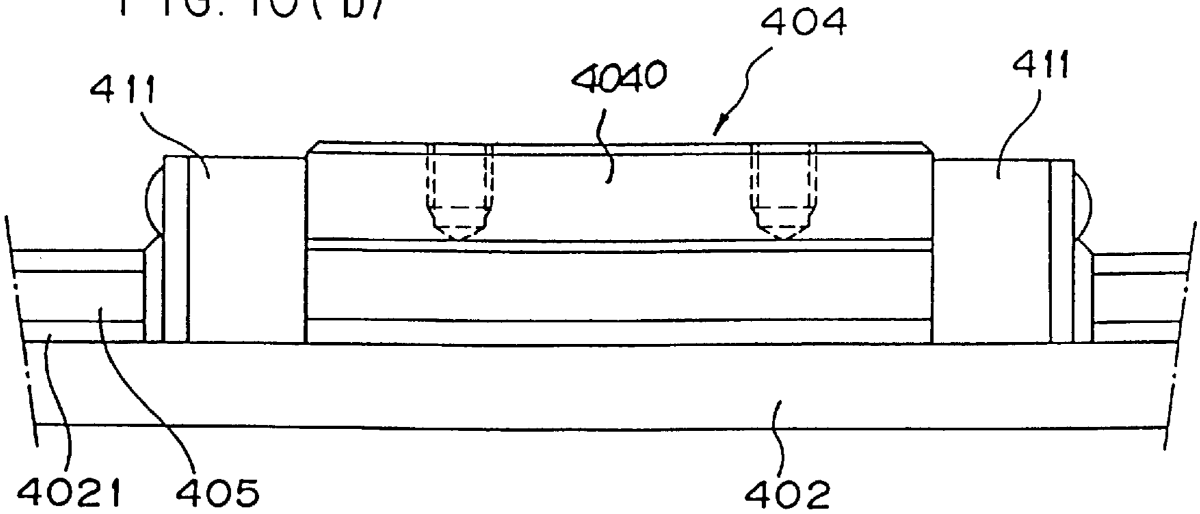


FIG. 11(a)

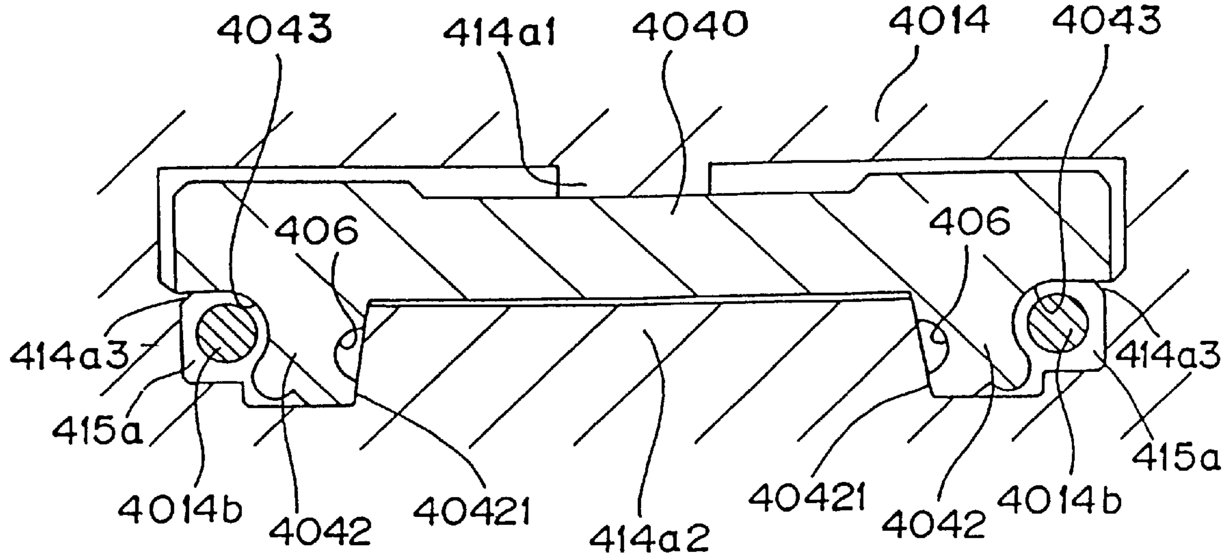


FIG. 11(b)

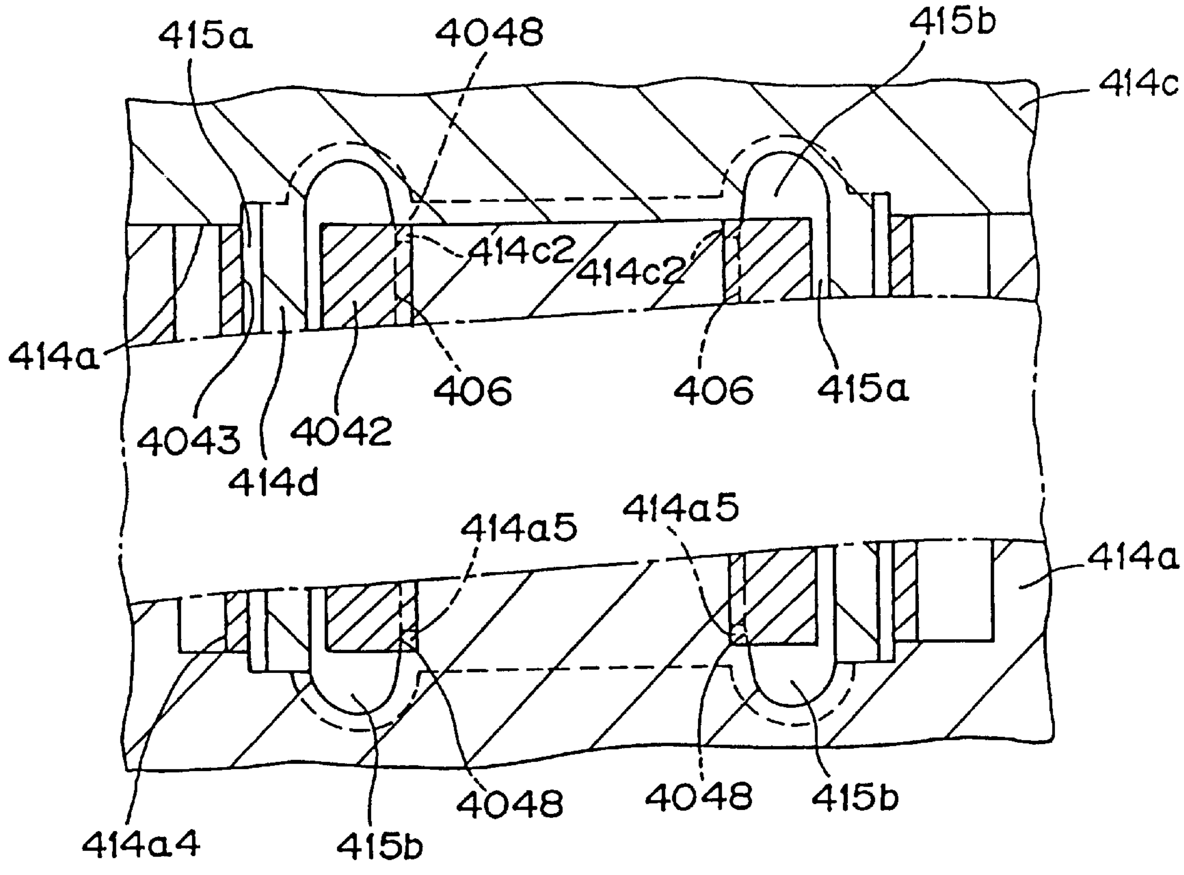


FIG. 12(a)

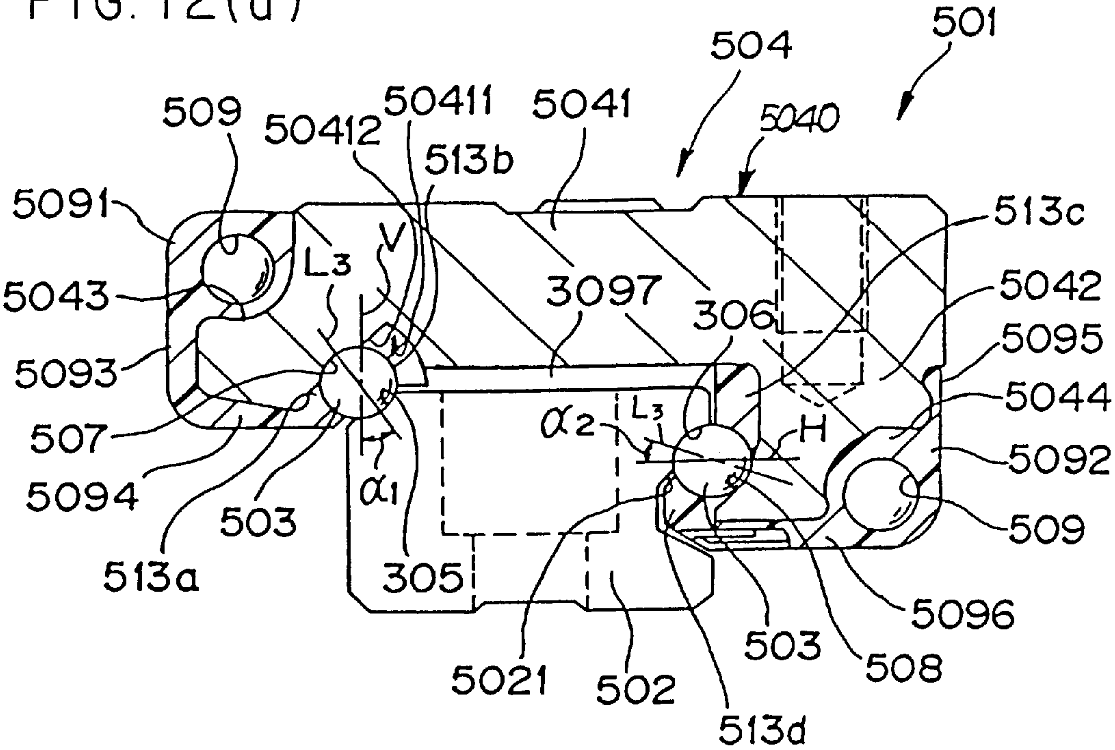
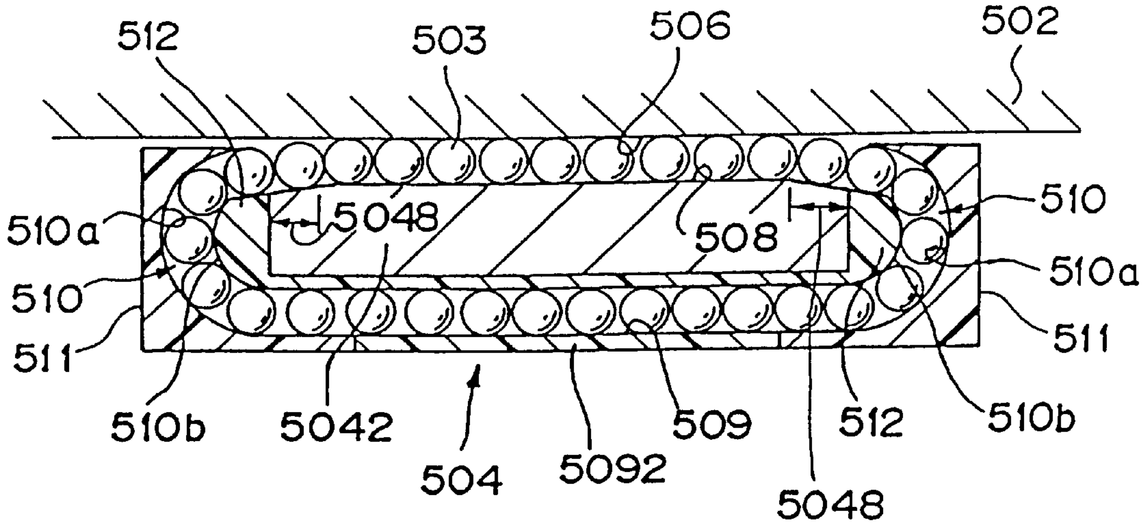


FIG. 12(b)



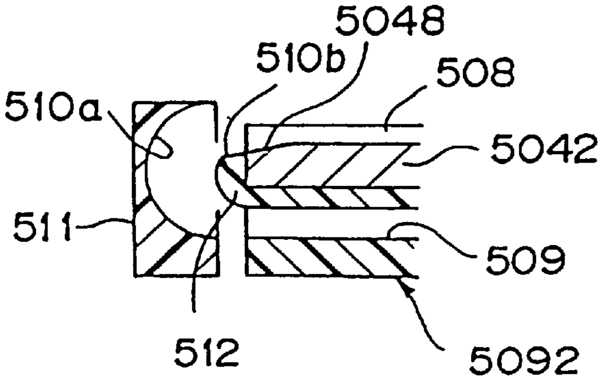


FIG. 12(c)

FIG. 13(a)

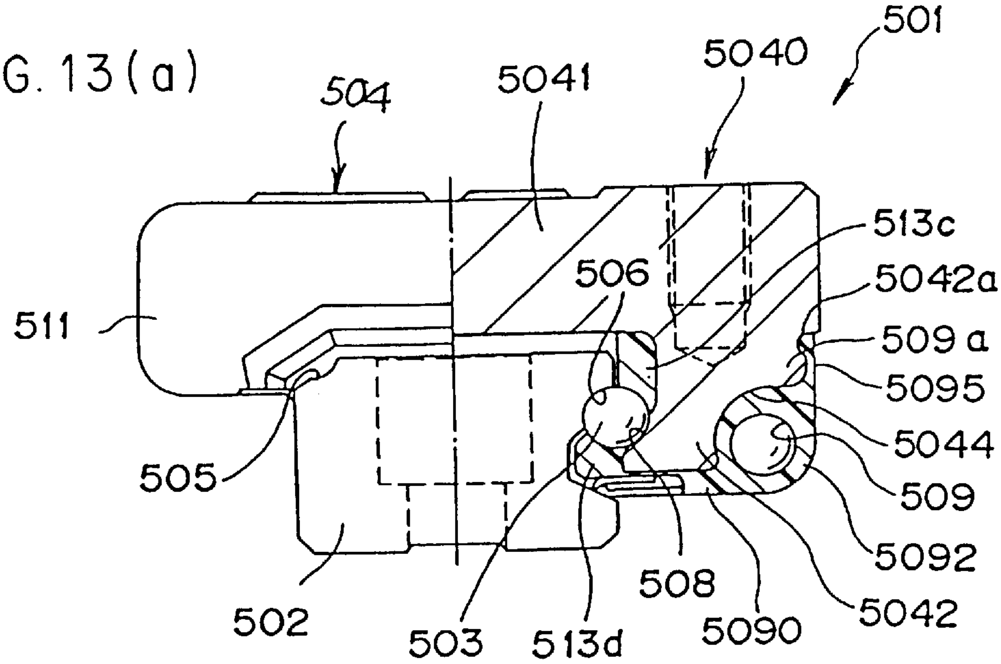


FIG. 13(b)

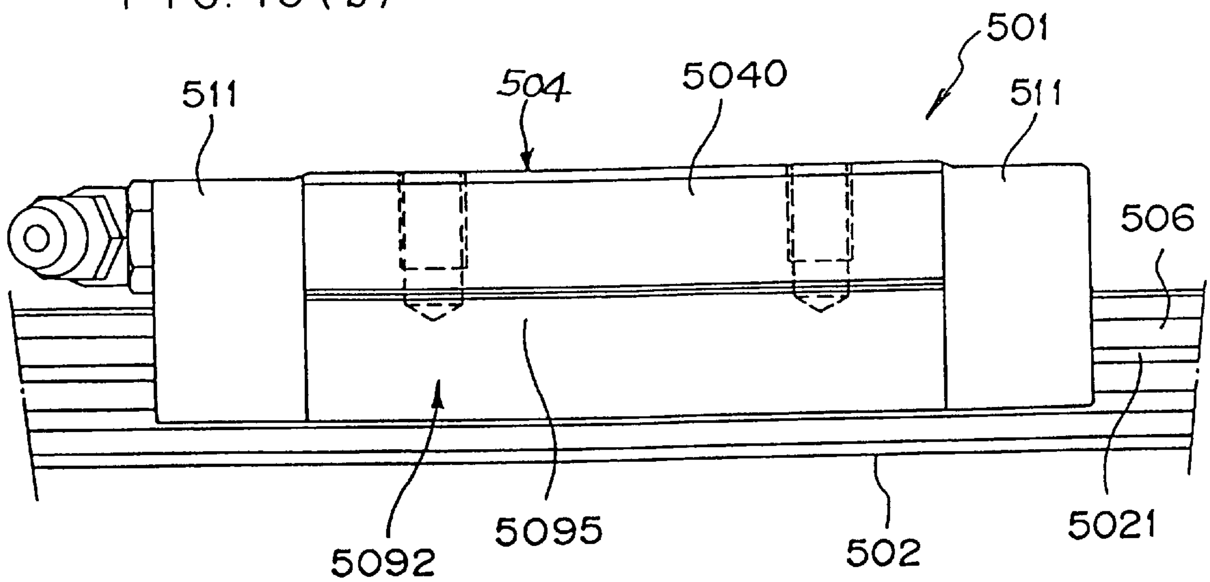


FIG. 14(a)

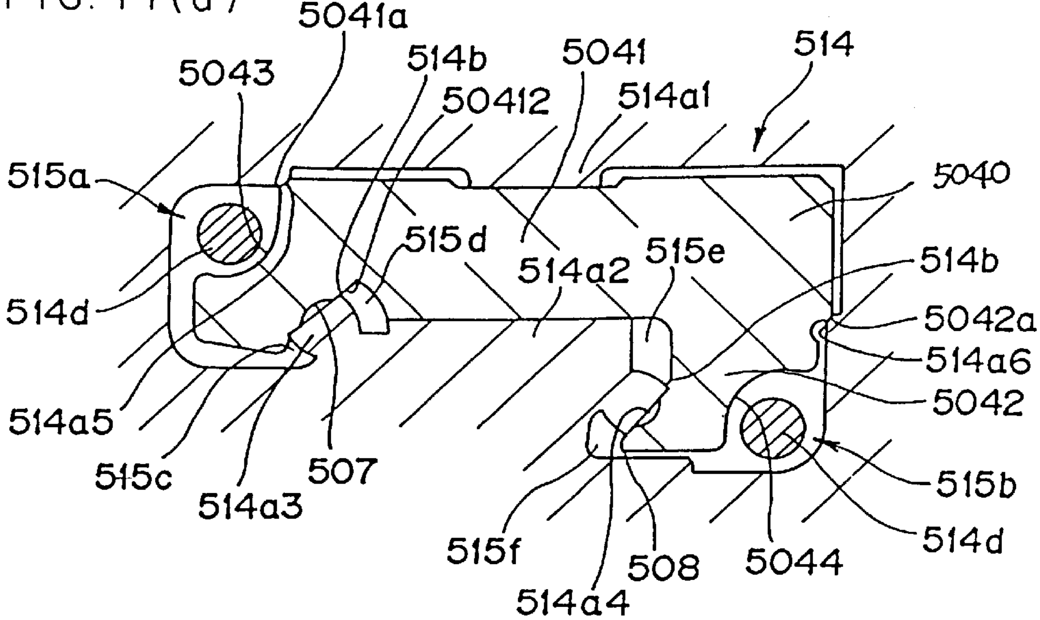
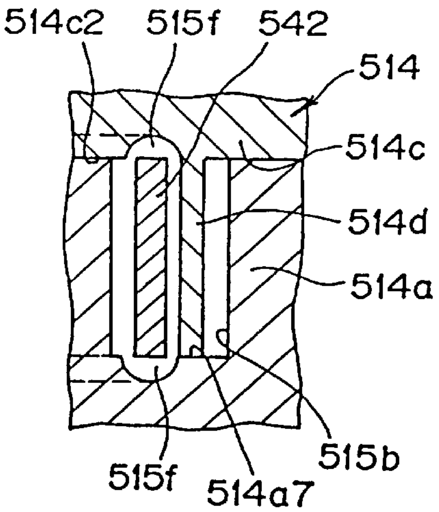


FIG. 14(b)



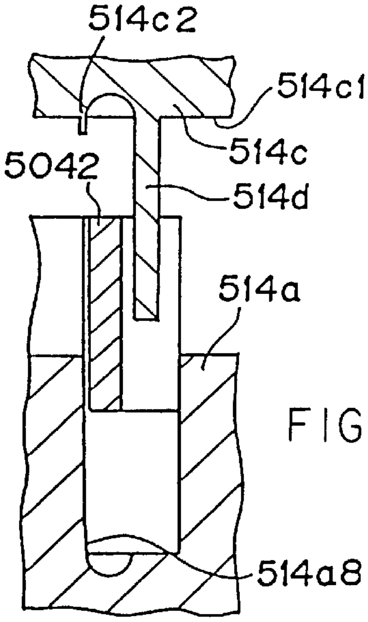


FIG. 14(c)

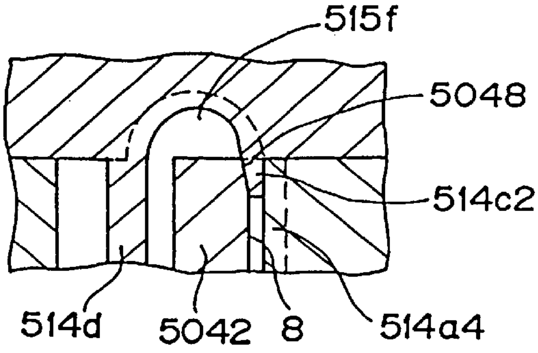


FIG. 14(d)

METHOD OF FORMING A MOVING BLOCK OF A ROLLING MOTION GUIDING DEVICE

TECHNICAL FIELD

The present invention relates to a method of molding a movable block for a rolling motion guide device in which a movable block is movably assembled to a track rail through rows of rolling members.

BACKGROUND ART

The rolling motion guide device of this type has a structure comprising a track rail formed with rolling member rolling grooves, a movable block provided to the track rail so as to be movable along the track rail, the movable block having a rolling member rolling groove which is opposed to the rolling member rolling groove formed to the track rail, and a row of rolling members (hereinafter referred to simply as "rolling members") disposed between the opposing rolling member rolling grooves formed to the track rail and the movable block.

The applicant of this invention had already proposed a rolling motion guide device in which a movable block is provided with a circulation passage for circulating the row of rolling members and at least part of the circulation passage is constituted as a molded portion (see Japanese Patent Laid-open Publication No. HEI 7-317762).

The molding operation is performed in such a manner that a movable block body is disposed in a molding die, then an integrally-molding is conducted by injecting molding material into a cavity formed between an inner surface of the molding die and the movable block body when the molding die is closed. In this case, conventionally, a supporting portion which engages with the rolling member rolling groove is provided in the molding die, so that the movable block body is positioned with reference to the rolling member rolling groove.

However, in the conventional method of molding the movable block described above, since the rolling member rolling groove is engaged with the supporting portion provided in the molding die, there may be a fear of the rolling member rolling groove being damaged or injured. In order to prevent such damage or injury of the rolling member rolling groove, it may be effective to reduce an engaging force between the supporting portion and the rolling member rolling groove. In this case, however, there may be a fear that the molding material will disadvantageously invade into the rolling member rolling groove and burrs are liable to occur thereto. Further, the positioning of the movable block body will be unstable.

The present invention has been achieved for solving the aforementioned problems encountered in the prior art, and an object of the present invention is to provide a method of molding a movable block for a rolling motion guide device which is capable of effectively preventing the formation of burrs in the rolling member rolling groove and accurately positioning the movable block body.

DISCLOSURE OF THE INVENTION

In order to achieve the aforementioned object, the present invention provides a method of molding a movable block for a rolling motion guide device comprising a track rail formed with rolling member rolling grooves, a movable block having rolling member rolling grooves opposing to the rolling member rolling grooves formed to the track rail, the movable block being movably provided along the track rail

and a row of rolling members disposed between the opposing rolling member rolling grooves formed to the track rail and the movable block, wherein a circulation passage for circulating the rows of rolling members is formed to the movable block, at least a part of the circulation passage is constituted by a die-molded portion, and the die-molded portion is integrally molded with a movable block body by an inserting molding method in which the movable block is disposed in a molding die, the method comprising the steps of:

- positioning the movable block body in a width direction and in a vertical direction in the molding die by supporting a plain surface having no rolling member rolling groove of the movable block body;
- positioning the movable block body in a longitudinal direction by supporting both end surfaces in a longitudinal direction of the movable block body;
- preventing a molding material from invading into the rolling member rolling grooves by shutting off the molding material at both ends or both side peripheries of the rolling member rolling grooves; and
- integrally molding the die-molded portion with the movable block body.

The molding die comprises a block supporting portion for positioning the movable block body in a width direction and in a vertical direction in the molding die by supporting a plain surface having no rolling member rolling groove of the movable block body, for positioning the movable block body in a longitudinal direction by supporting both end surfaces in a longitudinal direction of the movable block body, and for preventing a molding material from invading into the rolling member rolling grooves by shutting off the molding material at both end portions or both side peripheries of the rolling member rolling grooves.

According to the present invention described above, the positioning of the movable block body in width, vertical and longitudinal directions is performed at the plain surface which is different from the rolling member rolling groove, so that the damage or injury of the rolling member rolling groove can be prevented.

In addition, since the molding material is shut off at least at both end portions or both side peripheries of the rolling member rolling grooves, the molding material can be prevented from invading into the rolling member rolling grooves.

Accordingly, the movable block body can be stably positioned by being supported with a large supporting force regardless of the rolling member rolling grooves.

In another aspect of this invention, the method is characterized in that the movable block body comprises a horizontal portion extending in width and longitudinal directions, and a pair of leg portions protruding in a height direction from both the end portions in a width direction of the horizontal portion so as to oppose to side surfaces of the track rail, and in a case where inner side surfaces of the leg portions have inclined surfaces extending toward the protruded portions of the leg portions and gradually inclined toward a side of the track rail, the movable block body is positioned within the molding die in a width direction and in a height direction by supporting at least the inclined surfaces of both the inner side surfaces of both the leg portions and a lower surface of the horizontal portion.

The molding die comprises a block supporting portion for positioning the movable block in a width direction and in a height direction by supporting at least the inclined surfaces of both the inner surfaces of both the leg portions of the movable block body and a lower surface of the horizontal portion.

In this case, a backlash in a height direction of the movable block body is restricted and supported by the inclined surfaces of the inner surfaces of both the leg portions, while a backlash in a width direction of the movable block body is restricted and supported by the inner surfaces of both the leg portions.

In a further aspect of this invention, the method is characterized in that the movable block body comprises a horizontal portion extending in a width direction and a longitudinal direction and a pair of leg portions protruding in a height direction from both the end portions in a width direction of the horizontal portion so as to oppose to side surfaces of the track rail, and in a case where inner side surfaces of the leg portions have an almost vertical surfaces, the movable block body is positioned in a width direction and in a height direction by supporting at least the vertical surfaces of both the inner side surfaces of both the leg portions and both upper and lower surfaces of the horizontal portion.

The molding die comprises a block supporting portion for positioning the movable block body in a width direction and in a height direction by supporting at least the vertical surfaces of both the inner surfaces of both the leg portions and both upper and lower surfaces of the horizontal portion.

In this case, since the inner side surfaces of both the leg portions are vertical surfaces, a backlash in a height direction of the movable block body is restricted and supported by the lower surface of the horizontal portion, while a backlash in a width direction of the movable block body is restricted and supported by the inner surfaces of both the leg portions.

In a still further aspect of this invention, the method is characterized in that the movable block body comprises a horizontal portion extending in a width direction and in a longitudinal direction, and a pair of leg portions protruding in a height direction from both the end portions in a width direction of the horizontal portion so as to oppose to side surfaces of the track rail, and in a case where inner side surfaces of the leg portions have inclined surfaces extending toward the protruded portions of the leg portions and gradually inclined toward a side opposite to the track rail, the movable block body is positioned in a width direction and in a height direction by supporting at least the inclined surfaces of both the inner side surfaces of both the leg portions and an upper surface of the horizontal portion.

The molding die comprises a block supporting portion for positioning the movable block body in a width direction and in a height direction by supporting at least the inclined surfaces of both the inner surfaces of both the leg portions of the movable block body and an upper surface of the horizontal portion.

In this case, a backlash in a height direction of the movable block body is restricted and supported between the inner surfaces of both the leg portions and an upper surface of the horizontal portion, while a backlash in a width direction of the movable block body is restricted and supported by the inner surfaces of both the leg portions.

In a still further aspect of this invention, the method is characterized in that the movable block body comprises a horizontal portion extending in a width direction and in a longitudinal direction, and a leg portion protruding in a height direction from one end portion in a width direction of the horizontal portion so as to oppose to one side surface of the track rail, and in a case where an inner side surface of the leg portion has an almost vertical surface or an inclined surface extending toward a protruded end portion and gradually inclined to a side of the track rail, the movable block body is positioned within the molding die in a width direction and in a height direction by supporting at least both the inner and outer side surfaces of the leg portion and both upper and lower surfaces of the horizontal portion.

The molding die comprises a block supporting portion for positioning the movable block body in a width direction and in a height direction by supporting at least both the inner and outer side surfaces of the leg portion and both upper and lower surfaces of the horizontal portion.

In a case where the inner side surface of the leg portion is a vertical surface, a backlash in a height direction of the movable block body is restricted and supported by both the upper and lower surfaces of the horizontal portion, while a backlash in a width direction of the movable block body is restricted and supported by both the inner and outer side surfaces of the leg portion.

In a case where the inner side surface of the leg portion is an inclined surface, a backlash in a height direction of the movable block body is restricted and supported by both the upper and lower surface of the horizontal portion.

In a still further aspect of this invention, the method is characterized in that the positioning in a longitudinal direction of the movable block body in the molding die is performed by supporting a direction changing guide portion formed to both end portions of the rolling member rolling groove of the movable block body.

The molding die comprises a block supporting portion for positioning the movable block body in a longitudinal direction by supporting the direction changing guide portion formed to both end portions of the rolling member rolling groove of the movable block body.

The direction changing guide portion is provided for allowing the rolling members to smoothly change the rolling direction of the rolling members such that a load is gradually applied to the rolling members when the rolling members are moved from a non-loaded region to a loaded region. When the movable block body is positioned with reference to this direction changing guide portion, the positioning of the movable block body and the shutting off the molding material can be performed simultaneously.

In a still further aspect of this invention, the method is characterized in that the circulation passage comprises the rolling member rolling groove to be formed to the movable block, a rolling member return passage to be formed in parallel to the rolling member rolling groove, and a direction changing passage for connecting the rolling member rolling groove to the rolling member return passage, wherein the die molded portion constitutes at least one of a rolling member retaining portion to be formed at both side peripheries of the rolling member rolling groove, a return passage forming portion for forming the rolling member return passage, and a direction changing inner peripheral guide forming portion for forming an inner peripheral portion of the direction changing passage.

The position of the movable block body in the molding die is accurately determined, so that the boundary portion between the end portion of the rolling member rolling groove formed to the movable block and the direction changing passage inner peripheral portion can be formed without causing irregularities.

Further, in a case where the rolling member return passage and the movable block body are integrally molded, a location of the rolling member return passage with respect to the movable block body can be accurately made.

Furthermore, in a case where the rolling member retaining portion and the movable block body are integrally molded, a location of the rolling member retaining portion with respect to the rolling member rolling groove can be accurately made.

In addition, when both the rolling member returning passage and the direction changing passage inner periphery guide portion are integrally formed with the movable member, the joint portion between the rolling member returning passage and the direction changing inner periphery guide portion can be molded so as to provide a continuous surface without causing irregularities.

In a case where the direction changing passage inner periphery guide portion and the rolling member retaining portion are integrally formed, the joint portion between the rolling member retaining portion and the direction changing inner periphery guide portion can be molded without causing irregularities.

In addition, in a case where all of the rolling member retaining portion, the direction changing passage inner periphery guide portion and the rolling member returning passage are integrally molded with the movable block body, each of the joint portions to be formed at an entire circumference of the circulation passage can be molded without causing irregularities.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view showing a first embodiment of a rolling motion guide device according to the present invention, in which

FIG. **1**(*a*) is a cross sectional view taken along the plane orthogonal to the track rail,

FIG. **1**(*b*) is a view showing a structure of a ball circulating passage,

FIG. **1**(*c*) is a partially exploded sectional view showing a direction changing passage, and

FIG. **1**(*d*) is a sectional view showing a ball retaining portion.

FIG. **2** is a view showing a first embodiment of a rolling motion guide device according to the present invention, in which

FIG. **2**(*a*) is a front view of a half-sectioned movable block and

FIG. **2**(*b*) is a side view of a half sectioned movable block.

FIG. **3** is a view showing a method of molding the movable block, in which

FIG. **3**(*a*) is a cross sectional view of a fixed molding-die to which the movable block body is inserted,

FIG. **3**(*b*) is a longitudinal sectional view showing a molding die in an opened-state,

FIG. **3**(*c*) is a longitudinal sectional view showing a molding die in a closed-state,

FIG. **3**(*d*) is a view showing a state where the molding material is shut off at side peripheries of the ball rolling groove, and

FIG. **3**(*e*) is a schematically and partially cross sectional view showing a state where the molding material is shut off at both ends of the ball rolling groove.

FIG. **4** is a view showing a second embodiment of a rolling motion guide device according to the present invention, in which

FIG. **4**(*a*) is a cross sectional view taken along a plane orthogonal to the track rail,

FIG. **4**(*b*) is a view showing a structure of a circulation passage, and

FIG. **4**(*c*) is a partially exploded sectional view showing a direction changing passage.

FIG. **5** is a view showing a second embodiment of a rolling motion guide device according to the present invention, in which

FIG. **5**(*a*) is a front view of a side cover of the movable block of which half portion is omitted and

FIG. **5**(*b*) is a side view showing the movable block.

FIG. **6** is a view showing a second embodiment of the method of molding the movable block according to the present invention, in which

FIG. **6**(*a*) is a cross sectional view of a fixed molding die to which the movable block body is inserted,

FIG. **6**(*b*) is a longitudinal sectional view showing a molding die in an opened-state,

FIG. **6**(*c*) is a longitudinal sectional view showing a molding die in a closed-state,

FIG. **6**(*d*) is a view showing a state where the molding material is shut off at side peripheries of the ball rolling groove, and

FIG. **6**(*e*) is a schematically and partially cross-sectional view showing a state where the molding material is shut off at both end portions of the ball rolling groove.

FIG. **7** is a view showing a third embodiment of a rolling motion guide device according to the present invention, in which

FIG. **7**(*a*) is a front view, half in section, of a movable block in a state where a side cover is detached from the end surface of the movable block,

FIG. **7**(*b*) is a side view, partially broken, of the movable block, and

FIG. **7**(*c*) is a partially enlarged cross sectional view showing a direction changing passage.

FIG. **8** is a view showing a third embodiment of the method of molding the movable block according to the present invention, in which

FIG. **8**(*a*) is a cross sectional view of a fixed molding die into which the movable block body is inserted and

FIG. **8**(*b*) is a partially omitted longitudinal sectional view showing a molding die in a closed-state.

FIG. **9** is a view showing a fourth embodiment of a rolling motion guide device according to the present invention, in which

FIG. **9**(*a*) is a cross sectional view in a direction orthogonal to the track rail,

FIG. **9**(*b*) is a view showing a structure of a ball circulating passage, and

FIG. **9**(*c*) is a partially exploded sectional view showing a direction changing passage.

FIG. **10** is a view showing a fourth embodiment of a rolling motion guide device according to the present invention, in which

FIG. **10**(*a*) is a front view of a half-sectioned movable block and

FIG. **10**(*b*) is a side view of the movable block.

FIG. **11** is a view showing a fourth embodiment of the method of molding the movable block according to the present invention, in which

FIG. **11**(*a*) is a cross sectional view of a fixed molding die into which the movable block body is inserted and

FIG. **11**(*b*) is a partially omitted longitudinal sectional view showing a molding die in a closed-state.

FIG. **12** is a view showing a fifth embodiment of a rolling motion guide device according to the present invention, in which

FIG. **12**(*a*) is a cross sectional view in a direction orthogonal to the track rail, FIG. **12**(*b*) is a view showing a structure of a ball circulating passage, and

FIG. **12**(*c*) is a partially exploded sectional view showing a direction changing passage.

FIG. **13** is a view showing a fifth embodiment of a rolling motion guide device according to the present invention, in which

FIG. **13**(*a*) is a front view, half in section, of an end surface of the movable block and

FIG. **13**(*b*) is a side view of the movable block.

FIG. **14** is a view showing a molding die used in the fifth embodiment of the method of molding the movable block according to the present invention, in which

FIG. **14**(*a*) is a cross sectional view of a fixed molding die,

FIG. **14**(*b*) is a partially sectional view, in a longitudinal direction, showing a molding die in a closed-state,

FIG. **14**(*c*) is a partially sectional view, in a longitudinal direction, showing a molding die in an opened-state, and

FIG. **14**(*d*) is a partially sectional view showing a state where the molding material is shut off at both end portions of the ball rolling groove.

BEST MODE FOR EMBODYING THE INVENTION

In order to explain the present invention in more detail, the preferred embodiments of this invention will be described hereunder with reference to the accompanying drawings.

First Embodiment

FIGS. **1** and **2** show a first embodiment of a rolling motion guide device according to the present invention.

As shown in FIG. **1**(*a*), the rolling motion guide device **1** is constructed by comprising a track rail **2** and a movable block **4** having a U-shape in section and movably supported by the track rail **2** through four rows in total of balls **3** in which two rows of balls are disposed to an upper surface side of the track rail **2** while one row of balls is disposed to each of right and left side surfaces of the track rail **2**.

The track rail **2** is an elongated member formed to provide a rectangular shape in section. Upper half portions of both right and left side surfaces of the track rail **2** are formed to provide tapered surfaces **21** so that the upper half portions gradually protrude outside as position advances upward. Each of the right and left tapered surfaces **21** is formed with one row of ball rolling groove as a rolling member rolling groove, respectively. In contrast, an upper surface of the track rail **2** is a plain surface and each of both right and left end portions thereof is formed with one row of ball rolling groove **5**, two rows in total.

The movable block **4** is a block body having a high rigidity and a U-shaped cross section, and has a movable block body **40** comprising a horizontal portion **41** opposing to the upper surface of the track rail **2** and a pair of leg portions **42** and **42** extending downward from both right and left side end portions of the horizontal portion **41** so as to clamp both the right and left side surfaces of the track rail **2**. At the lower surface of the horizontal portion **41** is formed with a pair of ball rolling grooves **7** and **7** corresponding to the paired ball rolling grooves **5** and **5** formed to the upper surface of the track rail **2**, while the inner side surfaces of both the right and left leg portions **42** and **42** are formed with ball rolling grooves **8**, **8** corresponding to the ball rolling grooves **6**, **6** formed to the right and left side surfaces of the track rail **2**.

The right and left leg portions **42** and **42** comprise outwardly directing inclined surfaces **421** each obliquely extending toward the protruded end portions so as to be gradually apart from the track rail **2** and comprise inwardly directing inclined surfaces **422** each obliquely extending in a direction so as to be close to the track rail **2**. The inwardly directing inclined surfaces **422** are formed with ball rolling grooves **7** and **7**.

The ball rows for receiving loads to be applied between the track rail **2** and the movable block **4** are constituted by disposing a number of balls **3** to portions between the four paired ball rolling grooves **5**, **7**; **6**, **8** that mutually correspond to each other and are formed to the opposing surfaces of the movable block **4** and the track rail **2**. The balls **3** are applied with a predetermined preload. As the rolling member other than balls, rollers or the like may be also applicable.

Both end portions of the ball rolling grooves **7**, **8** are performed with a crowning-working so as to provide a ball guide portion **48** having an inclination of which depth gradually increases toward the end portions of the ball rolling grooves. The ball guide portion **48** has a function of rolling and moving the balls from the direction changing passage **10** in a non-loaded region to portions between the ball rolling grooves **5**, **7**; **6**, **8** in a loaded region by gradually applying the load to the balls.

With respect to the balls **3** disposed between the upper surface of the track rail **2** and the horizontal portion **41** of the movable block body **40**, a contact angle line L1 connecting contact points of the respective balls to the ball rolling grooves **5**, **7**; **6**, **8** is set to almost about 90° with respect to a horizontal line H passing through a center of the ball **3**. In contrast, with respect to the balls **3** disposed between the right and left side surfaces of the track rail **2** and the right and left leg portions **42**, **42** of the movable block body **40**, a contact angle line L1 connecting contact points of the respective balls to the ball rolling grooves is set to upwardly incline with a predetermined angle of α with respect to a horizontal line H passing through a center of the ball **3** so as to extend toward a center of the track rail **2**. As a result, the balls have a structure that both the upper end right and left corner portions **22**, **22** of the track rail **2** are clamped by the two rows of balls **3** disposed to the right and left side surfaces and the two rows of balls **3** disposed to the upper surface of the track rail **2**.

The movable block **4** is provided with four rows of ball returning passages **9** for circulating and guiding the four rows of balls **3**. The ball returning passage **9** is constituted by a bore linearly extending in parallel to the respective ball rolling grooves **7**, **8** formed to the movable block **4**. Two rows of the ball returning passages are formed to the horizontal portion **41**, while two rows of the ball returning passages are formed to each of the right and left leg portions **42**, respectively.

The horizontal portion **41** of the movable block **4** is formed with a large-diameter through bore **43** having a diameter larger than that of a cross sectional area of the ball returning passage **9**. A first pipe portion **91** composed of resin as return passage forming member for forming the ball returning passage **9** is integrally bonded to an inner periphery of the through bore **43**.

On the other hand, outer side surface lower end corner portions of the right and left leg portions **42** of the movable block body **40** are formed with a concave portion **44** to which a second pipe portion **92** composed of resin for forming the ball returning passage **9** is integrally bonded. The second pipe portion **92** is formed to be continuous to a thickened lower end surface resin portion **93** covering a lower end surface of the leg portion **42** and to a side surface resin portion **94** covering an outer side surface lower end portion of the leg portion **42**. An upper end of the side surface resin portion **94** is formed with an engaging projection **94***a* which engages with an engaging groove **42***a* formed to an outer side surface of the leg portion **42**.

As shown in FIGS. **1**(*b*), (*c*) and FIG. **2**, a side cover **11**, constituting the direction changing passage **10** in a U-shaped-pipe form for changing the direction of the balls **3** disposed between the track rail **2** and the movable block body **40** toward the ball returning passage **9**, is attached to an end portions of the movable block body **40**. The side cover **11** per se is formed with only an outer peripheral portion **10***a* among the entire direction changing passage **10** in the U-shaped pipe form. Further, a direction changing passage inner peripheral piece portion **12** as a direction changing inner periphery forming member for forming an inner peripheral portion **10***b* of the direction changing passage **10** is integrally bonded to the end portions of the movable block body **40**, and the direction changing passage **10** is constituted by the side covers **11** and the direction changing inner peripheral piece portions **12**. In this regard, the reference numeral **11***a* in figures denotes an end seal for sealing a gap formed between the track rail **2** and the side cover **11** and a reference numeral **11***b* denotes a grease nipple.

In addition, as shown in FIG. **1**(*a*), the movable block **4** is provided with ball retaining members **13** along the four rows of balls **3** for preventing the balls **3** from dropping off from the movable block **4** when the movable block **4** is detached from the track rail **2**. The ball retaining members **13** are composed of resin and comprises a first retainer portion **13***a* integrally bonded to the lower surface of the horizontal portion **41** of the movable block body **40**, right and left second retainer portions **13***b* integrally bonded to a concave corner portion between the horizontal portion **41** and the right and left leg portions **42**, and right and left third retainer portions **13***c* integrally bonded to the inner surface lower end portions of the right and left leg portions **42**. The third retainer portions **13***c* are formed to be continuous to the lower end covering portion **93** covering the lower end portion of the leg portion **42** and integrally formed to the second pipe portion **92**.

The two rows of balls **3** disposed to upper surface of the track rail **2** are retained between both the right and left end portions of the first retainer portion **13***a* and the upper end portion of the second retainer portion **13***b*, while the right and left two rows of balls **3** disposed to the right and left side surfaces of the track rail **2** are retained between the right and left second retainer portions **13***b* and the third retainer portion **13***c*.

The first retainer portion **13***a* and the second retainer portion **13***b* are provided with first and second concave portions **45, 46** at which the lower surface of the horizontal portion **41** and the inwardly directing inclined surfaces **422** of the inner side surfaces of the movable block body **40** are exposed. The first and second concave portions **45, 46** are formed to have a shape corresponding to a convex portion for supporting the movable block body **40** within the molding die at the time of the insert molding operation. The first and second concave portions **45, 46** can be continuously formed to the movable block body **40** over an entire length thereof or can also be discontinuously and partially formed to the movable block body **40**.

On the other hand, as shown in FIG. **1**(*d*), at periphery portions of the first to third retainer portion **13***a*–**13***c* contacting to the ball rolling grooves **7, 8**, a plain portion **47** is exposed to a portion between side peripheries of the ball rolling grooves **7, 8**. The convex portion for preventing the molding material from penetrating into the ball rolling grooves **7, 8** at the time of the insert molding operation is abutted against the plain portion **47**.

In addition, all of the first and second pipe portions **91, 92** as the return passage forming member, the first to third retainer portions **13***a*, **13***b* as the ball retaining member **13** and the direction changing inner peripheral piece portion **12** is composed of a die-molded portion which is integrally molded with the movable block body **40**.

This integral molding is performed in accordance with an insert molding method in which a cavity corresponding to the die molded portion to be formed is formed between an inner wall of the molding die **14** and the movable block body **40** by disposing the movable block body **40** within a molding die **14** with reference to the ball rolling groove **7** formed to the movable block body **40**, and then the molding material is injected into the cavity.

FIG. **3** includes schematic views showing states where the movable block body **40** and the molding die **14** are closed or opened at the time of the insert molding operation.

A fixed die **14***a* comprises a first convex portion **14***a***1** abutting against the lower surface as the plain surface of the horizontal portion **41** of the movable block **40**, a second convex portion **14***a***2** abutting against the outwardly directing inclined surface **421** of the inner side surface of the leg portion **42**, a third convex portion **14***a***3** for shutting off the molding material by abutting against the plain portion **47** of the side periphery of the ball rolling grooves **7, 8** formed to the lower surface of the horizontal portion **41**, and a fourth convex portion **14***a***4** abutting against the plain portion **47** of the side periphery of the ball rolling grooves **8** formed to the inwardly directing inclined surface **422** of the inner side surface.

The first convex portion **14***a***1** and the second convex portions **14***a***2** are not required to be continuously formed to the movable block body **40** over an entire length thereof, and the convex portions can also be discontinuously formed to the movable block body **40**. However, the third convex portion **14***a***3** and the fourth convex portions **14***a***4** are required to be continuously formed to the movable block body **40** over an entire length of the ball rolling grooves **7, 8**.

On the other hand, a movable die **14***c* is provided with a pin **14***d* for forming the ball returning passage **9**.

Note, FIGS. **3**(*b*), (*c*) show only a circumference of the ball returning passage **9** formed to the side of the leg portion **42**.

Further, a cavity **15***a* for forming the first pipe portion **91** is provided in the through bore **43** formed to the horizontal portion **41** of the movable block body **40**, a cavity **15***b* for forming the second pipe portion **92** is provided in an outer side of the concave portion formed an outer corner portion of the leg portion **42**, cavities **15***c*–**15***e* for forming the first to third retainer portions **13***a*–**13***c* are provided at the horizontal portion **41** and inner circumferences of the leg portion **42**, and a cavity **15***f* for forming the direction changing passage inner peripheral piece portion **12** is provided at both front and rear end portions of the movable block body **40**, respectively.

The first convex portion **14***a***1** and the second convex portions **14***a***2** are projected into the cavities **15***c*, **15***d*, respectively, and abut against the lower surface of the horizontal portion **41** of the movable block body **40** and the outwardly directing inclined surface **421** of the inner side surface of the leg portion **42**, the lower surface and the inclined surface **421** being plain surfaces other than a surface having the ball rolling grooves **7**, **8**. Further, the third convex portion **14***a***3** abuts against the side periphery of the ball rolling grooves **7**, **8** formed to the horizontal portion **41**, while the fourth convex portion **14***a***4** abuts against the inwardly directing inclined surface **422** of the inner side surface of the leg portion **42**, whereby a position of the movable block body **40** in a width and height directions is determined.

That is, a backlash in a height direction of the movable block body **40** is restricted and supported by the first convex portion **14***a***1** abutting against the lower surface of the horizontal portion **41**, the second convex portion **14***a***2** abutting against the outwardly directing inclined surfaces **421** of the inner surfaces of both the leg portions **42**, and the third and fourth convex portions **14***a***3**, **14***a***4**. While, a backlash in a width direction of the movable block body **40** is restricted and supported by the second to fourth convex portions **14***a***2**–**14***a***4**.

In addition, as shown in FIG. **3**(*d*), by the action of the third and fourth convex portions **14***a***3** and **14***a***4**, the molding material such as resin material or the like can be prevented from invading into the ball rolling grooves **7**, **8** formed to the movable block body **40**.

On the other hand, the position of the movable block body **40** in a longitudinal direction is determined by a bottom wall **14***a***5** of the fixed die **14***a* and an end wall **14***c***1** of the movable die **14***c* against which both end portions in a longitudinal direction of the movable block body **40** are abutted.

As shown in FIGS. **3**(*b*), (*e*), the shutting-off the molding material between the both end portions of the ball rolling grooves **7**, **8** and the direction changing inner peripheral piece portion **12** can be performed by the engaging convex portions **14***a***6**, **14***c***2** to be engaged with the ball guide portion **48** subjected to a crowning working and provided to both end portions of the ball rolling grooves **7**, **8**.

According to the present invention described above, the positioning of the movable block body **40** in width, vertical and longitudinal directions is performed at the plain surface which is different from the ball rolling grooves **7**, **8**, so that the damage or injure of the ball rolling grooves **7**, **8** can be prevented. Further, the movable block body **40** can be stably positioned by being supported with a large supporting force regardless of the ball rolling grooves **7**, **8**.

Accordingly, the positions of the cavity **15***a* for forming the first pipe portion **91**, the cavity **15***b* for forming the second pipe portion **92**, the cavities **15***c*–**15***e* for forming the first to third retainer portions **13***a*–**13***c* and the cavity **15***f* for forming the direction changing passage inner peripheral piece portion **12** with respect to the movable block **4** can be accurately determined. As a result, there is no fear of causing irregularities due to assembling errors at a joint portion formed between the direction changing passage inner peripheral piece portion **12** and the ball rolling grooves **7**, **8** and at a joint portion between the direction changing passage inner peripheral piece portion **12** and the ball returning passages **9** to be formed of the first and second pipe portions **91**, **92**, so that it becomes possible to smoothly circulate the balls **3**, and to reduce the noise generation.

By the way, in order to prevent the generation of burr, it is not always necessary to completely or tightly contact the respective members such as the plain portion **47** of the side periphery of the ball rolling grooves **7**, **8** formed to the movable block body **40** and the third and fourth convex portions **14***a***3**, **14***a***4**; or the engaging convex portions **14***a***6**, **15***c***2** and each of the ball guide portions **48**. Even if a gap is formed between the members, such gap is within an allowable range as far as the gap has a size capable of preventing the invasion of the molding material.

In the present embodiment, although all of the first and second pipe portions **91**, **92** as the ball returning passage forming member, the first, second and third retainer portions **13***a*–**13***c* as the ball retaining member, and the direction changing passage inner peripheral piece portion **12** as the direction changing passage inner peripheral portion forming member is integrally formed with the movable block body **40** by the insert molding method to form a die-molded portion, there may be also applicable a method in which at least one of the aforementioned members is integrally molded by the insert molding method.

That is, there will be applicable various cases e.g., a case where only the first and second pipe portions **91**, **92** are integrally molded, a case where only the first to third retainer portions **13***a*–**13***c* are integrally molded, a case where only the direction changing passage inner peripheral piece portion **12** is integrally molded, a case where the first and second pipe portions **91**, **92** and the first to third retainer portions **13***a*–**13***c* are integrally molded, a case where the first to third retainer portions **13***a*–**13***c* and the direction changing passage inner peripheral piece portion **12** are integrally molded, a case where the first and second pipe portions **91**, **92** and the direction changing passage inner peripheral piece portion **12** are integrally molded.

Second Embodiment

FIG. **4** shows a second embodiment of a rolling motion guide device according to the present invention.

The rolling motion guide device **201** is constructed by comprising a track rail **202** and a movable block **204** having a U-shape in section and movably supported by the track rail **202** through four rows, in total, of balls **203** in which two rows of balls are vertically disposed to each of the right and left side surfaces of the track rail **202**.

The track rail **202** is an elongated member formed to provide a rectangular shape in section. Both right and left side surfaces of the track rail **202** are provided with protruded portions **2021** each protruding outside. Each of upper and lower side surfaces of the right and left protruded portions **2021** is formed with rows of ball rolling grooves **205**, **206** as the rolling member rolling grooves.

The movable block **204** is a block body having a high rigidity and a U-shaped cross section and has a movable block body **2040** comprising a horizontal portion **2041** opposing to the upper surface of the track rail **202** and a pair of leg portions **2042** and **2042** extending downward from both right and left side end portions of the horizontal portion **2041** so as to clamp both the right and left side surfaces of the track rail **202**. The inner side surfaces of the right and left leg portions **2042** have a vertical surfaces **20423** each extending in an almost vertical direction, outwardly directing inclined surfaces **20421** formed at base portions of the right and left leg portions **2042**, and inwardly directing inclined surfaces **20422** formed at top portions of the leg portions **2042**.

The outwardly directing inclined surfaces **20421** and the inwardly directing inclined surfaces **20422** are formed with two rows of ball rolling grooves **207** and **208** corresponding to the paired ball rolling grooves **205** and **206** formed to the right and left side surfaces of the track rail **202**.

The ball rows for receiving loads to be applied between the track rail **202** and the movable block body **2040** are constituted by disposing a number of balls **203** to portions between the four paired ball rolling grooves **205**, **208**; **206**, **207** that mutually correspond to each other and are formed to the opposing surfaces of the movable block body **2040** and the track rail **202**. The balls **203** are applied with a predetermined preload. As the rolling member other than balls, rollers or the like can be also applied.

Both end portions of the ball rolling grooves **207, 208** are performed with a crowning-working so as to provide a ball guide portion **2048** having an inclination of which depth gradually increases toward the end portions of the ball rolling grooves. The ball guide portion **2048** has a function of rolling and moving the balls from the direction changing passage **210** in a non-loaded region to portions between the ball rolling grooves **205, 207; 206, 208** in a loaded region by gradually applying the load to the balls.

Contact angle lines each connecting contact points of the respective balls **203** to the ball rolling grooves **205, 208; 206, 207** have an inclined structure so as to be close toward a center of the track rail **202,** and the contact angle is set to almost about 45° with respect to a horizontal line H.

The right and left leg portions **2042** of the movable block body **2040** are provided with four rows of ball returning passages **209** for circulating and guiding the four rows of balls. The ball returning passage **209** is constituted by a bore linearly extending in parallel to the respective ball rolling grooves **207, 208** formed to the movable block body **2040**.

The outer side surfaces of the right and left leg portions **2042** of the movable block body **2040** are formed with a cutout portion **2043**. A return passage forming member **2091** composed of resin for forming the ball returning passage **209** is integrally bonded to the cutout portion **2043**. Upper and lower two rows of the ball returning passage **209, 209** are formed to the return passage forming member **2091**.

The return passage forming member **2091** is formed to be continuous to an end surface resin portion **2092** covering a lower end surface of the leg portion **2042**.

A side cover **211** constituting the direction changing passage **210**, in a U-shaped-pipe form for changing the direction of the balls **203** disposed between the track rail **202** and the movable block body **2040** toward the ball returning passage **209**, is attached to an end portions of the movable block body **2040**. The side cover **211** per se is formed with only an outer peripheral portion **210***a* of the entire direction changing passage **210** in the U-shaped pipe form. Further, a direction changing passage inner peripheral piece portion **212** as a direction changing inner periphery forming member for forming an inner peripheral portion **210***b* of the direction changing passage **210** is integrally bonded to the end portions of the movable block body **2040,** and the direction changing passage **210** is constituted by the side covers **211** and the direction changing inner peripheral piece portions **212**.

In addition, the movable block body **2040** is provided with ball retaining members **213** along the four rows of balls **203** for preventing the balls **203** from dropping off from the movable block **204** when the movable block **204** is detached from the track rail **202**. The ball retaining members **213** are composed of resin and comprises a first retainer portion **213***a* integrally bonded to the lower surface of the horizontal portion **2041**, right and left second retainer portions **213***b* integrally bonded to an inner side surface center portion of the right and left leg portions **242**, and right and left third retainer portions **213***c* integrally bonded to the inner surface lower end portions of the right and left leg portions **242**. The third retainer portions **213***c* is formed to be continuous to the lower end covering portion **2092** covering the lower end portion of the leg portion **242** and integrally formed to the ball returning passage forming member **2091**.

The upper side two rows of balls **203** are retained between both the right and left end portions of the first retainer portion **213***a* and the upper end portion of the second retainer portion **213***b*, while the right and left two rows of balls **203** disposed to the right and left side surfaces of the track rail **202** are retained between the right and left second retainer portions **213***b* and the third retainer portion **213***c*.

The second retainer portion **213***b* is provided with a second concave portion **2046** at which the vertical surface of the inner side surface of the leg portion **242** is exposed. The second concave portion **2046** is formed to have a shape corresponding to a convex portion for supporting the movable block body **2040** within the molding die **214** at the time of the insert molding operation. The second concave portions **2046** can be continuously formed to the movable block body **2040** over an entire length thereof or can also be discontinuously and partially formed to the movable block body **2040**.

On the other hand, at periphery portions of the first to third retainer portion **13***a*–**13***c* contacting to the ball rolling grooves **207, 208**, plain surfaces of the outwardly and inwardly directing inclined surfaces **20421, 20422** are exposed to a portion between side peripheries of the ball rolling grooves **207, 208**. The outwardly and inwardly directing inclined surfaces **20421, 20422** each having a plain surface becomes shutting-off surfaces for preventing the molding materials such as resin material or the like from penetrating into the ball rolling grooves **207, 208** at the time of the insert molding operation.

In addition, all of the aforementioned return passage forming member **209**, the first to third retainer portions **213***a*–**213***c* as the ball retaining member **213** and the direction changing inner peripheral piece portion **212** is integrally molded with the movable block body **2040**.

This integral molding is performed in accordance with an insert molding method in which a cavity corresponding to the resin molded portion to be formed is formed between an inner peripheral wall of the molding die **214** and the movable block body **2040** by disposing the movable block body **2040** within a molding die **214**, and then, the molding material is injected into the cavity.

FIG. **6** is a schematic view showing an engaging state of the movable block body **2040** with the molding die **214** at the time of the insert molding operation.

A fixed die **214***a* comprises a first convex portion **214***a***1** abutting against the lower surface of the horizontal portion **2041** of the movable block body **2040**, a second convex portion **214***a***2** abutting against the vertical surface **20423** of the inner side surface of the leg portion **2042**, a third convex portion **214***a***3** for shutting off the molding material by abutting against the outwardly directing inclined surface **20422**, and a fourth convex portion **214***a***4** for shutting off the molding material by abutting against the inwardly directing inclined surface **20422**.

The first convex portion **214***a***1** and the second convex portions **214***a***2** are not required to be continuously formed to the movable block body **2040** over an entire length thereof, and the convex portions can also be discontinuously formed to the movable block body **2040**. However, the third convex portion **214***a***3** and the fourth convex portions **214***a***4** are required to be continuously formed to the movable block body **2040** over an entire length of the ball rolling grooves **207, 208**.

A movable die **214***c* is provided with a pin **214***d* for forming the ball returning passage **209**.

Further, a cavity **215***a* for forming the return passage forming member **2091** is provided at the cutout portions **2043** of outer side surfaces of the right and left leg portions **2042**, cavities **215***b*–**215***d* for forming the first to third retainer portions **213*a*–213*c*** are provided at the horizontal portion **241** and inner circumferences of the leg portion **242**, and a cavity **215*e*** for forming the direction changing passage inner peripheral piece portion **212** is provided at both front and rear end portions of the movable block body **2040**, respectively.

The first convex portion **214*a*1** is projected into the right and left cavities **215*b*** while the second convex portions **214*a*2** is projected into the cavities **215*c***, respectively, and the convex portions abut against the lower surface of the horizontal portion **2041** of the movable block body **2040** and the vertical surface **20423** of the inner side surface of the leg portion **2042**, the lower surface and the vertical surface being plain surfaces other than a surface having the ball rolling grooves **207**, **208**. Further, the third convex portion **214*a*3** abuts against the side periphery of the ball rolling grooves **207** formed to the horizontal portion **2041**, while the fourth convex portions **214*a*4** abuts against the inwardly directing inclined surface **20422** of the inner side surface of the leg portion **2042**, whereby a position of the movable block body **2040** in a width and height directions is determined.

That is, a positioning in a height direction of the movable block body **2040** is performed by the first convex portion **214*a*1** abutting against the lower surface of the horizontal portion **2041**, and the third and fourth convex portions **214*a*3**, **214*a*4** abutting against the outwardly and inwardly directing inclined surfaces **20421**, **20422** of the inner side surfaces of both the leg portions **2042**. While, a positioning of the movable block body **2040** in a width direction is performed by the second to fourth convex portions **214*a*2–214*a*4**.

In addition, by the action of the third and fourth convex portions **214*a*3** and **214*a*4**, the molding material such as resin or the like can be prevented from invading into the ball rolling grooves **207**, **208** formed to the movable block body **2040**.

On the other hand, the position of the movable block body **2040** in a longitudinal direction is determined by a bottom wall **214*a*5** of the fixed die **214*a*** and an end wall **214*c*1** of the movable die **214*c*** against which an elongated end wall in a longitudinal direction of the movable block body **2040** are abutted.

As shown in FIGS. **6**(*b*), (*e*), the shutting-off of the molding material at the both end portions of the ball rolling grooves **207**, **208** can be performed by the engaging convex portions **214*a*6**, **214*c*2** to be engaged with the ball guide portion **2048** which had been subjected to a crowning working and provided to both end portions of the ball rolling grooves **207**, **208**.

According to the present invention described above, the positioning of the movable block body **2040** in width, vertical and longitudinal directions is performed at the plain surface which is different from the ball rolling grooves **207**, **208**, so that the damage or injure of the ball rolling grooves **207**, **208** can be prevented. Further, the movable block body **2040** can be stably positioned by being supported with a large supporting force regardless of the ball rolling grooves **207**, **208**.

In particular, the positional relation between the cavity **215*a*** for forming the ball returning passage forming member **2091**, the cavities **215*c*–215*e*** for forming the first to third retainer portions **213*a*–213*c*** and the cavity **215*f*** for forming the direction changing passage inner peripheral piece portion **212** with respect to the movable block body **2040** can be accurately determined.

Third Embodiment

FIGS. **7** and **8** show a third embodiment of the present invention.

The rolling motion guide device **301** is constructed by comprising a track rail **302** and a movable block **304** having a U-shape in section and movably supported by the track rail **302** through four rows, in total, of balls **303** in which two rows of balls are vertically disposed to each of the right and left side surfaces of the track rail **302**.

The track rail **302** is an elongated member formed to provide a rectangular shape in section. Each of the right and left side surfaces of the track rail **302** is formed to provide an almost vertical surface and is provided with two rows of ball rolling grooves **305**, **306** as the rolling member rolling grooves, respectively.

The movable block **304** is a block body having a high rigidity and a U-shaped cross section and has a movable block body **3040** comprising a horizontal portion **3041** opposing to the upper surface of the track rail **302** and a pair of leg portions **3042** extending downward from both right and left side end portions of the horizontal portion **3041** so as to clamp both the right and left side surfaces of the track rail **302**. Each of the inner side surfaces of the right and left leg portions is almost a vertical surface and is formed with two rows of ball rolling grooves **307** and **308** corresponding to the paired ball rolling grooves **305** and **306** formed to the right and left side surfaces of the track rail **302**.

The ball rows for receiving loads to be applied between the track rail **302** and the movable block body **3040** are constituted by disposing a number of balls **303** to portions between the four paired ball rolling grooves **305**, **307**; **306**, **308** that mutually correspond to each other and are formed to the opposing surfaces of the movable block body **3040** and the track rail **302**. The balls **303** are applied with a predetermined preload. As the rolling member other than balls, rollers or the like can be also applied.

Both end portions of the ball rolling grooves **307**, **308** are performed with a crowning-working so as to provide a ball guide portion **3048** having an inclination of which depth gradually increases toward the end portions of the ball rolling grooves. The ball guide portion **3048** has a function of rolling and moving the balls from the direction changing passage **310** in a non-loaded region to portions between the ball rolling grooves **305**, **307**; **306**, **308** in a loaded region by gradually applying the load to the balls.

The right and left leg portions **3042** of the movable block body **3040** are provided with four rows of ball returning passages **309** for circulating and guiding the four rows of balls. The ball returning passage **309** is constituted by a bore linearly extending in parallel to the respective ball rolling grooves **307**, **308** formed to the movable block body **3040**.

The right and left leg portions **3042** of the movable block body **3040** are formed with a through bore **3043**. A return passage forming member **3091** composed of resin for forming the ball returning passage **309** is integrally bonded to the through bore **3043**. Upper and lower two rows of the ball returning passage **309**, **309** are formed to the return passage forming member **3091**.

A side cover **311** constituting the direction changing passage **310** in a U-shaped pipe form for changing the rolling direction of the balls **303** disposed between the track rail **302** and the movable block body **3040** toward the ball returning passage **309** is attached to an end portions of the movable block body **3040**. The side cover **311** per se is formed with only an outer peripheral portion **310*a*** of the entire direction changing passage **310** in the U-shaped pipe form. Further, a direction changing passage inner peripheral piece portion **312** as a direction changing inner periphery forming member for forming an inner peripheral portion **310***b* of the direction changing passage **310** is integrally bonded to the end portions of the movable block body **3040**, and the direction changing passage **310** is constituted by the side covers **311** and the direction changing inner peripheral piece portions **312**.

The present embodiment is different from the previous first and second embodiments in a point that the side peripheries of the ball rolling grooves **307, 308** formed to the movable block body **3040** is not provided with ball retaining members for preventing the balls **303** from dropping off from the movable block body.

Further, the aforementioned return passage forming member **309** and the direction changing passage inner peripheral piece portion **312** are integrally formed with the movable block body **3040**.

This integral molding is performed in accordance with an insert molding method in which a cavity corresponding to the resin molded portion to be formed is formed between an inner peripheral wall of the molding die **314** and the movable block body **3040** by disposing the movable block body **3040** within a molding die **314**, and then, the molding material is injected into the cavity.

FIG. **8** is a schematic view showing an engaging state of the movable block body **3040** and the molding die **314** at the time of the insert molding operation.

A fixed die **314***a* comprises a first convex portion **314***a***1** abutting against the lower surface of the horizontal portion **3041** of the movable block body **3040**, a second convex portion **314***a***2** abutting against the vertical surface **30423** of the leg portion **3042**, and a third convex portion **314***a***3** for suppressing the upper surface of the horizontal portion **3041**.

The first to third convex portions **314***a***1**–**314***a***3** are not required to be continuously formed to the movable block body **3040** over an entire length thereof, and the convex portions can also be discontinuously formed to the movable block body.

A movable die **314***c* is provided with a pin **314***d* for forming the ball returning passage **309**.

Further, a cavity **315***a* for forming the return passage forming member **3091** is provided at the through bore **3043** of the right and left leg portions **3042**, and a cavity **315***e* for forming the direction changing passage inner peripheral piece portion **312** is provided at both front and rear end portions of the movable block body **3040**, respectively.

The first to third convex portions **314***a***1**–**314***a***3** support the lower surface of the horizontal portion **3041** of the movable block body **3040**, the inner side surfaces **30423** of the leg portions **3042** and the upper surface of the horizontal portion **3041**, the respective surfaces being plain surfaces other than a surface having the ball rolling grooves **307, 308**, whereby a position of the movable block body **3040** in a width and height directions is determined.

That is, a positioning in a height direction of the movable block body **3040** is performed by the first convex portion **314***a***1** abutting against the lower surface of the horizontal portion **3041** and the third convex portion **314***a***3** abutting against the upper surface of the horizontal portion. In addition, a positioning of the movable block body **3040** in a width direction is performed by the second convex portion **314***a***2** abutting against the inner side surfaces of the right and left leg portions **3042**.

On the other hand, the position of the movable block body **3040** in a longitudinal direction is determined by a bottom wall **314***a***5** of the fixed die **314***a* and an end wall **314***c***1** of the movable die **314***c* against which an elongated end wall in a longitudinal direction of the movable block body **3040** are abutted.

The shutting-off the molding material at both the end portions of the ball rolling grooves **307, 308** can be performed by the engaging convex portions **314***a***5**, **314***c***2** to be engaged with the ball guide portion **348** which had been subjected to a crowning working and provided to both end portions of the ball rolling grooves **307, 308**.

According to the present invention described above, the positioning of the movable block body **3040** in width, vertical and longitudinal directions is performed at the plain surface, which is different from the ball rolling grooves **307, 308**, so that the damage or injure of the ball rolling grooves **307, 308** can be prevented. Further, the movable block body **3040** can be accurately positioned to a predetermined position.

In particular, the positional relation between the cavity **315***a* for forming the ball returning passage forming member **3091** and the cavity **315***f* for forming the direction changing passage inner peripheral piece portion **312** with respect to the movable block body **3040** can be accurately determined.

When the molding material is shut off at the ball guide portion **348** provided to both the end portions of the ball rolling grooves **307, 307**, it becomes possible to prevent the molding materials such as resin or the like from invading into the ball rolling grooves **307, 307**, while preventing the damage or injure of the ball rolling grooves.

Fourth Embodiment

FIGS. **9** to **11** show a fourth embodiment of a rolling motion guide device according to the present invention.

The rolling motion guide device **401** is constructed by comprising a track rail **402** and a movable block **404** having a U-shape in section and movably supported by the track rail **402** through two rows, in total, of balls **403** in which one row of balls is disposed to each of the right and left side surfaces of the track rail **402**.

The track rail **402** is composed of an elongated member formed to provide a rectangular shape in section. Upper half portions of both the right and left side surfaces of the track rail **402** are formed to provide tapered surfaces **4021** so that the upper half portions are gradually narrowed inside as the position advances upward. Each of the right and left tapered surfaces **4021** is formed with one row of ball rolling groove **405** as a rolling member rolling groove, respectively.

The movable block **404** is a block body having a high rigidity and a U-shaped cross section and has a movable block body **4040** comprising a horizontal portion **4041** opposing to the upper surface of the track rail **402** and a pair of leg portions **4041** and **4041** extending downward from both right and left side end portions of the horizontal portion **4041** so as to clamp both the right and left side surfaces of the track rail **402**. Each of the inner surfaces of the right and left leg portions **4042, 4042** is formed with one row of ball rolling groove **407** corresponding to the ball rolling grooves **405** formed to the right and left side surfaces of the track rail **402**. The inner side surfaces **40421** of both the right and left leg portions **405** and **405** provide an outwardly directing inclined surface which inclined in a direction so as to open downwardly.

The ball rows for receiving loads to be applied between the track rail **402** and the movable block **404** are constituted by disposing a number of balls **403** to portions between the two paired ball rolling grooves **405, 407** that mutually correspond to each other and are formed to the opposing surfaces of the movable block **404** and the track rail **402**. The balls **403** are applied with a predetermined preload. As the rolling member other than balls **403**, rollers or the like can be also applied.

Both end portions of the ball rolling grooves **407** are performed with a crowning-working so as to provide a ball guide portion **4048** having an inclination of which depth gradually increases toward the end portions of the ball rolling grooves. The ball guide portion **4048** has a function of rolling and moving the balls from the direction changing passage **410** in a non-loaded region to portions between the ball rolling grooves **405, 407** in a loaded region by gradually applying the load to the balls.

A contact angle line L4 connecting contact points of the respective balls **403** to the ball rolling grooves **405, 407** is inclined with a predetermined angle of α 4 so as to be gradually lowered toward a center of the track rail **402**.

The movable block **404** is provided with two rows of ball returning passages **409** for circulating and guiding the two rows of balls **403**. The ball returning passage **409** is constituted by a bore linearly extending in parallel to the respective ball rolling grooves **407** formed to the movable block **404**. One row of the ball returning passage **409** is formed to the right and left leg portions **4042**, respectively.

Outer side surface lower end corner portions of the right and left leg portions **4042** of the movable block body **4040** are formed with a circular-arc-shaped concave portion **4043** to which a pipe portion **4091** composed of resin for forming the ball returning passage **409** is integrally bonded. The pipe portion **4091** is formed to be continuous to a lower end surface resin portion **4092** covering a lower end surface of the leg portion **4042**. A top end of the lower end surface resin portion **4092** is formed with an engaging projection **4092*a*** which engages with an engaging groove **4042*a*** formed to the lower end surface of the leg portion **4042**.

A side cover **411** constituting the direction changing passage **410** in a U-shaped-pipe form for changing the rolling direction of the balls **403** disposed between the track rail **402** and the movable block body **4040** toward the ball returning passage **409** is attached to an end portions of the movable block body **4040**. The side cover **411** per se is formed with only an outer peripheral portion **410*a*** of the entire direction changing passage **410** in the U-shaped pipe form. Further, a direction changing passage inner peripheral piece portion **412** as a direction changing inner periphery forming member for forming an inner peripheral portion **410*b*** of the direction changing passage **410** is integrally bonded to the end portions of the movable block body **4040**, and the direction changing passage **410** is constituted by the side covers **411** and the direction changing inner peripheral piece portions **412**.

In addition, the pipe portions **4091** as the return passage forming member and the direction changing inner peripheral piece portion **412** are integrally molded with the movable block body **4040**.

This integral molding is performed in accordance with an insert molding method in which a cavity corresponding to the die molded portion to be formed is formed between an inner wall of the molding die and the movable block **4040** by disposing the movable block **4040** within a molding die, and then the molding material is injected into the cavity.

FIG. **11** is a schematic view showing an engaging state of the movable block **4040** and the molding die **414** at the time of the insert molding operation.

A fixed die **414*a*** comprises a first convex portion **414*a*1** abutting against the upper surface of the horizontal portion **4041** of the movable block **4040**, and a second convex portion **414*a*2**. The side surfaces of the second convex portion **414*a*2** are tightly contacted to outwardly directing inclined surfaces **40421** of the right and left leg portions **4042**. Further, each of the outer surfaces of the leg portions **4042** is formed with a concave portion **4043** into which a pin **414*b*** for forming the ball returning passage **409** is inserted. The fixed die **414*a*** is formed with a step portion **414*a*3** engaging with a corner portion of the concave portion **4043**. A cavity **415*a*** for forming a pipe portion **4091** is formed between the concave portion **4043** and the pin **414*b***.

Further, a cavity **415*b*** for forming the direction changing passage inner peripheral portion **412** is formed to both the front and rear end portions of the movable block **4040**, respectively.

In this embodiment, the upper surface of the horizontal portion **4041** is supported by the first convex portion **414*a*1**, while the lower surface of the horizontal portion **4041** is supported by the second convex portion **414*a*2**, whereby the a position of the movable block **4040** in a height direction is determined. In addition, the inner side surfaces **40421** of the leg portions **4042** of the movable block **4040** are supported by both right and left side surfaces of the second convex portion **414*a*2**, whereby the position of the movable block **4040** in a width direction is determined.

In addition, both the right and left side surfaces of the second convex portion **414*a*2** are interfitted to the inner side surfaces **40421** of the leg portions **4042** in a wedge form, so that there is no fear of causing burrs at inner peripheries of the ball rolling grooves **407, 407**.

Furthermore, the end portions of the movable block **4040** in a longitudinal direction are supported by the bottom surface **414*a*4** of the fixed die **414*a*** and the end wall **414*c*1** of the movable die **414*c*** in a die-closing direction, whereby the position of the movable block is determined.

As described above, the position of the movable block **4040** is stably determined in the molding die **414** without causing any backlash, so that the cavity **415*a*** for molding the pipe portion **4091** for forming the ball returning passage **409** can be accurately formed at circumference of the movable block **4040**.

In this embodiment, the upper end portions **4043*a*** of the concave portions **4043** formed to outer corner portions of the right and left leg portions **4042** abut against the step portion **414*a*3** formed to the inner periphery of the molding die **4014**, so that the movable block **4040** is supported more stably.

The shutting-off the molding material at the both end portions of the ball rolling groove **407** can be performed by the engaging convex portions **414*a*5, 414*c*2** to be engaged with the ball guide portion **4048** which had been subjected to a crowning working and provided to both end portions of the ball rolling groove **407**.

Fifth Embodiment

FIGS. **12** to **14** show a fifth embodiment of a rolling motion guide device according to the present invention.

The rolling motion guide device **501** is constructed by comprising a track rail **502** and a movable block **504** movably supported by the track rail **502** through balls **503** disposed to one side end portion of both the right and left side ends of an upper surface side of the track rail **502** and another balls **503** disposed to the other side end portion of both the right and left side surfaces of the track rail **502**.

The track rail **502** is an elongated member formed to provide a rectangular shape in section. One row of ball rolling groove **507** as rolling member rolling groove is formed to a left side end (as shown in figure) of an upper surface of the track rail **502**. On the other hand, an upper half portion of a right side surface (as shown in figure) of the track rail **502** is formed to provide a tapered surface **5021** so that the upper half portion gradually protrudes outside as the position advances upward. The tapered surfaces **5021** is formed with one row of ball rolling groove **506** as a rolling member rolling groove.

The movable block **504** is a block body having a high rigidity and an L-shaped cross section and has a movable block body **5040** comprising a horizontal portion **5041** opposing to the upper surface of the track rail **502** and a leg portion **5042** extending downward from the right side end portion of the horizontal portion **5041** so as to oppose to the right side surface of the track rail **502**. At the lower surface of the horizontal portion **5041**, is formed with a ball rolling groove **507** corresponding to the ball rolling groove **505** formed to the upper surface of the track rail **502**, while the inner side surface of the leg portions **5042** is formed with a ball rolling groove **508** corresponding to the ball rolling groove **505** formed to the right and left side surfaces of the track rail **502**.

The ball rolling groove **507** to be formed to the lower surface of the horizontal portion **5041** is formed to an inclined upper bottom **50412** of the concave portion **50411** formed to the lower surface of the horizontal portion **5041**. Further, a portion close to a lower end portion of the inner side surface of the leg portion **5042** is provided with an inwardly directing inclined surface **50422** which protrudes inside as a position is lowered. The inwardly directing inclined surface **50422** is formed with a ball rolling groove **507**.

The ball rows for receiving loads to be applied between the track rail **502** and the movable block body **5040** are constituted by disposing a number of balls **503** to portions between the two paired ball rolling grooves **505, 507**; **506, 508** that mutually correspond to each other and are formed to the opposing surfaces of the movable block body **5040** and the track rail **502**. The balls **503** are applied with a predetermined preload. As the rolling member other than balls **503**, rollers or the like can be also applied.

Both end portions of the ball rolling grooves **507, 508** are performed with a crowning-working so as to provide a ball guide portion **5048** having an inclination of which depth gradually increases toward the end portions of the ball rolling grooves. The ball guide portion **5048** has a function of rolling and moving the balls from the direction changing passage **510** in a non-loaded region to portions between the ball rolling grooves **505, 507**; **506, 508** in a loaded region by gradually applying the load to the balls.

With respect to the balls **503** disposed to the upper surface of the track rail **502**, a contact angle line L3 connecting contact points of the respective balls **503** to the ball rolling grooves **505, 507** is set so as to provide an inclined line which is counter-clockwisely inclined with a predetermined inclination angle of α 1 with respect to a vertical line V passing through a center of the ball. In contrast, with respect to the balls **503** disposed to the side surface of the track rail **502**, a contact angle line L3 connecting contact points of the respective balls **503** to the ball rolling grooves **506, 508** is set so as to provide an inclined line which is clockwisely inclined with a predetermined inclination angle of α 2 with respect to a horizontal line H passing through a center of the ball **503**.

The movable block **504** is provided with two rows of ball returning passages **509** for circulating and guiding the two rows of balls **503**. The ball returning passage **509** is constituted by a bore linearly extending in parallel to the respective ball rolling grooves **505, 506** formed to the movable block **504**. The ball returning passage **509** is formed to a left upper corner portion of the horizontal portion **5041** and to a right lower corner portion of the leg portion **5042**, respectively.

An upper left corner portion of the horizontal portion **5041** of the movable block body **5040** is formed with an arc-shaped concave portion **5043** to which a first pipe portion **5091** composed of resin for forming the ball returning passage **509** is integrally bonded. The first pipe portion **5091** is formed to be continuous to a side surface resin portion **5093** covering a left side surface of the horizontal portion **5041** and to a lower surface resin portion **5094** covering a left lower surface of the horizontal portion **5041**.

On the other hand, a right lower corner portion of the leg portion **5042** of the movable block body **5040** is formed with a concave portion **5044** to which a second pipe portion **5092** composed of resin for forming the ball returning passage **509** is integrally bonded. The second pipe portion **5092** is formed to be continuous to a side surface resin portion **5095** covering an outer side surface of the leg portion **5042** and to an end surface resin portion **5094** covering a lower end surface of the leg portion **5042**.

A side cover **511** constituting the direction changing passage **510** in a U-shaped-pipe form for changing the direction of the balls **503** disposed between the track rail **502** and the movable block body **5040** toward the ball returning passage **509** is attached to an end portion of the movable block body **5040**. The side cover **511** per se is formed with only an outer peripheral portion **510***a* of the direction changing passage **510** in the U-shaped pipe form. Further, a direction changing passage inner peripheral piece portion **512** as a direction changing inner periphery forming member for forming an inner peripheral portion **510***b* of the direction changing passage **510** is integrally bonded to the end portion of the movable block **504**, and the direction changing passage **510** is constituted by the side covers **511** and the direction changing inner peripheral piece portions **512**.

In addition, the movable block body **5040** is provided with ball retaining members **513** along the two rows of balls **503** for preventing the balls **503** from dropping off from the movable block body **5040** when the movable block body **5040** is detached from the track rail **502**. The ball retaining members **513** are composed of resin and comprise a pair of first and second retainer portions **513***a* and **513***b* extending so as to clamp both side peripheries of the ball rolling groove **507** formed to the horizontal portion **5041**, and a pair of third and fourth retainer portions **513***c* and **513***d* extending so as to clamp both side peripheries of the ball rolling groove **508** formed to the leg portion **5042**.

The first retainer portions **513***a* is formed to be continuous to a left lower surface covering portion **5094**, and is integrally formed with the first pipe portion **5091**. The second retainer portion **513***b* and the third retainer portion **513***c* are formed to be continuous through a center lower surface covering portion **5097** which covers the lower surface of the horizontal portion **5041**. Further, the fourth retainer portions **513***d* is formed to be continuous to an end surface covering portion **5096** and is integrally formed with the second pipe portion **5092**.

On the other hand, at periphery portions of the first to third retainer portions **513***a*–**513***c* contacting to the ball rolling grooves, a plain portion **547** is exposed to a portion between side peripheries of the ball rolling grooves **507, 508**. The convex portion for preventing the molding material from invading into the ball rolling grooves **507, 508** at the time of the insert molding operation is abutted against the plain portion **547**.

In addition, all of the first and second pipe portions **5091, 5092** as the return passage forming member, the first to fourth retainer portions **513***a*–**513***d* as the ball retaining member **513** and the direction changing inner peripheral piece portion **512** is integrally molded with the movable block body **5040**.

This integral molding is also performed in accordance with the insert molding method in which a cavity corresponding to the die molded portion to be formed is formed between an inner wall of the molding die and the movable block body **5040** by disposing the movable block body **5040** within a molding die with reference to the ball rolling grooves **507**, **508** formed to the movable block body **5040**, and then the molding material is injected into the cavity.

FIG. **14** is a schematic view showing an engaging state of the movable block body **5040** and the molding die **514** at the time of the insert molding operation. A fixed die **514***a* of the molding die comprises first and second convex portions **514***a***1**, **514***a***2** abutting against the lower surface of the horizontal portion **5041** of the movable block body **5040**, a third convex portion **514***a***3** abutting against the upper bottom portion **50412** of the concave portion formed to the horizontal portion **5041** and engaging with both the side peripheries of the ball rolling groove **507**, and a fourth convex portion **514***a***4** engaging with the inwardly directing inclined surface **50422** of the inner side surfaces of the leg portion **5042**.

The first convex portion **514***a***1** and the second convex portions **514***a***2** are not required to be continuously formed to the movable block body **5040** over an entire length thereof, and the convex portions can also be discontinuously formed to the movable block body **5040**. However, the third convex portion **514***a***3** and the fourth convex portions **514***a***4** are required to be continuously formed to the movable block body **5040** over an entire length of the ball rolling grooves **507**, **508**.

A pin **514***d* is inserted into the concave portion **5043** formed to the left upper corner portion of the horizontal portion **5041**, whereby a cavity **515***a* for forming the first pipe portion **5091** is formed. Further, a pin **514***d* is also inserted into the concave portion **5044** formed to the outer side surface of the leg portion **5042** of the movable block body **5040**, whereby a cavity **515***b* for forming the second pipe portion **5092** in the concave portion **5045** is formed.

A first step portion **514***a***5** abutting against an upper end portion of the concave portion **5043** formed to the left upper corner portion of the horizontal portion **5041**, and a second step portion **514***a***6** abutting against an upper end portion of the concave portion **5044** formed to the right lower corner portion of the leg **5042** are provided to the inner periphery of the fixed die **514***a*.

Cavities **515***c*–**515***f* for forming the first to fourth retainer portions **513***a*–**513***d* are provided at the horizontal portion **5041** and an inner circumference of the leg portion **5042**. Further, a cavity **515***f* for forming the direction changing passage inner peripheral piece portion **512** is provided at both the front and rear end portions of the movable block body **5040**, respectively.

In this embodiment, the upper surface of the horizontal portion **5041** of the movable block body **5040** is supported by the first convex portion **514***a***1**, while the lower surface of the horizontal portion **5041** is supported by the second convex portion **514***a***2**, whereby the position of the movable block body **5040** in a height direction is determined.

Further, the position of the movable block body **5040** in a width direction is determined by the third convex portion **514***a***3**, the fourth convex portions **514***a***4**, the first step portion **514***a***5** and the second step portion **514***a***6**.

In addition, by the action of the third and fourth convex portions **514***a***3** and **514***a***4**, the molding material can be prevented from invading into the ball rolling grooves **507**, **508** formed to the movable block body **5040**. As described above, the position of the movable block body **5040** is determined in the molding die **514** to a predetermined position.

On the other hand, the position of the movable block body **5040** in a longitudinal direction is determined by being supported by a bottom wall **514***a***5** of the fixed die **514***a* and an end wall portion **514***c***1** of the movable die **514***c*.

The shutting-off of the molding material at the both end portions of the ball rolling grooves **507**, **508** can be performed by the engaging convex portions **514***a***8**, **514***c***2** to be engaged with the direction changing guide portion **548** which had been subjected to a crowning working and provided to both end portions of the ball rolling grooves **507**, **508**.

According to the present invention described above, the positioning of the movable block body **5040** in width, vertical and longitudinal directions is performed at plain surfaces that are different from the ball rolling grooves **507**, **508**, so that the damage or injure of the ball rolling grooves can be prevented.

In addition, since the molding material is shut off at either both end portions or side peripheries of the ball rolling grooves **507**, **508**, the molding material can be prevented from invading into the ball rolling grooves **507**, **508**.

Accordingly, the movable block body **5040** can be stably positioned by being supported with a large supporting force regardless of the ball rolling grooves **507**, **508**.

As described above, according to the present invention, the positioning of the movable block body in a width, vertical, and longitudinal directions is performed at the plain surface which is different from the rolling member rolling groove, so that the damage or injure of the rolling member rolling groove can be prevented.

In addition, since the molding material is shut off at either both end portions or both side peripheries of the rolling member rolling grooves, the molding material can be prevented from invading into the rolling member rolling grooves.

Accordingly, the movable block body can be stably positioned by being supported with a large supporting force regardless of the rolling member rolling grooves.

INDUSTRIAL APPLICABILITY

As described above, the method of molding a movable block for a rolling motion guide device according to the present invention is effective to a movable block used for various rolling motion guide devices such as linear guide device, ball spline, ball bush or the like in which the movable block is movably assembled to a track rail through various rolling members and particularly effective for the integral molding of a resin portion with the movable block body.

What is claimed is:

1. A method of molding a movable block for a rolling motion guide device comprising a track rail formed with rolling member rolling grooves, a movable block having rolling member rolling grooves opposing said rolling member rolling grooves formed in said track rail, said movable block being movably provided along said track rail and a row of rolling members disposed between the opposing rolling member rolling grooves formed in said track rail and the movable block, wherein a circulation passage for circulating the rows of rolling members is formed to said movable block, at least a part of said circulation passage is constituted by a die-molded portion, and said die-molded portion is integrally molded with a movable block body by an inserting molding method in which said movable block is disposed in a molding die, the method comprising the steps of:

positioning said movable block body in a width direction and in a vertical direction in the molding die by supporting said movable block body with a die portion abutting against a plain surface of said movable block body having no rolling member rolling groove of said movable block body;

positioning said movable block body in a longitudinal direction by supporting both end surfaces in a longitudinal direction of said movable block body;

preventing a molding material from invading into said rolling member rolling grooves by shutting off the molding material at both side peripheries of said rolling member rolling grooves; and

integrally molding said die-molded portion with the movable block body.

2. A method of molding a movable block for a rolling motion guide device according to claim **1**, wherein said movable block body comprises a horizontal portion extending in a width direction and in a longitudinal direction and a pair of leg portions protruding in a height direction from both the end portions in a width direction of said horizontal portion so as to oppose to side surfaces of said track rail, and in a case where inner side surfaces of said leg portions have inclined surfaces extending toward the protruded portions of said leg portions and gradually inclined toward a side of the track rail, said movable block body is positioned within the molding die in a width direction and in a height direction by supporting at least the inclined surfaces of both the inner side surfaces of both the leg portions and a lower surface of said horizontal portion.

3. A method of molding a movable block for a rolling motion guide device according to claim **1**, wherein said movable block body comprises a horizontal portion extending in a width direction and in a longitudinal direction, and a pair of leg portions protruding in a height direction from both the end portions in a width direction of said horizontal portion so as to oppose to side surfaces of said track rail, and in a case where inner side surfaces of said leg portions have an almost vertical surfaces, said movable block body is positioned in a width direction and in a height direction by supporting at least the vertical surfaces of both the inner side surfaces of both the leg portions and both upper and lower surfaces of said horizontal portion.

4. A method of molding a movable block for a rolling motion guide device according to claim **1**, wherein said movable block body comprises a horizontal portion extending in a width direction and in a longitudinal direction and a pair of leg portions protruding in a height direction from both the end portions in a width direction of said horizontal portion so as to oppose to side surfaces of said track rail, and in a case where inner side surfaces of said leg portions have inclined surfaces extending toward the protruded portions of said leg portions and gradually inclined toward a side opposite to said track rail, said movable block body is positioned in a width direction and in a height direction by supporting at least the inclined surfaces of both the inner side surfaces of both the leg portions and an upper surface of said horizontal portion.

5. A method of molding a movable block for a rolling motion guide device according to claim **1**, wherein said movable block body comprises a horizontal portion extending in a width direction and in a longitudinal direction and a leg portion protruding in a height direction from one end portion in a width direction of said horizontal portion so as to oppose to one side surface of said track rail, and in a case where an inner side surface of said leg portion has an almost vertical surface or an inclined surface extending toward a protruded end portion and gradually inclined to a side of said track rail, said movable block body is positioned within the molding die in a width direction and in a height direction by supporting at least the vertical surface or the inclined surface of the inner side surfaces and outer side surfaces of said leg portion and both upper and lower surfaces of said horizontal portion.

6. A method of molding a movable block for a rolling motion guide device according to any one of claims **1** to **5**, wherein said positioning in a longitudinal direction of said movable block body in the molding die is performed by supporting a direction changing guide portion formed to both end portions of said rolling member rolling groove of said movable block body.

7. A method of molding a movable block for a rolling motion guide device according to claim **1**, wherein said circulation passage comprises a rolling member rolling groove to be formed to said movable block, a rolling member return passage to be formed in parallel to said rolling member rolling groove, and a direction changing passage for connecting said rolling member rolling groove to said rolling member return passage,

wherein said die molded portion constitutes at least one of a rolling member retaining portion to be formed at both side peripheries of said rolling member rolling groove, a return passage forming portion for forming said rolling member return passage, and a direction changing inner peripheral guide forming portion for forming an inner peripheral portion of said direction changing passage.

* * * * *

US006045265A

United States Patent [19]

Shirai et al.

[11] **Patent Number: 6,045,265**

[45] **Date of Patent: Apr. 4, 2000**

[54] **ROLLING MOTION GUIDE APPARATUS AND METHOD OF MANUFACTURING MOVABLE MEMBER OF ROLLING MOTION GUIDE APPARATUS**

[75] Inventors: **Takeki Shirai; Tadashi Hirokawa,** both of Tokyo, Japan

[73] Assignee: **THK Co., Ltd.,** Tokyo, Japan

[21] Appl. No.: **08/983,340**

[22] PCT Filed: **May 1, 1997**

[86] PCT No.: **PCT/JP97/01507**

§ 371 Date: **Apr. 15, 1998**

§ 102(e) Date: **Apr. 15, 1998**

[87] PCT Pub. No.: **WO97/42422**

PCT Pub. Date: **Nov. 13, 1997**

[30] **Foreign Application Priority Data**

May 2, 1996 [JP] Japan 8-135887

[51] **Int. Cl.**[7] **F16C 29/06**

[52] **U.S. Cl.** **384/45**

[58] **Field of Search** 384/43, 44, 45; 464/168

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,128,279 12/1978 Ernst et al. .
4,659,239 4/1987 Teramachi .

FOREIGN PATENT DOCUMENTS

1-176811 7/1989 Japan .
2-142918 6/1990 Japan .
2-142919 6/1990 Japan .
3-144114 6/1991 Japan .
7-208465 8/1995 Japan .
7-317762 12/1995 Japan .
2 282 192 3/1995 United Kingdom .

Primary Examiner—Lenard A. Footland
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland, & Naughton

[57] **ABSTRACT**

An object of this invention is to provide a rolling motion guide apparatus and a method of manufacturing a movable member for the apparatus enabling to enhance a working efficiency by sufficiently minimizing the boundary portion between the molding shaped portion and the movable member body. The apparatus and the method are characterized in that a pipe portion **(14)** for forming a rolling member return passage is integrally provided to an inner periphery portion of a through bore **(13)** formed so as to penetrate through a movable block body **(6)**, and a boundary portion between a molding die portion and the movable block body **(6)** is limited to portions, i.e., a portion between an end surface **(61)** of the movable block body and a round piece portion **(16)** and a portion between a ball rolling groove **(10)** and a ball retaining portion **(12)**.

1 Claim, 5 Drawing Sheets

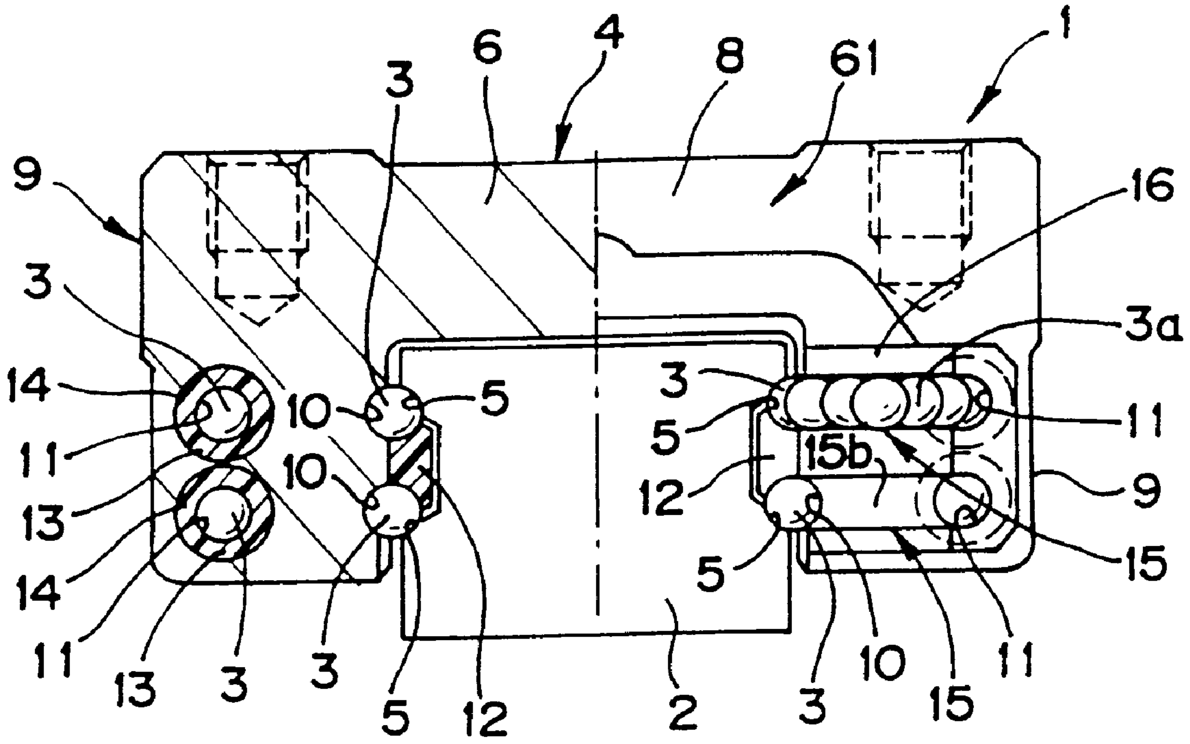


FIG. 1

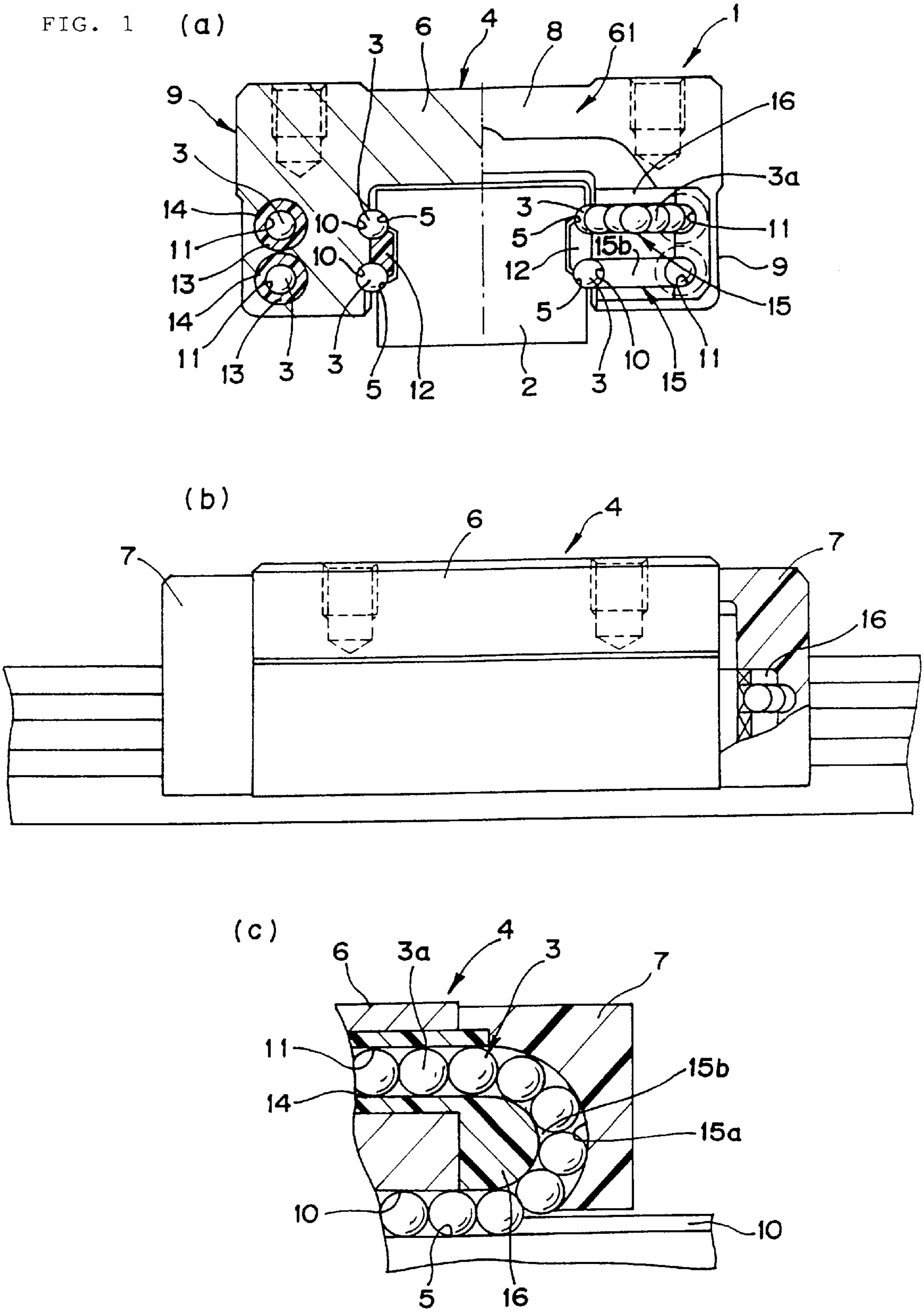

(a)
1
3
6
4
8
61
9
16
3
3a
14
10
5
3
11
11
5
15b
10
12
9
13
14
15
5
11
13
3
3
5
12
2
3
10
15
11
(b)
6
4
7
7
16
(c)
6
3a
4
3
7
11
15b
14
15a
10
10
5
16

FIG. 2

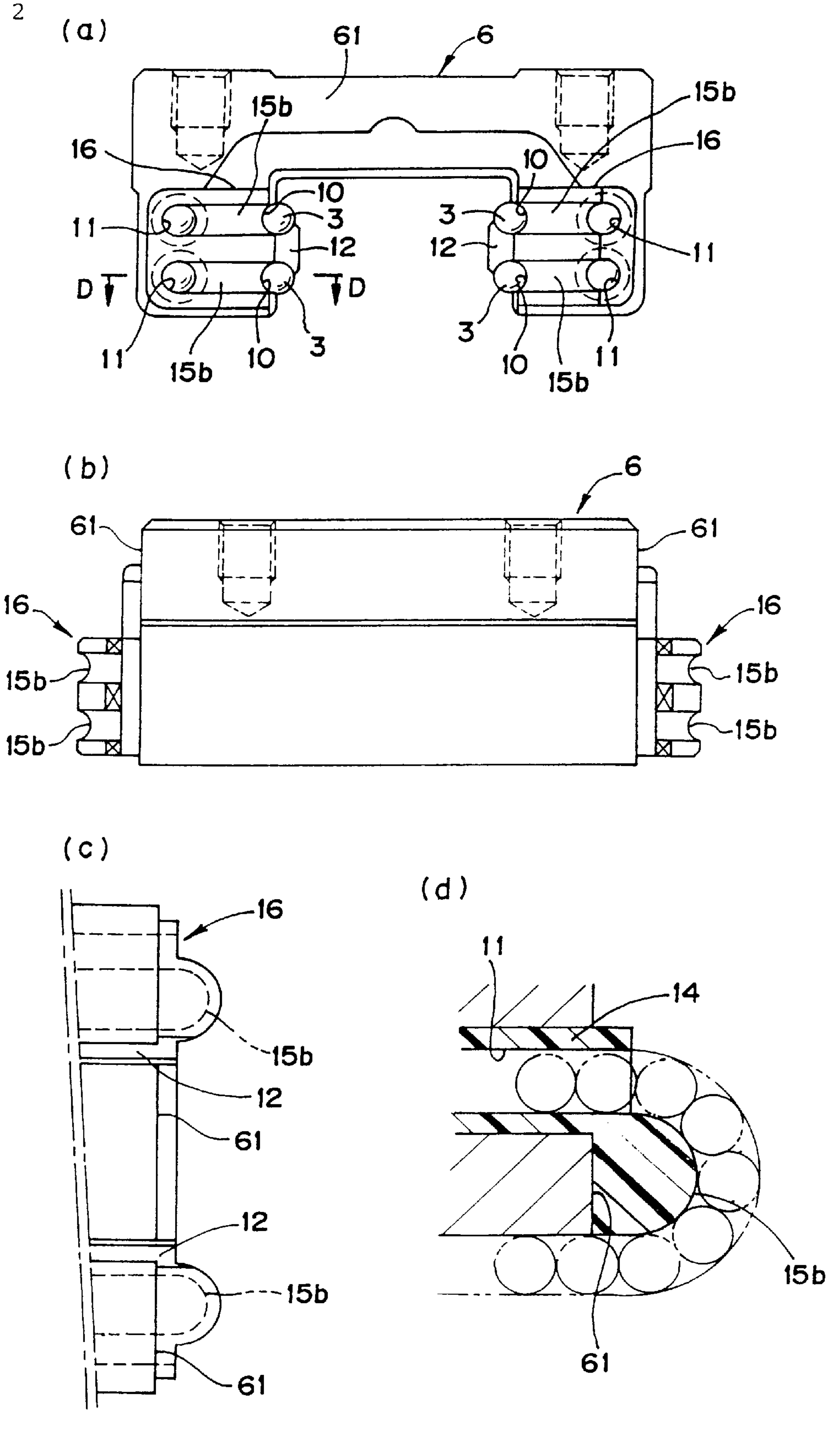

(a)
61
6
15b
15b
16
16
10
10
11
3
3
12
12
11
D
D
11
15b
10
3
3
10
15b
11
(b)
6
61
61
16
16
15b
15b
15b
15b
(c)
16
15b
12
61
12
15b
61
(d)
11
14
15b
61

FIG. 3

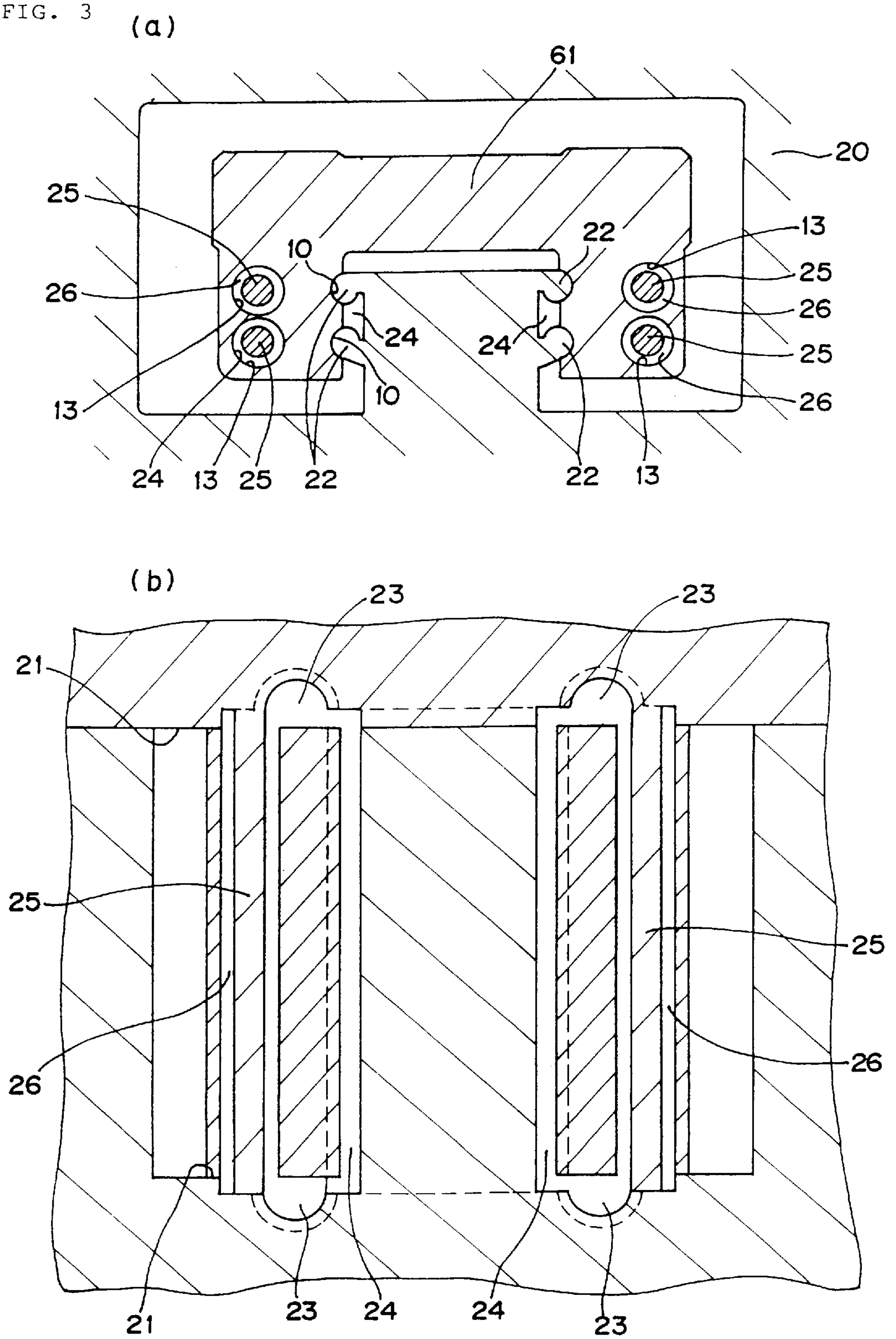
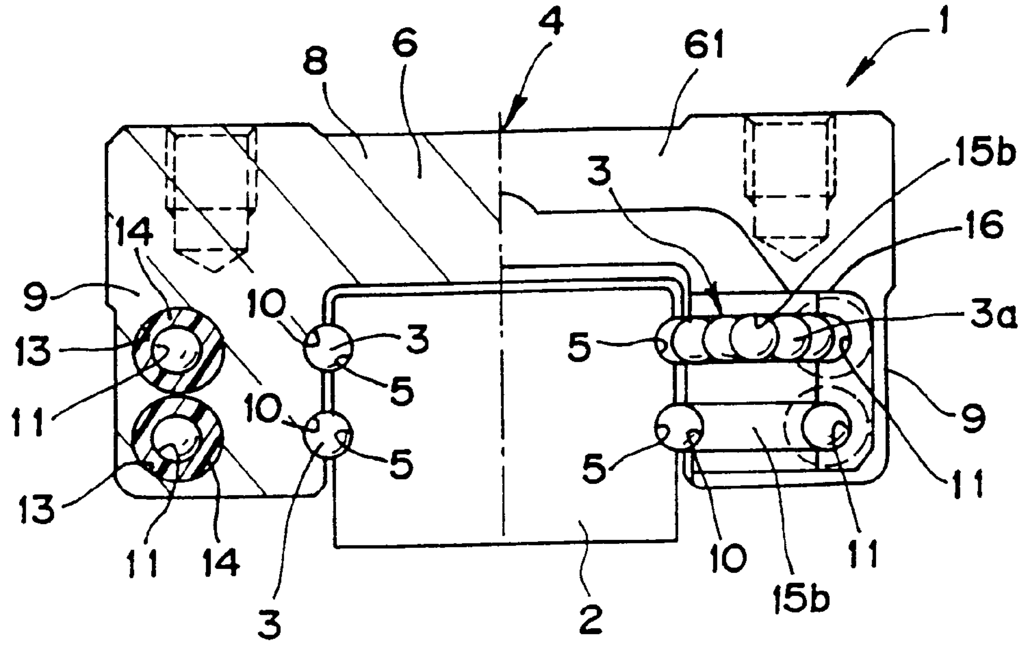

(a)
61
20
25
22
13
10
25
26
26
24
24
25
13
10
26
24 13 25 22
22 13
(b)
23
23
21
25
25
26
26
21
23 24
24 23

FIG. 4

(a)


4
1
8
6
61
3
15b
16
3a
14
9
10
3
5
13
11
10
5
5
9
11
13
11
14
3
2
10
11
15b

(b)

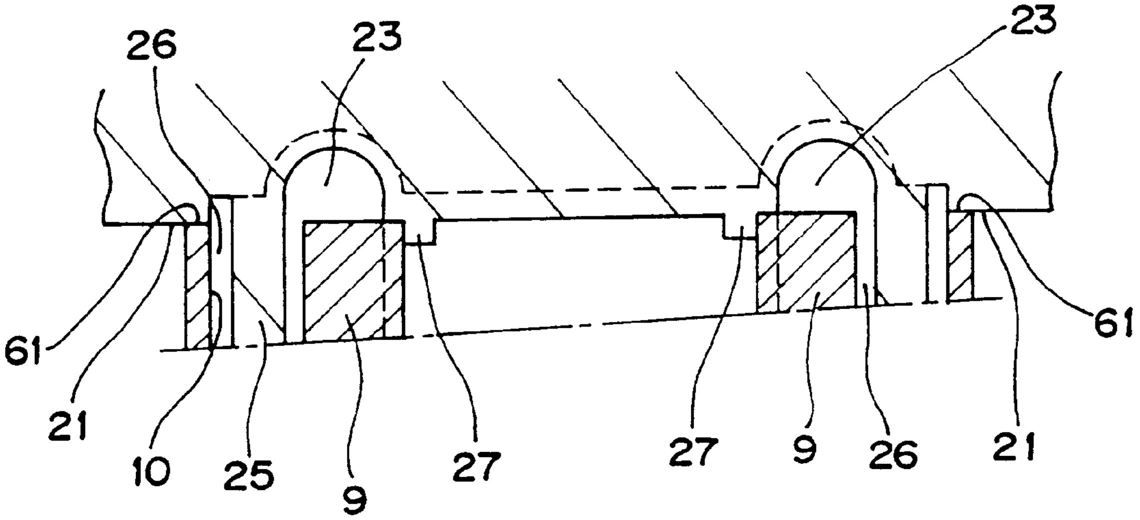
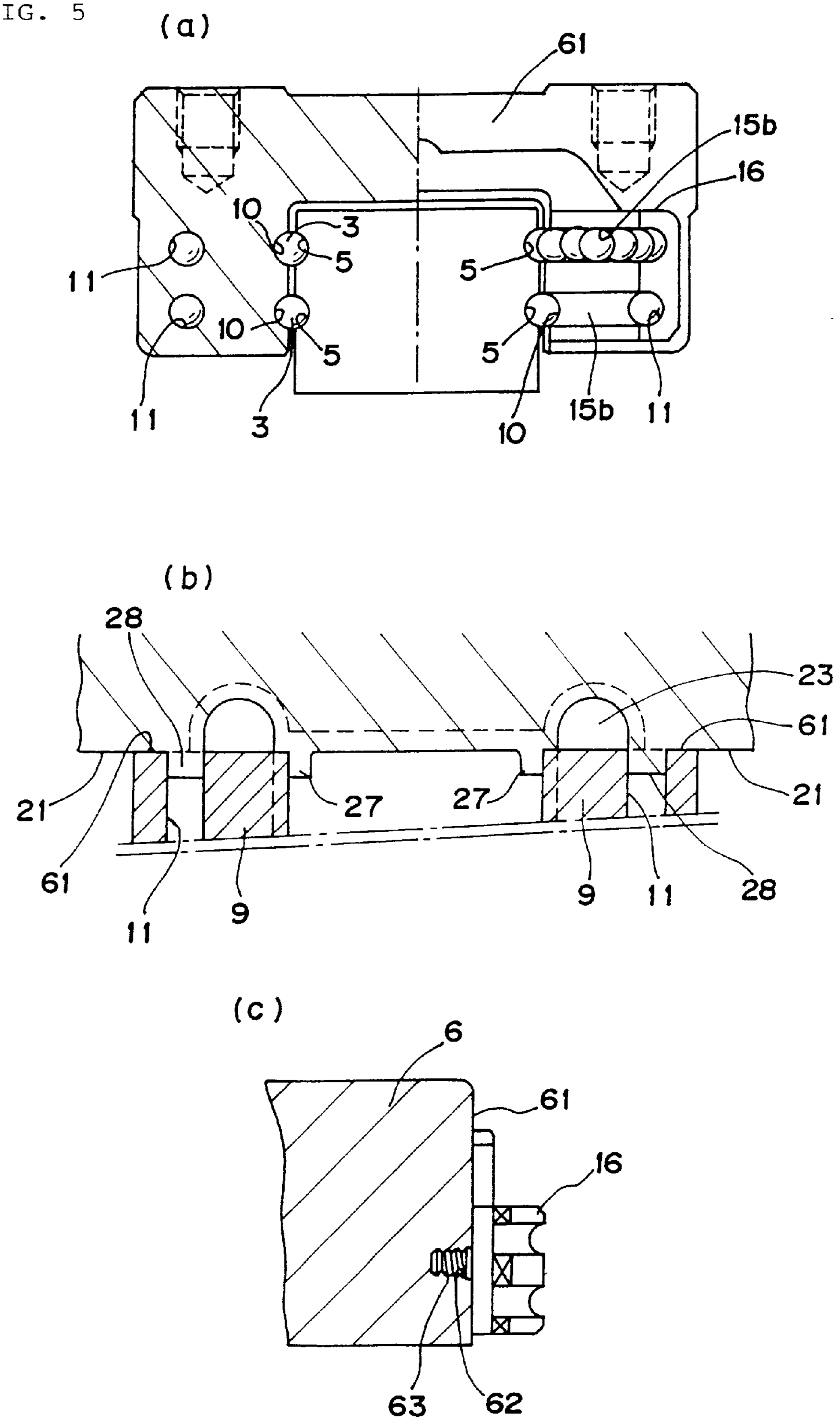

26
23
23
61
21
10
25
9
27
27
9
26
21
61

FIG. 5


(a)
61
15b
16
10
3
5
11
5
10
5
5
11
3
10
15b
11
(b)
28
23
61
21
27
27
21
61
11
9
9
11
28
(c)
6
61
16
63
62

ROLLING MOTION GUIDE APPARATUS AND METHOD OF MANUFACTURING MOVABLE MEMBER OF ROLLING MOTION GUIDE APPARATUS

TECHNICAL FIELD

The present invention relates to a rolling motion guide apparatus in which a movable member is movably assembled to a track shaft through a rolling member, particularly to a structure for an inner periphery guide portion of a rolling member rolling direction changing passage which is integrally formed to a movable member body.

BACKGROUND ART

As an example of the conventional rolling motion guide apparatus of this type, the applicant had already proposed a rolling motion guide apparatus, as disclosed in Japanese Patent Laid-Open Publication No. HEI 7-317762, in which a circulating passage of the rolling member is integrally formed to the movable member body as a molding shaped portion composed of resin or the like.

That is, the movable member has a structure comprising: a movable member body having a loaded rolling member rolling portion corresponding a loaded rolling member rolling portion formed to the track shaft, and a rolling member return passage for returning a rolling member from one end of the loaded rolling member rolling portion to the other end thereof; and a direction changing passage member provided both end portions of the movable member body, the direction changing passage member constituting a rolling member rolling direction changing passage for scooping up the rolling member from the loaded rolling member rolling portion and then guiding the rolling member to the rolling member return passage.

Further, a rolling member retaining portion provided at a side peripheral portion of the loaded rolling member rolling portion, the inner periphery guide portion of the rolling member rolling direction changing passage and the rolling member return passage portion are integrally formed to the movable member body as a molding shaped portion composed of resin or the like (see Japanese Patent Laid-Open Publication No. HEI 7-317762).

However, in a case of the prior art technics described above, a boundary between the molding shaped portion and the movable member body consists of three boundary portions i.e., a boundary portion between both end surfaces of the movable member body and a shaped portion of the direction changing passage inner periphery guide portion, a boundary portion between the rolling member rolling portion and a shaped portion of the rolling member retaining portion formed at both side peripheral portion of the rolling member rolling portion, and a boundary portion between a side surface of the movable member opposing to a side surface to which rolling member rolling portion is formed and a shaped portion of a rolling member return bore. As a result, the three boundary portions are ranged over three side surfaces of the movable member.

When a clearance between the respective boundary portions between the movable member body and the molding shaped portion and a molding die supporting portion are not set to within a predetermined range, burrs will be disadvantageously formed from a molding material, so that it is required to take a countermeasure against the burrs. In this regard, the conventional movable member is inevitably required to take the countermeasure against the burrs with respect to the three side surfaces of the movable member.

Accordingly, the molding die and the movable member were required to be precisely formed so that each of the three side surfaces thereof should have an accurate dimension.

The present invention was conceived for solving the aforementioned problems and an object of the present invention is to provide a rolling motion guide apparatus and a method of manufacturing a movable member for the apparatus enabling to enhance a working efficiency by sufficiently minimizing the boundary portion between the molding shaped portion and the movable member body.

DISCLOSURE OF THE INVENTION

In order to achieve the afore-mentioned object, the present invention provides a rolling motion guide apparatus comprising a track shaft and a movable member movably disposed to the track shaft through a number of rolling members,

- wherein the movable member comprises: a movable member body having a loaded rolling member rolling portion corresponding to a loaded rolling member rolling portion formed to the track shaft, and a rolling member return passage for returning the rolling member from one end of the loaded rolling member rolling portion to the other end thereof; and a direction changing passage member provided both end portions of the movable member body, the direction changing passage member constituting a rolling member rolling direction changing passage for scooping up the rolling member from the loaded rolling member rolling portion and then guiding the rolling member to the rolling member return passage,
- wherein a rolling member retaining portion, the direction changing passage inner periphery guide portion and the rolling member return passage constituting portion to be provided at side peripheral portion of the loaded rolling member rolling portion are integrally formed to the movable member body by inserting the movable member body into a molding die,
- wherein the rolling member return passage constituting portion is integrally provided to an inner peripheral portion of a through bore formed so as to penetrate the movable member body, and
- wherein boundary portions between each of the rolling member retaining portion, the direction changing inner periphery guide portion, the rolling member return passage constituting portion and the movable member body are limited to portions between an end portion of the movable member body and the direction changing passage inner periphery guide portion and between the rolling member rolling portion and the rolling member retaining portion.

Accordingly, the countermeasure against the burrs is required for only two portions of the end surface of the movable member body and the rolling member rolling groove portion, so that an accuracy in dimension is not required for a portion between a side surface opposing to the side surface of the movable member body to which rolling member rolling groove is formed and the molding die. In this case, the direction changing passage inner periphery guide portions provided at both end portions of the movable member body are connected to the rolling member return passage member through the rolling member retaining portion, so that the direction changing passage inner periphery guide portions are not detachable therefrom.

In addition, in a case where the rolling member retaining portion is not provided to a side peripheral portion of the rolling member rolling groove of the movable member body, the apparatus is characterized in that the boundary portions between the direction changing passage inner periphery guide portion, the rolling member return passage member and the movable member body are limited to portions i.e., a portion between the end portion of the movable member body and the direction changing passage inner periphery guide portion, and a portion between both the end portions of the rolling member rolling portion and the direction changing passage inner periphery guide portion.

According to the structure described above, the portions to be required to take the countermeasure against the burrs are limited to the portions of the end surface of the movable member body and both the end portions of the rolling member rolling portion. In this case, the direction changing passage inner periphery guide portions provided at both end portions of the movable member body are connected by the rolling member return passage member, so that the direction changing passage inner periphery guide portions are not detachable therefrom.

Further, in a case where the rolling member retaining portion is not provided to a side peripheral portion of the rolling member rolling groove of the movable member body and the rolling member return passage is not molding-shaped, the apparatus is characterized in that the boundary portion between the direction changing passage inner periphery guide portion and the movable member body is limited to portions i.e., a portion between both the end portions of the movable member body and the direction changing passage inner periphery guide portion, a portion between both the end portions of the rolling member rolling portion and the direction changing passage inner periphery guide portion, and a portion between both the end portions of the rolling member return passage and the direction changing passage inner periphery guide portion.

According to the structure described above, the portion to be required to take the countermeasure against the burrs is limited to the portions of the end surface of the movable member body, both the end portions of the rolling member rolling portion, and both the end portions of the rolling member return passage.

In this case, when the direction changing passage inner periphery guide portion member is constructed so that both end surfaces of the movable member body are provided with engaging holes and the direction changing passage inner periphery guide portion is provided with an engaging convex portion for locking which is formed from a molding material flowing into the engaging hole, the direction changing passage inner periphery guide portion can be prevented from dropping off.

In this regard, when the engaging hole is formed to be a screwed hole having a thread groove formed at inner periphery portion of the screwed hole and the engaging convex portion is formed to have a male thread groove with which the thread groove of the screwed hole is engaged, the prevention of the dropping-off can be further ensured.

The method of manufacturing a movable member for the rolling motion guide apparatus having a movable member comprising: a movable member body having a loaded rolling member rolling portion corresponding to a loaded rolling member rolling portion formed to the track shaft, and a rolling member return passage for returning a rolling member from one end of the loaded rolling member rolling portion to the other end thereof; and a direction changing passage member provided both end portions of the movable member body, the direction changing passage member constituting a rolling member rolling direction changing passage for scooping up the rolling member from the loaded rolling member rolling portion and then guiding the rolling member to the rolling member return passage; the method characterized by comprising the steps of:

- forming a through bore for forming the rolling member return passage to the movable member body;
- supporting the movable member body within a molding die with reference to the end surfaces and the rolling member rolling portion of the movable member body, and setting each of contact conditions between the end surface of the movable member body and an end surface supporting portion of the molding die and between the rolling member rolling portion of the movable member body and a rolling member rolling portion supporting portion to a contact condition enabling to shut off a circulation of the molding material therebetween;
- forming a cavity for forming the direction changing passage inner periphery guide portion at a portion between the end portion of the movable member body and the end surface supporting portion of the molding die, forming a cavity for forming the rolling member retaining portion at a portion between the rolling member rolling portion of the movable member body and a side periphery portion of a rolling member rolling portion supporting portion of the molding die, and forming a cavity for forming the rolling member return passage at a portion between a core pin to be inserted into the through bore of the movable member body and the inner periphery portion of the through bore; and
- injecting the molding material into the respective cavities for forming the direction changing passage inner periphery guide portion, the rolling member retaining portion and the rolling member return passage, thereby to integrally form the direction changing passage inner periphery guide portion, the rolling member retaining portion and the rolling member return passage to the movable member body.

According to the molding method described above, each of positions of the direction changing passage inner periphery guide portion, the rolling member retaining portion and the rolling member return passage is determined with reference to the rolling member rolling portion. Therefore, each of joint portions between the rolling member rolling portion and the direction changing passage inner periphery guide portion and between the direction changing passage and the rolling member return passage can be formed as a continuous surface having no difference in level, so that smooth circulation and movement of the rolling member can be effectively secured.

In another aspect of the present invention of a case where the rolling member retaining portion is not provided at the side peripheral portion of the rolling member rolling groove of the movable member body, the method comprises the steps of:

- forming a through bore for forming the rolling member return passage at the movable member body;
- supporting the movable member body within a molding die at both the end surfaces of the movable member body and an end portion of the rolling member rolling portion, and setting each of contact conditions between the the end surface of the movable member body and an end surface supporting portion of the molding die and between the rolling member rolling portion of the movable member body and a rolling member rolling portion end supporting portion of the molding die to a

contact condition enabling to shut off a circulation of the molding material therebetween;

forming a cavity for forming the direction changing passage inner periphery guide portion at a portion between the end portion of the movable member body and the end surface supporting portion of the molding die and forming a cavity for forming the rolling member return passage at a portion between a core pin to be inserted into the through bore of the movable member body and the inner periphery portion of the through bore; and

injecting the molding material into the respective cavities for forming the direction changing passage inner periphery guide portion and the rolling member return passage, thereby to integrally form the direction changing passage inner periphery guide portion and the rolling member return passage to the movable member body.

Furthermore, in another aspect of this invention of a case where the rolling member retaining portion is not provided to a side peripheral portion of the rolling member rolling groove of the movable member body and the rolling member return passage is not constituted by the molding-shaped portion, the method is characterized by comprising the steps of:

supporting the movable member body within a molding die at both the end surfaces of the movable member body and an end portion of the rolling member rolling portion, and setting each of contact conditions between the end surface of the movable member body and an end surface supporting portion of the molding die, between an end portion of the rolling member rolling portion of the movable member body and a rolling member rolling portion end supporting portion of the molding die and between an end portion of the rolling member return passage of the movable member body and an return passage end supporting portion of the molding die to a contact condition enabling to shut off a circulation of the molding material therebetween;

forming a cavity for forming the direction changing passage inner periphery guide portion at a portion between the end portion of the movable member body and the end surface supporting portion of the molding die; and

injecting the molding material into the cavity for forming the direction changing passage inner periphery guide portion, thereby to integrally form the direction changing passage inner periphery guide portion to the movable member body.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view showing one embodiment of a rolling motion guide apparatus according to the present invention, in which FIG. **1**(*a*) is a cross sectional view of the apparatus, FIG. **1**(*b*) is a side view of the apparatus and FIG. **1**(*c*) is a cross sectional view showing a direction changing passage of the apparatus.

FIG. **2** is a view showing a movable block body of the apparatus according to the present invention, in which FIG. **2**(*a*) is a view showing an end surface of the movable block body, FIG. **2**(*b*) is a side view of the movable block body, FIG. **2**(*c*) is a rear end view showing a part of a direction changing passage of the movable block body and FIG. **2**(*d*) is a cross sectional view taken along the line D—D of FIG. **2** (*a*).

FIG. **3** is a view showing a shape-molding method of the movable block body.

FIG. **4** is a view showing another embodiment of a rolling motion guide apparatus according to the present invention in which FIG. **4**(*a*) is a front view, half in section, showing a movable block body and FIG. **4**(*b*) is a view showing a construction of a molding die for forming a round piece portion.

FIG. **5** is a view showing still another embodiment of a rolling motion guide apparatus according to the present invention in which FIG. **5**(*a*) is a front view, half in section, showing a movable block body, FIG. **5**(*b*) is a view showing a construction of a molding die for forming a round piece portion and FIG. **5**(*c*) is a cross sectional view showing a construction in which an engaging convex portion is provided to the round piece portion.

BEST MODE FOR EMBODYING THE INVENTION

In order to explain the present invention in more detail, the preferred embodiments of this invention will be described hereunder with reference to the accompanying drawings.

FIGS. **1** to **3** are views each showing one embodiment of a rolling motion guide apparatus according to the present invention.

In FIG. **1**, a reference numeral **1** denotes an entire rolling motion guide apparatus which substantially comprises a track rail **2** as the track shaft and a movable block **4** as the movable member disposed to be movable on the track rail **2** through a ball row **3** consisting of a number of balls **3***a* as the rolling members.

The track rail **1** is an elongated member formed to provide a rectangular shape in section so that each of lateral right and left side surfaces of the track rail **1** is provided with two ball rows, respectively, i.e., totally four ball rows B**1**, B**2**, B**3** and B**4** through which the movable block **4** is guided. The right and left side surfaces of the track rail **1** are provided with four rows of loaded ball rolling grooves **5**, **5**, **5** and **5** as the loaded rolling member rolling portions corresponding to the four ball rows B**1**, B**2**, B**3** and B**4** so as to extend to an entire length of the track rail **4**.

The movable block **4** comprises a movable block body **6** and a pair of end plates **7** constituting the direction changing passage member that are provided at both end portions of the movable block body **6**. The movable block body **6** is composed of a block body having an inverted U-shaped cross-section and further comprises a horizontal portion **8** opposing to an upper surface of the track rail **2** and a pair of supporting leg portions **9** and **9** opposing to right and left side surfaces of the track rail **2**. The inner side surfaces of the respective right and left supporting leg portions **9** and **9** are provided with loaded ball rolling grooves **10**, **10**, **10** and **10** corresponding to the loaded ball rolling grooves **5**, **5**, **5** and **5** formed to the right and left side surfaces of the track rail **2**. Further, at the inner side surfaces of the respective right and left supporting leg portions **9** and **9**, ball retaining portions **12** and **12** are provided between the loaded ball rolling grooves **5**, **5** and **5**, **5** so as to prevent the ball from dropping off therefrom when the movable block **4** is detached from the track rail.

Further, solid portions of the respective supporting leg portions **9** and **9** are provided with four rows of ball return passages **11**, **11**, **11** and **11** as the rolling member return passages extending in an axial direction for returning the ball from one end portion to the other end portion of the respective loaded ball rolling grooves **10**, **10**, **10** and **10**. The ball return passages **11**, **11**, **11** and **11** are formed from pipe portions **14**, **14**, **14** and **14** as the return passage members which are bonded to the inner circumferential portions of the through bores **13**, **13** **13** and **13** formed to the respective supporting leg portions **9** and **9**.

On the other hand, the end plate **7** is also formed to have an inverted U-shaped cross-section corresponding to the shape of the movable block body **6** and is provided with ball direction changing passage **15**, **15**, **15** and **15** for scooping up the balls **3***a* from the loaded ball rolling grooves **10**, **10** **10** and **10** and then guiding the balls **3***a* to the ball return passages **11**, **11**, **11** and **11**. The end plate **7** is provided with outer periphery guide portions **15***a*, **15***a*, **15***a* and **15***a* of the ball direction changing passages **15**, **15**, **15** and **15**. The ball direction changing passage **15** is constructed by fitting the end plate **7** to the round piece portions **16** and **16** provided with inner periphery guide portions at the end surface of the movable block body **6**.

In this regard, as shown in FIG. **2**, the ball retaining portions **12** and **12** to be formed at side peripheral portions of the loaded ball rolling grooves **5**, **5**, **5** and **5**, the round piece portions **16** and **16** as the direction changing passage inner periphery guide portions and the pipe portions **14**, **14**, **14** and **14** as the rolling member return passage member are integrally formed to the movable block body **6** by inserting the movable block body **6** into a molding die. In this case, the die-molding operation can be performed by utilizing a resin molding method or a die-casting molding method using aluminum material or the like.

In addition, boundary portions between each of the round piece portion **15**, the ball retaining portion **12**, the pipe portion **14** and the movable member body **6** are limited to portions between the end surface **61** of the movable member body **6** and the round piece portions **15** and **16** as the direction changing passage inner periphery guide portion and between the ball rolling grooves **10**, **10**, **10** and **10** and the ball retaining portions **12** and **12**.

Accordingly, the countermeasure against the burrs is required for only the portions of the end surface **61** of the movable member body **6** and the ball rolling grooves **10**, **10**, **10** and **10**, so that an accuracy in dimension is not required for a portion between a side surface opposing to the side surface of the movable member body **6** to which rolling member rolling groove **10**, **10**, **10** and **10** are formed and the molding die. In this case, the round piece portions **16** and **16** provided at both end portions of the movable member body **6** are connected to the pipe portions **14**, **14**, **14** and **14** through the ball retaining portions **12** and **12**, so that the round piece portions **16** and **16** are not detachable therefrom.

Further, as shown in FIG. **3**, a method of manufacturing a movable block **4** for the rolling motion guide apparatus of the present invention comprises the steps of forming a through bore **13** for forming the ball return passage **11** at the movable block body **6** and supporting the the movable block body **6** within a first and a second molding dies **201** and **202** with reference to both the end surfaces **61** and the rolling member rolling grooves **10** of the movable block body **6**, and setting each of contact conditions between the end surface **61** of the movable block body **6** and the end surface supporting portions of the molding dies **201** and **202**, and between the ball rolling groove **10** of the movable block body **6** and a ball rolling groove supporting portion **22** of the first molding die **201** to a contact condition enabling to shut off a circulation of a fluidized resin material therebetween.

In this regard, the respective members are not required to be completely close-contacted to each other. As far as gaps of portions between the respective members are small enough, the circulation of the resin material can be shut off, so that a gap enabling to shut off the circulation shall be allowed. Both the end surfaces **61** and **61** can be securely shut off the resin circulation by a mold clamping force of the first and second molding dies **201** and **202**.

Then, a cavity **23** for forming the round piece portion **16** as the direction changing passage inner periphery guide portion is formed at a portion between both the end portions **61** and **61** of the movable block body **6** and the end surface supporting portions **21** and **21** of the first and second molding dies **201** and **202**, a cavity **24** for forming the ball retaining portion **12** is formed at the ball rolling groove **10** of the movable block body **6** and the side periphery portion of the ball rolling groove supporting portion **22** of the first molding die **201** and a cavity **26** for forming the ball return passage **11** at a portion between a core pin **25** to be inserted into the through bore **13** of the movable block body **6** and the inner periphery portion of the through bore **13**.

The respective cavities described above are communicated with each other. When the molding material is injected into the respective cavities **23**, **24** and **26**, the round piece portion **16**, the ball retaining portion **12** and the pipe portion **14** constituting the ball return passage **11** are integrally formed to the movable block body **6**.

[Other Embodiments]

Next, the other embodiments of the present invention will be explained hereunder. Notes, in the following explanations, only the points different from those of the aforementioned embodiment will be explained. Namely, detailed explanations regarding to the same constitutional elements or parts as those in the aforementioned embodiment will be omitted by adding the same reference numerals to the corresponding elements or parts.

A mode of an embodiment shown in FIG. **4** shows a case where the ball retaining portion **12** is not provided to a side peripheral portion of the ball rolling groove **10** of the movable block body **6**.

Namely, in this embodiment, the boundary portion between the round piece portion **16** to be die-molded and the movable block body **6** is limited to portions i.e., a portion between the end surface of the movable block body **6** and the round piece portion, and a portion between both the end portions of the ball rolling groove **10** and the round piece portion **16**.

According to the structure described above, the portion to be required to take the countermeasure against the burrs is limited to only the end surface of the movable block body **6** and both the end portions of the ball rolling groove **10**. As a result, the number of portions required for pressing the movable block body can be reduced in comparison with that of the afore-mentioned embodiment. At the time of the mold-shaping operation, as shown in FIG. **4**(*b*), when a groove end supporting portion **27** for supporting only a groove end of the ball rolling groove **10** is provided, the formation of the burrs of the molding material to the ball rolling groove **10** can be prevented. As a matter of course, a ball rolling groove supporting portion **22** for supporting the ball rolling groove can also be provided in the entire length of the ball rolling groove **10**.

In this case, the round piece portion **16** provided at both end portions of the movable block body **6** is connected by the pipe portion **14** for forming the ball return passage member, so that the round piece portion is not detachable therefrom.

Further, a mode of an embodiment shown in FIG. **5** shows a case where the ball retaining portion **12** is not provided at a side peripheral portion of the ball rolling groove **12** of the movable block body **6** and the ball return passage **11** is not formed by mold-shaping. The apparatus is characterized in that the boundary portion between the round piece portion **16** and the movable block body **6** is limited to portions i.e., a portion between the end portion **61** of the movable block body **6** and the round piece portion **12**, a portion between both the end portions of the ball rolling groove **10** and the round piece portion **16**, and a portion between both the end portions of the ball return passage **11** and the round piece portion **16**.

According to the structure described above, the portion to be required for taking the countermeasure against the burrs is limited to the portions of the end surface of the movable block body **6**, both the end portions of the ball rolling groove **10** and both the end portions of the ball return passage **11**.

That is, at the time of die-molding operation, as shown in FIG. **5**(*b*), when a groove end supporting portion **27** for supporting only the groove end of the ball rolling groove **10** and a passage end supporting portion **28** for supporting a passage end portion of the ball return passage **11** are provided, the molding material can be prevented from flowing into the ball rolling groove **10** and the ball return passage **11**, so that the formation of the burrs due to the molding material to the ball rolling groove **10** can be prevented.

In this case, as shown in FIG. **5**(*c*), when the round piece portion **16** is constructed so that both end surfaces **61** of the movable block body **6**, to which the round piece portion **16** is bonded, are provided with an engaging hole **62** while the round piece portion **16** is provided with an engaging convex portion **63** for locking which is formed from a molding material flowing into the engaging hole **62**, the dropping-off of the round piece portion **16** can be prevented.

In particular, when the engaging hole **62** is formed to be a screwed hole having a thread groove formed to an inner periphery portion of the screwed hole while the engaging convex portion **63** is formed to have a male thread groove with which the thread groove of the screwed hole is engaged, the prevention of the dropping-off can be further secured.

By the way, although the embodiments have been explained by exemplifying the linear motion guide apparatus as the rolling motion guide apparatus, the present invention is not limited to those embodiments, and it should be understood, as a matter of course, that the present invention is also generally applicable to various rolling motion guide apparatuses in which a movable member is movably assembled to a guide shaft through various rolling members such as ball spline, ball bush or the like.

According to the present invention described above, the portion requiring for the countermeasure against the burrs is limited to only the end surface of the movable member body and the rolling member rolling groove portion, while an accuracy in dimension is not required for a portion between a side surface opposing to the side surface of the movable member body to which rolling member rolling groove is formed and the molding die. Therefore, the preparation of the movable member body and the molding die can be simplified, so that a productivity of the apparatus can be increased.

In addition, according to the method of manufacturing the movable member of the present invention, the movable member body portion is supported by the end surface of the movable member body and the rolling member rolling portion, and each of the positions of the rolling member retaining portion, the direction changing passage inner periphery guide portion and the rolling member return passage are determined with reference to the rolling member rolling portion. Therefore, each of the joint portions between the rolling member rolling portion and the direction changing passage inner periphery guide portion and between the direction changing passage and the ball return passage can be formed as continuous surfaces each having no difference in level, so that smooth circulation and movement of the rolling member can be effectively achieved.

Industrial Applicability

As described above, the rolling motion guide apparatus and the method of manufacturing the movable member for the apparatus according to the present invention are effective to the linear motion guide apparatus in which a movable member is movably assembled to a guide shaft through various rolling members such as linear ball guide device, ball spline, ball bush or the like, and particularly effective to apparatus in which a resin molded portion is integrally formed to the movable member body.

What is claimed is:

1. A rolling motion guide apparatus comprising a track shaft and a movable member movably disposed on said track shaft through a number of balls,

wherein said movable member comprises: a movable member body having a loaded rolling member rolling portion corresponding to a loaded rolling member rolling portion formed on said track shaft and a rolling member return passage for returning the balls from one end of said loaded rolling member rolling portion to the other end thereof; and a direction changing passage member provided at both end portions of said movable member body, said direction changing passage member constituting a rolling member rolling direction changing passage for scooping up the balls from said loaded rolling member rolling portion and then guiding the balls to said rolling member return passage,

wherein a rolling member retaining portion, a direction changing passage inner periphery guide portion and the rolling member return passage constituting portion to be provided at side peripheral portions of said loaded rolling member rolling portion are integrally formed to said movable member body by inserting said movable member body into a molding die,

wherein said rolling member return passage constituting portion is integrally formed to an inner peripheral portion of a through bore formed so as to penetrate said movable member body, and

wherein boundary portions between each of said rolling member retaining portion, said direction changing inner periphery guide portion, said rolling member return passage constituting portion and the movable member body are limited to a boundary portion between an end portion of the movable member body and said direction changing passage inner periphery guide portion and a single boundary portion between said rolling member rolling portion and said rolling member retaining portion.

* * * * *

US006042269A

United States Patent [19]
Konomoto

[11] **Patent Number: 6,042,269**
[45] **Date of Patent: Mar. 28, 2000**

[54] **METHOD OF MAKING A SLIDER OF A LINEAR GUIDE DEVICE**

[75] Inventor: **Masashi Konomoto**, Tokyo, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **09/137,844**

[22] Filed: **Aug. 21, 1998**

Related U.S. Application Data

[62] Division of application No. 08/845,151, Apr. 21, 1997.

[30] **Foreign Application Priority Data**

Apr. 25, 1996 [JP] Japan 8-105856

[51] **Int. Cl.**[7] **F16C 29/06**
[52] **U.S. Cl.** **384/45**; 384/43
[58] **Field of Search** 384/43, 45; 29/898.03

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,615,569	10/1986	Hirata	384/45
5,082,374	1/1992	Narumiya	384/45
5,277,498	1/1994	Kawaguchi	384/45
5,308,167	5/1994	Tsukada	384/45
5,445,455	8/1995	Holweg	384/45
5,464,288	11/1995	Tanaka	384/45 X
5,672,011	9/1997	Eder et al.	384/45
5,755,516	5/1998	Teramachi et al.	384/45

FOREIGN PATENT DOCUMENTS

7-317762 12/1995 Japan .

Primary Examiner—David A. Bucci
Assistant Examiner—Brandon C. Stallman
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

The present invention relates to a slider of a linear guide device for guiding a movable body such as a work table or an industrial robot or the like of a machine tool under load which moves along a track rail arranged at a fixed portion such as a bed, or a column. The block main body is made of a metal which becomes a core part of the slider in a predetermined shape and forming load rolling faces of balls on the block main body by machine. The block main body is inserted into a mold and injection molding of a synthetic resin is performed by which ball retaining portions are built on both sides of the load rolling faces of block main body. Pairs of smooth faces for shielding the molten synthetic resin are formed along the both edges in the longitudinal direction of the load rolling faces formed on block main body whereas the block main body is fixed at a predetermined position in the mold by bringing a projected support portion on the side of the mold into contact with the smooth faces for shielding the molten synthetic resin.

1 Claim, 8 Drawing Sheets

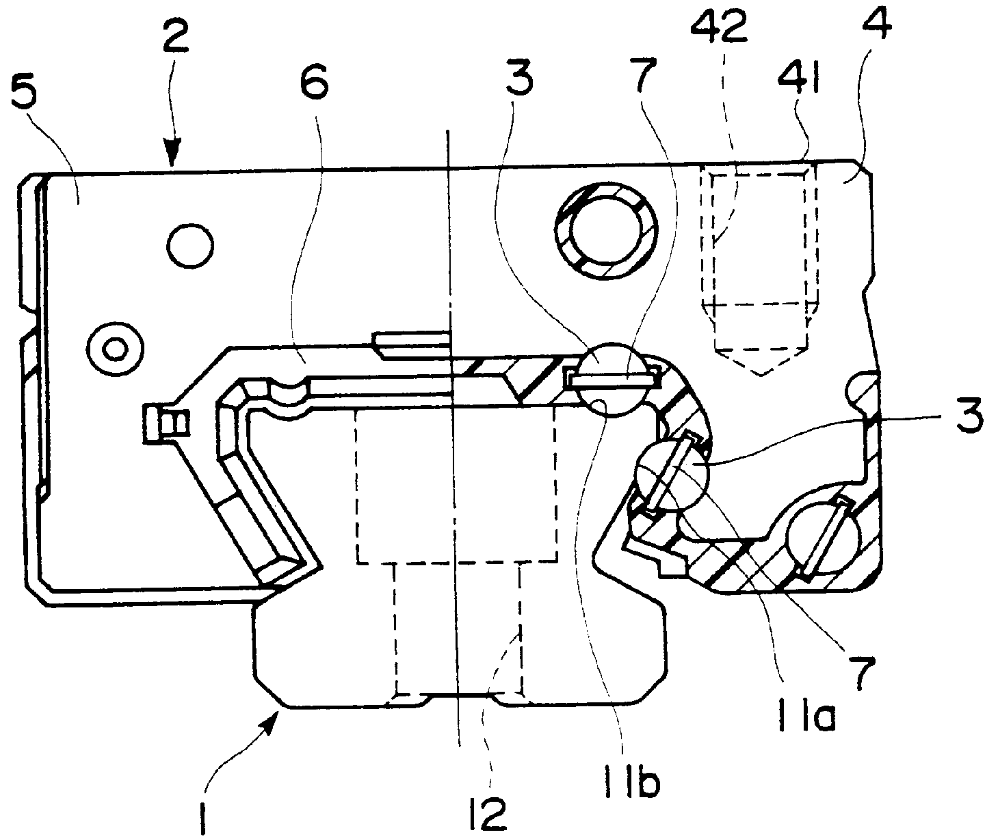


Fig.1

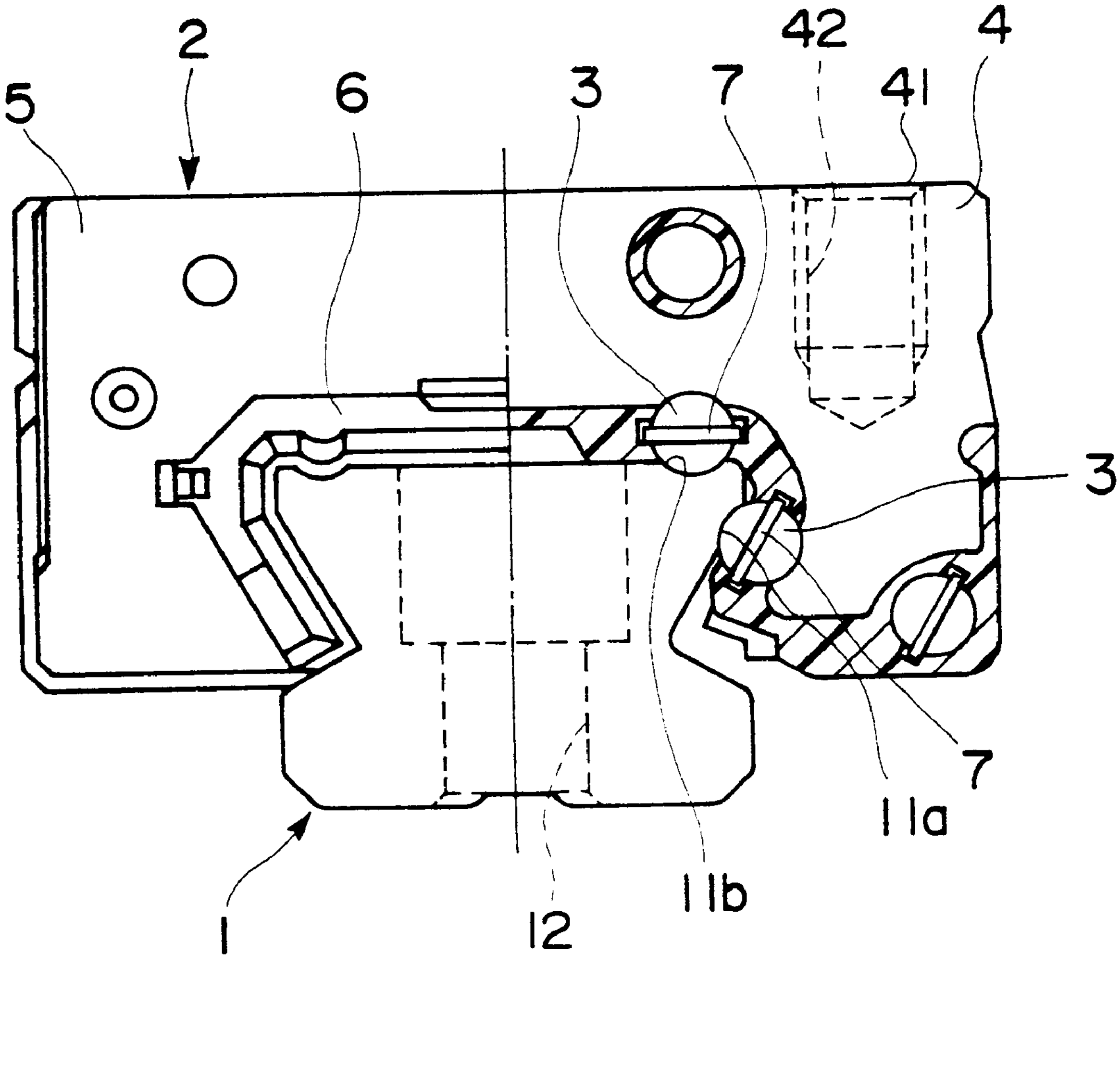


Fig.2

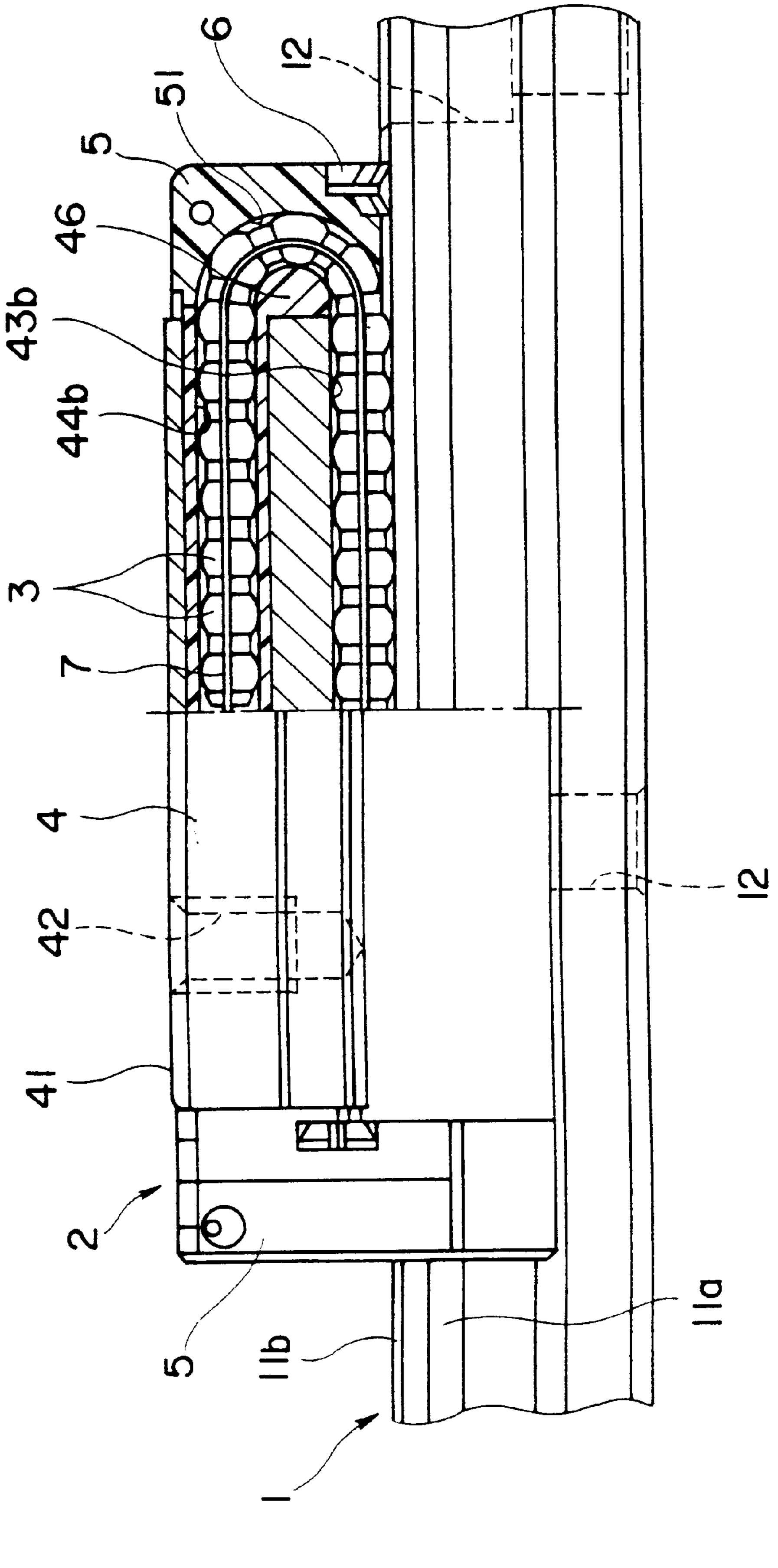


Fig.3

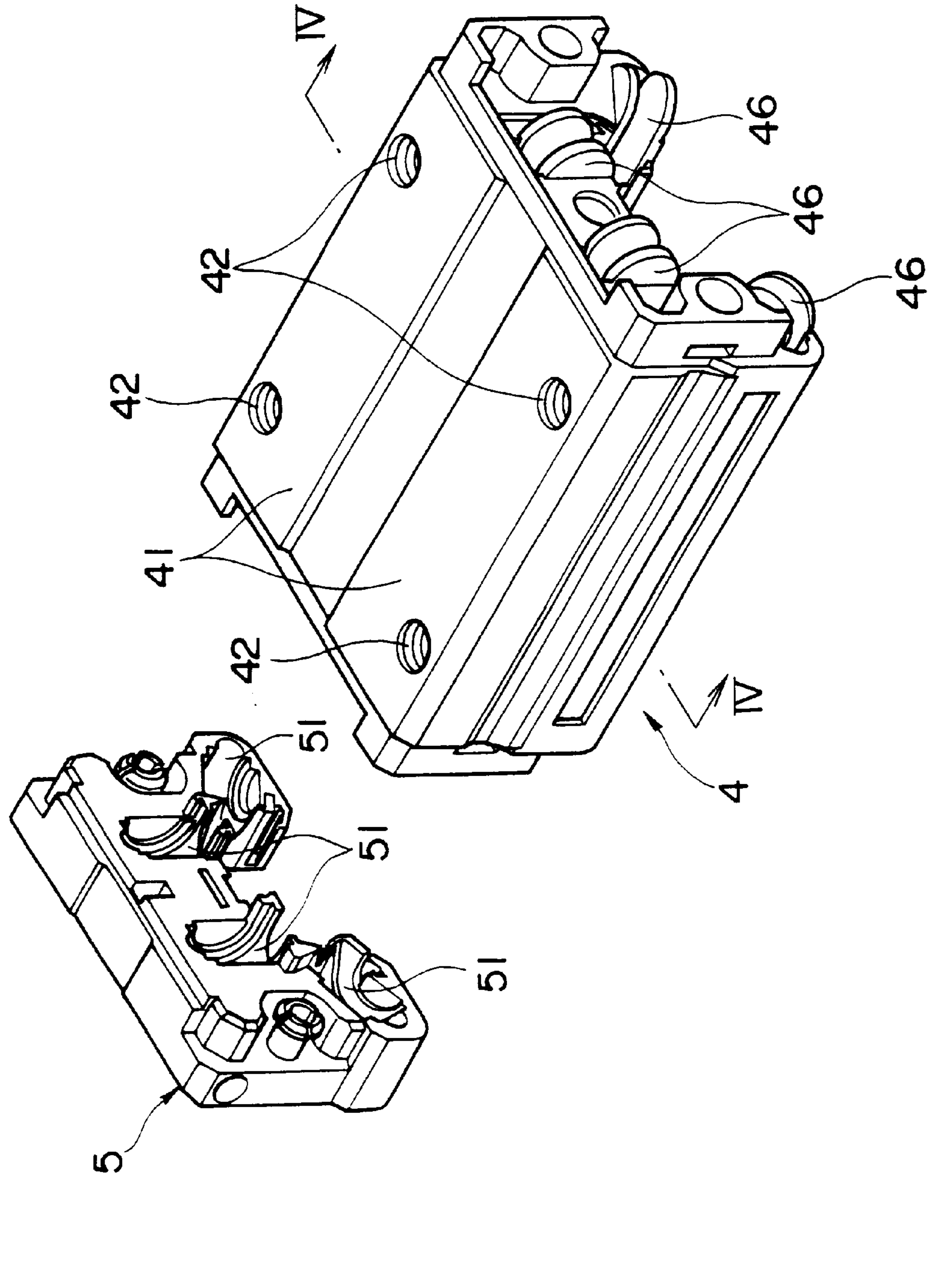


Fig.4

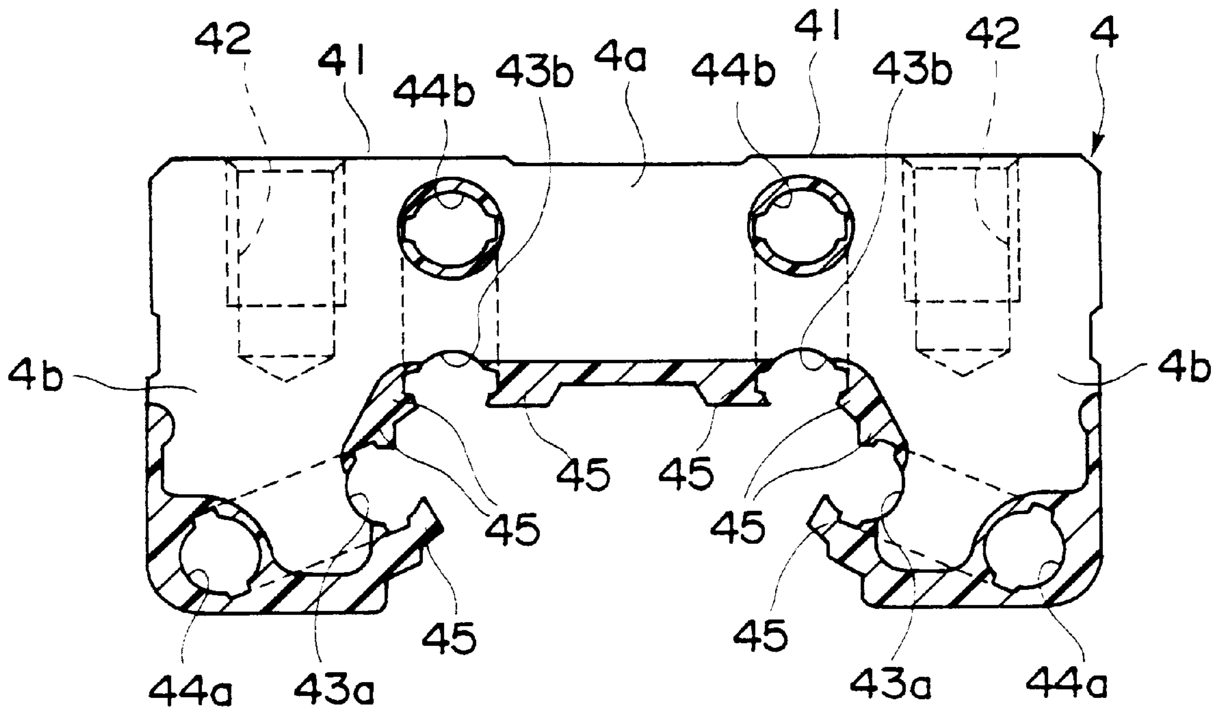

42
41
44b
43b
4a
44b
41
43b
42
4
4b
4b
45
45
45
45
45
45
44a
43a
43a
44a

Fig.5

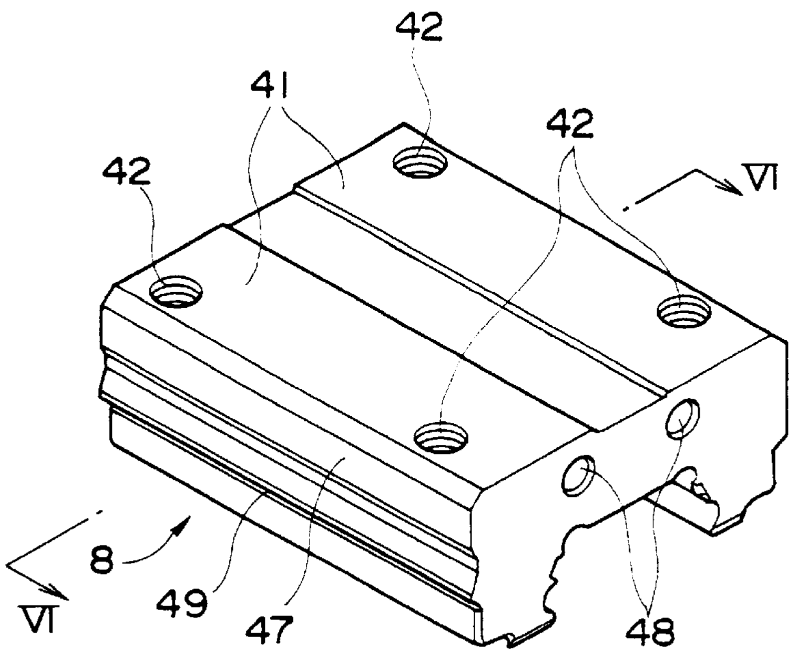

42
41
42
42
Ⅵ
8
Ⅵ
49
47
48

Fig.6

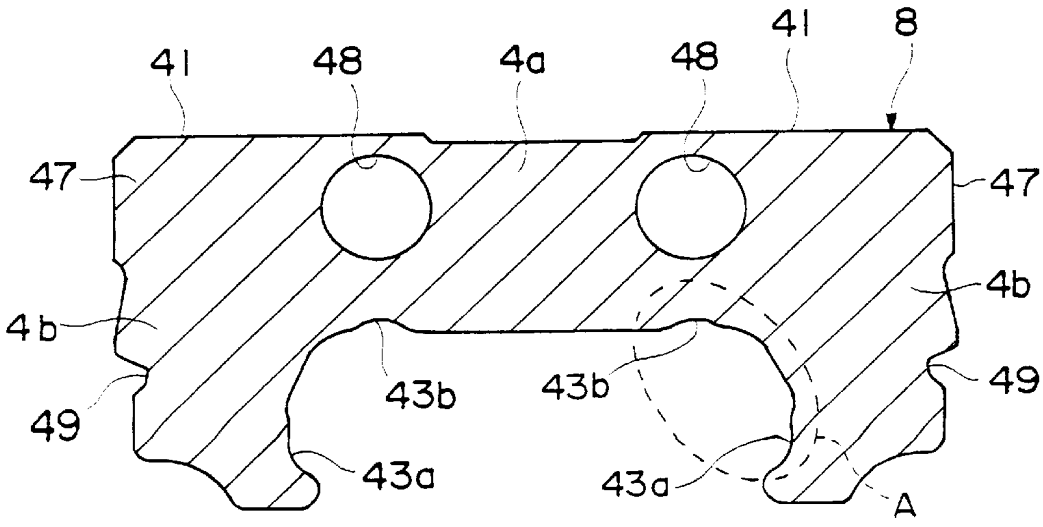

41
48
4a
48
41
8
47
47
4b
4b
49
49
43b
43b
43a
43a
A

Fig.7

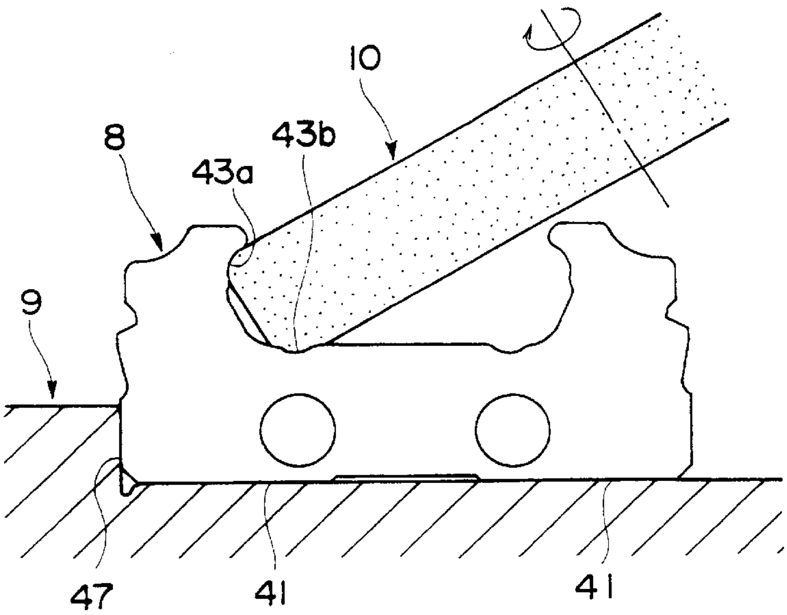


Fig.8

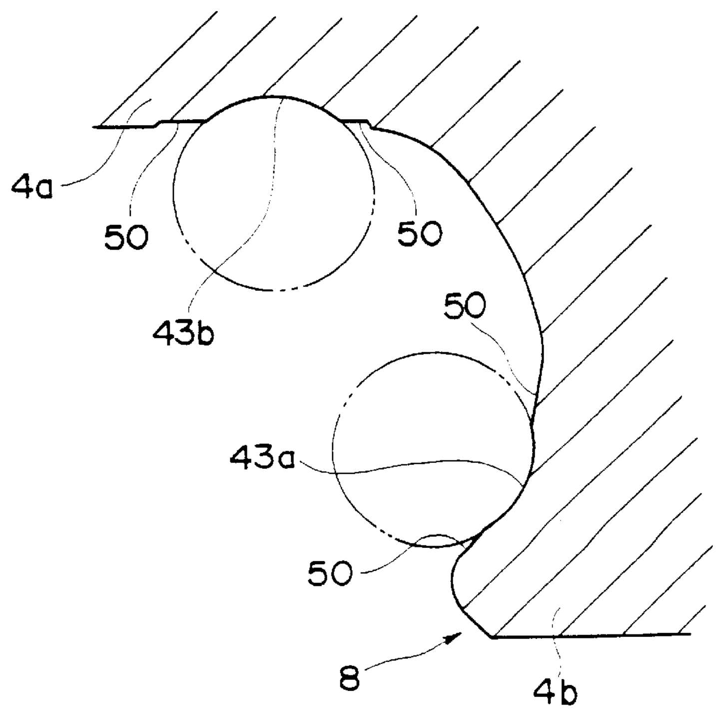


Fig.9

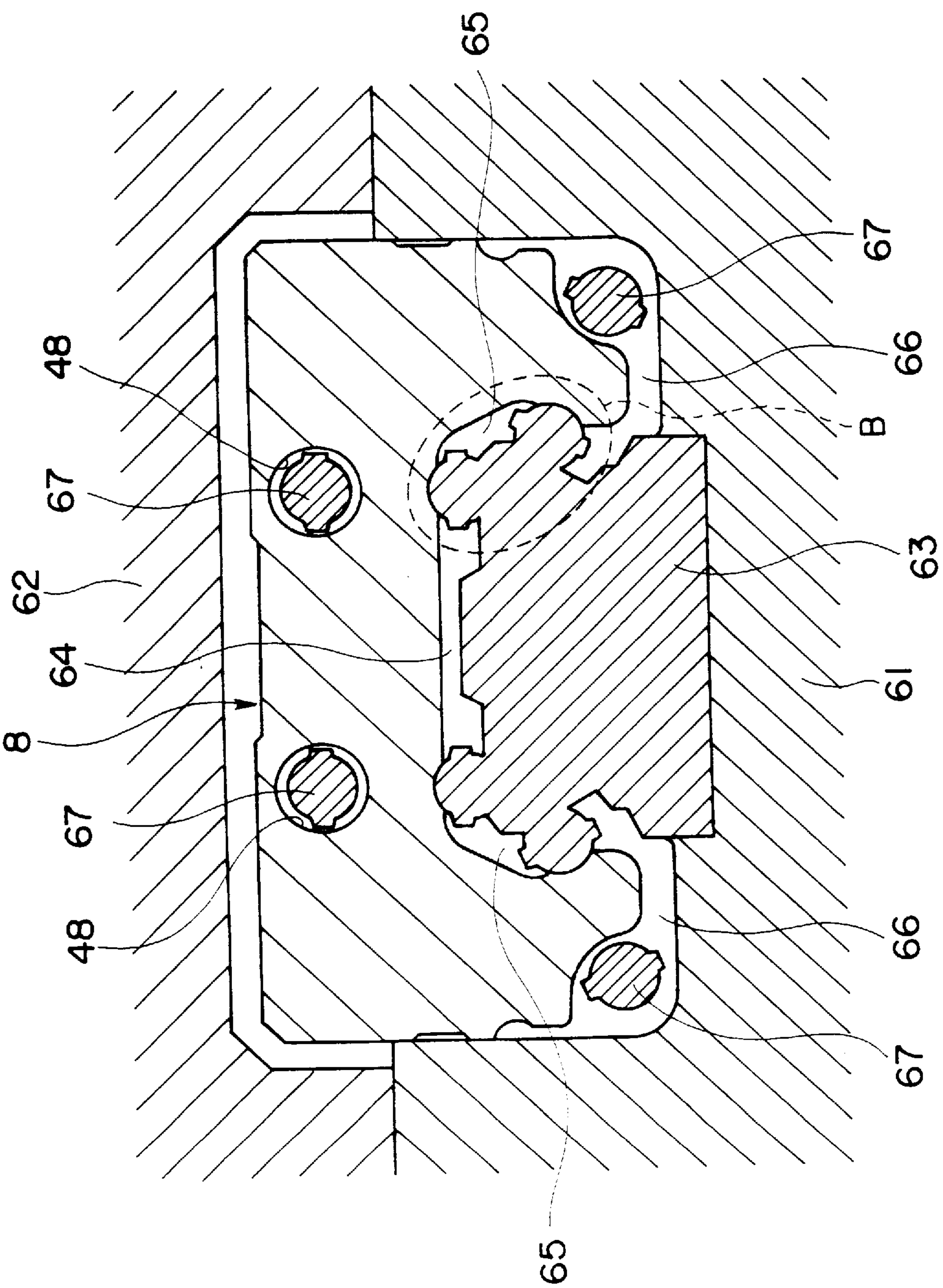
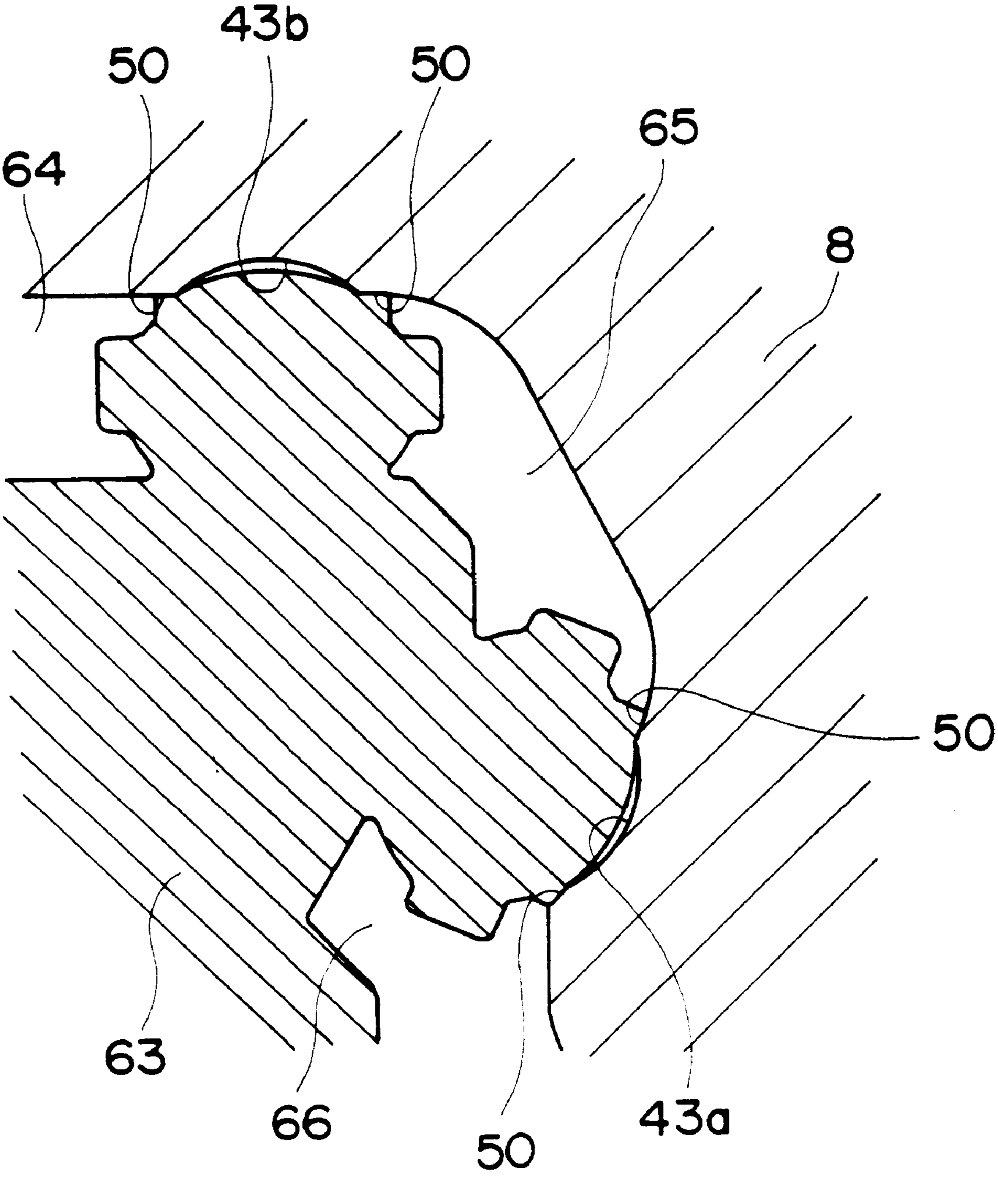


Fig.10



METHOD OF MAKING A SLIDER OF A LINEAR GUIDE DEVICE

This application is a division of Ser. No. 08/845,151 filed Apr. 21, 1997.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of making a slider of a linear guide device for guiding a movable body such as a work table of a machine tool or an industrial robot or the like moving along a track rail arranged at a fixed portion such as a bed, a column or the like while applying a load on the track rail, particularly to a method of forming a slider by building up a synthetic resin onto a block main body made of a metal.

2. Description of the Related Art

There has been known a conventional linear guide device of such a kind constituted by a track rail that is arranged at a fixed portion such as a bed or the like and on which rolling faces of balls are formed and a slider integrated to the track rail via a number of balls for moving along the track rail while supporting a movable body such as a table or the like.

Further, the above-described slider is constituted by a movable block having load rolling faces opposed to the rolling faces of the track rail via balls and ball return holes in parallel to the load rolling faces, which is movable along the track rail by rolling the balls, a pair of end caps respectively fixed to forward and backward end faces of the moving block and having direction change paths of the balls for communicating and connecting the load rolling faces with the ball return holes and ball retainers attached to the moving block for preventing the balls from coming off from the load rolling faces when the slider is removed from the track rail. Also, end portions of the load rolling faces and the ball return holes are connected by the direction change paths by fixing the end caps to the forward and rearward end faces of the moving block whereby infinite circulation paths of balls are completed in the slider.

Meanwhile, according to the conventional slider for the linear guide device constituted as described above, boring of the ball return hole, attaching operation of the ball retainers and the like are needed with respect to the moving block and considerable time and labor is required in manufacturing the slider. Therefore, the applicants have proposed to manufacture the slider by utilizing an injection molding process of a synthetic resin (Japanese Unexamined Patent Publication No. JP-7-317762).

Specifically, a synthetic resin is built up by injection molding onto a block main body made of a metal where the above-described load rolling faces have been ground and the ball return holes and the ball retainers are integrally formed with the block main body in the injection molding by which the moving block is manufactured, which is provided with an advantage whereby a moving block having a complicated shape can easily be manufactured.

Meanwhile, in building up a synthetic resin onto the block main body made of a metal, the ball retaining portions are formed on the both sides of the load rolling faces of the block main body as described above, where it is necessary to expose the load rolling faces per se on which the balls run without putting the synthetic resin on the load rolling faces. Therefore, it is necessary to cover the load rolling faces against the molten synthetic resin in the injection molding.

Accordingly, conventionally, in fixing the block main body in the mold of the injection molding, a projected

support portion provided on the side of the mold is brought into contact with the load rolling faces of the block main body and the load rolling faces are covered against the molten synthetic resin by the projected support portion.

However, when the load rolling faces are covered by bringing the projected support portion of the mold into direct contact with the load rolling faces, since the load rolling faces are formed in a curved face corresponding to the curvature of the ball, it is necessary to form the projected support portion in contact with the load rolling faces also in a curved face in compliance with the curvature of the load rolling faces and if the curved faces of both are not brought into accurate alignment, the molten synthetic resin forming the retainers invades a clearance therebetween.

Furthermore, when the molten synthetic resin invades the clearance between the load rolling faces and the projected support portion of the mold, the molten synthetic resin constitutes burrs of the synthetic resin covering the load rolling faces and the smooth running of the balls is significantly hampered under such a state. Also, once the ball retainers are formed on the both sides of the load rolling faces, the load rolling faces cannot be polished since the ball retainer becomes a hazard for the polishing operation and therefore, the constituted burrs cannot be removed. Accordingly, in the method of manufacturing the moving block utilizing the injection molding, a countermeasure for preventing the occurrence per se of burrs covering the load rolling face is indispensable.

Meanwhile, it is preferable to set the block main body to the mold with the load rolling faces which have been formed, as positioning references in fixing the block main body in injection molding, since the ball retaining portions are needed to form accurately in the positional relationship thereof with the load rolling faces.

However, it is difficult to position the block main body by bringing the load rolling faces in contact with the projected support portion on the side of the mold, which is also formed in a curved face since the load rolling faces are formed in a curved face as described above. Especially, when the load rolling faces face in different four directions, it is extremely difficult to accurately position the block main body in the mold.

Also, when the projected support portion of the mold is brought into contact with the load rolling faces, the load rolling faces, which have been ground in the finishing operation, may be damaged with high probability and the grinding operation of the block main body prior to the injection molding operation may be completely be ruined.

SUMMARY OF THE INVENTION

The present invention has been carried out in view of such a problem and it is an object of the present invention to provide a method of making a slider of a linear guide device in which in forming the slider of the linear guide device installed with ball return holes and ball retaining portions by building up a synthetic resin onto a block main body made of a metal, the synthetic resin does not bring about burrs on load rolling faces of the block main body and the ball return holes and the retainers can be formed accurately.

In order to achieve the above-described object, a method of making a slider according to the present invention is comprising a first step of forming a block main body made of a metal which becomes a core part of the slider in a predetermined shape by machining and forming load rolling faces of balls on the block main body, and a second step of inserting the block main body formed in the first step into a mold and executing an injection molding of a synthetic resin whereby ball retaining portions are built on both sides of the load rolling faces of the block main body, wherein according to the first step pairs of smooth faces for shielding the molten synthetic resin are formed on both edges in the longitudinal direction of the load rolling faces formed on the block main body, whereas according to the second step the block main body is fixed at a predetermined position in the mold by bringing a projected support portion erected on the mold into contact with the smooth faces for shielding the molten synthetic resin.

As described above, in forming the ball retaining portions on the both sides of the load rolling faces by utilizing the injection molding of a synthetic resin, it is necessary to prevent the molten synthetic resin from invading the load rolling faces. According to the method having the above-described steps, with respect to the main body fixed in the mold the pairs of faces for shielding the synthetic resin formed along the both edges of the load rolling faces are brought into contact with the projected support portion erected on the mold and therefore, the molten synthetic resin for forming the ball retaining portions can be prevented from flowing to the load rolling faces by the smooth faces for shielding the molten synthetic resin. Moreover, the smooth faces for shielding a molten synthetic resin are not formed in a curved face as in the load rolling faces but in a smooth face and therefore, no clearance is formed between the smooth faces for shielding the molten synthetic resin and the projected support portion of the mold which are brought into contact with each other and the molten synthetic resin can firmly be prevented from invading the load rolling faces. Therefore, according to the invented method formation of burr of the synthetic resin on the load rolling faces can firmly be prevented.

Meanwhile, when the slider made by this method is observed, it is recognized that the pairs of smooth faces for shielding the molten synthetic resin mold which become positioning references for fixing the main body in the injection molding and which are disposed between the load rolling faces and the ball retaining portions on the both sides of the load rolling faces, are exposed without being covered by the ball retaining portions. Accordingly, whether a slider is made by the invented method, can be determined by whether the pairs of faces for shielding the molten synthetic resin, which has been finished smoothly to a degree whereby they can be utilized as positioning references, are exposed on the both edges along the longitudinal direction of the load rolling faces. That is, according to another aspect of the present invention, there is provided a slider of a linear guide device wherein pairs of faces for shielding a molten synthetic resin which become references for fixing a block main body in injection molding, are exposed on both edges along the longitudinal direction of load rolling faces.

Also, according to the invented method, in the second step the block main body is positioned and fixed in the mold by bringing the projected support portion of the mold into contact with the smooth faces for shielding the synthetic resin and therefore, the positioning accuracy of the block main body in the mold is promoted in comparison with the conventional case in which the positioning is carried out by using the load rolling faces in a curved face whereby the positioning relationship between the ball retaining portions built up on the block main body by injection molding and the load rolling faces can be made accurate. Thereby, it can be prevented that noise is caused due to contact of the balls running on the load rolling faces with the ball retaining portions or the circulation of the balls becomes unstable in using the linear guide device.

Further, according to the invented method the block main body is fixed in the mold by bringing the projected support portion of the mold into contact with the faces for shielding the synthetic resin. It is preferable in this procedure that the projected support portion is brought into contact with the faces for shielding the molten synthetic resin which are formed on the both edges to span across the load rolling faces whereby spaces are formed between the projected support portion and the load rolling faces. The reason is that according to the invented method the machining of the load rolling faces are completed in the first step prior to the injection molding and therefore, if the projected support portion in the mold is brought into contact with the load rolling faces in the second step, the load rolling faces which have been finished with a predetermined face accuracy will be roughened.

As described above, according to the invented method the both edges of load rolling faces of the block main body which becomes a core part of a slider, are formed with the pairs of smooth faces for shielding the molten synthetic resin and in the step of the insert molding for building the synthetic resin on the block main body the faces for shielding the molten synthetic resin and the projected support portion erected on the mold are brought into contact. Therefore, the formation of burrs of the synthetic resin on the load rolling faces through the process of the insert molding can be prevented and the ball retaining portions can be formed accurately on the block main body whereby the slider of a linear guide device on which the balls run smoothly and in which generation of noise accompanied by the circulation of the balls is restrained as less as possible, can be manufactured.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a partially cut front view showing a preferred exemplary embodiment of a linear guide device of the present invention;

FIG. **2** is a partially cut side view showing the preferred exemplary embodiment of the linear guide device of the present invention;

FIG. **3** is an exploded perspective view of a slider in accordance with the preferred exemplary embodiment of the present invention;

FIG. **4** is a sectional view taken along a line IV—IV of FIG. **3**;

FIG. **5** is a perspective view showing a block main body constituting a core part of a moving block according to the preferred exemplary embodiment of the present invention;

FIG. **6** is a sectional view taken along a line VI—VI of FIG. **5**;

FIG. **7** is a front view showing a behavior of grinding operation on load rolling faces and smooth faces with respect to the block main body;

FIG. **8** is an enlarged view showing details of a region encircled by a circle A described by a broken line in FIG. **6**;

FIG. **9** is a sectional view showing the block main body inserted into a mold; and

FIG. **10** is an enlarged view showing details of a region encircled by a circle B drawn by a broken line in FIG. **9**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A detailed explanation will be given of a slider of a linear guide device according to the present invention in reference to the attached drawings as follows.

FIG. **1** and FIG. **2** illustrate a preferred exemplary embodiment of a linear guide device in which a slider of the present invention is integrated with a track rail. In FIGS. **1** and **2**, numeral **1** designates a track rail arranged to a fixed portion such as a bed or the like of a machine tool, numeral **2** designates a slider for guiding a movable body such as a table or the like along the track rail **1** and numeral **3** designates a ball rolling under load between the track rail **1** and the slider **2** and infinitely circulated in the slider **2**.

Firstly, the section of the track rail **1** is formed in substantially a square shape in which a total of four tracks of ball rolling face **11***a* and **11***b* on which the balls **3** run, are formed along the longitudinal direction (orthogonal to the paper face of FIG. **1**). These ball rolling faces **11***a* and **11***b* are formed on the both side faces and the both edge portions of the upper face of the track rail **1** in which the ball rolling faces **11***a* on the both side faces are formed **30** downwardly from the left and right direction of the paper face whereas the ball rolling faces **11***b* on the upper face are formed upwardly in the vertical direction. Further, bolt attaching holes **12** are formed in the track rail **1** at pertinent intervals in the longitudinal direction and the track rail **1** is fixed to a fixed portion by fixing bolts, not illustrated, which are inserted into the bolt attaching holes **12**.

Meanwhile, the slider **2** is constituted by a moving block **4** having an attaching face **41** for attaching a movable body such as a table or the like and tap holes **42** for screwing fixing bolts of the movable body and a pair of end caps **5** fixed to the foreword and rearward end faces of the moving block **4** and infinite circulation paths of the balls **3** are provided in the slider by fixing the end caps **5** to the moving block **4**. Further, seal members **6** which are brought into abrasive contact with the track rail **1** are attached to the end caps **5** for preventing dust or dirt attached onto the track rail **1** from invading the inside of the slider **2** accompanied by the movement of the slider **2**.

As illustrated in FIG. **3** and FIG. **4**, the moving block **4** is provided with a horizontal portion **4***a* where the attaching face **41** is formed and a pair of skirt portions **4***b* hanging down from the horizontal portion **4***a* and the section thereof is formed in substantially a saddle form and four tracks of load rolling faces **43***a* and **43***b* are formed on the lower face of the horizontal portion **4***a* and on the inner faces of the respective skirt portions **4***b* opposingly to the ball rolling faces **11***a* and **11***b* of the track rail **1**. Also, ball return holes **44***a* and **44***b* respectively corresponding to the load rolling faces **43***a* and **43***b* are formed at the horizontal portion **4***a* and the skirt portions **4***b* and the respective load rolling faces **43***a* and **43***b* and the corresponding ball return holes **44***a* and **44***b* are connected by direction change paths **51** of the balls **3** formed in the end caps **5** thereby forming the infinite circulation paths of the balls.

Thereby, when the balls **3** which have been under load between the rolling faces **11***a* and **11***b* of the track rail **1** and the load rolling faces **43***a* and **43***b* of the moving block **4**, finish running on the load rolling faces **43***a* and **43***b* with the movement of slider **2**, they are relieved from the load and enter the direction change paths **51** of one of the end caps **5**, and run under no load in the ball return holes **44***a* and **44***b* of the moving block **4** toward a direction reverse to the running direction at the load rolling faces **43***a* and **43***b*. Further, the balls **3** which have finished running in the ball return holes **44***a* and **44***b*, enter again between the track rail **1** and the moving block **4** via the direction change paths **51** of the other one of the end caps **5** and run on the load rolling faces **43***a* and **43***b* under load.

Further, ball retaining portions **45** are formed on the both sides of the respective load rolling faces **43***a* and **43***b* as if covering the load rolling faces **43***a* and **43***b* thereby preventing the balls **3** which are disposed on the load rolling faces **43***a* and **43***b* from rolling down from the slider **2** when the slider **2** is removed from the track rail **1**.

Further, according to the preferred exemplary embodiment, in view of avoiding contact among balls in the infinite circulation paths and preventing as less as possible the wear of the balls **3**, ball chains are constituted by rotatably fitting the balls **3** in belt-like cages **7** made of a synthetic resin and the ball chains are integrated to the infinite circulation paths. Therefore, recessed grooves for supporting the both edge portions of the belt-like cages **7** circulating in the infinite circulation paths along with the balls **3**, are formed in the ball return holes **44***a* and **44***b* and the ball retaining portions **45**.

Furthermore, as illustrated in FIG. **3**, ball guide portions **46** in a semicircular shape are projected at the foreword and rearward end faces of the moving block **4** for guiding the balls **3** entering and leaving the ball return holes **44***a* and **44***b* in cooperation with the direction change paths **51** of the end caps **5**.

The moving block **4** is formed by building by injection molding a synthetic resin onto the block main body **8** made of a metal which is formed by mechanical working. Portions requiring mechanical strength such as the movable body attaching face **41**, the load rolling faces **43***a* and **43***b* of the balls **3** and the like, are formed in the block main body **8**, whereas portions with no significance in mechanical strength such as the ball return holes **44***a* and **44***b*, the ball retaining portions **45** and the ball guide portions **46** and the like, are formed by a synthetic resin whereby light weight formation of the moving block **4** is achieved as light as possible. FIG. **5** and FIG. **6** show the block main body **8** before building a synthetic resin thereon. According to the block main body **8**, after the outline shape of the horizontal portion **4***a* and the skirt portions **4***b* has been formed by drawing, the movable body attaching face **41** and reference side faces **47** are formed with a predetermined accuracy by polishing and through holes **48** which become base holes for the ball return holes **44***b*, are formed by boring. Further, in the drawing process, recessed portions **49** which become resin storages are formed on the outer side of the skirt portions **4***b* with a purpose of promoting adherence of a synthetic resin which is to be built in later steps with respect to the block main body **8**.

The load rolling faces **43***a* and **43***b* are needed to form on the block main body **8** and the load rolling faces **43***a* and **43***b* are formed as illustrated in FIG. **7** after forming the movable body attaching face **41** and the reference side faces **47**. That is, the movable body attaching face **41** and the reference side faces **47** which have already been formed, are brought into contact with attaching reference faces of a polishing stage **9** thereby fixing the block main body **8**, under which the grindstone **10** is brought into contact with the block main body **8** whereby the load rolling faces **43***a* and **43***b* are polished. At this occasion the load rolling faces **43***a* and **43***b* are polished in one machining operation by using the same grindstone **10** in order to render accurate the positional relationship among the load rolling faces **43***a* formed at the skirt portions and the load rolling faces **43***b* formed at the horizontal portion.

FIG. **8** is an enlarged view showing the surroundings of the load rolling faces **43***a* and **43***b* which have been polished. According to the polishing operation using the grindstone **10** not only the load rolling faces **43***a* and **43***b* are formed but pairs of smooth faces **50** are formed along both edges in the longitudinal direction of the respective load rolling faces. That is, the grindstone **10** is a formed polishing grindstone having a shape reverse to the shape of the load rolling faces **43**_a_ and **43**_b_ faces **50** and the smooth are formed with a constant positional accuracy in respect of the load rolling faces **43**_a_ and **43**_b_ which are disposed contiguously to the smooth faces **50**.

In steps of injection molding of a synthetic resin, mentioned later, the smooth faces **50** function as positioning reference faces of the block main body **8** in the mold and are used as measuring reference faces in measuring whether the load rolling faces **43**_a_ and **43**_b_ are formed with a predetermined dimensional accuracy.

Next, an explanation will be given of a step of building a synthetic resin by injection molding onto the block main body **8** which has been finished in a predetermined shape in this way.

The injection molding is executed by a process in which the block main body **8** all the machining of which has been finished, is arranged in a mold as a core, which is referred to as insert molding, whereby a synthetic resin is built only at predetermined positions of the block main body **8** by which the ball return holes **44**_a_ and **44**_b_, the ball retaining portions **45** and the like, are formed.

FIG. **9** is a sectional view showing the block main body **8** which is inserted into molds **61** and **62**. A projected support portion **63** for fixing the block main body **8** is erected on the mold **61** and positioning of the block main body **8** in the molds **61** and **62** is carried out by fitting the block main body **8** in respect of the projected support portion **63** from the axial direction (orthogonal to paper face) and cavities **64** and **65** corresponding to the ball retaining portion **45** of the moving block **4** are formed between the block main body **8** and the projected support portion **63** whereas cavities **66** for forming the ball return holes **44**_a_ are formed between the skirt portions **4**_b_ of the block main body **8** and the mold **61**. Further, rod-like mold bodies **67** having a sectional shape in agreement with the shape of the ball return holes **44**_a_ and **44**_b_, are inserted into the through holes **48** of the block main body **8** and the cavities **66** by which the ball return holes **44**_a_ and **44**_b_ are formed when the molten synthetic resin is filled in the through holes **48** and the cavities **66**.

Also, the mold **61** is brought into contact with the lower end edges of the reference side faces **47** of the block main body **8** by which the shielding of the molten synthetic resin filled in the cavities **66** is carried out and the synthetic resin is prevented from covering the reference side faces **47**.

Meanwhile, FIG. **10** is an enlarged view showing details of a state of contact between the projected support portion **63** and block main body **8**. When the synthetic resin is put on the load rolling faces **43**_a_ and **43**_b_ formed on the block main body **8**, it becomes a hazard against the running of the balls **3** and therefore, it is required in such an insert molding that shielding of the molten synthetic resin is firmly carried out between the load rolling faces **43**_a_ and **43**_b_ and the contiguous cavities **64**, **65** and **66**. Accordingly, in fitting the block main body **8** to the projected support portion **63**, the projected support portion **63** is brought into contact with the smooth faces **50** which are formed on the both edges of the load rolling faces **43**_a_ and **43**_b_ whereby the shielding the molten synthetic resin filled in the cavities **64**, **65** and **66** is carried out. Further, the projected support portion **63** is brought into contact with the smooth faces **50** to span across the load rolling faces **43**_a_ and **43**_b_ to prevent the load rolling faces **43**_a_ and **43**_b_ which have been finished in a predetermined accuracy from damaging by the contact with the projected support portion **63**.

Further, after inserting the block main body **8** into the molds **61** and **62**, the molten synthetic resin is filled in the cavities **64**, **65** and **66** formed by the block main body **8** and the mold **61** and the synthetic resin is built on the main body **8** whereby the moving block as illustrated by FIG. **3** and FIG. **4** is completed.

According to the step of the insert molding which is carried out as has been described above, in positioning the block main body **8** in the mold **61** in this embodiment, the projected support portion **63** erected on the mold **61** for fitting to the block main body **8**, is brought into contact with the pairs of smooth faces **50** which are formed along the both edges of the load rolling faces. Therefore, the following advantages are achieved in comparison with the conventional manufacturing method in which the positioning of the block main body is carried out by bringing the projected support portion in direct contact with the load rolling faces.

That is, the smooth faces **50** are formed by polishing them simultaneously with the load rolling faces **43**_a_ and **43**_b_ and therefore, the accuracy of the formed positions and the smoothness are significantly excellent and by bringing the projected support portion **63** into contact with the smooth faces **50** which have been formed with such a high accuracy, the projected support portion **63** and the smooth faces **50** are brought into close contact with each other whereby the molten synthetic resin can be shielded with certainty by the smooth faces **50**. Therefore, according to the moving block **4** manufactured by the method of this embodiment, no burr of synthetic resin is caused on the load rolling faces **43**_a_ and **43**_b_ whereby smooth running of ball can be guaranteed.

Also, it is possible to promote the positioning accuracy of the block main body **8** inserted into the molds **61** and **62** by bringing the projected support portion **63** into contact with the smooth faces **50** which have been formed with high accuracy, whereby the locations of forming the ball retaining portions **45** in respect of the load rolling faces **43**_a_ and **43**_b_ of the block main body **8** are made accurate. Therefore, the balls **3** running on the load rolling faces **43**_a_ and **43**_b_ can be prevented from being brought into contact with the ball retaining portions **45** and generation of noise can be avoided as less as possible in circulating the balls **3**.

Incidentally, according to the preferred exemplary embodiment, when the block main body **8** is inserted into the molds **61** and **62**, the load rolling faces **43**_a_ and **43**_b_ with a predetermined accuracy prior to the insert molding, are not damaged by the step of the insert molding since spaces are formed between the load rolling faces **43**_a_ and **43**_b_ and the projected support portion **63** whereby the smooth running of the balls **3** can be guaranteed.

What is claimed is:

1. A slider of a linear guide device comprising:

a block main body made of metal and having load rolling faces of balls which are infinitely circulated;

synthetic resin portions formed by injection molding on the block main body in a state of positioning the block main body in a mold as a core;

ball retaining portions including the synthetic resin portions and formed on both sides of the load rolling faces; and

pairs of polished faces formed on the block main body contiguously to each side of the load rolling faces, and brought into contact with the mold in the injection molding for positioning the block main body in the mold and shielding a molten synthetic resin,

wherein the pair of polished faces are exposed between the load rolling faces and the ball retaining portion.

* * * * *

US006042268A

United States Patent [19]

Shirai

[11] **Patent Number: 6,042,268**

[45] **Date of Patent: Mar. 28, 2000**

[54] **LINEAR ROLLER GUIDE DEVICE**

[75] Inventor: **Takeki Shirai**, Ichikawa, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **09/029,011**

[22] PCT Filed: **May 20, 1997**

[86] PCT No.: **PCT/JP97/01696**

§ 371 Date: **May 22, 1998**

§ 102(e) Date: **May 22, 1998**

[87] PCT Pub. No.: **WO97/48912**

PCT Pub. Date: **Dec. 24, 1997**

[30] **Foreign Application Priority Data**

Jun. 18, 1996 [JP] Japan 8-177328
Dec. 28, 1996 [JP] Japan 8-358929

[51] **Int. Cl.**[7] **F16C 29/06**
[52] **U.S. Cl.** **384/44**
[58] **Field of Search** 384/44, 45, 43; 464/168

[56] **References Cited**

FOREIGN PATENT DOCUMENTS

63-91722 6/1988 Japan .

Primary Examiner—Lenard A. Footland
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

An object is to increase structural rigidity of a movable block by improving a contacting structure and arranging relations of four rows of rollers disposed between the movable block and a track rail.

The device is characterized in that upper two rows of rollers 21, 22 are arranged to portions close to a center side from side ends of the upper surface of the track rail 1, while roller rolling surfaces 61, 62 corresponding to the rollers 21, 22 are formed to the upper surface of the track rail 1 and a lower surface of a horizontal portion 4 of the movable block 3, that lower two rows of rollers 23, 24 are arranged such that one row of rollers is disposed to right and left side surfaces of the track rail 1, respectively, while roller rolling surfaces 63, 64 corresponding to the lower two rows of rollers 23, 24 are formed to the right and left side surfaces of the track rail 1 and inner side surfaces of the supporting leg portions 5, 5 of the movable block 3.

15 Claims, 15 Drawing Sheets

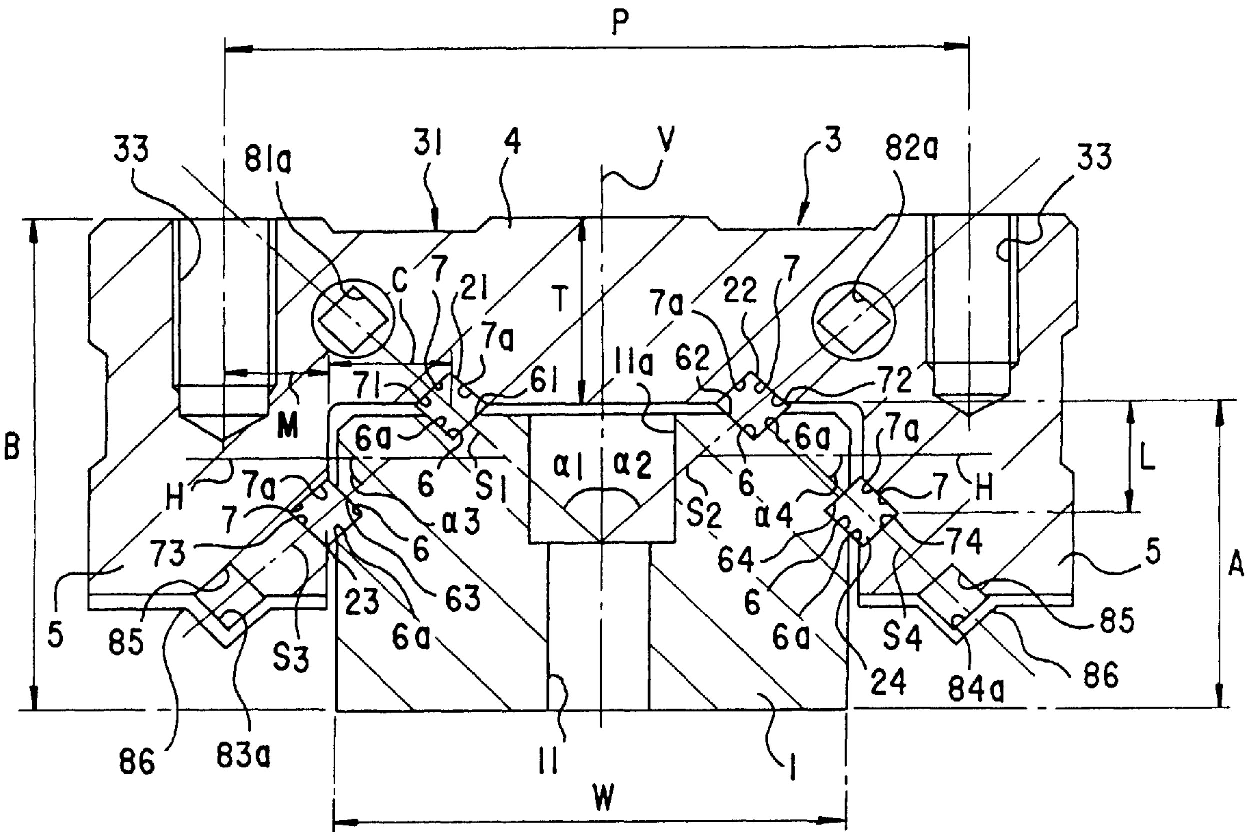


FIG.1(a)

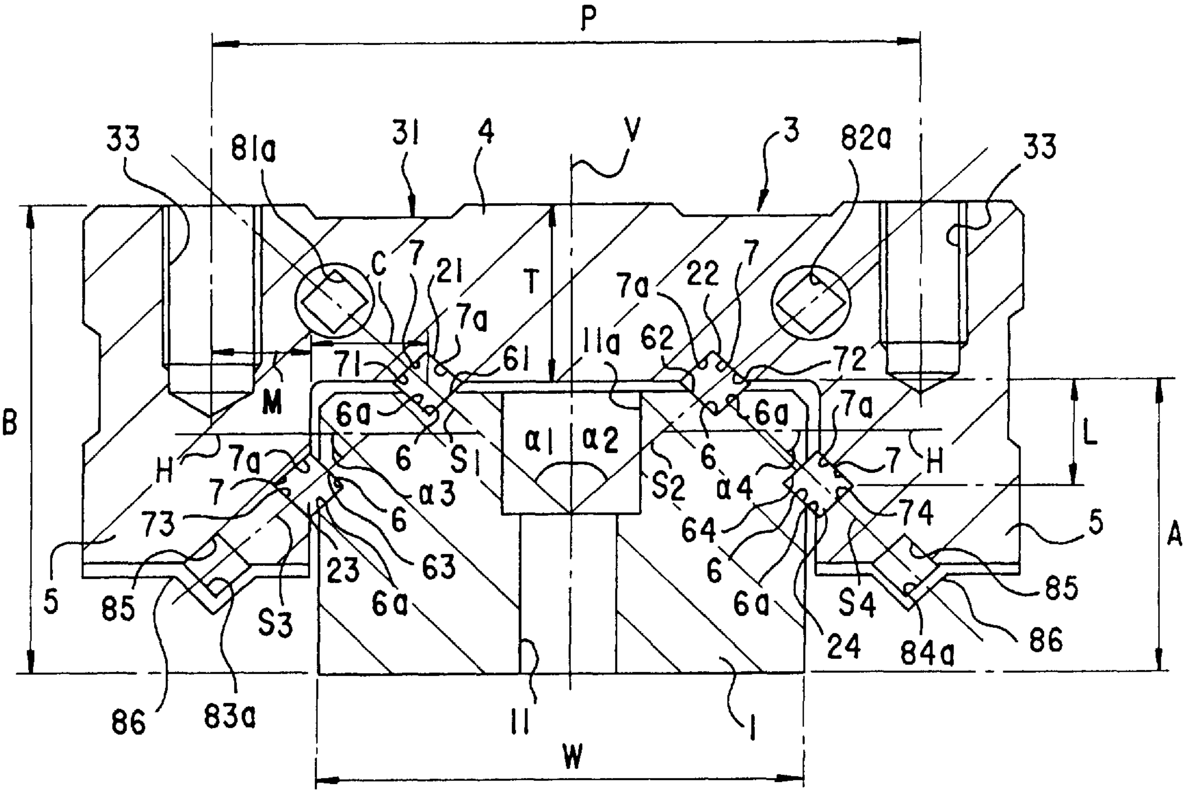
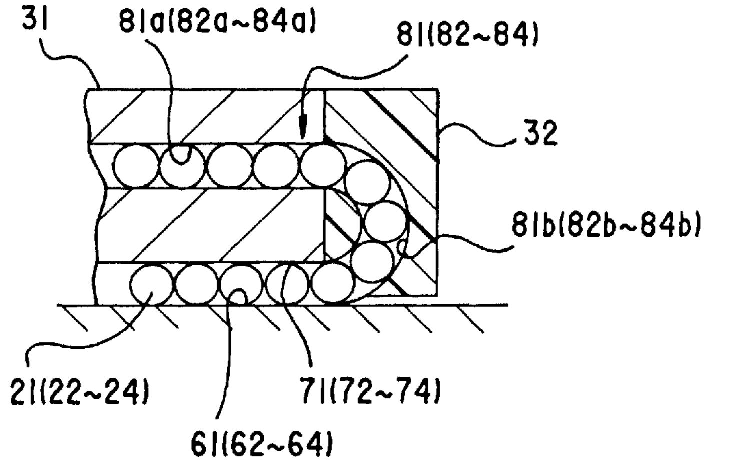

P
33
81a
31
4
V
3
82a
33
C
7
21
T
7a
22
7
7a
71
61
11a
62
72
6a
6a
7a
B
M
6
S1
α1
α2
S2
6
L
H
7a
α3
α4
7
H
7
6
64
74
73
5
5
A
23
63
6
S4
85
85
5
85
S3
6a
6a
24
84a
86
86
83a
11
1
W

FIG.1(b)


31
81a(82a~84a)
81(82~84)
32
81b(82b~84b)
21(22~24)
71(72~74)
61(62~64)

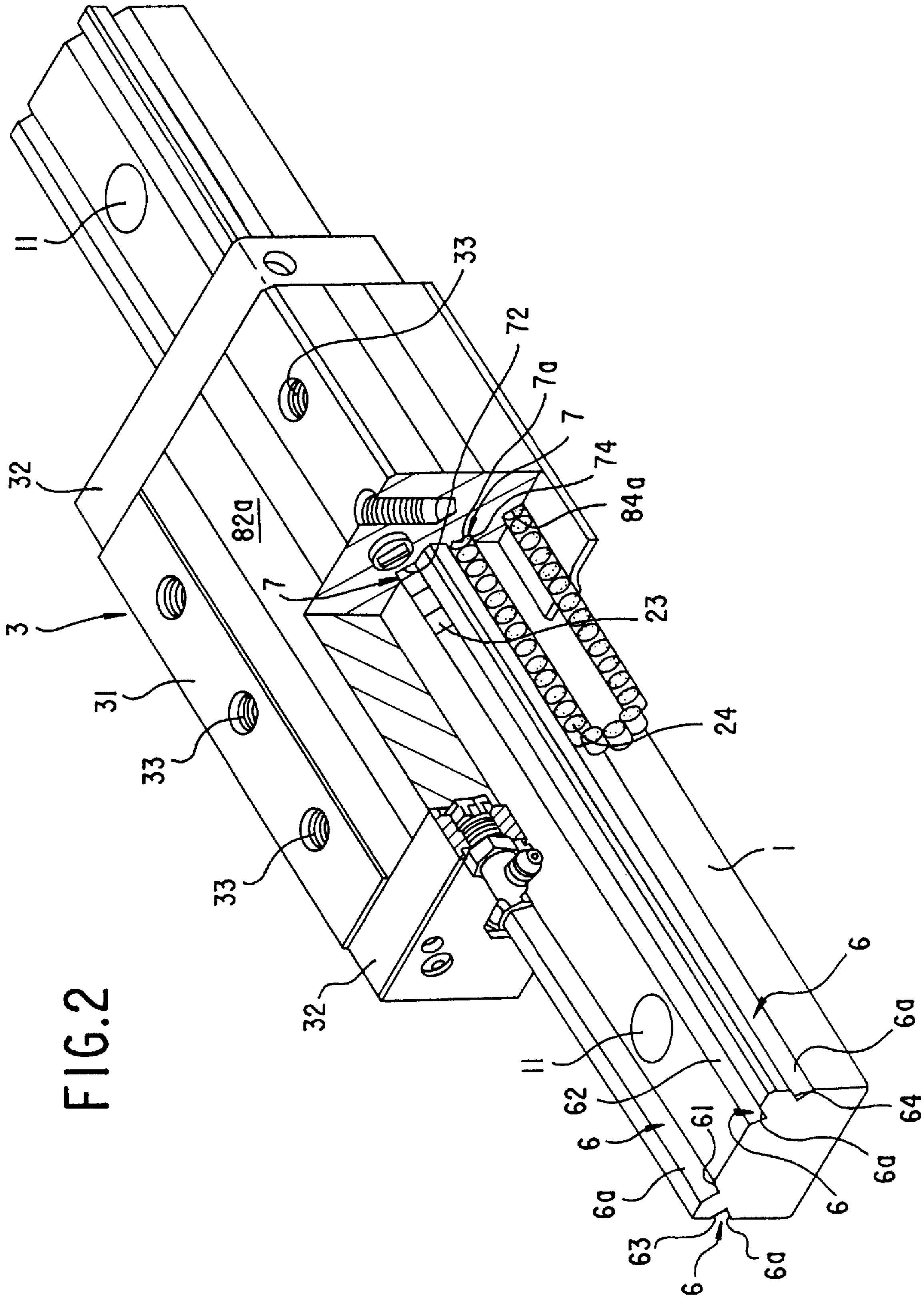

11
33
72
7a
7
74
84a
32
82a
7
3
23
31
24
33
33
1
6
32
6a
11
62
64
6
61
6a
6a
6
63
6a
6

FIG.2

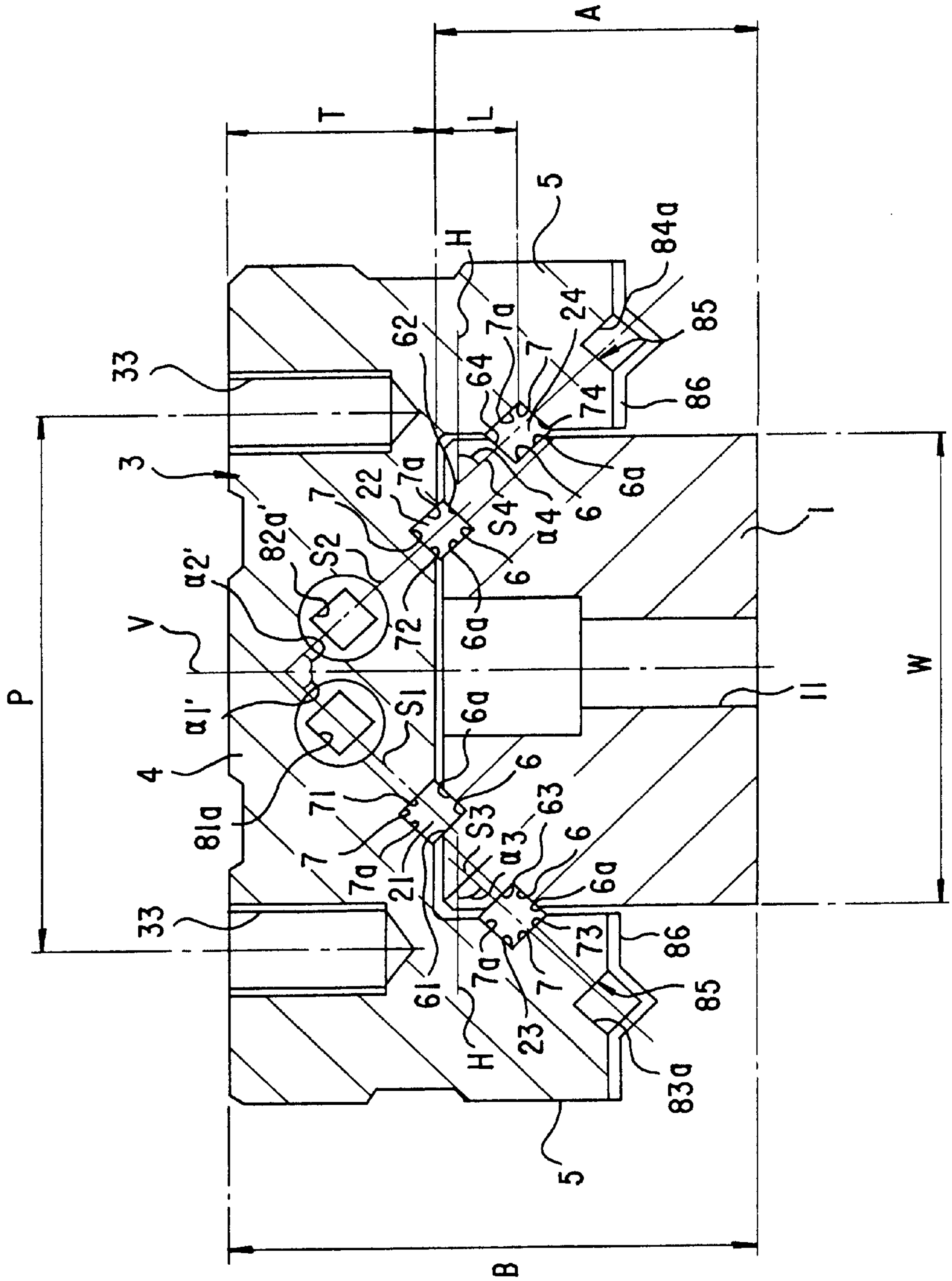

A
T
L
5
H
84a
62
7a
24
33
64
7
85
74
86
3
22
7a
S4
6a
a4
6
82a'
7
S2
6
I
a2'
72
6a
V
W
P
S1
II
a1'
6a
6
4
71
S3
63
81a
7
a3
6
7a
21
6a
33
73
86
61
7a
7
85
H
23
83a
5
B

FIG. 3

FIG.4

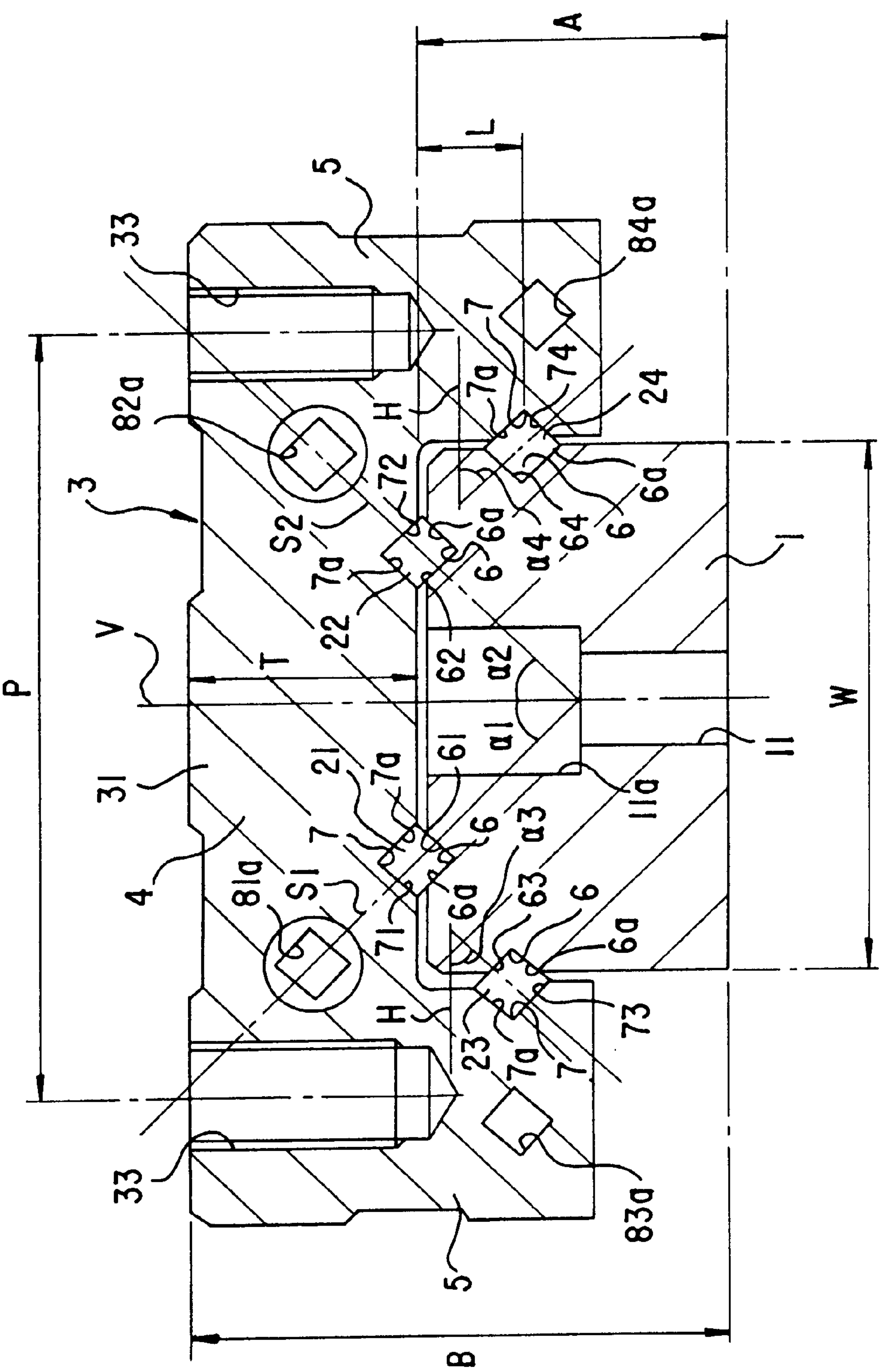

A
L
5
33
84a
7
74
7a
24
H
82a
3
72
6a
6
S2
7a
6a
6
α4
64
22
62
α2
V
T
P
W
l
α1
61
11
11a
21
7a
31
6
α3
7
4
81a
S1
71
6a
63
6
6a
H
23
73
7a
7
33
83a
5
B

FIG.5(a)

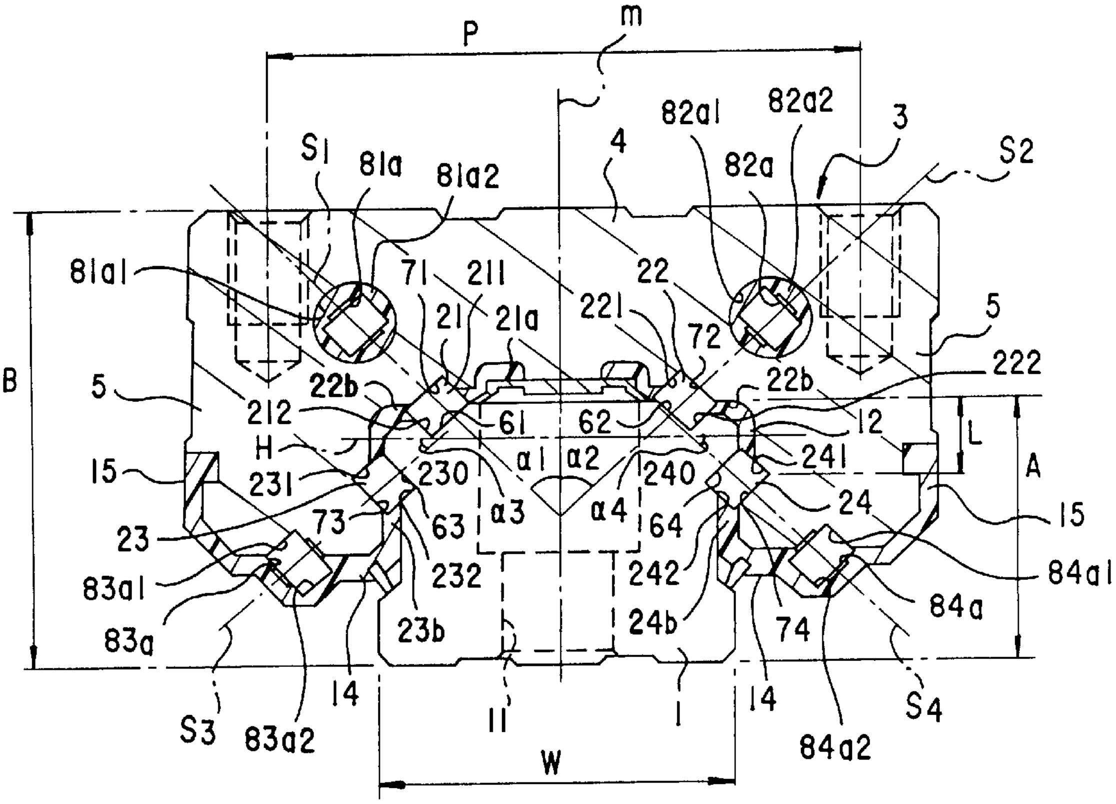
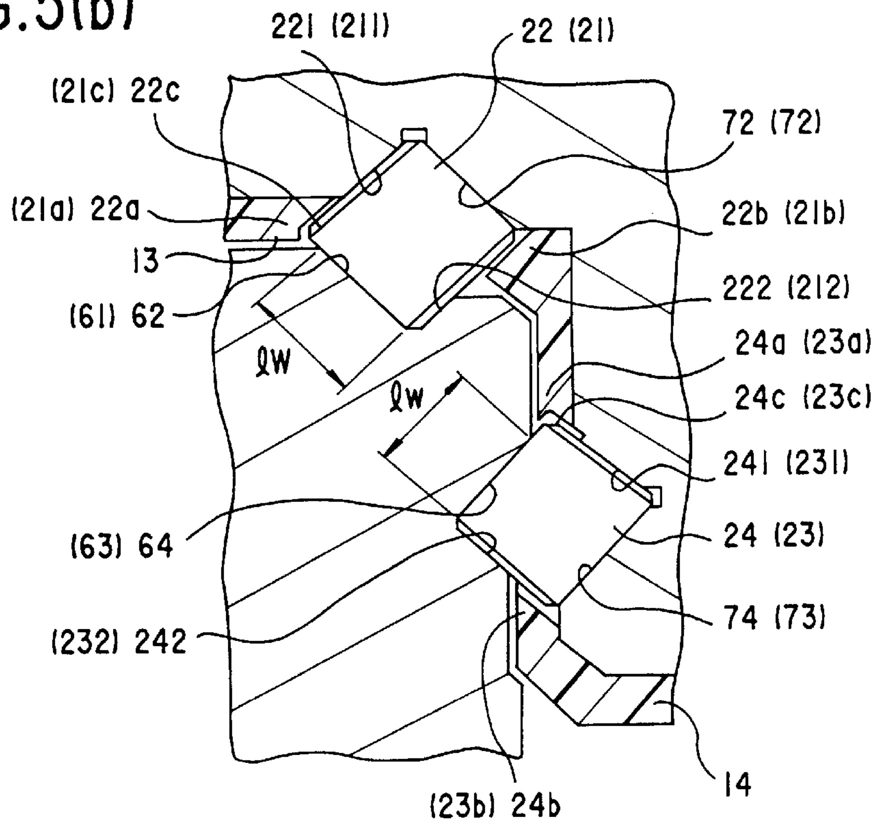

P
m
S1
81a
81a2
82a1
82a2
3
S2
4
82a
81a1
71
211
22
21
21a
221
5
72
B
5
22b
22b
222
212
61
62
12
H
L
15
231
230
α1
α2
240
241
A
73
α3
α4
64
24
23
63
15
232
242
83a1
84a1
23b
24b
84a
83a
74
S3
14
11
1
14
S4
83a2
84a2
W

FIG.5(b)


221 (211)
22 (21)
(21c) 22c
72 (72)
(21a) 22a
22b (21b)
13
222 (212)
(61) 62
24a (23a)
ℓw
ℓw
24c (23c)
241 (231)
(63) 64
24 (23)
74 (73)
(232) 242
14
(23b) 24b

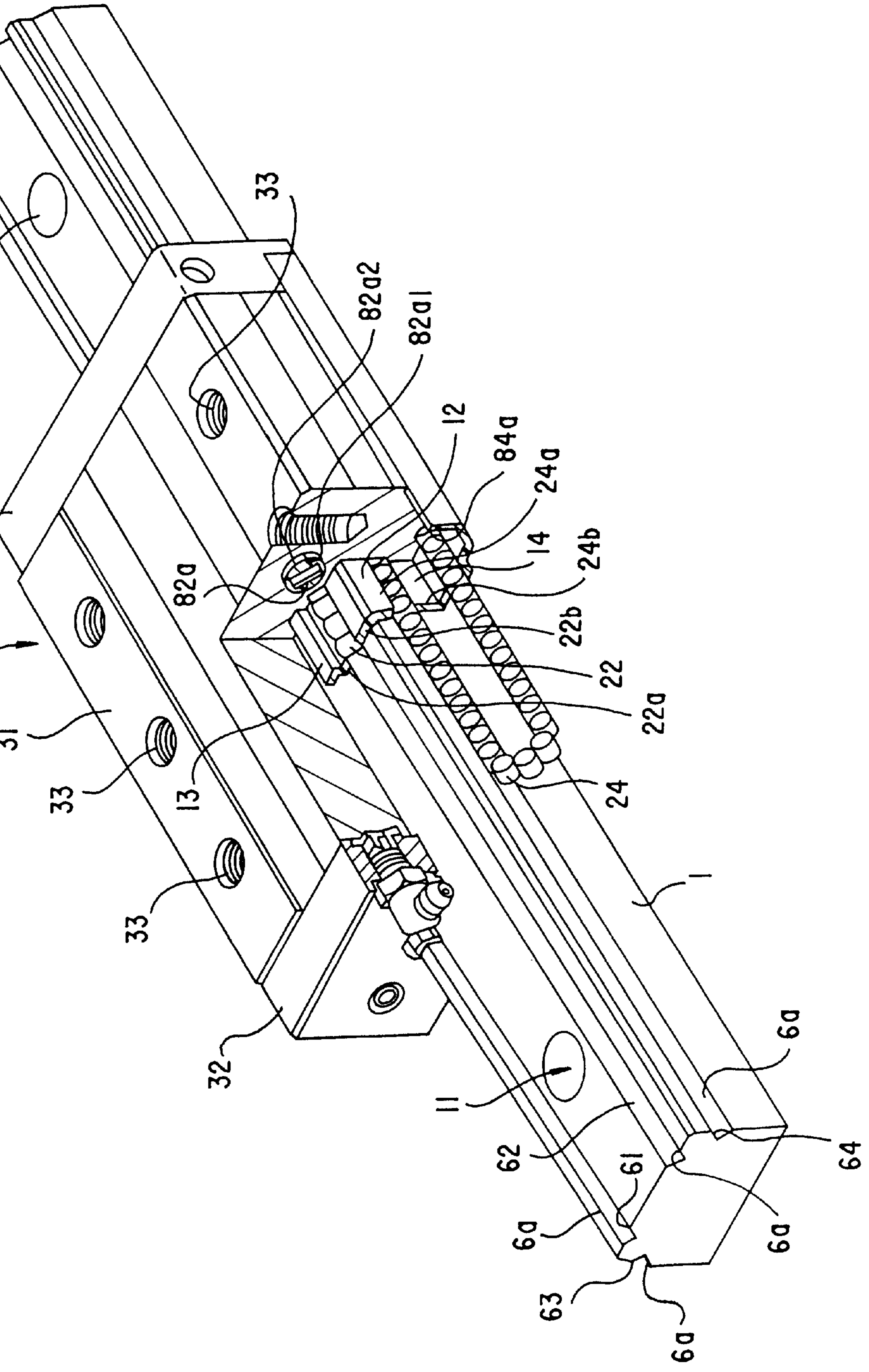

11
33
82a2
82a1
12
84a
24a
14
24b
22b
22
22a
24
32
3
31
33
13
82a
33
1
32
11
6a
62
64
61
6a
63
6a

FIG.6

FIG.7(a)

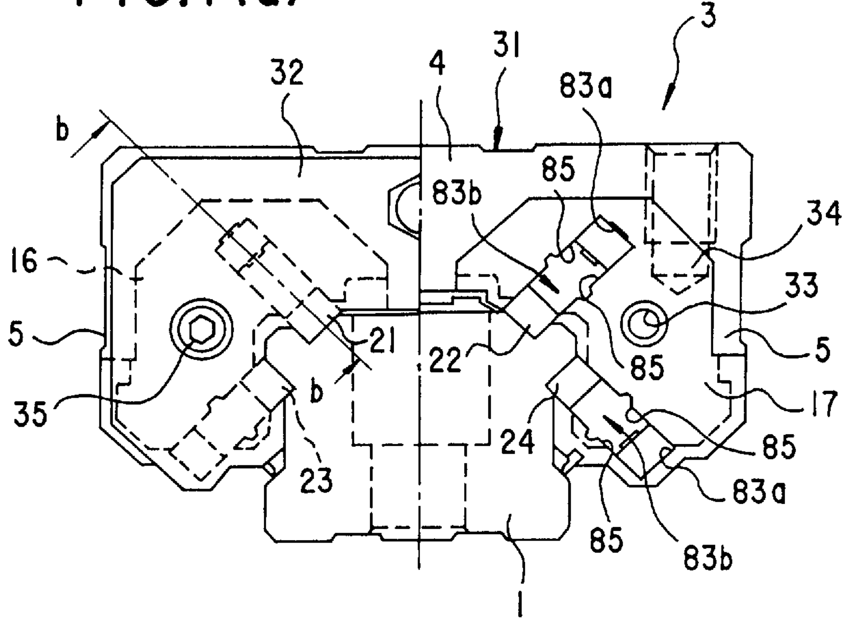


FIG.7(b)

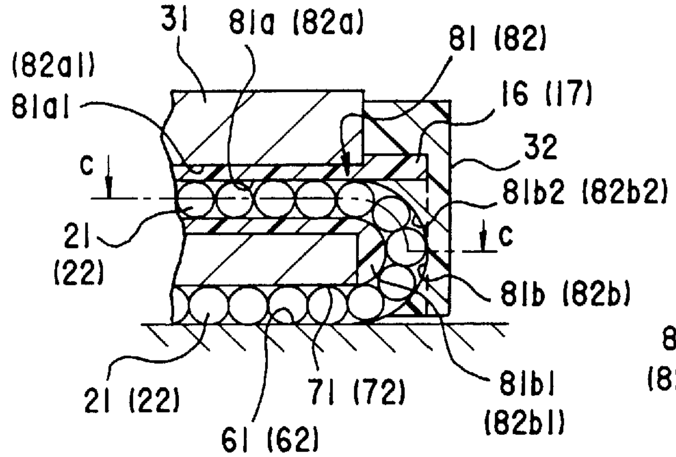
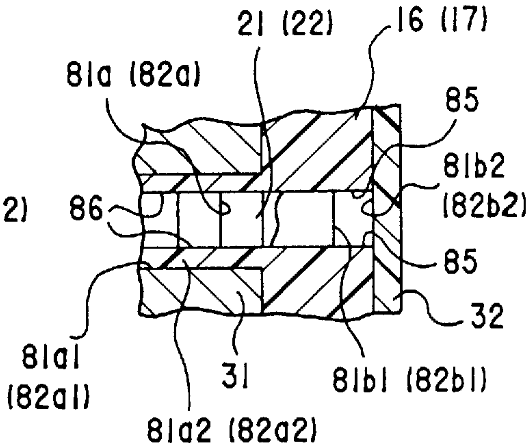


FIG.7(c)



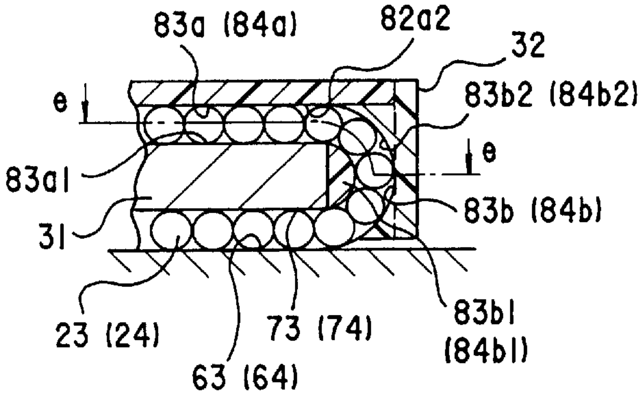


FIG.7(d)

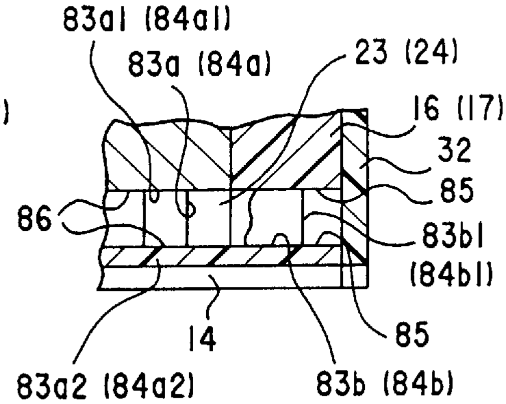


FIG.7(e)

FIG.8(a)

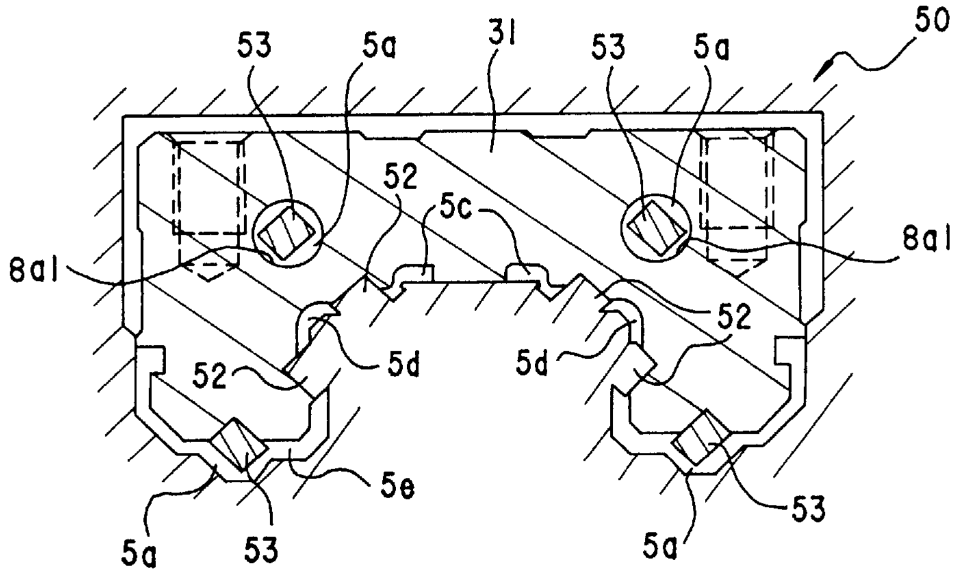


FIG.8(b)

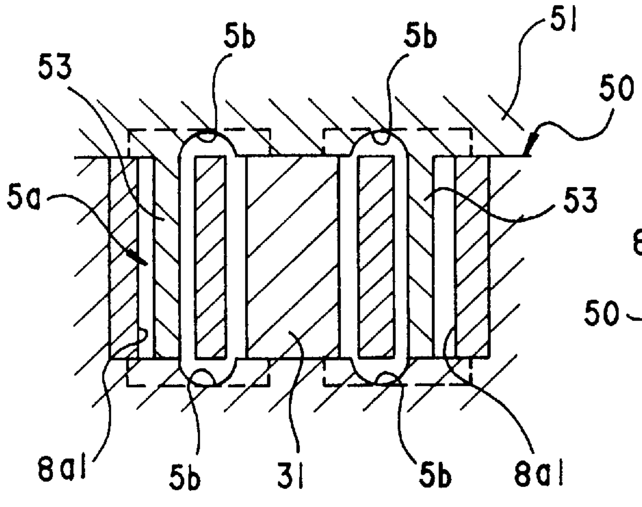


FIG.8(c)

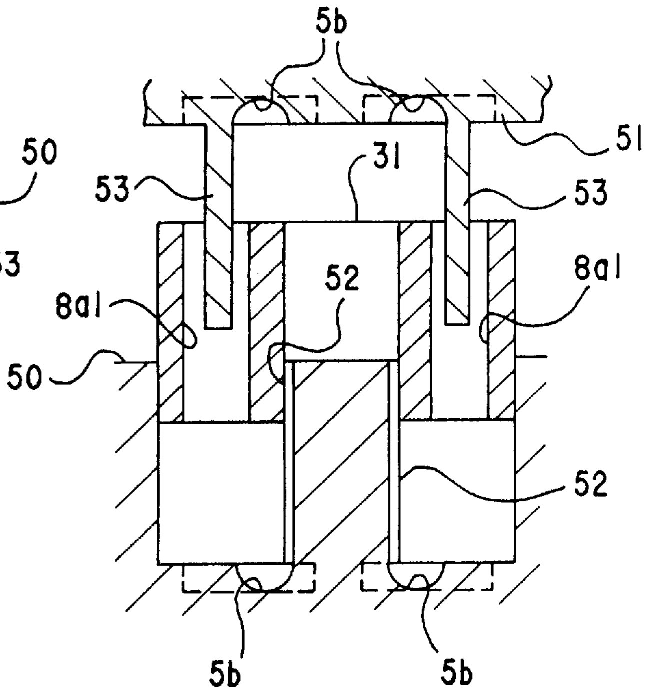


FIG.9(a)

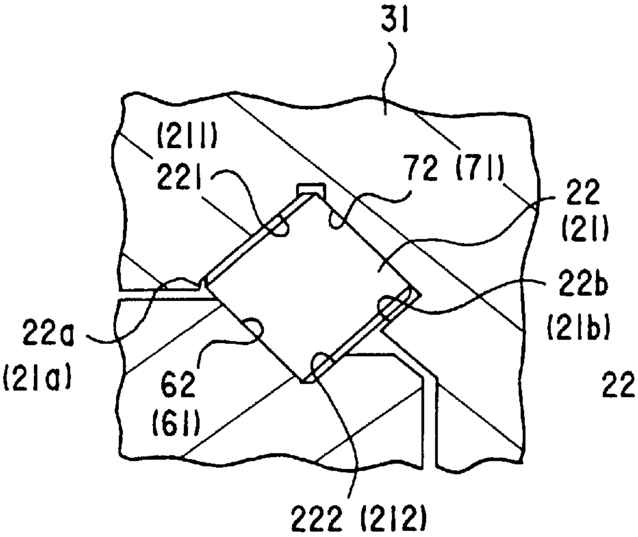


FIG.9(b)

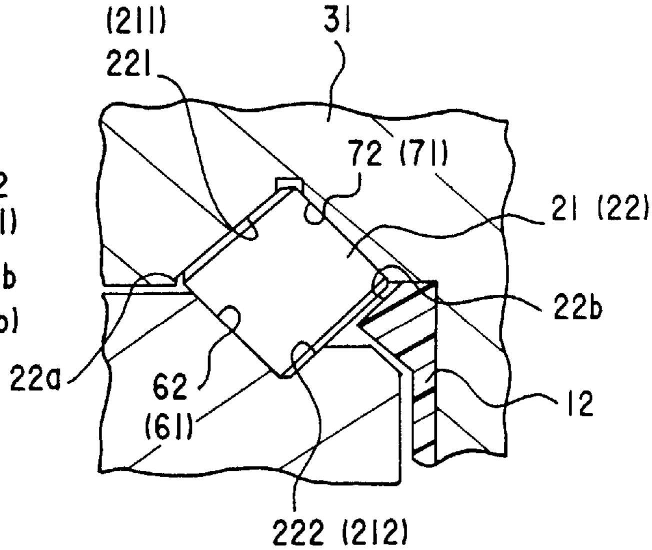


FIG.9(c)

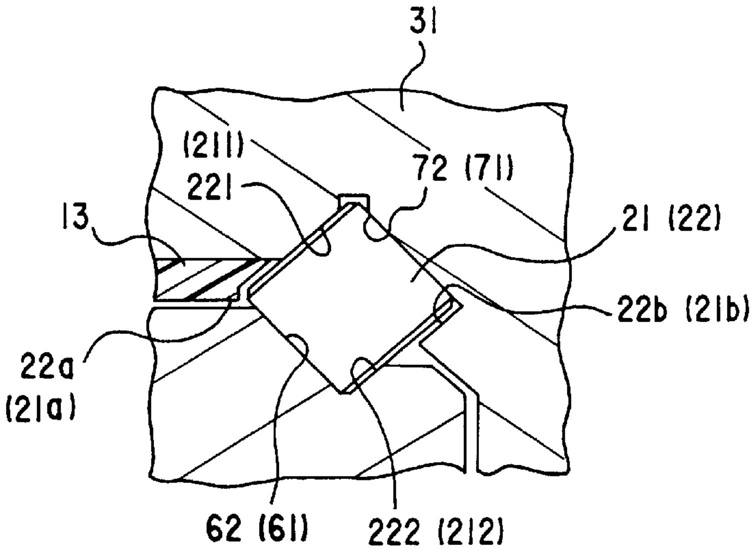


FIG.10(a)

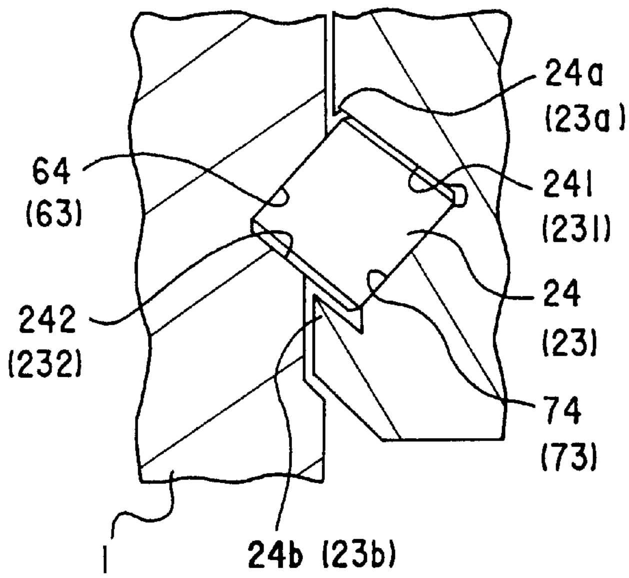


FIG.10(b)

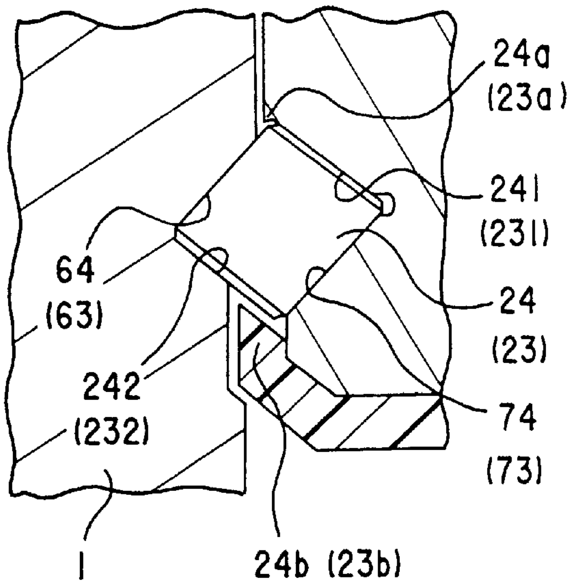


FIG.10(c)

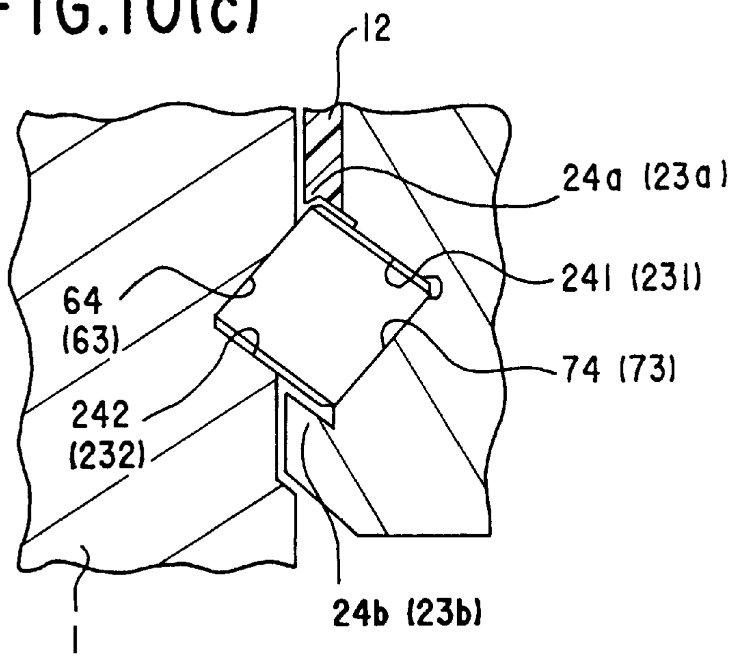


FIG.11(a)

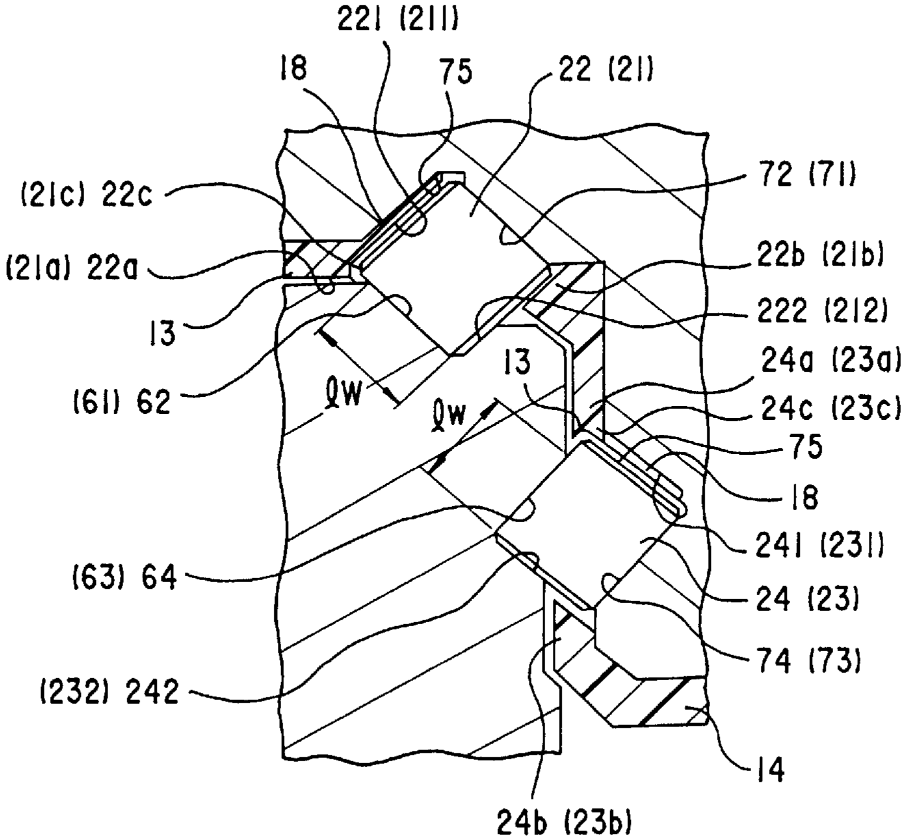


FIG.11(b)

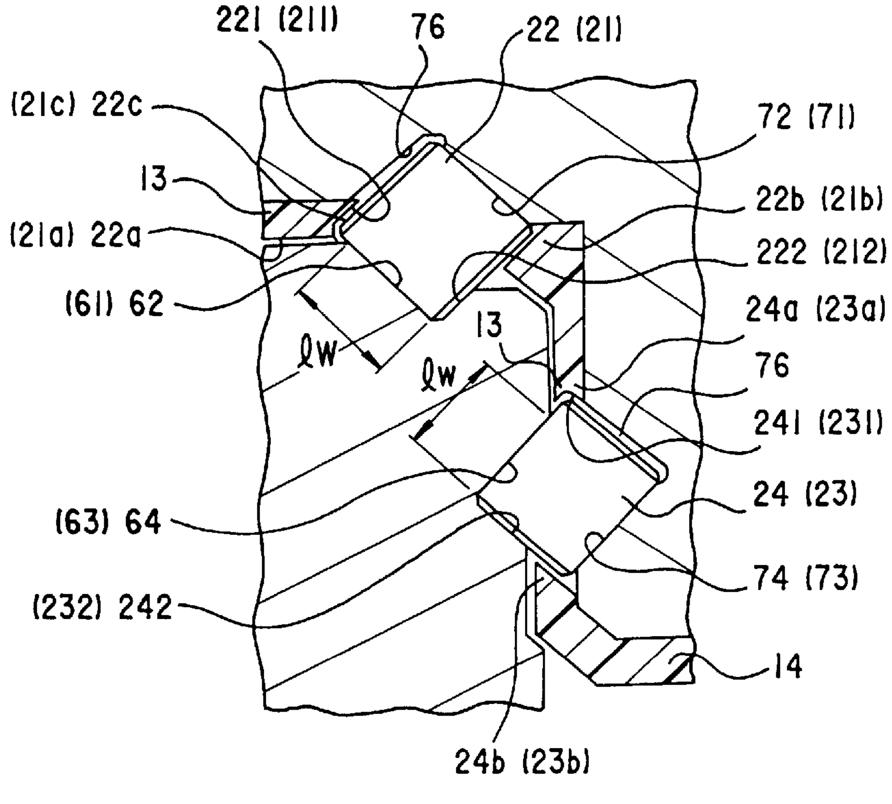


FIG.12

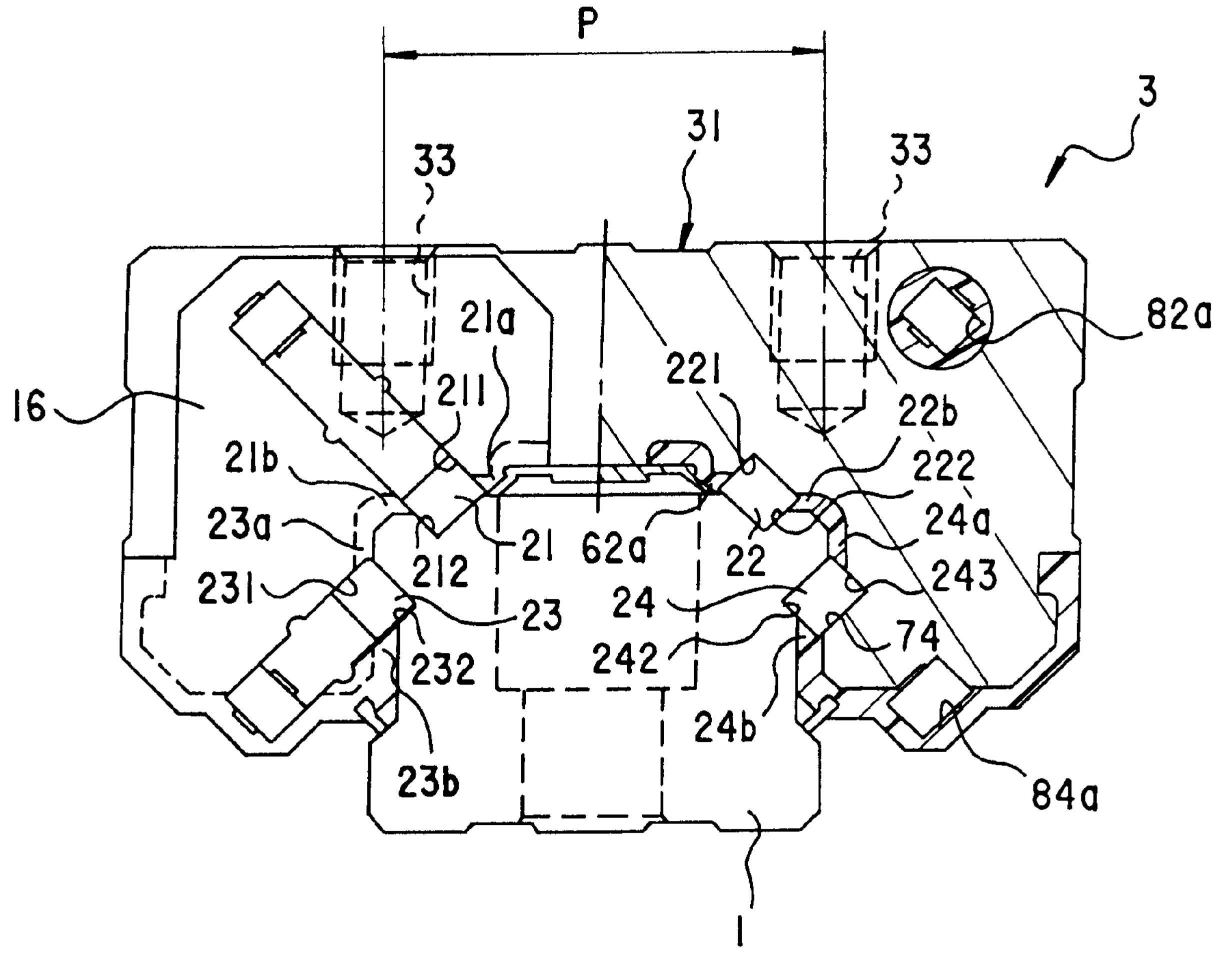

P
3
31
33
33
82a
21a
16
211
221
22b
21b
222
23a
24a
21
62a
22
212
243
231
23
24
74
242
232
24b
23b
84a
1

FIG.13(a)

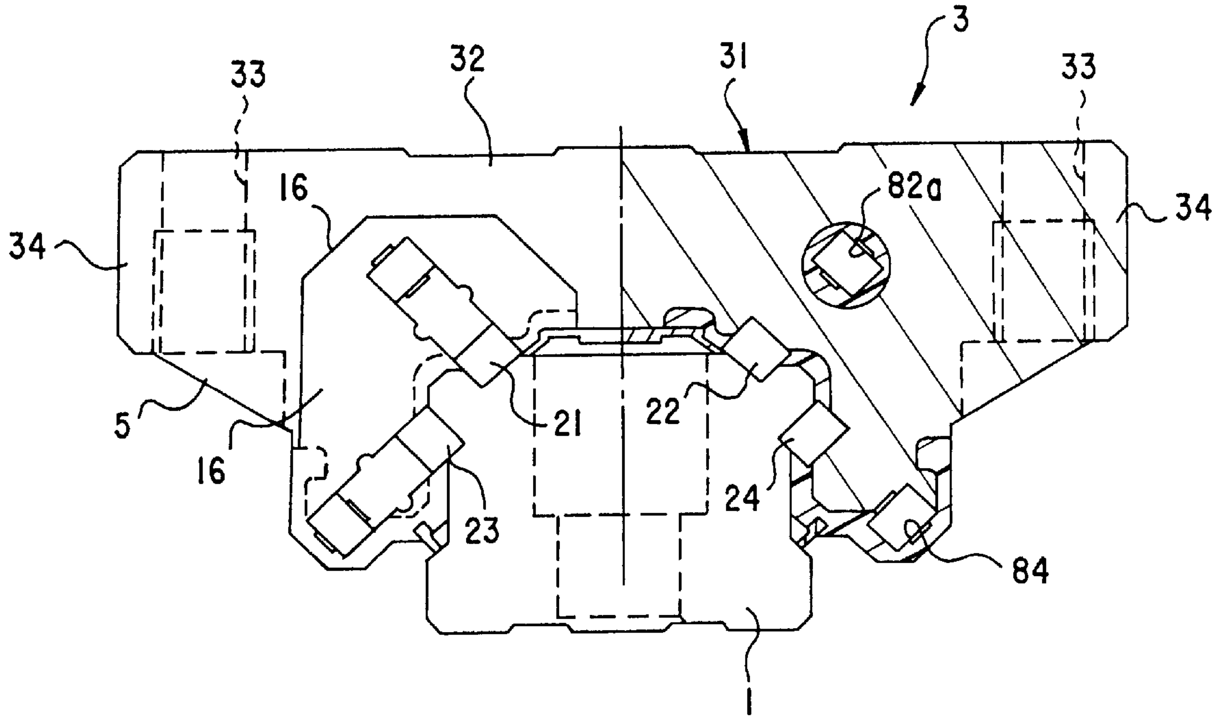


FIG.13(b)

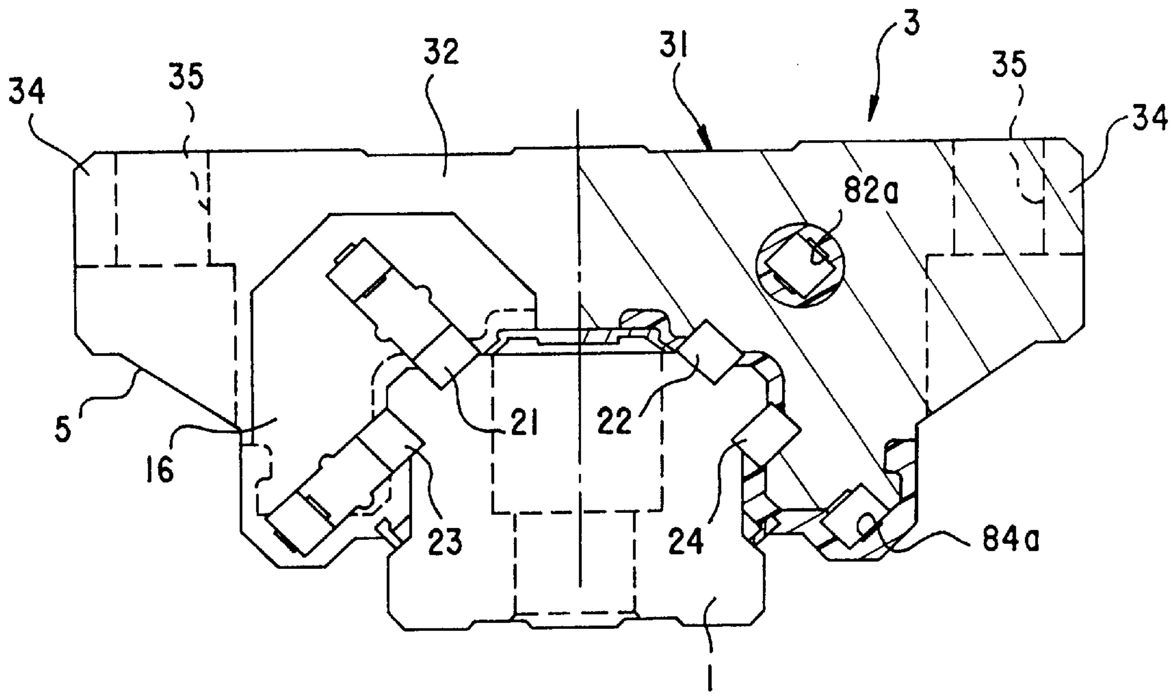


FIG.14(a)

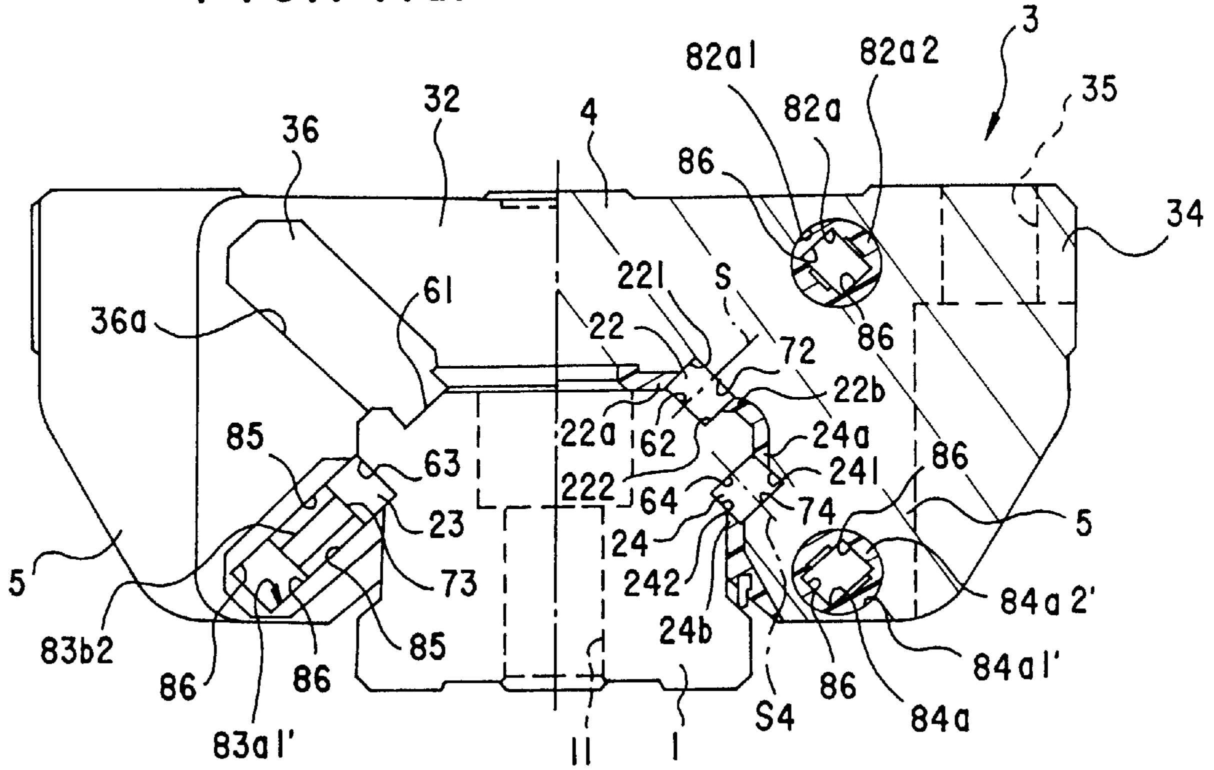


FIG.14(b)

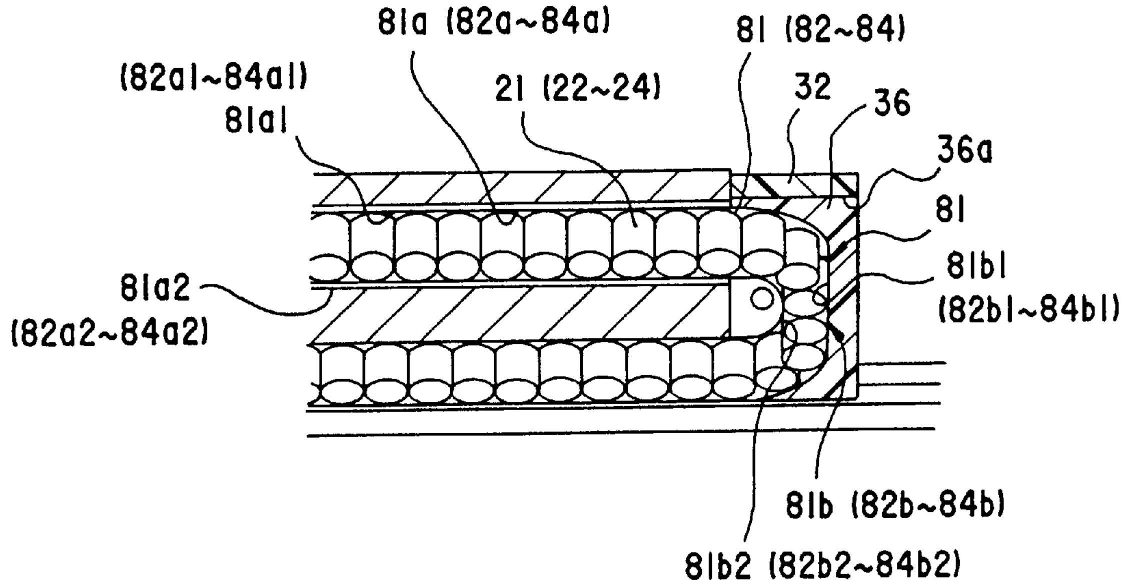


FIG.15(a)

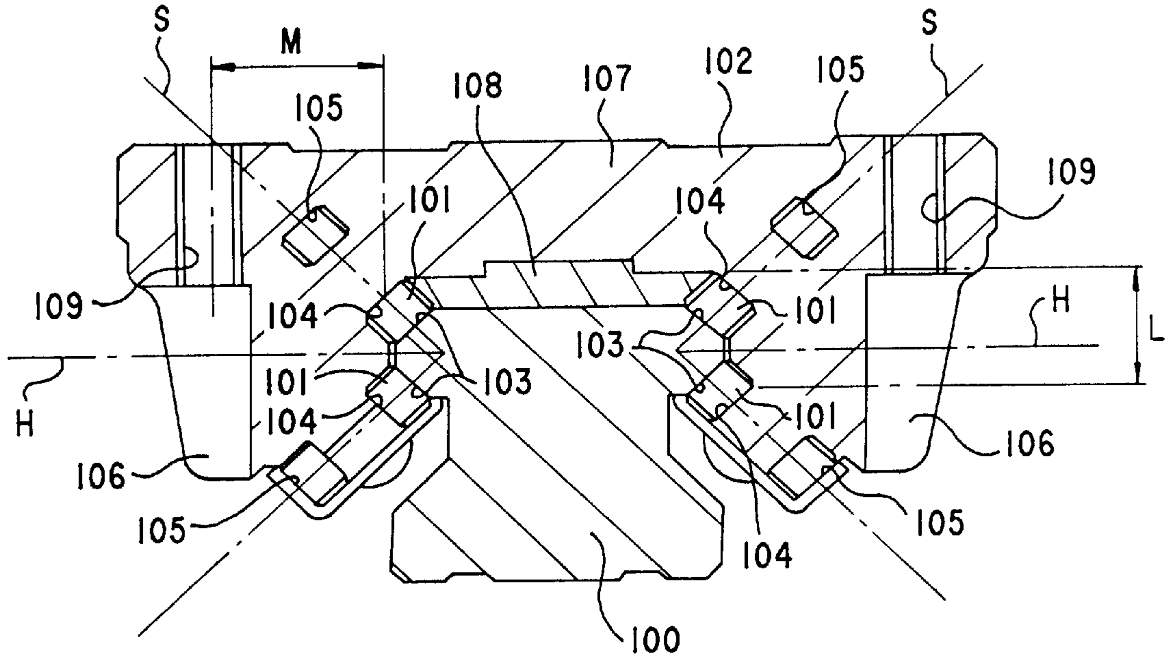
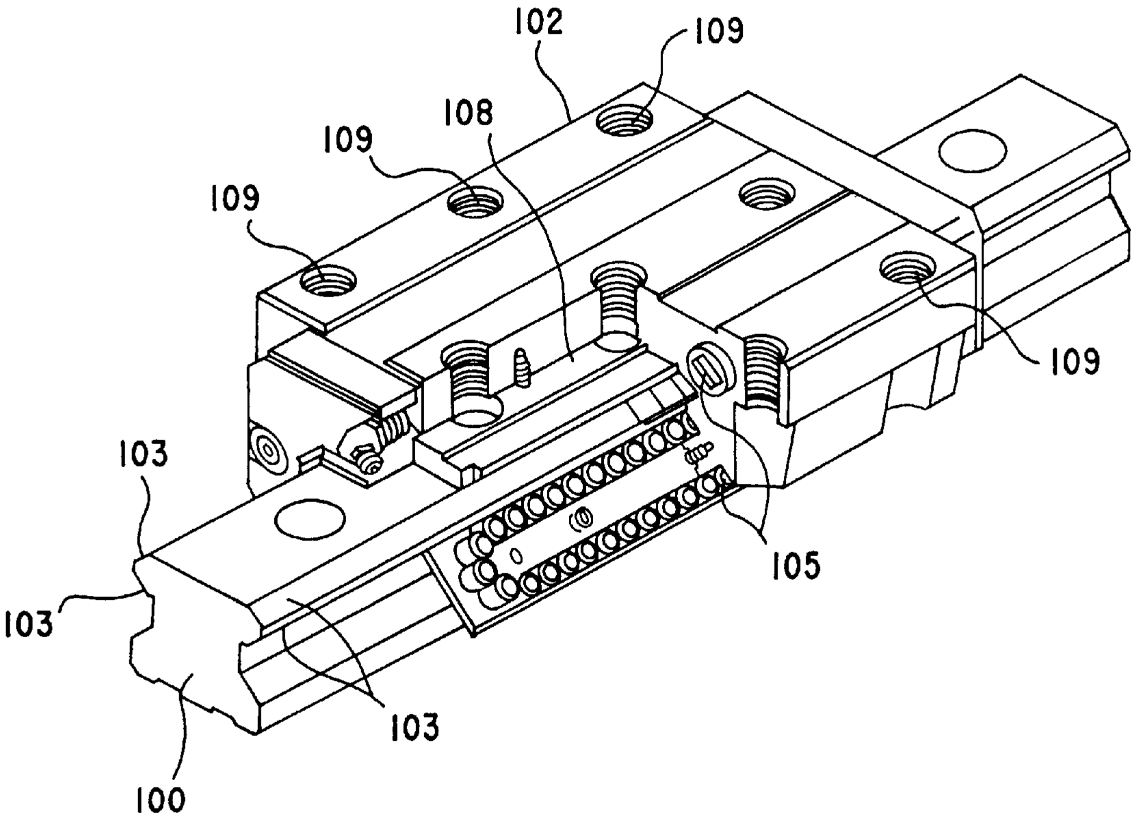


FIG.15(b)



LINEAR ROLLER GUIDE DEVICE

TECHNICAL FIELD

The present invention relates to a linear roller guide device using rollers as rolling elements, and more particularly, to a linear roller guide device in which rigidity of a movable block is highly improved.

BACKGROUND ART

As a conventional linear roller guide device of this type, for example, a guide device shown in FIG. **15** is well known.

Namely, this linear roller guide device has a structure in which a movable block **102** is movably guided along a track rail **100** through a number of rollers **101** disposed to right and left portions of the track rail **100**. Two rows of the rollers **101** are disposed to each of the right and left portions of the track rail **100** in vertical direction. As a result, four rows of rollers **101** in total are disposed to the track rail **100**. Further, four rows of roller rolling surfaces **103** for rolling the four rows of rollers **101** are formed to the track rail **100** in an entire range in which the movable block **102** is moved.

On the other hand, the movable block **102** is provided with four rows of roller rolling surfaces **104** for clamping the rollers **101** so as to oppose to the roller rolling surfaces **103** formed to the track rail **100**. The movable block **102** is also provided with four rows of roller circulating passages **105** in unloaded region for circulating the rollers **101** clamped between the roller rolling surfaces **103;104** from one ends to the other ends of the roller rolling surface **103** of the movable block **102**.

These four rows of the rollers **101** are disposed in a form of four rows in total so that a pair of rows of rollers disposed vertically are arranged along each of right and left side surfaces of the track rail **100**. These four rows of the rollers **101** have a contacting structure in which a contact angle line S constituted by a line orthogonal to center axes of the rollers **101** disposed in upper two rows is set so as to downwardly incline towards the track rail **100** with an inclination angle of almost **45** with respect to a horizontal line H, while a contact angle line S constituted by a line orthogonal to center axes of the rollers **101** disposed in a pair of lower two rows is set so as to upwardly incline towards the track rail **100** with an inclination angle of almost 45° with respect to a horizontal line H, thus adopting a contacting structure in which the loads applied from every four directions are equally supported by the rollers.

In the linear roller guide device described above, however, there was posed a problem that a high rigidity property inherent in the roller **101** cannot be utilized.

In the case of this linear roller guide device, if deformations to be caused by pre-load or external loads applied to the movable block are not eliminated, a contacting state of the rollers **101** with respect to the roller rolling surfaces **103** and **104** are changed, so that a preferable result excellent in rigid performance cannot be obtained.

Namely, conventionally, the paired upper and lower rows of rollers **101** are arranged along the right and left side surfaces of the track rail **100** so as to be apart from each other in a vertical direction, so that a length L from a base portion of a supporting leg portion **106** of the movable block **102** to the lower roller **101** is made long. As a result, when the preload is applied to the roller **101** or when a load in a horizontal direction is applied to an upper surface of the movable block **102** from the right or left direction as an external load, a moment applied in a direction spreading the supporting leg portion **106** is disadvantageously increased.

Further, when a lifting load (i.e., a load applied in a direction detaching the movable block **102** from the track rail **100**) is applied as the external load, a force directing upward is applied to upper surfaces of both right and left end portions of the movable block **102** through screw holes **109** formed at upper surfaces of both right and left end portions of the movable block **102**. As a reaction of the upward force, a force directing downward is applied to the roller rolling surfaces **104** of the lower side of the rollers **101**. These vertically balancing forces are applied so as to be apart from each other with a lateral distance M between the screw hole **109** and the lower side roller **101**, so that a bending moment in a direction for spreading the supporting leg portion **106** will occur.

The bending moment due to this lifting load is caused by separating the screw hole **109** from the lower side roller **101** to each other in a horizontal direction, so that it is ideal to locate the screw hole **109** and the lower side roller **101** at the same position. However, due to exitence of the roller circulating passages **105** in unloaded region, it is difficult to form the screw hole **109** to a central portion of the movable block **102**.

With respect to the bending moment to be applied to these supporting leg portions **106**, a flexural rigidity at a horizontal portion **107** of the movable block **102** copes with the bending moment. However, when a thickness of the horizontal portion **107** is increased, a height dimension of the movable block **102** will be disadvantageously increased.

Further, conventionally, a skew of the roller **101** has been prevented by retaining both end surfaces of the roller **101** in an axial direction thereof by means of a vertical wall **104*a*** and a roller end surface guide member **108**, the vertical wall **104*a*** being provided to one side periphery of the roller rolling surface **104** of the movable block **102** while the roller end surface guide member **108** being provided to the other side periphery of the roller rolling surface **104**.

In this regard, the skew is a phenomenon of the roller **101** being rolled in a state where a central axis of the roller **101** is inclined with respect to an axis orthogonal to the rolling direction of the roller **101**. When this skew occurs, an excessive stress concentration will occur at the end portion of the roller **101** to thereby cause a deterioration in durability of the roller **101** and the roller rolling surfaces. Therefore, the generation of the skew must be sufficiently prevented.

However, even if the roller end surface guide member **108** is provided as conventionally made, when the movable block **102** per se is deformed as described above, the roller rolling surface **104** is displaced. As a result. thus bringing into the sane result as in the skew generation.

Furthermore, in a conventional art, since the roller end surface guide member **108** for retaining the roller **101** is interposed between the horizontal portion **107** and the upper surface of the track rail **100**, a space for installing the roller end surface guide member **108** is required to a portion between the horizontal portion **107** and the upper surface of the track rail **100**. As a result, the thickness of the horizontal portion **107** of the movable block **102** is obliged to be decreased and the rigidity thereof cannot be set to a large level.

The present invention has been achieved for solving the problems encountered to the prior art described above, and an object of this invention is to provide a linear roller guide device capable of increasing a structural rigidity of the movable block by improving the arranging relations of the rollers.

Another object of the present invention is to provide a linear roller guide device capable of sufficiently extending a contact length of the roller and sufficiently realizing high-rigidity characteristics of the roller by improving structures of the roller end surface guide portion and the roller retaining portion.

DISCLOSURE OF THE INVENTION

In order to achieve the afore-mentioned object, the present invention provides a linear roller guide device in which a movable block is guided along a track rail through four rows of rollers disposed on the track rail,

wherein the movable block comprises a horizontal portion opposing to an upper surface of the track rail and supporting leg portions projected downwardly from both end portions of the horizontal portion so as to oppose to right and left side surfaces of the track rail,

wherein the track rail is provided with four rows of roller rolling surfaces for rolling and guiding the rollers in an entire range of the track rail in which the movable block is moved, and

wherein, on the other hand, the movable block comprises four rows of roller rolling surfaces opposing to the roller rolling surfaces of the track rail for rollingly clamping the four rows of rollers and four rows of roller circulating passages provided at unloaded region for circulating the rollers clamped between the roller rolling surfaces of the track rail and the movable block from one end portion to the other end portion of the roller rolling surface of the movable block,

the linear motion guide device being characterized in that an upper two rows of rollers among the four rows of rollers are arranged to a portion close to a center side from a side end of the upper surface of the track rail, while roller rolling surfaces corresponding to the upper two rows of rollers are formed to the upper surface of the track rail and the lower surface of the horizontal portion of the movable block,

that the lower two rows of rollers among the four rows of rollers are arranged such that one row of rollers is disposed to an upper portion of right and left side surfaces of the track rail, respectively, while roller rolling surfaces corresponding to the lower two rows of rollers are formed to the right and left side surfaces of the track rail and inner side surfaces of the supporting leg portions of the movable block,

that the upper two rows of rollers has a structure in which a line orthogonal to a rotation axis of the roller is inclined with respect to a vertical line with a predetermined inclination angle, and

that the lower two rows of rollers has a structure in which a line orthogonal to a rotation axis of the roller is inclined with respect to a horizontal line with a predetermined inclination angle so as to upwardly extend towards a side of the track rail.

According to the structure described above, since the upper two rows of rollers are arranged to a portion close to center side from the end portion of the upper surface of the track rail and the lower two rows of the rollers are arranged to upper portions of the right and left side surfaces of the track rail, the lengths from the base portion of the right and left supporting leg portions of the movable block to the lower side rollers can be shortened in comparison with a conventional case where the two rows of rollers are arranged to the right and left sides surfaces of the track rail, respectively.

Accordingly, even if a reaction force of the preload applied to the roller or a lateral load acting in a direction so as to displace the movable block in a horizontal direction with respect to the track rail is applied, it becomes possible to decrease the bending moment acting in a direction spreading the supporting leg portions.

Further, in general, due to the moment acting in a direction spreading the supporting leg portions, a center portion of the horizontal portion is bent so as to close to the upper surface of the track rail. However, in the present invention, a bending deformation of the horizontal portion is suppressed by the action of the upper two rows of rollers disposed between the horizontal portion and the upper surface of the track rail, whereby the spreading of the supporting leg portions can be sufficiently decreased in co-operation with the reduction of the bending moment.

As described above, even if the preload is applied to the roller or a lateral load in a horizontal direction is applied, the deformation in a direction spreading the supporting leg portions of the movable block can be prevented and a degree of parallelization between the opposing roller rolling surfaces can be maintained to a constant level, whereby non-uniform contact of the rollers can be prevented.

In another aspect of this invention, the linear motion guide device may have a structure in which the upper two rows of rollers are arranged to portions close to a center side portion deviated from a side end of the upper surface of the track rail, while the roller circulating passages in unloaded region are also arranged to portions close to the center side portion with respect to the roller circulating passages in unloaded region corresponding to the lower two rows of the rollers, and wherein a screw hole for fixing the movable block is provided at portions on the upper surface of right and left end portions of the horizontal portion of the movable block, and the portions are set to upper positions of the roller circulating passages in unloaded region for the lower two rows of rollers or set to positions close to the center side.

When a lifting load in a direction so as to detach the movable block from the track rail is applied, a force directing upward is applied to the movable block through the screw holes. As a reaction of the upward force, a force directing downward is applied to the roller rolling surfaces of the lower side of the rollers. These vertically balancing forces are applied so as to be apart from each other with a lateral distance between the screw hole and the lower side roller, so that a bending moment in a direction for spreading the supporting leg portion will occur.

This bending moment is also basically supported by the upper two rows of rollers disposed between the horizontal portion and the upper surface of the track rail, thereby to sufficiently decrease the spreading of the supporting leg portions.

In general, the bending moment due to this lifting load is caused by separating the screw hole from the lower side roller so as to be apart from each other in a horizontal direction, so that it is ideal to form the screw hole and the lower side roller at the same position. However, due to existence of the roller circulating passages for the upper two rows of rollers in unloaded region, it is difficult to form the screw hole to a central portion of the movable block.

As a countermeasure of the above matter, in the present invention, the upper two rows of rollers are arranged to portions close to a center side portion deviated from a side end of the upper surface of the track rail, while the roller circulating passages in unloaded region corresponding to the upper two rows of rollers are also arranged to portions close to the center side portion with respect to the roller circulating passages in unloaded region corresponding to the lower two rows of the rollers, whereby an interference of the upper two rows of the rollers with the roller circulating passages can be avoided.

Simultaneously, the screw hole is provided at the roller circulating passages in unloaded region for the lower two rows of rollers or inside of the roller circulating passages, whereby the length in the horizontal direction between the screw hole and the lower side rollers is sufficiently shortened.

According to the structure described above, not only in a case when the preload is applied to the roller or the lateral load is applied but also in a case when the lifting load is applied, the moment can be decreased, the deformation in a direction so as to spread the supporting leg portions is prevented, and the degree of parallelization between the roller rolling surfaces is maintained to a constant level whereby the non-uniformity in contacting of the rollers can be prevented.

Further, when an angle between a line orthogonal to the rotation axis of each of the upper two rows of rollers disposed on the upper surface of the track rail and a vertical line is set at almost 45° and an angle between a contact angle line of the lower two rows of rollers disposed on the side surfaces of the track rail and a horizontal line is set at almost 45°, the same rated load can be obtained with respect to a radial load applying from upper direction (i.e., a load in a direction pressing the movable block onto the track rail), lifting load and the lateral loads applied from right and left directions, whereby any of the load applied from every direction can be supported. In other words, the device can be used in any attitudes or positions, and available to wide applications.

Further, it is effective to adopt a structure in which a track rail having a track groove having a V-shape in cross section comprising two inclined surfaces is used, and the roller rolling surfaces to be formed to the track rail and the movable block so as to correspond to the four rows of rollers are formed to one of the inclined surfaces while the other inclined surface is used as a guide surface for guiding the roller end surfaces, whereby the end surfaces of the rollers are guided while a pitch of the rollers is maintained to a predetermined value in a portion between the guide surface of the track groove of the track rail side and the guide surface of the movable block side which are opposed to each other.

If the track groove is formed to have a V-shaped in cross section described above, a locating relation between the respective track grooves can be accurately measured by using a roller pin, whereby the locating relation between the respective track grooves can be molded or formed with a high accuracy. Accordingly, the four rows of rollers disposed between the track rail and the movable block accurately contact to the roller rolling surfaces formed to a pair of track grooves corresponding to the four rows of rollers, and the end surfaces of the roller are accurately guided by the action of the guide surfaces of the paired track grooves.

As described above, the movable block has a rigidity regardless of the direction of the loads, so that the locating relation between the track rail and the movable block is normally maintained to a constant value. Further, the movable block is supported by the track rail at a position where the preload applied to the respective four rows of rollers and the reaction force of the preload are balanced, so that a gap between the end surface of the roller and the guide surface can be normally maintained to a constant level in co-operation with the effect of accurately forming the locating relation between the respective track grooves as described above.

In particular, the movable block is formed in a shape having a high rigidity, so that a high preload can be applied. Therefore, the high rigidity of the movable block and the high preload are synergistically effected to realize an effect such that the gap between the end surface of the roller and the guide surface can be maintained to a constant level. As a result, the skew preventing effect for the roller can be enhanced and a smooth circulation and a rolling accuracy of the rollers can be secured.

Further, the space for installing the roller end surface guide member, which is conventionally required to be provided to the lower surface of the movable block, becomes unnecessary in this invention, so that the thickness of the horizontal portion of the movable block can be increased with an amount equivalent to the space, whereby the the flexural rigidity of the horizontal portion can be increased and also the rigidity of the movable block can be enhanced. In addition, by enhancing the rigidity of the movable block, the effect of preventing the skew generation can be further synergistically improved.

When the roller rolling surfaces and the end surface guide surfaces are constituted by the track groove having a V-shape in cross section, the roller rolling surfaces and the end surface guide portions of the track groove can be simultaneously finished by a grinding work, so that a guiding accuracy of the rollers and surface roughness are improved and an enhanced effect in skew prevention can be obtained. In addition, the working amount for the track groove can be minimized.

Further, when a retainer for the roller is eliminated and the roller contacts to the roller rolling surface at an entire length of the roller, the rigidity of the roller per se can be effectively utilized.

Further, another invention is as follows.

Namely, there is also provided a linear roller guide device in which a movable block is guided along a track rail through rollers disposed on the track rail,

wherein the track rail is provided with roller rolling surfaces for rolling and guiding the rollers, and

wherein, on the other hand, the movable block comprises roller rolling surfaces opposing to the roller rolling surfaces formed to the track rail for rollingly clamping the rollers and roller circulating passages provided at unloaded region for circulating the rollers clamped between the roller rolling surfaces of the track rail and the movable block from one end portion to the other end portion of the roller rolling surface of the movable block,

the linear motion guide device being characterized in that a first end surface guide portion for guiding one end surface of the roller is provided to one side periphery of the roller rolling surface formed to the movable block so as to rise up at an almost right angle with respect to the roller rolling surface, while a second end surface guide portion for guiding the other end surface of the roller is provided to the other side periphery of the roller rolling surface formed to the track rail so as to rise up at an almost right angle with respect to the roller rolling surface,

that a radial direction retaining portion having a projection for preventing the roller from falling out in a radial direction by being engaged with a peripheral corner portion of the roller end surface is provided to one side periphery of the roller rolling surface formed to the track rail, while the roller is contacted to the roller rolling surface formed to the track rail at an almost entire contact length in a peripheral surface of the roller except an engaging width required for engaging with the radial direction retaining portion, and

that, on the other hand, an axial direction retaining portion for preventing the roller from falling out in an axial direction is provided to a side periphery of the roller rolling surface formed to the movable block, the side periphery being opposite to the side periphery to which the first end surface guide portion is provided.

According to this invention, one end surface of the roller is guided by the first end surface guide portion provided to one side periphery of the roller rolling surface formed to the movable block, while the other end surface of the roller is guided by the second end surface guide portion provided to the other side periphery of the roller rolling surface formed to the track rail, whereby the skew of the roller can be prevented.

In this regard, the skew is a phenomenon of the roller being rolled in a state where a central axis of the roller is inclined with respect to an axis orthogonal to the rolling direction of the roller. When this skew occurs, an excessive stress concentration will occur at the end portion of the roller to thereby cause a deterioration in durability of the roller and the roller rolling surfaces. Therefore, the generation of the skew must be sufficiently prevented.

In the present invention, the roller end surfaces are guided by the first and second end surface guide portions, whereby the center axis of the roller is maintained in an orthogonal direction with respect to the rolling direction of the roller.

On the other hand, when the movable block is detached from the track rail, the second end surface guide portion provided to the track rail is also detached from the other end surface of the roller. However, the roller is retained between the first end surface guide portion provided to one side of the roller rolling surface formed to the movable block and the axial direction retaining portion provided to the other side periphery thereof, so that the falling-out of the roller in an axial direction can be prevented.

Further, a peripheral portion of the one end surface of the roller is retained by the radial direction retaining portion provided to a portion of the track rail side from the first end surface guide portion with respect to the roller rolling surface, so that the falling-out of the roller in a radial direction can be also prevented.

As described above, the radial direction retaining portion is engaged with only a periphery of the one end surface of the roller, and the second end surface guide portion is provided to the other side periphery of the roller rolling surface formed to the track rail, so that a peripheral surface of the roller except the engaging portion for engaging with the radial direction retaining portion can be contacted to the roller rolling surface formed to the track rail so that the end surface is closely contacted to the second end surface guide portion, whereby the contact length of the roller can be sufficiently secured in a long length. Accordingly, the high rigidity characteristic of the roller can be sufficiently utilized.

In another aspect of this invention, the linear motion guide device is characterized in that the first end surface guide portion is integrally formed with a member for constituting a block body of the movable block.

According to this structure, the block body and the first end surface guide portion can be worked so as to have a high rigidity and high accuracy, and the end surfaces of the roller are guided in a portion between the first end surface guide portion and the second end surface guide portion provided to the track rail also having a high rigidity, whereby the skew generation can be further securely prevented.

In still another aspect of this invention, the device is characterized in that the first end surface guide portion is integrally formed with the block body by inserting the block body into a molding die.

According to this structure, the end surface guide portions can be accurately positioned without causing any attaching error, and the gap between the roller end surface and the first end surface guide portion can be further decreased without impairing the circulating motion of the rollers, so that the skew preventing effect for the roller can be enhanced.

Further, when this first end surface guide portion is constituted by a resin member, the roller end surface is guided by the resin member, so that a friction resistance is decreased whereby a smoothness in roller guiding can be increased.

Furthermore, the roller end surface would not wear, so that the skew prevention can be stably secured.

In still another aspect of this invention, the linear motion guide device is characterized in that a guide wall opposing to the roller end surface in a non-contact state is provided to one side periphery of the roller rolling surface formed to the movable block, the radial direction retaining portion is provided to an end portion of the guide wall, and the first end surface guide portion contacting to a circumferential portion of the roller end surface is constituted by an opposing surface of the radial direction retaining portion so that the opposing surface is opposed to the roller end surface.

According to this structure, contact areas of the first end surface guide portion and the roller end surface are decreased, so that a friction resistance can be decreased whereby a smoothness in roller circulation can be increased.

When both the first and second end surface guide portions are integrally formed with the block body by inserting the block body into a molding die, both the radial and axial direction retaining portions can be accurately positioned without causing any attaching error, so that a predetermined gap between the roller and the radial direction retaining portion or the axial direction retaining portion can be accurately formed during the rolling of the rollers, whereby the roller would not interfere with the radial and axial direction retaining portions. Accordingly, the rollers are smoothly rolled and moved in co-operation with the skew preventing effect for the rollers by the action of the first and second end surface retaining portions.

On the other hand, the linear motion guide device is characterized in that the roller circulating passage in unloaded region comprises an unloaded roller returning passage extending in an axial direction and a direction changing passage for connecting both ends of the unloaded roller returning passage to both ends of a roller rolling passage in loaded region to be formed between the opposing roller rolling surfaces of the track rail and the block body, wherein a direction changing passage inner periphery member for constituting an inner periphery portion of the direction changing passage, together with both radial and axial direction retaining portions, are integrally formed with the block body by inserting the block body into a molding die.

According to this structure, a connected portion of the loaded roller rolling surface and the direction changing passage inner periphery portion can be continuously formed without causing irregularities, so that the rollers are smoothly rolled and moved.

Further, in still another aspect of this invention, the linear motion guide device is characterized in that an unloaded roller returning passage member for constituting the unloaded roller returning passage, together with the direction changing passage inner periphery member and both the radial and axial direction retaining portions, are integrally formed with the block body by inserting the block body into a molding die.

According to this structure, each of the connected portions between the loaded roller rolling surface, the direction changing passage inner periphery portion and the unloaded roller returning passage can be continuously formed without causing irregularities, so that the rollers are smoothly circulated and moved in all around a circulating passage.

Further, in still another aspect of this invention, the linear motion guide device is characterized in that the direction changing passage inner periphery member and the unloaded roller returning passage member are integrally provided with an end surface guide portion for guiding at least one end surface of the roller.

According to this structure, the end surface guide portions of the direction changing passage inner periphery member and the unloaded roller returning passage member are continuously formed without causing irregularities, so that the skew of the roller can be prevented in all around the circulating passage and the rollers are smoothly circulated.

In still another aspect of this invention, the linear motion guide device is characterized in that four rows of rollers are provided in total among which two rows of the rollers are disposed on an upper surface of a track rail, and one row of the rollers is disposed to right and left side surfaces of the track rail, respectively,

wherein the movable block comprises a horizontal portion opposing to the upper surface of the track rail and supporting leg portions each extending downwardly from both ends of the horizontal portion and opposing to the right and left side surfaces of the track rail,

wherein among the four rows of the rollers, two rows of the rollers disposed on the upper surface of the track rail are arranged to portions close to a center side apart from a side end of the upper surface of the track rail with a predetermined distance, while roller rolling surfaces corresponding to the upper two rows of rollers are formed to the upper surface of the track rail and the lower surface of the horizontal portion of the movable block, and roller rolling surfaces corresponding to the lower two rows of rollers are formed to the right and left side surfaces of the track rail and inner side surfaces of the supporting leg portions of the movable block,

wherein the upper two rows of rollers has a structure in which a line orthogonal to a rotation axis of the roller is inclined with respect to a vertical line at a predetermined inclination angle, and

wherein the lower two rows of rollers has a structure in which a line orthogonal to a rotation axis of the roller is inclined with respect to a horizontal line at a predetermined inclination angle so as to upwardly extend towards a side of the track rail.

According to the structure described above, when the upper two rows of rollers are arranged to portions close to center side apart from the end portion of the upper surface of the track rail and the lower two rows of the rollers are arranged to upper portions of the right and left side surfaces of the track rail, the lengths from the base portions of the right and left supporting leg portions of the movable block to the lower side rollers can be shortened in comparison with a conventional case where the two rows of rollers are arranged to the right and left sides surfaces of the track rail, respectively.

Accordingly, even if a reaction force of the preload applied to the roller or a lateral load acting in a direction so as to displace the movable block in a horizontal direction with respect to the track rail is applied, it becomes possible to decrease the bending moment acting in a direction so as to spread the supporting leg portions.

Further, in general, due to the moment acting in a direction so as to spread the supporting leg portions, a center portion of the horizontal portion is bent so as to close to the upper surface of the track rail. However, in the present invention, a bending deformation of the horizontal portion is suppressed by the action of the upper two rows of rollers disposed between the horizontal portion and the upper surface of the track rail, whereby the spreading of the supporting leg portions can be sufficiently decreased in co-operation with the reduction of the bending moment.

As described above, even if the preload is applied to the roller or a lateral load in a horizontal direction is applied, the deformation in a direction so as to spread the supporting leg portions of the movable block can be prevented and a degree of parallelization between the opposing roller rolling surfaces can be maintained to a constant level, whereby non-uniform contact of the rollers can be prevented.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view showing one embodiment of a linear roller guide device according to the present invention.

FIG. **2** is a perspective view partially in section of the linear roller guide device shown in FIG. **1**.

FIG. **3** is a view showing a modification of a roller contact structure for the upper two rows of the rollers used in the linear roller guide device shown in FIG. **1**.

FIG. **4** is a view showing a modification of a roller returning passage for the lower two rows of the rollers used in the linear roller guide device shown in FIG. **1**.

FIG. **5** is a view showing another embodiment of a linear roller guide device according to the present invention in which FIG. **5**(*a*) is a longitudinal sectional view and FIG. **5**(*b*) is an enlarged view of a portion close to the rollers disposed at an upper surface and a side surface.

FIG. **6** is a perspective view partially in section of the linear roller guide device shown in FIG. **5**.

FIG. **7**(*a*) is a view showing a structure of an end portion of the movable block used in the linear roller guide device shown in FIG. **1**,

FIG. **7**(*b*) is a view partially in section showing a structure of a roller circulating passage for upper surface side roller.

FIG. **7**(*c*) is a cross sectional view taken along the line c—c of FIG. **7**(*b*).

FIG. **7**(*d*) is a view partially in section showing a structure of a roller circulating passage for side surface side roller, and

FIG. **7**(*e*) is a cross sectional view taken along the line e—e of FIG. **7**(*d*).

FIGS. **8**(*a*)–(*c*) are views each showing a molding state of the linear roller guide device shown in FIG. **1**.

FIGS. **9**(*a*)–(*c*) are views showing modifications of radial and axial direction retaining portions for the upper surface side rollers.

FIGS. **10**(*a*)–(*c*) are views showing modifications of radial and axial direction retaining portions for the side surface side rollers.

FIGS. **11**(*a*), (*b*) are views showing another embodiments of a first end surface guide portion.

FIG. **12** is a view showing another embodiment of a linear roller guide device.

FIGS. **13**(*a*), (*b*) are views showing still another embodiments of a linear roller guide device.

FIG. **14**(*a*) is a view showing still another embodiment of a linear roller guide device, and

FIG. **14**(*b*) is a view partially in section of a direction changing passage shown in FIG. **14**(*a*).

FIG. **15** is a view showing a conventional linear roller guide device.

BEST MODE FOR EMBODYING THE INVENTION

Hereunder, the present invention will be explained with reference to the accompanying drawings.

FIGS. **1** and **2** are views showing an embodiment of a linear roller guide device according to the present invention. The linear roller guide device has a structure in which a number of rollers **21–24** are arranged in a form of four rows of rollers in total of which two rows of rollers are vertically disposed to right and left portions of a track rail **1** respectively, and a movable block **3** is guided along a track rail **1** through a number of rollers **21–24**.

The movable block **3** comprises a horizontal portion **4** opposing to an upper surface of the track rail **1**, and supporting leg portions **5**, **5** extending downwardly from both end portions of the horizontal portion **4** so as to oppose to right and left side surfaces of the track rail **1**.

The track rail **1** has a rectangular shape in section, an upper surface of the track rail is formed with two rows of roller rolling surfaces while each of right and left side surfaces of the track rail is formed with one row of roller rolling surface, respectively, i.e., totally four rows of the roller rolling surfaces **61–64** are formed to the track rail **1** over entire length of a range in which the movable block **3** is moved. Further, the track rail **1** is forced with a plurality of bolt insertion holes **11** for fixing the track rail in a longitudinal direction, and an upper opening portion of each bolt insertion holes **11** is formed at a center of the upper surface of the track rail **1**.

On the other hand the movable block **3** is provided with four rows of roller rolling surfaces **71–74** for rollingly clamping the four rows of rollers **21–24** so as to oppose to the roller rolling surfaces **61–64** of the track rail **1**. The movable block **3** is also provided with four rows of roller circulating passages **81–84** at unloaded region for circulating the rollers **21–24** clamped between the roller rolling surfaces **61, 71**; **62, 72**; **63, 73**; **64, 74** formed to the track rail **1** and the movable block **3** from one end to the other end of the roller rolling surfaces **71–74** of the movable block **3**.

The movable block **3** comprises a block body **31** and side covers **32, 32** to be attached to both end surfaces in an axial direction of the block body **31**. The roller rolling surfaces **61–64** are formed to the block body **31**. The roller circulating passages **81–84** comprises roller returning passages **81***a*–**84***a* formed to the block body **31** so as to be in parallel to each of the roller rolling surfaces **61–64** and direction changing passages **81***b*–**84***b* having a U-shape to be formed to the side covers **32, 32**.

The roller returning passages **81***a*, **82***a* for the upper two rows of rollers **21, 22** are constituted by penetration bores penetratingly formed to the block body **31**. Each of the roller returning passages **83***a*, **84***a* for the lower two rows of rollers **23, 24** has a rectangular shape in cross section and comprises an inverse V-shaped groove **85** formed to lower end surface of the supporting leg portion **5**, and a retainer **86** having a V-shape in cross section for covering the groove **85**.

The upper two rows of rollers **21, 22** are arranged to portions close to a center side from side ends of the upper surface of the track rail with a predetermined distance C, while roller rolling surfaces **61, 71**; **62, 72** corresponding to the upper two rows of rollers **21, 22** are formed to the upper surface of the track rail **1** and the lower surface of the horizontal portion **4** of the movable block **3**.

Further, the roller returning passages **81***a*, **82***a* constituting the upper two rows of the roller circulating passages together with the roller returning passages **81***a* in unloaded region are arranged to portions close to center side portion with respect to the roller circulating passages **83***a*, **84***a* in unloaded region corresponding to the lower two rows of the rollers **23, 24**.

In addition, a screw hole **33** for fixing the movable block is provided at portions on the upper surface of both right and left end portions of the horizontal portion **31** of the movable block, and the portions are set to upper positions of the roller returning passages **83***a*, **84***a* for the lower two rows of rollers **23, 24** or set to positions close to the center side. Owing to this structure, a pitch P between the right and left screw holes **33, 33** is narrowed whereby the screw holes can be formed to the position close to the lower side rollers **23, 24**.

When a lifting load in a direction so as to lift the movable block **3** from the track rail **1** is applied. a force in a direction so as to detach the movable block **3** from the track rail **1** is applied while the above described screw holes **33, 33** are acting as points of application, in contrast, a reaction force against the force is applied to the roller rolling surfaces **73, 74** for the lower two rows of rollers **23, 24**. The force applied to the screw hole **33** and the reaction force constitute a relation of a couple of forces, whereby a bending moment in a direction for spreading the supporting leg portions **5, 5** will occur.

In the case of this embodiment, the upper two rows of rollers **21, 22** are arranged to portions close to a center side portion, so that an interference of the upper two rows of the rollers **21, 22** with the screw hole **33** can be avoided. Simultaneously, the screw hole **33** is provided at a portion close to the lower side rollers **23, 24**, so that a distance M in the horizontal direction between the screw hole **33** and the lower side rollers **23, 24** can be sufficiently shortened, whereby the bending moment in a direction for spreading the supporting leg portions **5, 5** can be reduced.

In addition, a relation between a lateral width W and a height A of the track rail **1** is set so as to satisfy $A/W<1$, so that stability of the track rail **1** can be enhanced, and simultaneously, an interference with an upper end opening portion **11**a of a bolt inserting hole to be opened at a center of the upper surface of the track rail **1** can be avoided.

Furthermore, the lower two rows of rollers **23, 24** among the four rows of rollers **21–24** are arranged such that one row of rollers is disposed to right and left side surfaces of the track rail **1** respectively, while the roller rolling surfaces **63, 73**; **64, 74** corresponding to the lower two rows of rollers **23, 24** are formed to the right and left side surfaces of the track rail **1** and inner side surfaces of the supporting leg portions **5, 5** of the movable block **3**.

The upper two rows of rollers **21, 22** have a structure in which contact angle lines **S1, S2** each constituted by a line orthogonal to a center axis of the upper two rows of rollers **21, 22** are inclined with respect to a vertical line V passing through a center between the rollers **21, 22** with predetermined inclination angles of α **1**, α **2** so as to open in a direction towards an opposite side of the track rail **1**. These contact angle lines **S1, S2** are indicated as lines connecting centers in a width direction of the respective roller rolling surfaces **61, 71**; **62, 72**.

In this case, the positions of the roller returning passages **81***a*, **82***a* are located at outside the rollers **21, 22** in right and left directions, respectively. Therefore, at a time of formation of the screw holes **33, 33**, it is required to take the interference with the roller returning passages **81***a*, **82***a* into consideration.

In a case shown in Figure, the positions of the roller returning passages **81***a*, **82***a* are located at almost upper portions of the rollers **23**, **24**, while the positions of the screw holes **33**, **33** are located at almost upper portions of the roller returning passages **83***a*, **84***a*. When the positions of the upper side rollers **21**, **22** and the roller returning passages **81***a*, **82***a* are shifted to portions further close to the center side, the positions of the screw holes **33**, **33** can be shifted from the upper positions of the roller returning passages **83***a*, **84***a* to the center side, close to the upper positions of the lower side rollers **23**, **24**.

As to this contact structure, as shown in FIG. **3**, there can be also proposed another structure in which the contact angle lines S1, S2 constituted by lines orthogonal to center axes of the upper two rows of rollers **21**, **22** are inclined with respect to a vertical line V passing through a center of between the rollers **21**, **22** with predetermined inclination angles of $\alpha1'$, $\alpha2'$ so as to close in a direction towards an opposite side of the track rail **1**.

According to this structure, the positions of the roller returning passages **81***a*, **82***a* are shifted to the center side with respect to positions of the rollers **21**, **22**, so that it becomes unnecessary to take an interference of the screw holes **33**, **33** with the roller returning passages **81***a*, **82***a* into consideration. Therefore, the positions of the screw holes **33**, **33** can be set to portions close to the center side from the upper position of the roller returning passages **83***a*, **84***a* for the lower two rows of the rollers **23**, **24** i.e., the screw holes **33**, **33** can be set to almost the upper portions of the lower two rows of the rollers **23**, **24**.

On the other hand, the linear motion guide device has a structure in which the contact angle lines S3, S4 constituted by lines orthogonal to center axes of the lower two rows of rollers **23**, **24** are inclined with respect to a horizontal line H passing through a center of between the rollers **21**, **22** with predetermined inclination angles of $\alpha3$, $\alpha4$ so as to upwardly direct to the track rail **1** side. These contact angle lines S3, S4 are also indicated as lines connecting the centers in a width direction of the respective roller rolling surfaces **63**, **73**; **64**, **74**.

In particular, in this embodiment, the contact angles $\alpha1$–$\alpha4$ are set to almost 45°.

Further, in a case of the device shown in Figure, the roller returning passages **81***a*–**84***a* are formed to be positioned on extended lines of the contact angle lines for respective rollers **21**–**24**. According to this structure, the rolling directions of the rollers **21**–**24** coincide with the directions of the direction changing passages **81***b*–**84***b*, so that the rollers **21**–**24** can be smoothly rolled and moved.

With respect to the roller returning passages **83***a* and **84***a* for the lower two rows of the rollers **23** and **24**, as shown in FIG. **4**, height positions of the passages **83***a* and **84***a* are set to almost the same as that of the roller rolling surface **73** in loaded region, so that a projecting length of each supporting leg portions **5**, **5** can be shortened, whereby the height of the track rail **1** can be reduced. As a result, an entire height B of the device can be lowered, and thus realizing the stabilized state of the linear motion guide device.

Further, in the present invention, the track rail **1** having track grooves **6**, **7** each having a V-shape in cross section comprising two inclined surfaces is used, and the roller rolling surfaces **61**, **71**; **62**, **72**; **63**, **73**; **64**, **74** to be formed to the track rail **1** and the movable block **3** are formed to one of the inclined surfaces, while the other inclined surface is used as guide surfaces **6***a*, **7***a* for guiding the roller end surfaces.

According to the present invention, since the upper two rows of rollers **21**, **22** are arranged so as to be shifted to a portion close to center side from the end portions of the upper surface of the track rail **1**, it is sufficient to form one row of roller rolling surface **73** or **74** to each of the inner side surfaces of the supporting leg portions **5**, **5** of the movable block **3**. As a result, the lengths L from the base portion of the supporting leg portions **5**, **5** to the lower side two rows of rollers **23**, **24** can be shortened, so that even if a reaction force of the preload applied to the rollers **21**–**24** or an external load is applied, it becomes possible to decrease the bending moment to be applied to the supporting leg portions **5**, **5**.

Further, in general, due to the moment acting in a direction spreading the supporting leg portions **5** and **5**, a center portion of the horizontal portion **4** will be bent so as to close to the upper surface of the track rail **1** However, in the present invention, a bending deformation of the horizontal portion **4** is suppressed by the action of the upper two rows of rollers **2** disposed between the horizontal portion **4** and the upper surface of the track rail **1**, whereby the spreading of the supporting leg portions **5** and **5** can be sufficiently decreased synergistically in co-operation with the reduction of the bending moment.

As described above, even if the preload is applied by the two rows of the rollers **21**, **22** disposed to the upper surface side of the track rail **1** or a lifting load is applied, the deformation in a direction so as to spread the supporting leg portions **5**, **5** of the movable block **3** can be prevented and a degree of parallelization between the opposing roller rolling surfaces **61**, **71**; **62**, **72**; **63**, **73**; **64**, **74** can be maintained to a constant level, whereby non-uniform contact of the rollers **21**–**24** can be prevented.

Further, when the angles between the contact angle lines S1, S2 of the upper two rows of rollers **21**, **22** disposed on the upper surface of the track rail **1** and a vertical line V is set at almost 45°, or a state shown in FIG. **3**, when the contact angle lines S1', S2' are set to be inclined with respect to the vertical line V with an inclination angle of almost 45 ° so as to open in a direction towards the track rail **1**, and when the angles between the contact angle lines S3, S4 of the lower two rows of rollers **23**, **24** disposed on the side surfaces of the track rail **1** with respect to a horizontal line H are set at almost 45°, the same rated loads can be obtained with respect to a radial load being applied from upper direction (i.e., a load in a direction so as to press the movable block **3** onto the track rail **1**), lifting load and the lateral loads applied from right and left directions, whereby any of the load applied from every direction can be supported. In other words, the device can be used in any attitudes or positions, and available to wide applications.

Further, the roller rolling surfaces **61**, **71**; **62**, **72**; **63**, **73**; **64**, **74** to be formed to the track rail **1** and the movable block **3** so as to correspond to the four rows of rollers **21**–**24** are formed to one of the inclined surfaces of the track grooves **6**. **7** each having a V-shape in cross section while the other inclined surface is used as guide surfaces **6***a*, **7***a* for guiding the roller end surfaces. whereby the end surfaces of the rollers are guided while a pitch of the rollers is maintained to a predetermined value in a portion between the guide surfaces **6***a*, **7***a* of the track grooves **6**, **7** formed to the track rail **1** side and the movable block **3** side which are opposed to each other.

As a result, a locating relation between the respective track grooves **6**, **7** can be accurately measured by using a roller pin or the like, whereby the above locating relation between the respective track grooves **6**, **7** can be formed or molded with high accuracy. Accordingly, the four rows of rollers **21–24** disposed between the track rail **1** and the movable block **3** can accurately contact to the roller rolling surfaces **61**, **71**; **62**, **72**; **63**, **73**; **64**, **74** formed to a pair of track grooves **6**, **7** corresponding to the four rows of rollers **21–24** disposed between the track rail **1** and the movable block **3**, and the end surfaces of the roller are accurately guided by the action of the guide surfaces **6***a*, **7***a* of the paired track grooves **6**, **7**.

As described above, the movable block **3** has a rigidity regardless of the direction of the loads, so that the locating relation between the track rail **1** and the movable block **3** is normally maintained to a constant value. Further, the movable block **3** is supported by the track rail **1** at a position where the preload applied to the respective four rows of rollers **21–24** and the reaction force of the preload are balanced, so that a gap between the end surfaces of the rollers and the guide surfaces **6***a*, **7***a* can be normally maintained to a constant level in co-operation with the effect of accurately forming the locating relation between the respective track grooves **6**, **7** as described above.

In particular, the movable block **3** is formed in a shape having a high rigidity, so that a high preload can be applied. Therefore, the high rigidity of the movable block **3** and the high preload are synergistically effected to realize an effect such that the gap between the end surfaces of the rollers **21–24** and the guide surfaces **6***a*, **7***a* can be maintained to a constant level. As a result, the skew preventing effect for the rollers **21–24** can be enhanced and a smooth circulation and a rolling accuracy of the rollers **21–24** can be secured.

Further, since the roller end surface guide member to be separately formed from the movable block **3** is not necessary in this invention, the thickness of the horizontal portion **31** of the movable block **3** can be increased with an amount equivalent to a space required for the roller end surface guide member, whereby the flexural rigidity of the horizontal portion **31** can be increased. In addition, by enhancing the rigidity of the movable block **3**, the effect of preventing the skew generation can be further synergistically improved.

Since the roller rolling surfaces **61**, **71**; **62**, **72** **63**, **73**; **64**, **74** and the guide surfaces **6***a*, **7***a* for guiding the end surfaces of the rollers are constituted by the track grooves **6**, **7** having a V-shape in cross section, the roller rolling surfaces **61**, **71**; **62**, **72**; **63**, **73**; **64**, **74** and the end surface guide surfaces **6***a*, **7***a* can be simultaneously finished by a grinding work, whereby a guiding accuracy and surface roughness of the roller rolling surfaces **61**, **71**; **62**, **72**; **63**, **73**; **64**, **74** and the guide surfaces **6***a*, **7***a* for guiding the end surfaces of the rollers are improved and a remarkable effect in skew prevention can be obtained. In addition, the working amount for the track grooves can be minimized.

As described above, according to the present invention, since the upper two rows of rollers are arranged to be shifted to portions close to center side apart from the end portions of the upper surface of the track rail and the lower two rows of the rollers are arranged to be shifted to upper portions of the right and left side surfaces of the track rail, the lengths from the base portions of the right and left supporting leg portions of the movable block to the lower side rollers can be shortened in comparison with a conventional case where the two rows of rollers are arranged to the right and left sides surfaces of the track rail, respectively.

Accordingly, even if a reaction force of the preload applied to the roller or a lateral load acting in a direction so as to displace the movable block in a horizontal direction with respect to the track rail is applied, it becomes possible to decrease the bending moment acting in a direction spreading the supporting leg portions.

Further, in general, due to the moment acting in a direction spreading the supporting leg portions, a center portion of the horizontal portion is bent so as to close to the upper surface of the track rail. However, in the present invention, such bending deformation of the horizontal portion is suppressed by the action of the upper two rows of rollers disposed between the horizontal portion and the upper surface of the track rail, whereby the spreading of the supporting leg portions can be sufficiently decreased in co-operation with the reduction of the bending moment.

As described above, even if the preload is applied to the roller or a lateral load in a horizontal direction is applied, the deformation in a direction spreading the supporting leg portions of the movable block can be prevented and a degree of parallelization between the opposing roller rolling surfaces can be maintained to a constant level, whereby non-uniform contact of the rollers can be prevented.

When a screw hole for fixing the movable block is provided at portions on the upper surface of right and left end portions of the horizontal portion of the movable block, and the portions are set to upper positions of the roller circulating passages in unloaded region for the lower two rows of rollers or set to portions close to the center side, whereby an interference of the upper two rows of the rollers with the roller circulating passages can be avoided and the length in the horizontal direction between the screw hole and the lower side rollers is sufficiently shortened, so that it becomes possible to decrease the bending moment acting in a direction so as to spread the supporting leg portions due to the lifting load.

According to the structure described above, not only in a case when the preload is applied to the roller or the lateral load is applied but also in a case when the lifting load is applied, the moment can be also decreased, the deformation in a direction spreading the supporting leg portions of the movable block can be prevented, and the degree of parallelization between the roller rolling surfaces is maintained to a constant level whereby the non-uniformity in contacting of the rollers can be prevented.

Further, when an angle between a line orthogonal to the rotation axis of the upper two rows of rollers disposed on the upper surface of the track rail and a vertical line is set at almost 45° and an angle between a line orthogonal to the rotation axis of the lower two rows of rollers disposed on the side surfaces of the track rail and a horizontal line is set at almost 45° the same rated load can be obtained with respect to a radial load being applied from the upper direction (i.e., a load in a direction so as to press the movable block onto the track rail), the lifting load and the lateral loads applied from right and left directions, whereby any of the load applied from every direction can be supported. In other words, the device can be used in any attitudes or positions, and available to wide applications.

Further, when a structure in which a track rail having a track groove having a V-shaped in cross section comprising two inclined surfaces is used and the roller rolling surfaces to be formed to the track rail and the movable block so as to correspond to the four rows of rollers are formed to one of the inclined surfaces while the other inclined surface is used as a guide surface for guiding the roller end surface whereby the end surfaces of the rollers are guided while a pitch of the rollers is maintained to a predetermined value in a portion between the guide surface of the track groove of the track rail side and the guide surface of the movable block side which are opposed to each other, a locating relation between the respective track grooves can be accurately measured by using a roller pin or the like. On this premise, the locating relation between the respective track grooves can be molded or formed with high accuracy. Accordingly, the contacting state between the rollers and the roller rolling surfaces as well as the gap between the roller end surface and the guide surface can be maintained with a higher accuracy.

As described above, the movable block has a rigidity regardless of the direction of the loads, so that the locating relation between the track rail and the movable block is normally maintained to a constant value. Further, the movable block is supported by the track rail at a position where the preload applied to the respective four rows of rollers and the reaction force of the preload are balanced, so that a gap between the end surface of the roller and the guide surface can be normally maintained to a constant level in co-operation with the effect of accurately working the locating relation of the respective track grooves as described above.

Accordingly, the four rows of rollers disposed between the track rail and the movable block accurately contact to the roller rolling surfaces formed to a pair of track grooves corresponding to the four rows of rollers. and the end surfaces of the roller are accurately guided by the action of the guide surfaces formed to the paired track grooves.

In particular, the movable block is formed in a shape having a high rigidity, so that a high preload can be applied. Therefore, the high rigidity of the movable block and the high preload are synergistically effected to realize an effect such that the gap between the end surface of the roller and the guide surface can be maintained to a constant level. As a result, the skew preventing effect for the rollers can be enhanced and a smooth circulation and a rolling accuracy of the rollers can be secured.

Further, the space for installing the roller end surface guide member, which is conventionally required to be provided to the lower surface of the movable block, becomes unnecessary in this invention, so that the thickness of the horizontal portion of the movable block can be increased with an amount equivalent to the space, whereby the flexural rigidity of the horizontal portion can be increased and also the rigidity of the movable block can be enhanced. In addition, by enhancing the rigidity of the movable block, the effect of preventing the skew generation can be further synergistically improved.

Further, since the roller rolling surfaces and the guide surfaces for guiding the roller end surfaces are constituted by the track groove having a V-shape in cross section, the roller rolling surfaces and the guide surfaces for guiding roller end surface can be simultaneously finished by a grinding work, so that the roller rolling surfaces and the guide surfaces for guiding roller end surfaces can be easily worked. In addition, a guiding accuracy of the rollers and surface roughness are also improved and a high effect in skew prevention can be obtained. In addition, the working amount for the track groove can be minimized.

Further, since a retainer for the roller is eliminated and the roller contacts to the roller rolling surface at an entire length of the roller, the rigidity of the roller per se can be effectively utilized. [Another Embodiment]

FIGS. **5** to **7** are views showing another embodiment of a linear roller guide device according to the present invention. Namely, the linear roller guide device of this embodiment has also a structure in which a number of rollers **21–24** are arranged in a form of four rows of rollers in total of which two rows of rollers are disposed on an upper surface of a track rail **1** and one row of rollers are disposed to right and left side surfaces of the track rail **1**, respectively, and a movable block **3** is guided along a track rail **1** through the upper surface side rollers **21**, **22** and the side surface side rollers **23**, **24**.

The movable block **3** comprises a horizontal portion **4** opposing to an upper surface of the track rail **1**, and supporting leg portions **5**, **5** extending downwardly from both end portions of the horizontal portion **4** so as to oppose to right and left side surfaces of the track rail **1**.

The track rail **1** has a rectangular shape in section, an upper surface of the track rail is formed with two rows of roller rolling surfaces while each of right and left side surfaces of the track rail is formed with one row of roller rolling surface, respectively, i.e., totally four rows of the roller rolling surfaces **61–64** are formed to the track rail **1** over entire length of the track rail **1**. Further, the track rail **1** is formed with a plurality of bolt insertion holes **11** for fixing the track rail in a longitudinal direction, and an upper opening portion of each bolt insertion holes **11** is formed at a center of the upper surface of the track rail **1**.

On the other hand, the movable block **3** is provided with four rows of roller rolling surfaces **71–74** for rollingly clamping the four rows of rollers **21–24** so as to oppose to the roller rolling surfaces **61–64** of the track rail **1**. The movable block **3** is also provided with four rows of roller circulating passages **81–84** at unloaded region for circulating both the upper surface side and side surface side rollers **21–24** clamped between the roller rolling surfaces **61**, **71**; **62**, **72**; **63**, **73**; **64**, **74** of the track rail **1** and the movable block **3** from one end to the other end of the roller rolling surfaces **71–74** of the movable block **3**.

As shown in FIGS. **6** and **7**, the movable block **3** comprises a block body **31** and side covers **32**, **32** to be attached to both end surfaces in an axial direction of the block body **31**. The roller rolling surfaces **71–74** are formed to the block body **31**. The roller circulating passages **81–84** comprises roller returning passages **81**a–**84***a* formed to the block body **31** so as to be in parallel to each of the roller rolling surfaces **71–74** and direction changing passages **81***b*–**84***b* having an U-shape a part of which is constituted by the side covers **32**, **32**.

As shown in FIG. **5**, the two rows of the upper surface side rollers **21**, **22** disposed to the upper surface of the track rail **1** has a contact structure in which contact angle lines **S1** and **S2** constituted by lines orthogonal to the rolling axes of the rollers **21**, **22** are inclined with respect to a center longitudinal axial line (vertical line) V, which equally divides the track rail **1** into right and left portions, with a predetermined inclination angle of α 1 so as to open upwardly. These contact angle lines **S1**, **S2** are indicated as lines connecting centers in a width direction of the respective roller rolling surfaces **61**, **71**; **62**, **72**.

In addition, the surface side rollers **23**, **24** disposed to the right and left side surfaces of the track rail **1** has a contact structure in which contact angle lines **S3** and **S4** constituted by lines orthogonal to the rolling axes of the rollers **23**, **24** are inclined with respect to the above vertical line m with a predetermined inclination angle of $\alpha 2$ so as to open downwardly. These contact angle lines **S3**, **S4** are also indicated as lines connecting centers in a width direction of the respective roller rolling surfaces **63**, **73**; **64**, **74**.

In particular, in this embodiment, each of the contact angles α 1–$\alpha°4$ is set to almost 45°. Further, in case of the device shown in Figure, the roller returning passages **81**a–**84**a are formed to be positioned on extended lines of the contact angle lines for respective upper surface side and side surface side rollers **21**–**24**. According to this structure, the rolling directions of the upper surface side and side surface side rollers **21**–**24** coincide with the directions of the direction changing passages **81**b–**84**b, so that the upper surface side and side surface side rollers **21**–**24** can be smoothly rolled and moved.

The two rows of the roller rolling surfaces **71, 72** to be formed to the lower surface of the horizontal portion **4** opposing to the roller rolling surfaces **61, 62** formed to the upper surface of the track rail **1** and the roller rolling surfaces **73, 74** to be formed to the inner side surfaces of the right and left supporting leg portions **5, 5** opposing to the roller rolling surfaces **63, 64** formed to the right and left side surfaces of the track rail **1** are formed so as to be laterally symmetric with respect to the center longitudinal axial line (vertical line) V passing through the center of the track rail **1**.

As shown in FIG. **5**(b) in detail, upper surface side roller first end surface guide portions **211, 221** for guiding one end surface at a side (inner side) of the center longitudinal axial line (vertical line) V of the upper surface side rollers **21, 22** are provided to one side periphery at a side the center longitudinal line (vertical line) V of the roller rolling surfaces **71, 72** to be formed to the lower surface of the horizontal portion **4** of the movable block **3** so as to rise up at an almost right angle with respect to the roller rolling surfaces **71** and **72**, while upper surface side second end surface guide portions **212, 222** for guiding the other end surface of the upper surface side rollers **21, 22** are provided to the other side (outer side) periphery at an opposing side with respect to the center longitudinal line (vertical line) V of the roller rolling surfaces **61, 62** formed to the track rail **1** so as to rise up at an almost right angle with respect to the roller rolling surfaces **61, 62**.

The upper surface side roller first end surface guide portions **211, 221** are constituted by a member per se constituting the block body **31**, while the upper surface side second end surface guide portions **212, 222** are constituted by the block body **31** per se.

In this embodiment, the roller rolling surfaces **61, 71; 62, 72** to be formed to the upper surface of the track rail **1** and the lower surface of the horizontal portion **4** of the movable block **3** are constituted by one inclined surface of the grooves each having a V-shape in cross section comprising two inclined surfaces, while the other inclined surface is used as both the upper and side surface sides first and second end surface guide portions **211, 221;231, 241** for guiding both end surfaces of the upper surface side rollers **21, 22**.

Each of the upper and side surface side first end surface guide portions **211, 221;231, 241** almost has a width equivalent to a diameter of each upper and side surface sides rollers **21** and **22**, while each of the upper surface side second end surface guide portions **212, 222** almost has a width equivalent to a radius of each upper surface side rollers **21** and **22**.

Further, radial direction retaining portions **21**a, **22**a each having a projection for preventing the upper surface side rollers **21, 22** from falling out in a radial direction by being engaged with peripheral corner portions of the upper surface side rollers **21, 22** when the movable block **3** is detached from the track rail **1**, are provided to one side periphery of the roller rolling surfaces **71, 72** formed to the lower surface of the horizontal portion **4**, the periphery being a position of a track rail **1** side which is shifted from the upper surface side roller first end surface guide portions **211, 221** with respect to the roller rolling surfaces **71** and **72**.

The radial direction retaining portions **21**a, **22**a are composed of resin moldings, and fixed through adhesion to the lower surface of the horizontal portion **4** so as to have a predetermined thickness. The projections **13, 13** are projected from a lower end portion of the roller end surface almost with a right angle so as to cover the peripheral corner portions **21**c, **22**c of the upper surface side rollers **21** and **22**. A projecting width is suppressed to a minimum degree to prevent the upper surface side rollers **21** and **22** from falling out.

In this embodiment, a length of each of the upper surface side rollers **21, 22** is slightly longer than a width of the roller rolling surfaces **61** and **62** formed to the track rail **1**. The end portions of the upper surface side rollers **21, 22** are slightly projected from upper side periphery of the roller rolling surfaces **61** and **62**. The projections **13, 13** of the radial direction retaining portions **21**a, **22**a are engaged with the projected periphery portions of the roller end surfaces.

The upper surface side rollers **21, 22** contact to the roller rolling surfaces **61, 62** at an almost entire length thereof except an engaging width (which is equivalent to a width projecting from the side periphery of the roller rolling surfaces **61** and **62**) which engages with the projections **13, 13** formed to the radial direction retaining portions **21**a and **22**a, whereby an effective contact length **1**w is secured to have a sufficiently long length.

On the other hand, axial direction retaining portions **21**b, **22**b for preventing the roller from falling out in an axial direction by opposing to the other end surface of the upper surface side rollers **21, 22** are provided to a side periphery of the roller rolling surfaces **71, 72** formed to the movable block **3**, the side periphery being opposite to the side periphery to which the first end surface guide portions **211** and **212** are provided.

The axial direction retaining portions **21**b, **22**b are provided to the other side peripheries of the roller rolling surfaces **71, 72** formed to the block body **31** and are opposing to the end surface portion of the upper surface side rollers **21, 22** which are not guided by the upper surface side roller second end surface guide portions **212, 222** formed to the side periphery of the roller rolling surfaces **61, 62** formed to the track rail **1**, so as to have a small gap therebetween.

The axial direction retaining portions **21**b, **22**b are also composed of resin moldings and fixed through adhesion to both right and left end portions of the lower surface of th e horizontal portion **4** so as to have a predetermined thickness.

The roller rolling surfaces **73, 74** to be formed to the inner side surfaces of the supporting leg portions **5, 5** so as to oppose to the roller rolling surfaces **63, 64** formed to right and left side surfaces of the track rail **1** are also formed so as to be laterally symmetric with respect to the center longitudinal axial line (vertical line) V.

Side surface side roller first end surface guide portions **231, 241** for guiding upper end surface of the upper surface side rollers **23, 24** are provided to an upper periphery of the roller rolling surfaces **73, 74** so as to rise up at an almost right angle with respect to the roller rolling surfaces **73** and **74**, while side surface side second end surface guide portions **232, 242** for guiding the lower end surface of the side surface side rollers **23, 24** are provided to an lower side periphery of the roller rolling surfaces **63, 64** formed to the track rail **1** so as to rise up at an almost right angle with respect to the roller rolling surfaces **63** and **64**.

The side surface side roller first end surface guide portions **231, 241** are constituted by a member per se constituting the block body **31**, while the side surface side second end surface guide portions **232**, **242** are constituted by the block body **31** per se.

The roller rolling surfaces **63**, **73**; **64**, **74** to be formed to the right and left side surfaces of the track rail **1** and the inner side surfaces of the right and left supporting leg portions **5**, **5** of the movable block **3** are constituted by one inclined surface of the grooves each having a V-shape in cross section comprising two inclined surfaces which open in a side direction, while the other inclined surface is used as both the side surface side first and second end surface guide portions **231**, **241**; **232**, **242** for guiding both end surfaces of the side surface side rollers **23**, **24**.

Each of the side surface side roller first end surface guide portions **231**, **241** almost has a width equivalent to a diameter of each side surface side rollers **23** and **24**, while each of the side surface side second end surface guide portions **232**, **242** almost has a width equivalent to a radius of each side surface side rollers **23** and **24**.

Further, radial direction retaining portions **23***a*, **24***a*, each having projections **13**, **13** for preventing the side surface side rollers **23**, **24** from falling out in a radial direction by being engaged with peripheral corner portions of the end surfaces of the side surface side rollers **23**, **24** when the movable block **3** is detached from the track rail **1**, are provided to upper slide periphery of the roller rolling surfaces **73** and **74**, the periphery being a position of a track rail **1** side which is shifted from the side surface side roller first end surface guide portions **232**, **242** with respect to the roller rolling surfaces **73** and **74**.

The radial direction retaining portions **23***a*, **24***a* are also composed of resin moldings and integrally bonded to the inner side surfaces of the supporting leg portions **5**, **5** of the movable block **3** so as to have a predetermined thickness. Upper end portions of the radial direction retaining portions **23***a*, **24***a* are formed to be continuous to the axial direction retaining portions **21***b*, **22***b* of the upper surface side rollers **21** and **22**.

In this embodiment, a length of each of the upper surface side rollers **21**, **22** is slightly longer than a width of the roller rolling surfaces **63** and **64** formed to the track rail **1**. The end portions of the side surface side rollers **23**, **24** are slightly projected from upper side periphery of the roller rolling surfaces **63** and **64**. The projections **13**, **13** of the radial direction retaining portions **23***a*, **24***a* are engaged with the projected periphery portions of the end surfaces of the side surface side rollers **23** and **24**.

The side surface side rollers **23**, **24** contact to the roller rolling surfaces **63**, **64** at an almost entire length thereof except an engaging width (which is equivalent to a width projecting from the side periphery of the roller rolling surfaces **63** and **64**) which engages with the projections **13**, **13** formed to the radial direction retaining portions **23***a* and **24***a*.

On the other hand, axial direction retaining portions **23***b*, **24***b* for preventing the roller from falling out in an axial direction by opposing to the other end surface of the side surface side rollers **23**, **24** are provided to a lower side periphery of the roller rolling surfaces **73**, **74** formed to the movable block **3**, the side periphery being opposite to the side periphery to which the first end surface guide portions **231** and **242** are provided.

The axial direction retaining portions **23***b*, **24***b* are also composed of resin moldings and fixed through adhesion to a portion lower than the roller rolling surface **74** formed to the inner side surfaces of the supporting leg portions **5** and **5**.

The upper surface side roller returning passages **81***a*, **82***a* for the upper surface side two rows of rollers **21**, **22** are constituted by upper surface side roller returning passage resin portions **81***a***2** and **82***a***2** as the roller returning passage forming material which fills large-sized penetration bores **81***a***1** and **82***a***1** penetratingly formed to the block body **31**. Each of the upper surface side roller returning passage resin portions **81***a***2** and **82***a***2** are formed to have a rectangular shape in cross section which correspond to a cross-sectional shape of the upper surface side rollers **21** and **22**.

The side surface side roller returning passages **83***a*, **84***a* for the side surface side rollers **23**, **24** are constituted by a V-shaped groove **83***a***1** provided to the supporting leg portions **5**, **5** of the block body **31** so as to open downwardly and by a side surface side roller returning passage resin portion **14** to be adhesively and integrally fixed to the lower end surface of the supporting leg portions **5** and **5**, the side surface side roller returning passage resin portion **14** having a V-shaped groove **83***a***2** which is provided so as to correspond to the V-shaped groove **83***a***1** and to open upwardly.

The side surface side roller returning passage resin portion **14** covers an entire lower surface of the supporting leg portions, and is integrally formed to be continuous to the axial direction retaining portions **23***b*, **24***b* of the side surface side rollers **23** and **24**, inner side end portions of the axial direction retaining portions **23***b*, **24***b* being adhesively fixed to the inner side surfaces of the supporting leg portions **5** and **5**. Further, an outer end of the side surface side roller returning passage resin portion **14** is integrally formed so as to be continuous to an outer resin portion **15** for covering lower portions of outer side surfaces of the lovable block **3**.

Further, at the end surface of the movable block **31** is provided with end surface resin portions **16** and **17** to which the direction changing passage inner periphery portions **81***b***1** –**84***b***1** of the direction changing passages **81***b*–**84***b* for the upper surface side rollers **21**, **22** and the side surface side rollers **23**, **24** are formed so that the end surface resin portions **16** and **17** are independently provided at right and left sides with respect to the center longitudinal axial line, respectively.

In addition, these end surface resin portions **16** and **17**, the upper surface side roller returning passage resin portions **81***a***2** and **82***a***2**, the radial direction retaining portions **21***a*, **22***a* and the axial direction retaining portions **21***b*, **22***b* for the upper surface side rollers **21** and **22**, the radial direction retaining portions **23***a*, **24***a* and the axial direction retaining portions **23***b*, **24***b* for the side surface side rollers **23** and **24**, the side surface side roller returning passage resin portion **14** and the supporting leg portion outer side surface resin portion **15** are integrally formed with the block body **31** by inserting the block body **31** into a molding die.

These end surface resin portions **16**. **17** are provided with a boss portion **34** corresponding to a tapped hole **33** so as to open the tapped hole **33** for fastening the side cover **32** attached to the end surface of the block body **31**.

The movable block of the linear roller guide device of this invention is manufactured in accordance with the following processes.

The movable block **31** is previously formed with the roller rolling surfaces **71**–**74**. Then, as shown in FIG. **8**, the movable block **31** is subjected to an insert molding in which the end surface resin portions **16** and **17**, the upper surface side roller returning passage resin portions **81***a***2** and **82***a***2**, the radial direction retaining portions **21***a*, **22***a* and the axial direction retaining portions **21***b*, **22***b* for the upper rollers **21** and **22**, the radial direction retaining portions **23***a*, **24***a* for the side surface side rollers **23** and **24**, the axial direction retaining portions **23***b*, **24***b* for the side surface side rollers **23** and **24**, the side surface side roller returning passage resin portions **14**, **14** and the outer side surface resin portion **15**, are integrally formed with the block body **31** by inserting the block body **31** into the molding die.

FIG. **8** is a schematic view showing a structure of the molding die in which cavities **5***a* for forming the upper surface side roller returning passage resin portions **81***a***2** and **82***a***2** are provided to the block body **31**, cavities **5***b* for forming the end surface resin portions **16** and **17** each having the direction changing passage inner peripheral portion are provided to both front and rear end portions of the supporting leg portion **5**, cavities **5***c* for forming the axial direction retaining portions **21***b*, **22***b* for the upper rollers **21**, **22** and the radial direction retaining portions **23***a*, **24***a* for the side surface side rollers **23** and **24** are provided to a corner portion between the supporting leg portion **5** and the horizontal portion **4**, cavities **5***d* for forming the radial direction retaining portions **21***a*, **22***a* for the upper surface side rollers **21** and **22** are provided to the lower surface of the horizontal portion **4**, and cavities **5***e* for forming the axial direction retaining portions **23***b*, **24***b* for the side surface side rollers **23** and **24**, the side surface side roller returning passage resin portion **14** and the outer side surface resin portion **15** are provided to a circumference from the lower end surface to both inner and outer side surfaces of the supporting leg portion **5**, respectively.

In addition, a fixed molding die **50** is provided with convex portions **52** for positioning by engaging the roller rolling surfaces **71**–**74** with the convex portions **52**, while a movable molding die **51** is provided with pins **53** for forming unloaded roller returning holes **81***a***1**–**84***a***1**.

At the time of the insert molding, as shown in FIG. **8**(*a*), the movable block **31** is positioned on the basis of the roller rolling surfaces **71**–**74**. As described above, the positions of the unloaded roller returning passages **81***a*–**84***a* and both radial and axial direction roller retaining portions **21***a*–**24***a*; **21***b*–**24***b* are determined on the basis of the roller rolling surfaces **71**–**74**, so that it is possible to accurately set the relatively positional relations between the roller rolling surfaces **71**–**74**, the direction changing passages **81***b*–**84***b* and the unloaded roller returning passages **81***a*–**84***a* which constitute roller circulating passages.

Further, at the time of positioning the block body **31** within the fixed molding die, when the block body **31** is positioned on the basis of the roller rolling surfaces **71**–**74**, the contact portions of the block body **31** are limited and minimized to the roller rolling surfaces **71**–**74**, while the other portions of the fixed molding die **50** can be maintained in a non-contacted state, so that it becomes unnecessary to accurately work the fixed molding die **50** and a manufacturing of the fixed molding die **50** can be simplified.

In this embodiment, gaps are formed between the fixed molding die **50** and the block body in a range from the upper surface of the horizontal portion of the block body **31** to the upper end portion of the outer side surfaces of the supporting leg portion lower resin portion formed to the outer side surfaces of the supporting leg portions. The block body **31** contacts to inner peripheral surfaces of the fixed molding die at an upper end portion of the cavities **5***e* in a contacting state enabling to seal resin material. A contacting state where a small gap is formed may be allowed as far as the resin material can be sealed.

Further, the direction changing passage inner periphery portions **81***b***1**–**84***b***4** together with the unloaded roller returning passages **81***a*–**84***a* are integrally formed with the block body **31** by utilizing the insert molding method.

According to this process, as well as the upper surface side roller returning passage resin portions **81***a***2**–**84***a***2** and the end surface resin portions **16** and **17**, the radial direction roller retaining portions **21***a*, **22***a* and the axial direction roller retaining portions **21***b*, **22***b* for the upper surface side rollers **21** and **22**, the radial direction roller retaining portions **23***a*, **24***a* for the side surface side rollers **23**, **24** and the axial direction roller retaining portions **23***b*, **24***b* for the side surface side rollers **23** and **24**, the side surface side roller returning passage resin portions **14**, **14** and the outer side surface resin portions **15** are also integrally formed with the block body **31** by utilizing the insert molding method.

Thereafter, a side cover **32** is assembled to both end portions of the block body **31** to thereby complete the direction changing passages.

According to the present invention, one end surface of the upper surface side and the side surface side rollers **21**–**24** is guided by the first end surface guide portions **211**, **221**, **231** **241** provided to one side periphery portions of the roller rolling surfaces **71**–**74** formed to the movable block **3**, while the other end surface of the upper surface side and the side surface side rollers **21**–**24** is guided by the second end surface guide portions **212**, **222**, **232**, **242** provided to the other side periphery portions of the roller rolling surfaces **61**–**64** formed to the track rail **1**.

Further, when the movable block **3** is detached from the track rail **1**, the second end surface guide portions **212**, **222**, **232**, **242** provided to the track rail **1** are also detached from the other end surfaces of the upper surface side and side surface side rollers **21**–**24**. However, the upper surface side and side surface side rollers **21**–**24** are retained between the first end surface guide portions **211**, **221**, **231**, **241** provided to one side of the roller rolling surfaces **71**–**74** formed to the movable block **3** and the axial direction retaining portions **21***b*, **22***b*, **23***b*, **24***b* provided to the other side periphery portions thereof.

Further, the peripheral portions **21***c*–**24***c* of the one end surface of the upper surface side and side surface side rollers **21**–**24** are retained by the upper surface side and side surface side roller radial direction retaining portions **21***a*, **22***a*;**23***a*, **24***a* provided to the first end surface guide portions **211**, **221**, **231** and **241**, so that the falling-out of the rollers in a radial direction can be prevented.

As described above, the radial direction retaining portions **21***a*–**24***a* for the both upper surface side and side surface side rollers are engaged with only periphery portions of the one end surface of the rollers **21**–**24**, and the second end surface guide portions **212**–**242** are provided to the other side periphery portions of the roller rolling surfaces **71**–**74** formed to the track rail **1**, so that a peripheral surface of each rollers **21**–**24** except the engaging portion for engaging with the radial direction retaining portions **21***a*–**24***a* can be contacted to the roller rolling surfaces **61**–**64** formed to the track rail **1** so that the end surface is closely contacted to the second end surface guide portions **212**–**242**, whereby the effective contact length of the rollers **21**–**24** can be sufficiently secured in a long length. Accordingly, the high rigidity characteristics of the rollers **21**–**24** can be sufficiently utilized.

Further, since the second end surface guide portions **212**–**242** are provided to a side of the roller rolling surfaces **61**–**64** of the track rail **1**, the second end surface guide portions **212**–**242** can be worked with a high accuracy, whereby the skew generation at the rollers **21**–**24** can be further securely prevented.

In addition, since the first end surface guide portions **211–241** are constituted by the member for constituting the block body **31** of the movable block **3**, the first end surface guide portions **211–241** can be worked so as to have a high rigidity and high accuracy, and the end surfaces of the rollers are guided at portions between the first end surface guide portions and the second end surface guide portions **212–242** provided to the track rail **1** also having a high rigidity, whereby the skew generation can be further securely prevented.

Further, since both the radial and axial direction retaining portions **21**_a_–**24**_a_; **221**_b_–**24**_b_ are integrally formed with the block body **31** by inserting the block body **31** into the molding die, both the radial and axial direction retaining portions **21**_a_–**24**_a_; **21**_b_–**24**_b_ can be accurately positioned without causing any attaching error. so that a predetermined small gap between the upper surface side and side surface side rollers **21–24** and the radial direction retaining portions and the axial direction retaining portions **21**_a_–**24**_a_; **21**_b_–**24**_b_ can be accurately formed during the rolling of the rollers, whereby the upper surface side and side surface side rollers **21–24** would not interfere with the radial and axial direction retaining portions **21**_a_–**24**_a_; **21**_b_–**24**_b_.

Accordingly, the rollers are smoothly rolled and moved in co-operation with the skew preventing effect for the upper surface side and side surface side rollers **21–24** by the action of the first and second end surface retaining portions **211–241**, **212–242**.

On the other hand, the end surface resin portions **16**, **17** as the direction changing passage inner periphery member constituting the direction changing passage inner periphery portions **81**_b_**1**–**84**_b_**1** , together with both the radial and axial direction retaining portions **21**_a_–**24**_a_; **21**_b_–**24**_b_, are integrally formed with the block body **31** by inserting the block body **31** into the molding die, so that the connected portions of the loaded roller rolling surfaces **71–74** and the direction changing passage inner periphery portions **81**_b_**1**–**84**_b_**1** can be continuously formed without causing irregularities, so that both the upper surface side and side surface side rollers **21–24** are smoothly rolled and moved.

Further, the returning passage forming resin portions **81**_a_**2**, **82**_a_**2** and the lower surface resin portions **83**_a_**2**, **84**_a_**2** as the unloaded roller returning passage member for constituting the unloaded roller returning passages **81**_a_–**84**_a_, together with the end surface resin portion **16** and **17**, the inner side resin portion **12** of the supporting leg portion and the lower surface resin portion **13** of the horizontal portion, are integrally formed with the block body **31** by inserting the block body **31** into the molding die, so that each of the connected portions between the loaded roller rolling surfaces **71–74**, the direction changing passage inner periphery portions **81**_b_**1**–**84**_b_**1** and the unloaded roller returning passages **81**_a_–**84**_a_ can be continuously formed without causing irregularities, whereby both the upper surface side and side surface side rollers **21–24** are smoothly circulated and moved in all around a circulating passage.

Further, the direction changing passage inner periphery portions **81**_b_**2**–**84**_b_**2** of the end surface resin portions **16**, **17** and the unloaded roller returning passage forming member of the returning passage forming resin portions **81**_a_**2**, **82**_a_**2** are integrally provided with end surface guide portions **85**, **86** for guiding at least one end surface of the upper surface side and side surface side rollers **21–24**.

According to this structure, the end surface guide portions **85**, **86** of the direction changing passage **81**_b_ and the unloaded roller returning passage **81**_a_ are continuously formed without causing irregularities, so that the skew of both the upper surface side and side surface side rollers **21–24** can be prevented in all around the circulating passage and the rollers are smoothly circulated.

On the other hand, the upper surface side rollers **21**, **22** disposed on the upper surface of the track rail **1** are arranged to a portion close to a center side apart from a side end of the upper surface of the track rail **1** with a predetermined distance, while the roller rolling surfaces **61**, **71**; **62**, **72** corresponding to the upper two rows of rollers **21**, **22** are formed to the upper surfaces of the track rail **1** and the lower surface of the horizontal portion **4** of the movable block **3**.

The roller returning passages **81**_a_, **82**_a_ constituting the circulation passage for the upper rollers are arranged to portions close to a center side with respect to the roller circulating passages **83**_a_, **84**_a_ in unloaded region corresponding to the side surface side two rows of the rollers **23**, **24**.

According to this invention, the upper two rows of rollers **21**, **22** are arranged so as to be shifted to portions close to center side from the end portion of the upper surface of the track rail **1**, so that it is sufficient to form one row of the roller rolling surface **73**, **74** to the inner side surfaces of the supporting leg portions **5**, **5**, and the length L from the base portion of the right and left supporting leg portions **5**, **5** to the lower side two rows of rollers **23**, **24** can be shortened. As a result, the bending moment to be applied to the supporting leg portions due to the reaction force of the preload applied to the rollers **21–24** or an external load can be reduced.

Further, due to the moment acting in a direction spreading the supporting leg portions **5**, **5**, a center portion of the horizontal portion **4** is liable to be bent so as to close to the upper surface of the track rail **1**. However, in the present invention, such a bending deformation of the horizontal portion **4** is suppressed by the action of the upper two rows of rollers **21**, **22** disposed between the horizontal portion **4** and the upper surface of the track rail **1**, whereby the spreading of the supporting leg portions **5**, **5** can be sufficiently and synergistically decreased in co-operation with the reduction of the bending moment.

According to the structure described above, in a case where the preload is applied by means of the upper two rows of the rollers **21**, **22** disposed to the upper surface side of the track rail **1** and the lower two rows of rollers **23**, **24** disposed to the side surface side of the track rail **1** or in a case where the lifting load is applied, the deformation of the movable block **3** in a direction spreading the supporting leg portions **5**, **5** can be prevented, and the degree of parallelization between the roller rolling surfaces **61**, **71**; **62**, **72**; **63**, **73**; **64**, **74** are maintained to a constant level, whereby the non-uniformity in contacting of the rollers **21–24** can be prevented.

Further, the angle between each of the contact angle lines S1, S2 of the upper two rows of rollers **21**, **22** disposed on the upper surface of the track rail **1** and the central longitudinal axial line (vertical line) V is set at almost 45° and the angle between each of the contact angle lines S3, S4 of the side lower two rows of rollers **23**, **24** disposed on the side surfaces of the track rail **1** and a horizontal line H is set at almost 45° so at to upwardly direct to the track rail **1**, so that the same rated load can be obtained with respect to a radial load applied from upper direction (i.e., a load in a direction so as to press the movable block **3** onto the track rail **1**), lifting load and the lateral loads applied from right and left directions, whereby any of the load applied from every direction can be supported. In other words, the device can be used in any attitudes or positions, and available to wide applications.

Further, the track rail **1** having grooves each having a V-shape in cross section is used, and the roller rolling surfaces **61**, **71**; **62**, **72**; **63**, **73**; **64**, **74** to be formed to the track rail **1** and the movable block **3** so as to correspond to the four rows of rollers **21**–**24** are formed to one of the inclined surface of the V-shaped groove, while the other inclined surface is used as the first and second end surface guide portions **211**–**241**, **212**–**242** for guiding the roller end surfaces, whereby the end surfaces of the rollers are guided.

As a result, the locating relation between the respective V-shaped grooves can be accurately measured by using a roller pin or the like, whereby the locating relation between the respective V-shaped grooves can be molded or formed with a high accuracy. Accordingly, the upper surface side and side surface side four rows of rollers **21**–**24** disposed between the track rail **1** and the movable block **3** accurately contact to the roller rolling surfaces **61**, **71**; **62**, **72**; **63**, **73**; **64**, **74** corresponding to the four rows of rollers **21**–**24**, and the end surfaces of the rollers are accurately guided by the action of the first and second end surface guide portions **211**–**241**;**212**–**242**.

As described above, the movable block **3** has a rigidity regardless of the direction of the loads, so that the locating relation between the track rail **1** and the movable block **3** is normally maintained to a constant level. Further, the movable block **3** is supported by the track rail **1** at a position where the preload applied to the respective four rows of rollers **21**–**24** and the reaction force of the preload are balanced, so that a gap between the end surface of the roller and the first and second end surface guide portions **211**–**241**;**212**–**242** can be normally maintained to a constant level in co-operation with the effect of accurately forming the locating relation between the respective roller rolling surfaces **61**, **71**; **62**, **72**; **63**, **73**; **64**, **74** as described above.

In particular, the movable block **3** is formed in a shape having a high rigidity, so that a high preload can be applied. Therefore, the high rigidity of the movable block **3** and the high preload are synergistically effected to realize an effect such that the gap between the end surface of the upper surface side and side surface side rollers **21**–**24** and the first and second end surface guide portions **211**–**241**; **212**–**242** can be maintained to a constant level. As a result, the skew preventing effect for the rollers **21**–**24** can be enhanced and a smooth circulation and a rolling accuracy of the rollers **21**–**24** can be secured.

Further, the first end surface guide portions **211**, **212** for the upper rollers **21**, **22** are constituted by the block body **31** per se, so that the thickness of the horizontal portion **4** can be increased, whereby the flexural rigidity of the horizontal portion **4** can be increased. Further, the rigidity of the movable block **3** can be enhanced. In addition, by enhancing the rigidity of the movable block **3**, the effect of preventing the skew generation can be further synergistically improved.

Further, the roller rolling surfaces **61**, **71**; **62**. **72**; **63**, **73**; **64**, **74** and the first and second end surface guide portions **211**–**241** **212**–**242** are constituted by the grooves each having a V-shape in cross section, so that the roller rolling surfaces **61**, **71**; **62**, **72**; **63**, **73**; **64**, **74** and the first and second end surface guide portions **211**–**241**; **212**–**242** can be simultaneously finished by a grinding work. As a result, a guiding accuracy for the rollers and surface roughness of the roller rolling surfaces **61**, **71** **62**, **72**; **63**, **73**; **64**, **74** and the first and second end surface guide portions **211**–**241**; **212**–**242** are improved and a high effect in skew prevention can be obtained. In addition, the working amount for the grooves can be minimized.

In addition a screw hole **33** for fixing the movable block is provided at portions on the upper surface of both right and left end portions of the horizontal portion **31** of the movable block, and the portions are set to upper positions of the roller returning passages **83***a*, **84***a* for the lower two rows of rollers **23**, **24** or set to positions close to the center side. Owing to this structure, a pitch P between the right and left screw holes **33**, **33** is narrowed, whereby the screw holes are arranged to the positions close to the lower side rollers **23**, **24**.

In addition, the relation between a lateral width W and a height A of the track rail **1** is set so as to satisfy $A/W<1$, so that stability of the track rail **1** is enhanced, and simultaneously, an interference with an upper end opening portion **11***a* of a bolt inserting hole to be opened at a center of the upper surface of the track rail **1** is avoided.

When a lifting load in a direction lifting the movable block **3** from the track rail **1** is applied, a force in a direction detaching the movable block **3** from the track rail **1** is applied while the above described screw holes **33**, **33** are acting as points of application, in contrast, a reaction force against the force is applied to the roller rolling surfaces **73**, **74** for the lower two rows of rollers **23**, **24**. The force applied to the screw hole **33** and the reaction force constitute a relation of a couple of forces, whereby a bending moment in a direction for spreading the supporting leg portions **5**, **5** will occur.

In the case of this embodiment, the upper two rows of rollers **21**, **22** are arranged to portions close to a center side portion, so that an interference of the upper two rows of the rollers **21**, **22** with the screw hole **33** can be avoided. Simultaneously, the screw hole **33** is formed at a portion close to the lower side rollers **23**, **24**, so that a distance M in the horizontal direction between the the screw hole **33** and the lower side rollers **23**, **24** can be sufficiently shortened, whereby the bending moment in a direction for spreading the supporting leg portions **5**, **5** can be reduced.

As shown in FIG. **12**, when the position of this screw hole **33** is set so as to coincide with the position of the side surface side rollers **23** and **24**, the distance between the screw hole **33** and the lower side rollers **23**, **24** in a horizontal direction becomes zero, so that the bending moment in a direction spreading the supporting leg portions **5**, **5** would not be applied, thus being advantageous. In the case shown in Figure, each of the screw holes **33** is arranged to a portion between the roller rolling surfaces **71**, **72** and the roller returning passages **81***a*, **82***a* for the upper side rollers **21**, **22**.

In this connection, as shown in FIG. **13**, a flange portion **34** can be provided to the movable block so as to laterally project therefrom, and the screw hole **33** for fixing the movable block way also be formed to the flange portion **34**.

FIG. **13**(*a*) shows an example in which a screw is formed to the screw hole **33**, and FIG. **13**(*b*) shows an example in which a screw inserting hole **35** is formed to the flange portion **34**.

In the embodiment described above, although there is shown an example in which the radial direction retaining portions and axial direction retaining portions **21***a*–**24***a*, **21***b*–**24***b* composed of resin materials for retaining the upper surface side rollers **21**, **22** and the side surface side rollers **23**, **24** are integrally formed to the block body **31**, the radial direction retaining portions **21***a*–**24***a* and axial direction retaining portions **21***b*–**24***b* may also be formed by mechanically working the block body **31** per se as shown in FIGS. **9** and **10**.

FIG. **9** shows an example of a structure for retaining the upper surface side roller **21**, **22**. Namely, FIG. **9**(*a*) shows an example in which both the radial direction retaining portions **21***a*, **22***a* and the axial direction retaining portions **21***b*, **22***b* are constituted by the block body **31**, FIG. **9**(*b*) shows an example in which the radial direction retaining portions **21***a*, **22***a* are constituted by the block body **31**, while the axial direction retaining portions **21***b*, **22***b* are constituted by the resin material, and FIG. **9**(*c*) shows an example in which the radial direction retaining portions **21***a*, **22***a* are constituted by the resin material, while the axial direction retaining portions **21***b*, **22***b* are constituted by the block body **31**.

FIG. **10** shows an example of a structure for retaining the side surface side roller **23**, **24**. Namely, FIG. **10**(*a*) shows an example in which both the radial direction retaining portions **23***a*, **24***a* and the axial direction retaining portions **23***b*, **24***b* are constituted by the block body **31**; FIG. **10**(*b*) shows an example in which the radial direction retaining portions **23***a*, **24***a* are constituted by the block body **31**, while the axial direction retaining portions **23***b*, **24***b* are constituted by the resin material; and FIG. **10**(*c*) shows an example in which the radial direction retaining portions **23***a*, **24***a* are constituted by the resin material, while the axial direction retaining portions **23***b*, **24***b* are constituted by the block body **31**.

FIG. **11** shows another example of a structure of the first end surface guide portion for the upper surface side and side surface side rollers.

FIG. **11**(*a*) shows a structure in which the first end surface guide portions **211**–**241** are integrally formed with the block body **31** by inserting the block body **31** into the molding die.

According to this structure, the first end surface guide portions **21**–**24** can be accurately positioned, so that the gap between the roller end surface and the first end surface guide portions **211**–**241** can be further decreased without impairing the circulating motion of the rollers **21**–**24**, whereby the skew preventing effect for the rollers **21**–**24** can be enhanced.

In particular, in this embodiment, the first end surface guide portions **211**–**241** are constituted by resin member **18**, and the roller end surfaces are guided by the resin member **18**, so that a friction resistance is decreased whereby a smoothness in roller guiding can be increased. Furthermore, the roller end surface would not wear, so that the skew prevention can be stably secured.

In the example shown in Figure, a guide wall **75** is constituted by the inclined surface of the V-shaped groove, and the inclined surface opposing to another inclined surface to which the roller rolling surfaces **71**–**74** are formed. The guide wall **75** is covered with the resin material having a predetermined thickness.

FIG. **11**(*b*) shows an example in which the first end surface guide portions **211**–**241** are constituted by the radial direction retaining portions **21***a*–**24***a*.

Namely, the guide wall **76** opposing to the roller end surface in a non-contact state is provided to one side periphery of the roller rolling surfaces **71**–**74** formed to the movable block **3**, the radial direction retaining portions **21***a*–**24***a* are provided to end portions of the guide wall **76**, and the first end portion guide portions **211**–**241** contacting to a circumferential portion of the roller end surface are constituted by opposing surfaces of the radial direction retaining portions **21***a*–**24***a*, the opposing surfaces being opposed to the roller end surface.

According to this structure, contact areas of the first end surface guide portions **211**–**241** and the roller end surface are decreased, so that a friction resistance can be decreased, whereby a smoothness in roller circulation can be increased.

In the respective embodiments described above. there has been explained examples in which the roller returning passages **83***a*, **84***a* in the unloaded region for the side surface side rollers **23**, **24** are constituted by the V-shaped grooves formed to the lower end surfaces of the supporting leg portions **5**, **5** of the movable block **3**.

However, in the same manner as in the roller returning passages **81***a*, **82***a* for the upper surface side rollers **21** and **22**, as shown in FIG. **14**, the roller returning passages **83***a*, **84***a* way also be constituted by covering the inner peripheral portions of the penetration bores **83***a***1**', **84***a***1**' with the resin portions **83***a***2**', **84***a***2**'.

In the case of this embodiment, the resin would not enter or flow toward the lower end surfaces and outer side surfaces of the supporting leg portions **5**, **5** of the movable block **3**.

Further, in the case of the former embodiment. the direction changing passages **81***b*–**84***b* are constituted by the side cover **32** to be attached to both end portions of the movable block **3**. However, in the case of this embodiment, the side cover **32** is integrally formed with the block body **31**, and a deflector **36** for constituting only the direction changing passage outer periphery portions **81***b***1**–**84***b***1** is used. The deflector **36** is attached to a recessed portion **36***a* to which the inner periphery guide portions **81***b***2**–**84***b***2** of the direction changing passages **81***b*–**84***b* of the side cover **32** is provided.

According to the present invention as described above, the radial direction retaining portion is engaged with only a periphery of the one end surface of the roller, and the second end surface guide portion is provided to the other side periphery of the roller rolling surface formed to the track rail, so that a peripheral surface of the roller except the engaging portion for engaging with the radial direction retaining portion can be contacted to the roller rolling surface formed to the track rail so that the end surface is closely contacted to the second end surface guide portion, whereby the contact length of the roller can be sufficiently secured in a long length. Accordingly, the high rigidity characteristic of the roller can be sufficiently utilized.

When the first end surface guide portion is integrally formed with a member for constituting a block body of the movable block, the first end surface guide portion can be worked so as to have a high rigidity and high accuracy, and the end surfaces of the roller are guided in a portion between the first end surface guide portion and the second end surface guide portion provided to the track rail also having a high rigidity, whereby the skew generation can be further securely prevented.

When the first end surface guide portion is integrally formed with the block body by inserting the block body into a molding die, the end surface guide portions can be accurately positioned without causing any attaching error, the gap between the roller end surface and the first end surface guide portion can be further decreased without impairing the circulating motion of the rollers, so that the skew preventing effect for the roller can be enhanced.

A guide wall opposing to the roller end surface in a non-contact state is provided to one side periphery of the roller rolling surface formed to the movable block, the radial direction retaining portion is provided to an end portion of the guide wall, and the first end surface guide portion contacting to a circumferential portion of the roller end surface is constituted by an opposing surface of the radial direction retaining portion, the opposing surface being opposed to the roller end surface.

According to this structure, contact areas of the first end surface guide portion and the roller end surface are decreased, so that a friction resistance can be decreased whereby a smoothness in roller circulation can be increased.

When both the first and second end surface guide portions are integrally formed with the block body by inserting the block body into the molding die, both the radial and axial direction retaining portions can be accurately positioned without causing any attaching error, so that a predetermined gap between the roller and the radial direction retaining portion or the axial direction retaining portion can be accurately formed during the rolling of the rollers, whereby the roller would not interfere with the radial and axial direction retaining portions. Accordingly, the rollers are smoothly rolled and moved in co-operation with the skew preventing effect for the rollers by the action of the first and second end surface retaining portions.

On the other hand, when the direction changing passage inner periphery member, together with both radial and axial direction retaining portions, is integrally formed with the block body by inserting the block body into the molding die, a connected portion of the loaded roller rolling surface and the direction changing passage inner periphery portion can be continuously formed without causing irregularities, so that the rollers can be smoothly circulated.

When the unloaded roller returning passage member, together with the direction changing passage inner periphery member and both the radial and axial direction retaining portions, is integrally formed with the block body by inserting the block body into the molding die, each of the connected portions between the loaded roller rolling surface, the direction changing passage inner periphery portion and the unloaded roller returning passage can be continuously formed without causing irregularities, so that the rollers can be smoothly circulated in all around the circulating passages.

When the direction changing passage inner periphery member and the unloaded roller returning passage member are integrally provided with an end surface guide portion for guiding the roller, the end surface guide portions of the direction changing passage inner periphery member and the unloaded roller returning passage member are continuously formed without causing irregularities, so that the skew of the roller can be prevented all around the circulating passages and the rollers can be smoothly circulated.

When the upper two rows of rollers are arranged to portions close to center side from the end portions of the upper surface of the track rail and the lower two rows of the rollers are arranged to upper portions of the right and left side surfaces of the track rail, the lengths from the base portion of the right and left supporting leg portions of the movable block to the lower side rollers can be shortened in comparison with a conventional case where the two rows of rollers are arranged to the right and left side surfaces of the track rail, respectively.

Accordingly, even if the reaction force of the preload applied to the roller or the lateral load acting in a direction so as to displace the movable block in a horizontal direction with respect to the track rail is applied, it becomes possible to decrease the bending moment acting in a direction so as to spread the supporting leg portions.

Further, due to the moment acting in a direction spreading the supporting leg portions, a center portion of the horizontal portion is bent so as to close to the upper surface of the track rail. However, in the present invention, a bending deformation of the horizontal portion is suppressed by the action of the upper two rows of rollers disposed between the horizontal portion and the upper surface of the track rail, whereby the spreading of the supporting leg portions can be sufficiently decreased in co-operation with the reduction of the bending moment.

As described above, even if the preload is applied to the roller or the lateral load in a horizontal direction is applied, the deformation in a direction spreading the supporting leg portions of the movable block can be prevented and a degree of parallelization between the opposing roller rolling surfaces can be maintained to a constant level, whereby the rollers can be smoothly circulated in co-operation with the effect of preventing the skew of the rollers by the action of the first and second end surface guide portions.

INDUSTRIAL APPLICABILITY

As described above, the linear roller guide device according to the present invention is widely applicable to linear guide mechanisms for various industrial equipments such as machine tool, robot operating system, inspecting or measuring apparatus, or the like.

I claim:

1. A linear roller guide device in which a movable block is guided along a track rail through four rows of rollers disposed on said track rail,

wherein said movable block comprises a horizontal portion opposing to an upper surface of said track rail and supporting leg portions projected downwardly from both end portions of said horizontal portion so as to oppose to right and left side surfaces of said track rail,

wherein said track rail is provided with four rows of roller rolling surfaces for rolling and guiding the rollers in an entire range of said track rail in which the movable block is moved, and

wherein, on the other hand, said movable block comprises four rows of roller rolling surfaces opposing to the roller rolling surfaces formed to said track rail for rollingly clamping the four rows of rollers and four rows of roller circulating passages provided at unloaded region for circulating the rollers clamped between the roller rolling surfaces formed to the track rail and the movable block from one end portion to the other end portion of the roller rolling surface of said movable block,

said linear motion guide device being characterized in that upper two rows of rollers among said four rolls of rollers are arranged in the upper surface of said track rail at portions spaced from side ends of the upper surface of said track rail, while roller rolling surfaces corresponding to said upper two rows of rollers are formed to the upper surface of said track rail and the lower surface of said horizontal portion of the movable block,

that said lower two rows of rollers among the four rows of rollers are arranged such that one row of rollers is disposed to an upper portion of right and left side surfaces of said track rail, respectively, while roller rolling surfaces corresponding to said lower two rows of rollers are formed to the right and left side surfaces of said track rail and inner side surfaces of said supporting leg portions of the movable block,

that each of said upper two rows of rollers has a structure in which a line orthogonal to a rotation axis of the roller is inclined with respect to a vertical line with a predetermined inclination angle, and that each of said lower two rows of rollers has a structure in which a line orthogonal to a rotation axis of the roller is inclined with respect to a horizontal line with a predetermined inclination angle so as to upwardly extend towards a side of the track rail.

2. A linear roller guide device according to claim **1**, wherein said upper two rows of rollers are arranged to portions close to a center side portion deviated from side ends of the upper surface of said track rail, while the roller circulating passages in unloaded region are also arranged to portions close to the center side portion with respect to the roller circulating passages in unloaded region corresponding to the lower two rows of the rollers and wherein a screw hole for fixing said movable block is provided at portions on the upper surface of right and left end portions of said horizontal portion of the movable block, and the portions are set to upper positions of the roller circulating passages in unloaded region for the lower two rows of rollers or set to positions close to the center side.

3. A linear roller guide device according to claim **1** or **2**, wherein an angle between a line orthogonal to a rotation axis of each of said upper two rows of rollers and a vertical line is set at almost 45°.

4. A linear roller guide device according to claim **1** or **2**, wherein an angle between a line orthogonal to a rotation axis of each of said lower two rows of rollers and a horizontal line is set at almost 45°.

5. A linear roller guide device according to claim **1** or **2**, wherein said track rail has a track groove having a V-shape in cross section comprising two inclined surfaces, and said roller rolling surfaces to be formed to said track rail and said movable block so as to correspond to said four rows of rollers are formed to one of said inclined surfaces, while the other inclined surface is used as a guide surface for guiding the roller end surfaces.

6. A linear roller guide device according to claim **5**, wherein said rollers contact to said roller rolling surfaces at an entire length of the roller.

7. A linear roller guide device according to claim **1** or **2**, wherein said rollers are applied with preload.

8. A linear roller guide device according to claim **1** or **2**, wherein a first end surface guide portion for guiding one end surface of said roller is provided to one side periphery of said roller rolling surface formed to said movable block, while a second end surface guide portion for guiding the other end surface of said roller is provided to the other side periphery of said roller rolling surface formed to said track rail,

wherein a radial direction retaining portion having a projection for preventing the roller from falling out in a radial direction by being engaged with a peripheral corner portion of the roller end surface is provided to one side periphery of said roller rolling surface formed to the track rail, while said roller is contacted to the roller rolling surface formed to the track rail in an almost entire contact length in a peripheral surface of the roller except an engaging width required for engaging with said radial direction retaining portion, and

wherein, on the other hand, an axial direction retaining portion for preventing the roller from falling out in an axial direction is provided to a side periphery of the roller rolling surface formed to the movable block, said side periphery opposing to the side periphery to which the first end surface guide portion is provided.

9. A linear roller guide device according to claim **8**, wherein said first end surface guide portion is integrally formed with a member for constituting a block body of said movable block.

10. A linear roller guide device according to claim **8**, wherein said first end surface guide portion is constituted by resin member which is integrally formed with the block body by inserting the block body into a molding die.

11. A linear roller guide device according to claim **8**, wherein a guide wall opposing to said roller end surface in a non-contact state is provided to one side periphery of said roller rolling surface formed to said movable block, said radial direction retaining portion is formed to an end portion of said guide wall, and said first end surface guide portion contacting to a circumferential portion of the roller end surface is constituted by an opposing surface of the radial direction retaining portion, the opposing surface being opposed to said roller end surface.

12. A linear roller guide device according to claim **8**, wherein both said radial and axial direction retaining portions are integrally formed with the block body by inserting the block body into a molding die.

13. A linear roller guide device according to claim **8**, wherein the roller circulating passage in unloaded region comprises an unloaded roller returning passage extending in an axial direction and a direction changing passage for connecting both ends of the unloaded roller returning passage to both ends of a roller rolling passage in loaded region to be formed between the opposing roller rolling surfaces of said track rail and said block body and wherein a direction changing passage inner periphery member for constituting an inner periphery portion of said direction changing passage, together with both radial and axial direction retaining portions, are integrally formed with said block body by inserting the block body into a molding die.

14. A linear roller guide device according to claim **13**, wherein an unloaded roller returning passage member for constituting the unloaded roller returning passage, together with said direction changing passage inner periphery member and both the radial and axial direction retaining portions, are integrally formed with said block body by inserting the block body into the molding die.

15. A linear roller guide device according to claim **14**, wherein said direction changing passage inner periphery member and said unloaded roller returning passage member are integrally provided with an end surface guide portion for guiding at least one end surface of the roller.

* * * * *

US005988883A

United States Patent [19]
Takamatu et al.

[11] **Patent Number: 5,988,883**

[45] **Date of Patent: Nov. 23, 1999**

[54] **ENDLESS RETAINER OF GUIDE DEVICE AND FABRICATION METHOD THEREOF**

[75] Inventors: **Hiroshi Takamatu; Hiroaki Mochizuki; Tomozumi Murata; Mitsuaki Honma**, all of Tokyo, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **09/117,037**

[22] PCT Filed: **Dec. 24, 1996**

[86] PCT No.: **PCT/JP96/03766**

§ 371 Date: **Jul. 23, 1998**

§ 102(e) Date: **Jul. 23, 1998**

[87] PCT Pub. No.: **WO98/28549**

PCT Pub. Date: **Jul. 2, 1998**

[51] **Int. Cl.**[6] **F16C 33/56**; F16C 43/08

[52] **U.S. Cl.** **384/45**; 29/898.067; 384/51

[58] **Field of Search** 384/49, 51, 523, 384/527, 572, 45; 29/898.067

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,732,606	5/1973	de Germond	29/893.063
4,886,377	12/1989	Adachi et al.	384/49
5,156,462	10/1992	Jacob et al.	384/49

FOREIGN PATENT DOCUMENTS

47-5408	3/1972	Japan .
63-502525	9/1988	Japan .
5-52217	3/1993	Japan .
5-126149	5/1993	Japan .
5-196036	8/1993	Japan .
5-196037	8/1993	Japan .
5-231433	9/1993	Japan .
6-56181	7/1994	Japan .

OTHER PUBLICATIONS

Abstract of Japanese Patent Publication No. 5–231432; dated Sep. 7, 1993.

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Nikaido, Marmelstein, Murray & Oram LLP

[57] **ABSTRACT**

An endless retainer of a guide device including a number of rolling bodies arranged at predetermined intervals for rolling at an inside of an infinite track formed in the guide device, a flexible resin connector having interposing portions interposed among the respective rolling bodies and connecting portions for connecting the respective interposing portions for holding the number of rolling bodies in an aligned state and rotatably, and the resin connector is molded by an injection molding with the rolling bodies as cores by using a resin having a dimension change rate before and after an oil absorbing or a water absorbing treatment larger than a mold shrinkage rate and is provided with clearances between the resin connector and the rolling bodies formed by the oil absorbing or the water absorbing treatment whereby handling thereof is facilitated without detaching the rolling bodies, automation of integrating the endless retainer to the guide device can be carried out and extremely smooth rotatability can be provided to the rolling bodies with certainty.

12 Claims, 9 Drawing Sheets

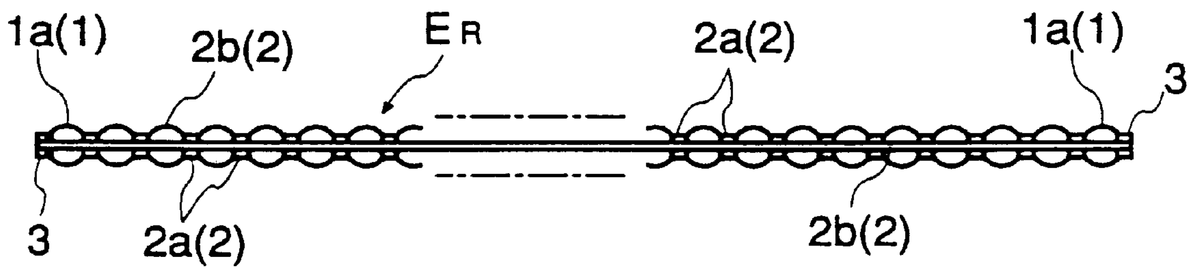


Fig.1

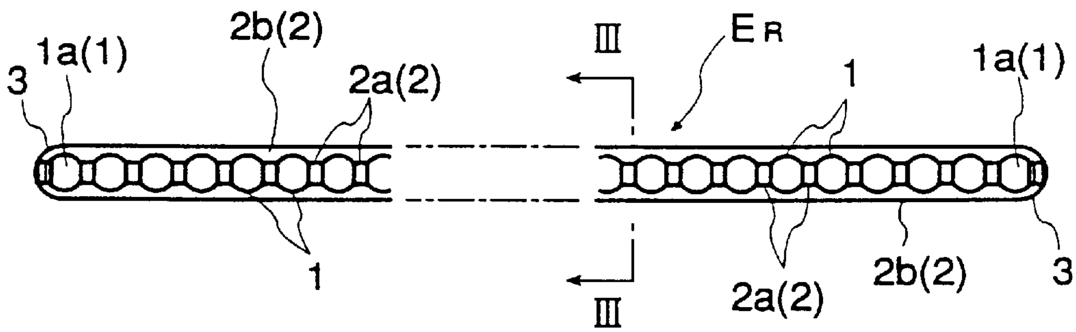

3
1a(1)
2b(2)
2a(2)
III
ER
1
1a(1)
1
III
2a(2)
2b(2)
3

Fig.2

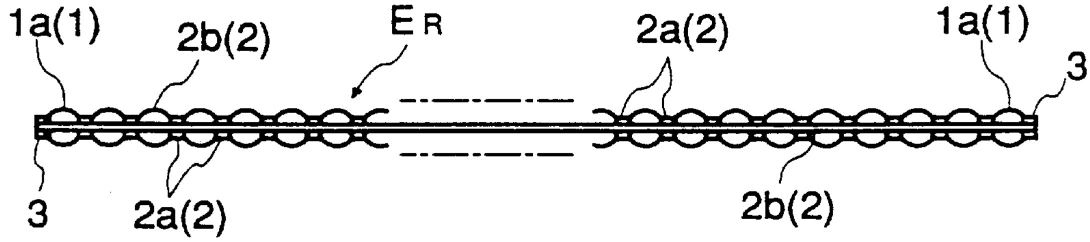

1a(1)
2b(2)
ER
2a(2)
1a(1)
3
3
2a(2)
2b(2)

Fig.3

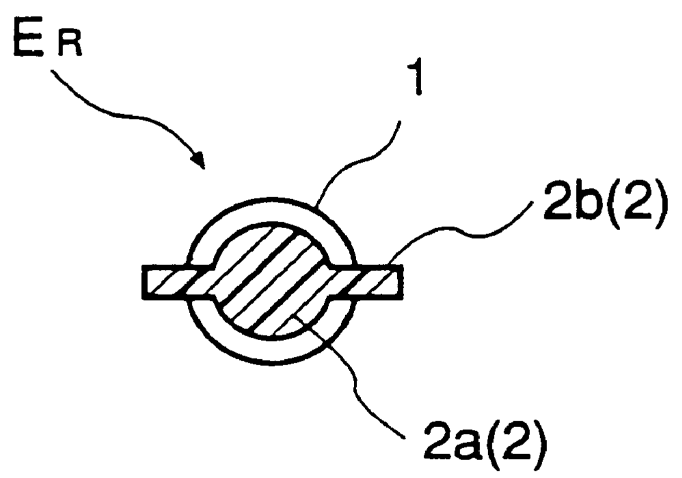


Fig.4

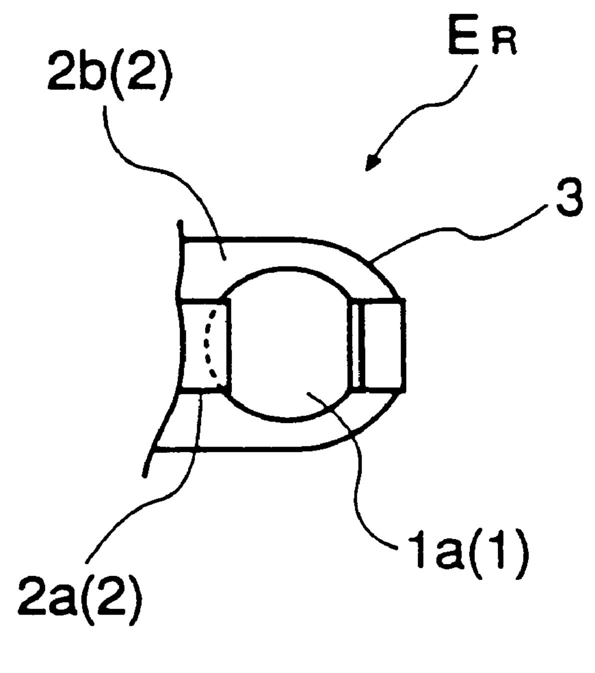


Fig.5

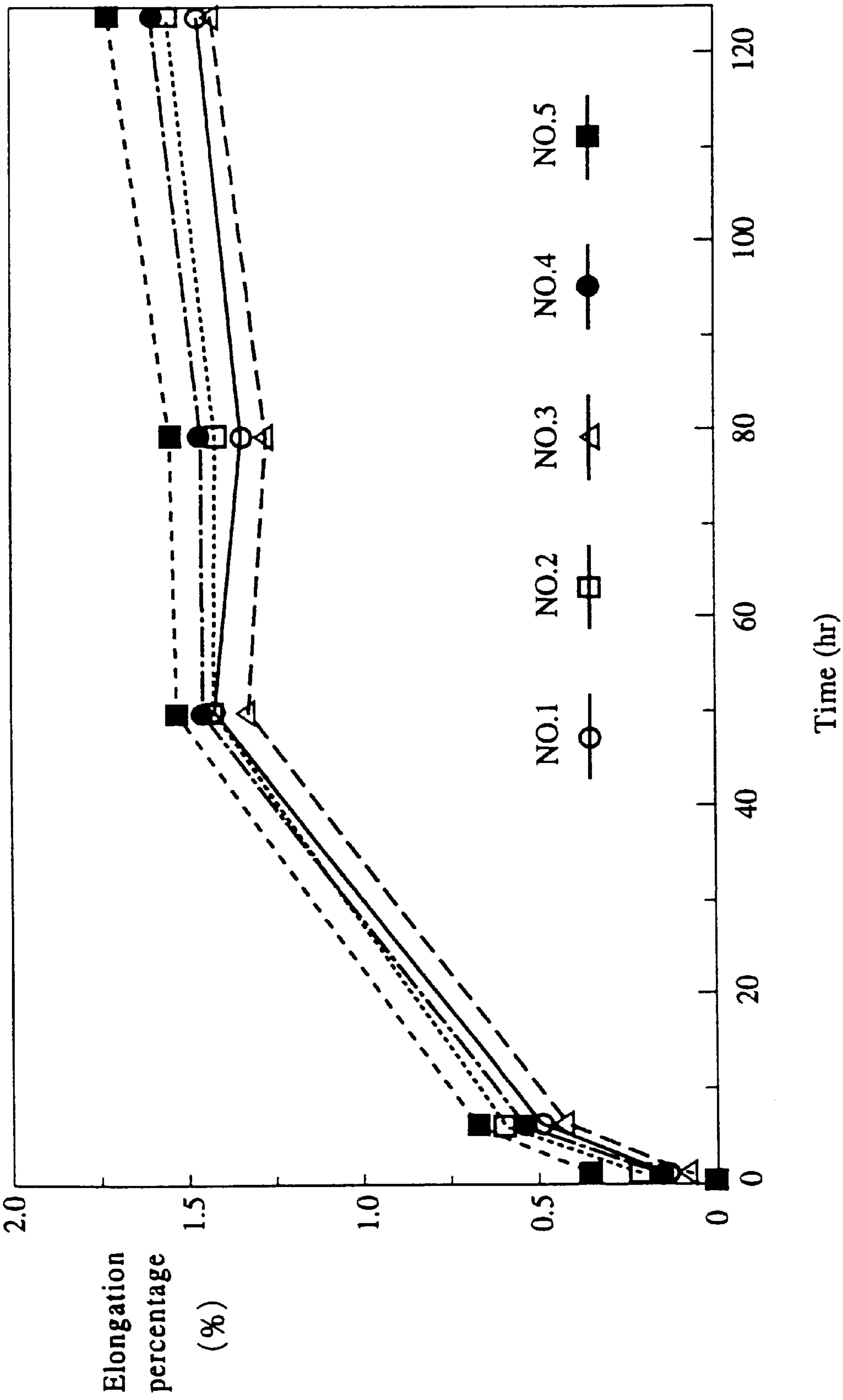

Elongation percentage (%)
2.0
1.5
1.0
0.5
0
0
20
40
60
80
100
120
Time (hr)
NO.1
NO.2
NO.3
NO.4
NO.5

Fig.6

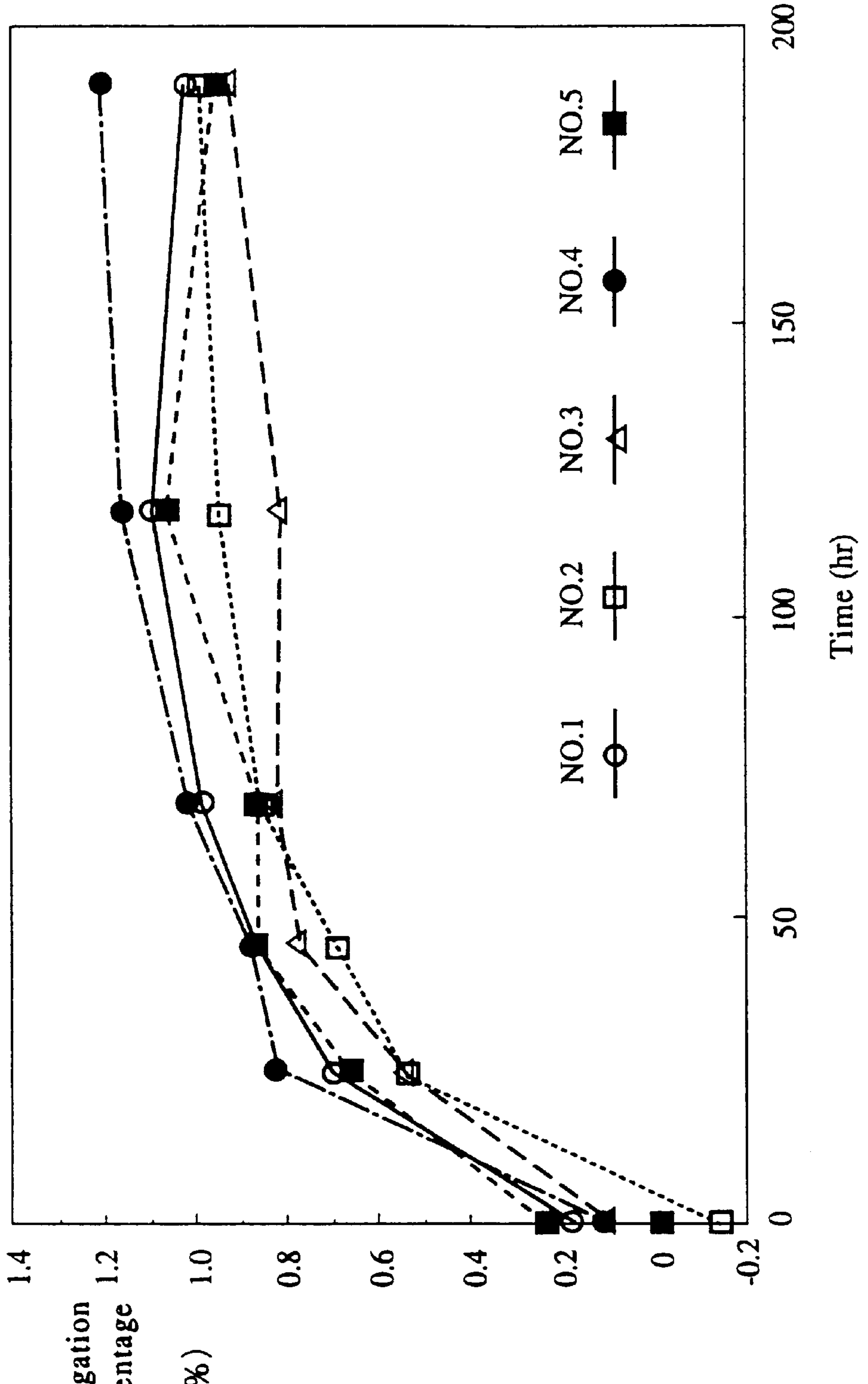

Elongation percentage (%)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
-0.2
0
50
100
150
200
Time (hr)
NO.1
NO.2
NO.3
NO.4
NO.5

Fig. 7

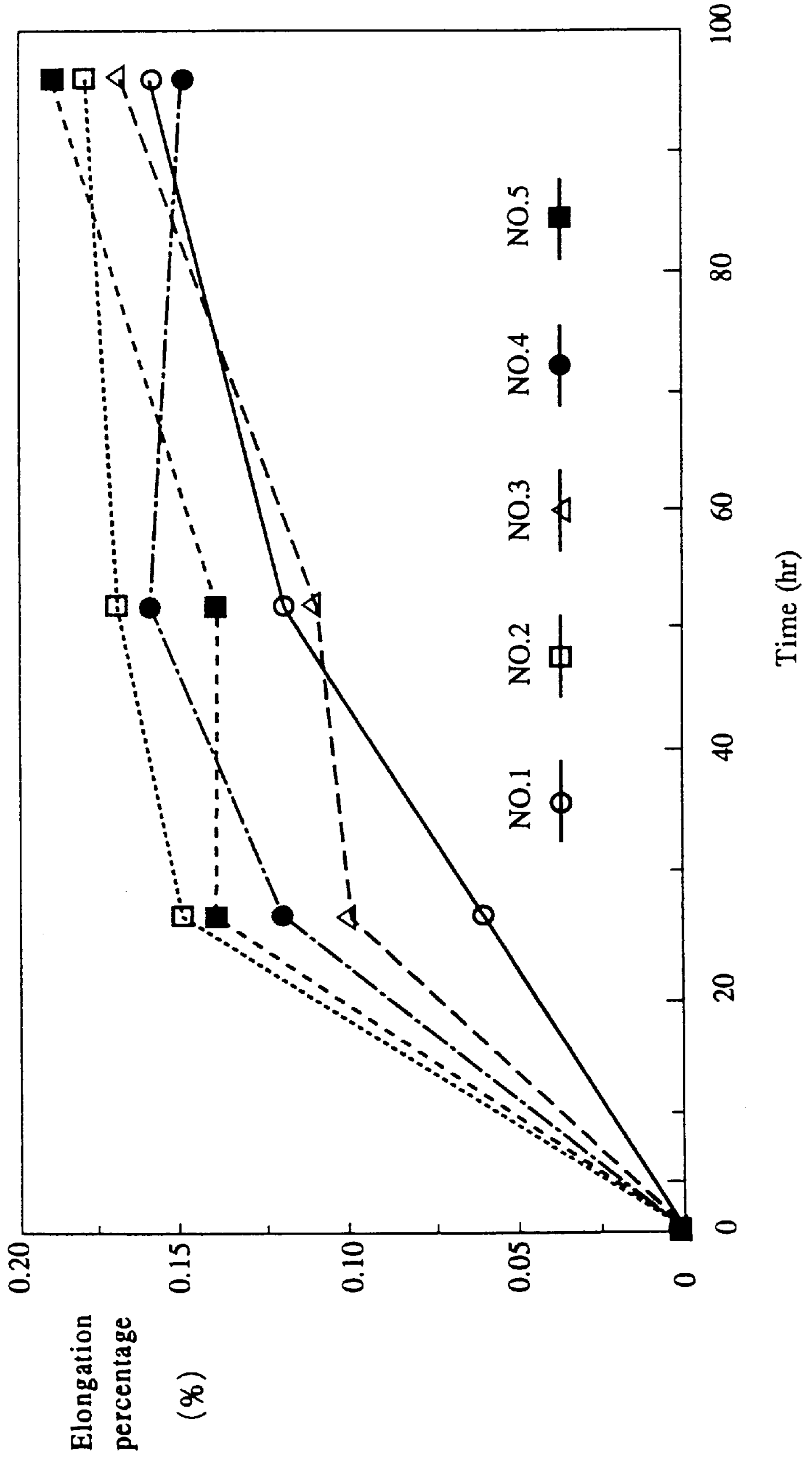
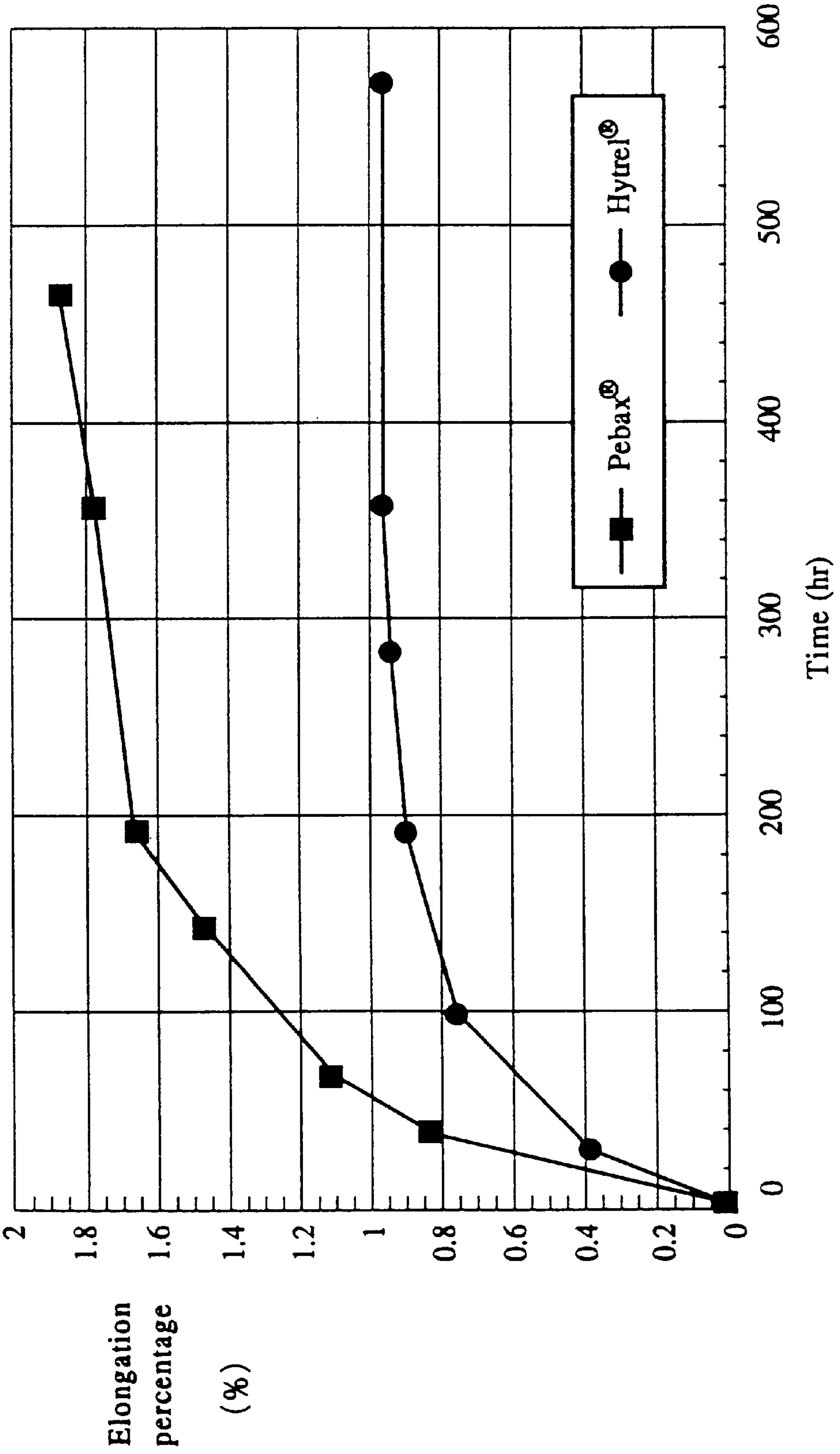

Elongation percentage (%)
0.20
0.15
0.10
0.05
0
0
20
40
60
80
100
Time (hr)
NO.1
NO.2
NO.3
NO.4
NO.5

Fig. 8


Elongation percentage (%)
Time (hr)
Pebax®
Hytrel®
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
100
200
300
400
500
600

Fig·9

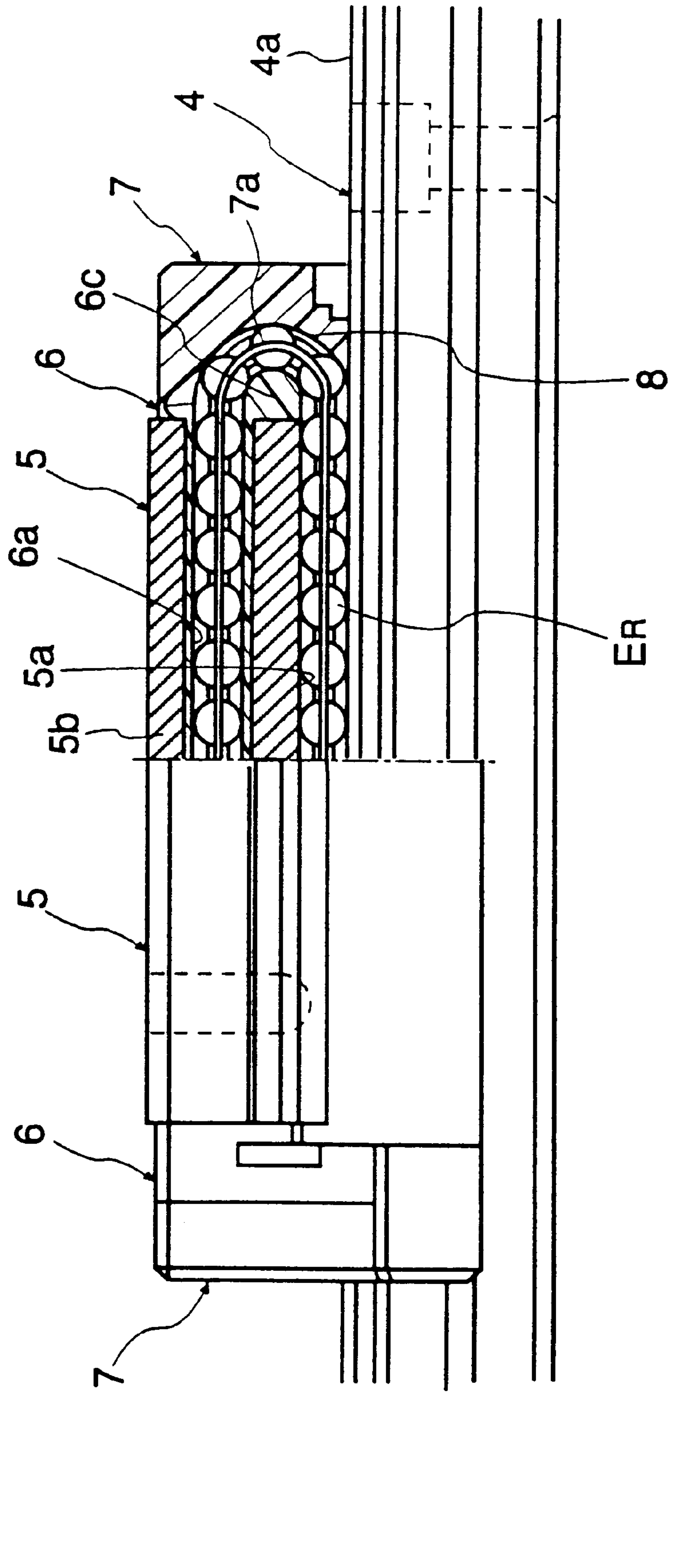


Fig.10

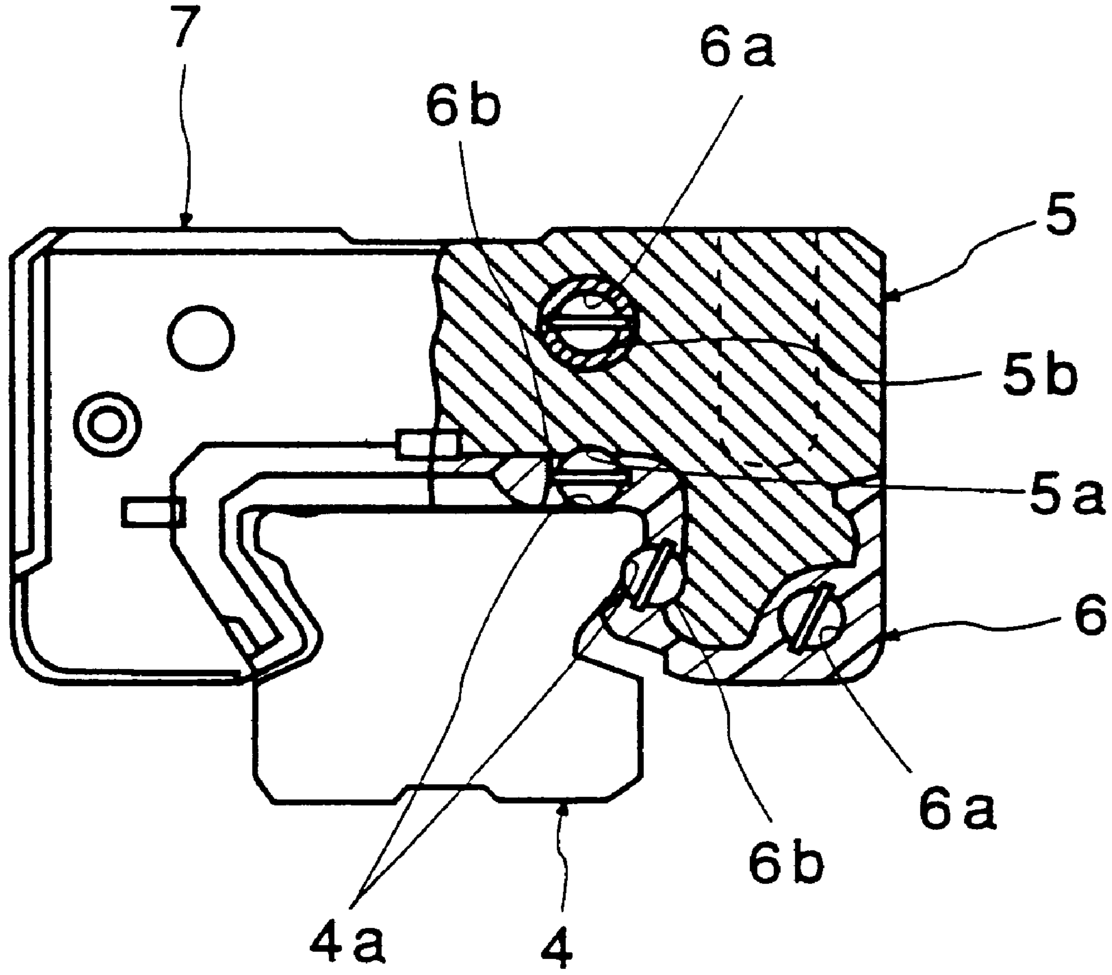
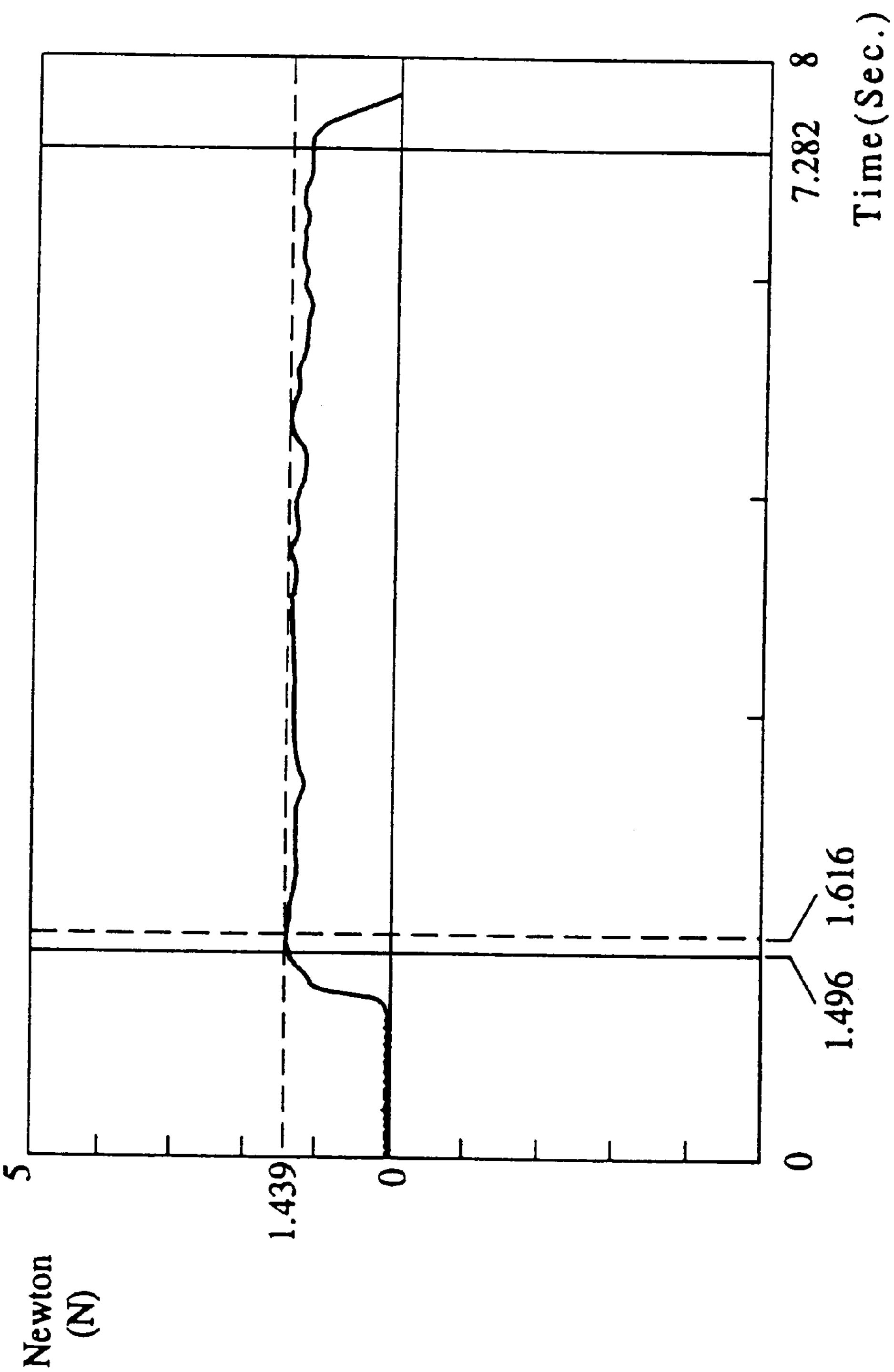


Fig. 11



ENDLESS RETAINER OF GUIDE DEVICE AND FABRICATION METHOD THEREOF

FIELD OF THE INVENTION

The present invention relates to an endless retainer in a guide device of, for example, a linear guide device, a curved guide device, a pivoting bearing or the like for infinite sliding, which is inserted into an infinite track thereof and which supports relative linear movement or rotational movement between a pair of bearing races forming the infinite track, and its fabrication method.

DESCRIPTION OF RELATED ART

According to various guide devices having bearings, linear movement or rotational movement between bearing races can be carried out by utilizing rolling movement of rolling bodies comprising balls or rollers sandwiched between a pair of the bearing races. It is general to integrate a number of the rolling bodies between the bearing races by holding them by a retainer or a cage made of a metal thin plate or synthetic resin with purposes of preventing detachment of the rolling bodies when the pair of bearing races are separated from each other, achieving reduction in frictional resistance by avoiding contact among the respective rolling bodies, obtaining smooth movement by aligning the respective rolling bodies at predetermined positions and so on.

However, according to a conventional guide device using a retainer, the guide device is integrated by integrating the retainer to a side of either of the bearing races, integrating the rolling bodies to a formed rolling path of the rolling bodies and successively integrating other of the bearing races. Particularly when the guide device includes an infinite track of the rolling bodies, skill is required in the operation of integrating the guide device using the retainer and its automation is difficult.

Further, according to a conventional guide device using a cage, the cage is provided with a number of pockets and the respective rolling bodies are rotatably held in the pockets and accordingly, there is provided an advantage where the operation of integrating a number of the rolling bodies to the guide device is facilitated. However, there poses other problem in which a number of the rolling bodies need to be integrated in the respective pockets of the cage and held thereby such that the rolling bodies are not detached and enormous time and labor is required in fabricating the cage per se.

Hence, in order to resolve such problems, there have been proposed a ball retainer or a ball cage in a chain-like shape which is fabricated by injection molding of resin where balls are arranged as cores at a substantially flat face in a mold and forms a predetermined shape by being folded or bent in using it (Japanese Examined Patent Publication No. JP-B-6-56181, Japanese Unexamined Patent Publication No. JP-A-5-52217, Japanese Unexamined Patent Publication No. JP-A-5-126149, Japanese Unexamined Patent Publication No. JP-A-5-196036 and Japanese Unexamined Patent Publication No. JP-A-5-196037).

However, according to the ball retainer or the ball cage in a chain-like shape, rotatability is provided to the balls which have been cast as cores in the resin by utilizing a property of the resin that it is contracted after the injection molding. Accordingly, there are cases where an extremely long period of time is required for providing the rotatability to the balls, it is difficult to provide the smooth rotatability and the rotatability cannot be provided to the balls depending on the kind of resin.

SUMMARY OF THE INVENTION

The present invention has solved difficulty in handling a conventional retainer or a cage for rolling bodies and resolved the problem of the ball cage or the ball retainer in a chain-like shape which has previously been proposed and it is an object of the present invention to provide an endless retainer not only having advantages where the retainer can be fabricated extremely easily, handling thereof is extremely facilitated without detaching rolling bodies and an automation in integrating the retainer to a guide device can be carried out, but being capable of extremely smooth rotatability to the rolling bodies with certainly, and its fabrication method.

Hence, according to an aspect of the present invention, there is provided an endless retainer of a guide device, the endless retainer comprising a number of rolling bodies arranged at predetermined intervals for rolling at an inside of an infinite track formed in the guide device, a flexible resin connector having interposing portions interposed among the respective rolling bodies and connecting portions for connecting the respective interposing portions for holding the number of rolling bodies in an aligned state and rotatably, and the resin connector is molded by an injection molding with the rolling bodies as cores by using a resin having a dimension change rate before and after an oil absorbing or a water absorbing treatment larger than a mold shrinkage rate and is provided with clearances between the resin connector and the rolling bodies formed by the oil absorbing or the water absorbing treatment.

Further, according to another aspect of the present invention, there is provided a method of fabricating an endless retainer for molding the resin connector holding the number of rolling bodies by an injection molding with the number of rolling bodies as cores by using a resin having a dimension change rate before and after an oil absorbing or a water absorbing treatment larger than a mold shrinkage rate, and forming clearances between the resin connector and the respective rolling bodies for rotating the rolling bodies by subjecting the resin connector to the oil absorbing or the water absorbing treatment after having been removed from a mold.

According to the present invention, resin used for molding the resin connector must be a resin having the dimension change rate before and after the oil absorbing or the water absorbing treatment larger than the mold shrinkage rate and a difference between the dimension change rate before and after the oil absorbing or the water absorbing treatment and the mold shrinkage rate preferably falls in a range of 0.1 through 2.0%, more preferably, 0.5 through 1.5%. When the difference between the dimension change rate before and after the oil absorbing or the water absorbing treatment and the mold shrinkage rate falls in a range of 0.1 through 2.0%, excellent rotatability of the rolling bodies can be provided by forming the clearances between the resin connector and the rolling bodies with certainty by the oil absorbing or the water absorbing treatment. Further, when the dimension change rate before and after the oil absorbing or the water absorbing treatment becomes excessively large by exceeding the magnitude of the mold shrinkage rate, there is a concern where the rolling bodies are detached from the resin connector after the oil absorbing or the water absorbing treatment, however, according to experiments by the inventors, the difference is the utmost of about 2 through 3% and there is no concern of detaching the rolling bodies from the resin connector with such a degree of the magnitude.

Here, the dimension change rate before and after the oil absorbing or the water absorbing treatment is a percentage of a value (elongation amount) of a length (length after treatment) of the resin connector (endless retainer) after the oil absorbing or the water absorbing treatment subtracted by a length (length before treatment) of the resin connector (endless retainer) before the oil absorbing or the water absorbing treatment as compared with the length (length before treatment) of the resin connector (endless retainer) before the oil absorbing or the water absorbing treatment and the mold shrinkage rate is a value calculated by the following equation in accordance with JIS K6911,5.7.

Mold shrinkage rate={(mold dimension−molded product dimension)÷mold dimension}×100

Further, in respect of the resin used for molding the resin connector according to the present invention, it is necessary that the molded resin connector can smoothly be moved along with the rolling bodies in an infinite track of the rolling bodies formed by bearing races of the guide device and for that purpose, the resin of the resin connector needs to have flexibility and Shore hardness of the resin preferably falls in a range of 35 through 75, more preferably, 40 through 60.

As the resin preferable in fabricating the resin connector having such a flexibility, for example, there are polyamide-base elastomer such as Pebax (commercial name made by Toray Corporation) or the like, polyester-base elastomer such as Hytrel (commercial name made by Toray and DuPont Corporations) or the like, elastomers of polyurethane-base elastomer, styrene-base elastomer, olefin-base elastomer and the like, soft polyvinyl chloride and so on and elastomers are preferable. Further, among the elastomers, in consideration of properties required for the resin connector, particularly, softness or flexibility, the dimension change rate in absorbing oil or absorbing water, chemical proof, elongation and the like, polyamide-base or polyester-base elastomer is more preferable and further, in consideration of a time period whereby the elongation amount reaches a saturated state in the oil absorbing or the water absorbing treatment, in other words, a time period until a change in dimension is stabilized (dimension stabilizing time), polyester-base elastomer is preferable.

Further, according to the present invention, a ball or a roller is pointed out as the rolling body used in the guide device and the ball is preferable in an endless retainer used in a guide device necessitating smooth slidability and the roller is preferable for an endless retainer used in a guide device necessitating to apply comparatively heavy load.

In fabricating an endless retainer according to the present invention, resin having the dimension change rate before and after the oil absorbing or the water absorbing treatment larger than the mold shrinkage rate is used, the resin connector holding the number of rolling bodies is molded by injection molding with the number of rolling bodies as cores and after removing the resin connector from a mold, clearances for rotating the rolling bodies are formed between the resin connector and the respective rolling bodies by subjecting the resin connector to the oil absorbing or the water absorbing treatment.

Here, in respect of injection molding with a number of rolling bodies as cores, so-called insert molding processes such as methods described in Japanese Examined Patent Publication No. JP-B-6-56181, Japanese Unexamined Patent Publication No. JP-A-5-52217, Japanese Unexamined Patent Publication No. JP-A-5-126149, Japanese Unexamined Patent Publication No. JP-A-5-196036 and Japanese Unexamined Patent Publication No. JP-A-5-196037 mentioned above are applicable.

Further, in respect of the oil absorbing or the water absorbing treatment for providing rotatability to the respective rolling bodies in the molded endless retainer, although arbitrary methods of a method of dipping an endless retainer which has been removed from a mold into oil or water, a method of spraying misty oil or water to an endless retainer which has been removed from a mold, a method of making an endless retainer which has been removed from a mold absorb oil or water under predetermined heating and pressing by using an autoclave or the like, a method of leaving an endless retainer which has been removed from a mold under high humidity, a method of leaving an endless retainer which has been removed from a mold in the atmosphere for a predetermined time period, and the like can be adopted, the preferable method is the method of dipping an endless retainer which has been removed from a mold into oil or into water and the more preferable method is the method for dipping the endless retainer into oil.

Further, also in respect of treatment conditions of the oil absorbing or the water absorbing treatment in this case, pertinent conditions can be selected and adopted depending on the method of treatment, the kind of resin used and the like, for example, according to the method of dipping an endless retainer which has been removed from a mold into oil or into water, normally, the endless retainer is normally dipped at temperature of normal temperature through 50° C. for several minutes through several hours, although the conditions differ also depending on the kind of resin.

The oil absorbing or the water absorbing treatment is for providing rotatability to a rolling body of a molded endless retainer and although when the rotatability is provided to the rolling body by the oil absorbing treatment, the rolling body can be integrated to a guide as it is, when, for example, moisture is adhered to the surface of the endless retainer after the treatment as in the case where the water absorbing treatment is carried out by dipping the endless retainer into water, the endless retainer is integrated to the guide device preferably after removing the moisture adhered to the surface.

As oil used in the oil absorbing treatment, although liquid lubricant, grease or petrolatum of semi-solid lubricant or the like having lubricating performance may be used, the oil is preferably liquid lubricant having lubricating performance, for example, lubricant of mineral oil-base or synthetic oil-base, lubricant of emulsion-base, liquid metal-base, water-base or the like can be pointed out.

Although in the oil absorbing or the water absorbing treatment, an elongation amount of an endless retainer after the treatment as compared with that before the treatment, that is, the elongation amount of the resin connector reaches to a saturated state after a constant period of time, the oil absorbing or the water absorbing treatment is not always necessary to carry out until the elongation amount reaches the saturated state, it is sufficient that the elongation amount of at least 0.1% or more, preferably, 0.3% or more in respect of the length before the treatment is shown and free rotatability of respective rolling bodies is provided to the resin connector.

However, when an endless retainer provided by finishing the oil absorbing or the water absorbing treatment is used by integrating it to a guide device before reaching the saturated state, the resin connector of the endless retainer absorbs lubricant used in the guide device and is elongated until it reaches the saturated state and there is a concern of effecting a hazard in the smooth sliding movement of the endless retainer in the guide device and accordingly, the oil absorbing or the water absorbing treatment is preferably carried out until the elongation amount of the endless retainer reaches a state near to the saturated state before being integrated to the guide device. Accordingly, in such a point of view, with respect to resin used as the resin connector, in consideration of the productivity, polyester-base elastomer having a comparatively short time period whereby elongation amount reaches the saturated state in the oil absorbing treatment (dimension stabilizing time) is preferable.

Further, according to the endless retainer of the present invention, chamfered guide portions are preferably formed at both distal ends of the resin connector by which in moving an infinite track formed by bearing races of the guide device, particularly when the front end portion of the endless retainer moves into a direction change path of the infinite track or when it moves out from the direction change path, the endless retainer can be moved by guiding the front end portion by the chamfered guide portion.

The chamfered guide portions formed at the both distal ends of the resin connector, are designed by considering a radius of curvature of the direction change path of the infinite track formed by the bearing races of the guide device and determining the size of the radius of curvature, the shape and so on. By forming the chamfered guide portions at the both distal ends of the resin connector, in the reciprocating movement of the guide device, the endless retainer can smoothly be guided in either of direction of progressing and regressing.

Further, although the length of the molded endless retainer is determined by considering the length of the infinite track of the guide device where it is used, when the guide device is large-sized and the length of the infinite track is large, the endless retainer may be molded by dividing it in a plural number of 2, 3 or the like by which the size of a mold for molding the endless retainer can be reduced. Further, in that case, it is preferable to form the chamfered guide portions respectively at both distal ends of the resin connector of each of the endless retainers divided in the plural number.

According to the present invention, in molding the resin connector by injection molding with the rolling bodies as cores, the resin connector holding the rolling bodies after having been removed from a mold, is shrunk in accordance with the magnitude of the mold shrinkage rate, by subjecting the resin connector to the oil absorbing or the water absorbing treatment, the resin connector is expanded in accordance with the magnitude of the dimension change rate before and after the oil absorbing or the water absorbing treatment and further, the dimension change rate before and after the oil absorbing or the water absorbing treatment is larger than the mold shrinkage rate and accordingly, portions surrounding the rolling bodies expand to exceed lengths at surroundings of the rolling bodies and as a result, clearances are formed between the rolling bodies and the resin connector with certainty by which excellent rotatability seems to be provided to the rolling bodies.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plane view showing an endless retainer in a chain-like shape according to an embodiment of the present invention;

FIG. **2** is a front view of FIG. **1**;

FIG. **3** is a sectional view taken along a line III—III of FIG. **1**;

FIG. **4** is a partially enlarged plane view showing an end portion of the endless retainer of FIG. **1** by enlargement;

FIG. **5** is a graph diagram showing a time-sequential change in an elongation rate when an oil absorbing treatment is carried out in accordance with Method A;

FIG. **6** is a graph diagram showing a time-sequential change in an elongation rate when an oil absorbing treatment is carried out in accordance with Method B;

FIG. **7** is a graph diagram showing a time-sequential change of an elongation rate when a water absorbing treatment is carried out in accordance with Method C;

FIG. **8** is a graph diagram showing a relationship between an elapse time and the elongation rate after dipping endless retainers in respect of two kinds of endless retainers provided in Embodiment 2;

FIG. **9** is a partially sectional side view showing a linear guide device for infinite sliding integrated with an endless retainer fabricated by the invented method (Method B);

FIG. **10** is a partially sectional front view of FIG. **9**; and

FIG. **11** is a graph diagram of measuring rolling resistance by using a load cell which has been measured in respect of the linear guide device of FIG. **9**.

DESCRIPTION OF REFERENCE NUMERAL

E_R: endless retainer, **1** or **1***a:* ball, **2**: resin connector, **2***a:* interposing portion, **2***b:* connecting portion, **3**: chamfered guide portion, **4**: track rail (one bearing race), **5**: sliding base (other bearing race), **5***a:* loaded ball rolling face, **5***b:* through hole, **6**: ball guide member, **6***a:* unloaded ball guide hole, **6***b:* loaded ball guide groove, **6***c:* direction change guiding unit, **7**: lid, **8**: direction change path.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A specific explanation will be given of an endless retainer according to the present invention and its fabrication method based on embodiments, test examples and application examples shown by attached drawings as follows.

Embodiment 1

FIG. **1** through FIG. **4** show an endless retainer E_R in a chain-like shape according to the embodiment of the present invention. The endless retainer E_R is constituted by a number of balls **1** made of bearing steel (SUJ 2) arranged at predetermined intervals and a flexible resin connector **2** having interposing portions **2***a* interposed among the respective balls **1** and connecting portions **2***b* for connecting the respective interposing portions **2***a* for holding a number of balls **1** linearly and rollably.

Further, according to the embodiment, as shown by FIG. **4**, at both distal ends of the resin connector **2**, chamfered guide portions **3** each having a section substantially in a circle concentric to the balls **1***a,* are formed at distal end portions surrounding the balls **1***a* disposed at the distal ends.

The endless retainer E_R is fabricated by the following procedure.

First, a mold with a number of the balls **1** as cores is used and the resin connector **2** is molded by injection molding of 6•6 nylon-polyamide-base elastomer (made by Toray Corporation, commercial name: Pebax® 5533SA, mold shrinkage rate: 0.43% in flow direction and 0.74% in direction orthogonal to flow, Shore hardness: 55) and fabricated by removing it from the mold along with the number of balls **1**.

Next, the endless retainer E_R fabricated in this way is subjected to an oil absorbing treatment or a water absorbing treatment by the following methods, length dimensions before and after the treatment are measured and dimension change rates before and after the oil absorbing or the water absorbing treatment are calculated.

Further, in calculating the dimension change rates before and after the oil absorbing or the water absorbing treatment, the dimension change rates are measured by preparing 5 pieces of samples of the endless retainer E_R and in respect of each of the samples.

[Method A]

The molded endless retainer E_R is immediately dipped into a mineral-base lubricant at normal temperature and left in the lubricant as it is and the dimension change rates (elongation rates) are calculated by measuring the lengths of the samples of the endless retainer E_R after 1 hour, after 6 hours, after 50 hours, after 80 hours and after 124 hours since the dipping operation has been started.

Table 1 shows the lengths of the samples of the endless retainer E_R in starting dipping operation, 1 hour after start of dipping and 6 hours after start of dipping and the elongation rates at the respective measurements are shown by FIG. **5**.

TABLE 1

	Length (mm, upper column) and Elongation rate (%, lower column)		
Sample No.	Start of dipping	1 hour after start of dipping	6 hours after start of dipping
No. 1	115.988	116.144	116.552
	(0.00)	(0.13)	(0.49)
No. 2	115.973	116.207	116.656
	(0.00)	(0.20)	(0.59)
No. 3	116.058	116.155	116.548
	(0.00)	(0.08)	(0.42)
No. 4	116.017	116.220	116.636
	(0.00)	(0.17)	(0.53)
No. 5	115.883	116.292	116.655
	(0.00)	(0.35)	(0.67)

The rotatability of ball is investigated as follows in respect of the samples of the endless retainer E_R. That is, the sample of the endless retainer E_R is sandwiched between two sheets of plates, one of the plates is fixed while the other thereof is moved and whether the sample of the endless retainer E_R is moved at the occasion and smoothness of movement when the sample is moved are qualitatively investigated.

As a result, in respect of the samples of 1 hour after start of dipping, the rotatability of ball is confirmed except the sample of No. 3, the comparatively smooth rotatability of ball is confirmed in respect of the samples of 6 hours after start of dipping and the extremely excellent rotatability of ball is confirmed in respect of samples of 50 hours after start of dipping.

[Method B]

The molded samples of the endless retainer E_R are immediately dipped into a mineral-base lubricant at normal temperature for 5 minutes, thereafter taken out from the lubricant and left in a room, and the dimension change rates (elongation rates) are calculated by measuring lengths of the samples of the endless retainer E_R at immediately after taking them out from the lubricant (0 hour), 24 hours thereafter, 45 hours thereafter, 69 hours thereafter, 118 hours thereafter and 190 hours thereafter, respectively.

The result is shown by FIG. **6**. Further, as a result of investigating the rotatability of ball similar to the case of Method A mentioned above, the rotatability of ball is recognized in respect of the samples of the endless retainer E_R immediately after having been taken out from the lubricant except the sample of No. 2 and the comparatively excellent rotatability of ball is recognized in respect of the samples of 24 hours or longer after starting to leave them in the room.

[Method C]

The molded samples of the endless retainer E_R are left in the atmosphere as they are (temperature 23° C., humidity 50 through 60%) and the dimension change rates (elongation rates) are calculated by measuring lengths of the samples of the endless retainer E_R of 24 hours after starting to leave them, 40 hours thereafter and 96 hours thereafter, respectively. The result is shown in FIG. **7**.

Further, as a result of investigating the rotatability of ball similar to the case of Method A mentioned above, the rotatability of ball is recognized in respect of the samples of the endless retainer E_R of 24 hours after starting to leave them in the atmosphere except the sample of No. 1 and the rotatability of ball is recognized in respect of all the samples of the endless retainer E_R of 48 hours after starting to leave them.

Embodiment 2

6•6 nylon-polyamide-base elastomer (made by Toray Corporation, commercial name: Pebax 5533SA) the same as that used in Embodiment 1 mentioned above and polyester-base elastomer (made by Toray Corporation and DuPont Corporation, commercial name: Hytrel® 4767, mold shrinkage rate: 1.2 through 1.5%, hardness under JIS K7215: 47) are used, the resin connectors **2** are molded similar to Embodiment 1 mentioned above, a oil absorbing treatment is successively carried out in accordance with the dipping method of Method A, the dimension change rate (elongation rate) in this occasion is time-sequentially investigated and a time period (dimension stabilizing time) until the change in dimensions is stabilized within a range of the elongation rate of 0.5 through 1.5% in carrying out the oil absorbing treatment, is investigated. The result is shown by FIG. **8**.

As is apparent from the result of FIG. **8**, in the case of 6•6 nylon-polyamide-base elastomer, the elongation rate exceeds about 0.8% at 100 minutes after starting to dip the sample in the oil absorbing treatment, successively, rapid change in dimension is observed up to about 200 hours and little by little change in dimension is caused thereafter even after 460 hours has elapsed. By contrast, in the case of polyester-base elastomer, the elongation rate exceeds 0.5% at about 50 hours after staring to dip the sample in the oil absorbing treatment and reaches about 0.8% for 100 hours, a gradual change in dimension is successively observed up to about 200 hours, however, almost no change in dimension is observed thereafter even exceeding 500 hours.

As a result, it is known that by using polyester-base elastomer, a time period for reaching a range of the preferable elongation rate of 0.5 through 1.5% is prolonged compared with the case of 6•6 nylon-polyamide-base elastomer, however, the dimension stabilizing time period for stabilizing the change in dimension is significantly shortened, which is advantageous in fabricating the endless retainer E_R.

Application Example 1

A linear guide device for infinite sliding shown by FIG. **9** and FIG. **10** is constituted by using the endless retainer E_R which has been subjected to the oil absorbing or the water absorbing treatment in accordance with Method B in Embodiment 1.

The linear guide device for infinite sliding is basically constituted by a rigid track rail (one bearing race) **4** made of metal, a rigid sliding base (other bearing race) **5** made of metal, a ball guide member **6** made of synthetic resin and attached to the sliding base **5** by insert molding and lids **7** made of synthetic resin and attached to the sliding base **5** along with the ball guide member **6**.

Further, the track rail **4** is formed with rolling faces **4***a* of balls **1** at both shoulder portions thereof and the sliding base **5** is formed with loaded ball rolling faces **5***a* of the balls **1** on which load is applied and through holes **5***b* through which the balls **1** in an unloaded state pass. Further, the ball guide member **6** is formed with unloaded ball guide holes **6***a* for guiding rolling of the balls **1** under the unloaded state, loaded ball guide grooves **6***b* for guiding rolling of the balls **1** under a loaded state and direction change guiding units **6***c* for guiding to change the direction of the balls **1** by communicating and connecting the unloaded ball holes **6***a* with the loaded ball guide grooves **6***b* by a predetermined radius of curvature. Further, the lid **7** is formed with direction change guide grooves **7***a* for constituting direction change paths **8** of the balls **1** along with the direction change guide portions **6***c* of the ball guide members **6** mentioned above.

According to the embodiment, an infinite track of the ball **1** is constituted by the loaded ball rolling face **5***a* of the sliding base **5** as well as the loaded ball guide groove **6***b* of the ball guide member **6** opposed thereto, the unloaded ball guide hole **6***a* of the ball guide member **6**, the direction change guide portions **6***c* of the ball guide members **6** and the direction change guide grooves **7***a* of the lids **7** opposed thereto.

In respect of the linear guide device fabricated in this way, rolling resistance of the sliding base **5** with respect to the track rail **4** is measured by fixing the track rail **4** and pushing the sliding base **5** by a load cell at a sampling frequency of 500 Hz of the load cell.

The result is as shown by FIG. **11** in which values of the rolling resistance in a moving region partitioned by bold lines are 1.389 Newton (N) in starting, 1.439 N as maximum rolling resistance, 1.179 N as minimum rolling resistance and 1.302 N as average rolling resistance which is found to be extremely smooth.

Industrial Applicability

An endless retainer according to the present invention is not only provided with advantages where fabrication thereof is extremely facilitated, handling thereof is extremely easy without detachment of rolling bodies and automation in integrating the retainer to a guide device can be carried out but is capable of providing extremely smooth rotatability to the rolling bodies with certainty.

Accordingly, the endless retainer of the present invention is extremely useful for use of, for example, a linear guide device or a curved guide device for infinite sliding and a guide device of pivoting bearing or the like.

What is claimed is:

1. An endless retainer of a guide device, said endless retainer comprising:

a number of rolling bodies arranged at predetermined intervals for rolling at an inside of an infinite track formed in the guide device;

a flexible resin connector having interposing portions interposed among the respective rolling bodies and connecting portions for connecting the respective interposing portions for holding the number of rolling bodies in an aligned state and rotatably; and

wherein the resin connector is molded by an injection molding with the rolling bodies as cores by using a resin having a dimension change rate before and after an oil absorbing or a water absorbing treatment larger than a mold shrinkage rate and is provided with clearances between the resin connector and the rolling bodies formed by the oil absorbing or the water absorbing treatment.

2. The endless retainer of a guide device according to claim **1**:

wherein a difference between the dimension change rate before and after the oil absorbing or the water absorbing treatment of the resin forming the resin connector falls in a range of 0.1 through 2.0%.

3. The endless retainer of a guide device according to claim **1** or **2**:

wherein an oil used in the oil absorbing treatment is a mineral oil-base or a synthetic oil-base lubricant.

4. The endless retainer of a guide device according to any one of claim **1** or **2**:

wherein chamfered guide portions for guiding a front end portion of the resin connector are installed at both distal ends of the resin connector.

5. The endless retainer of a guide device according to any one of claim **1** or **2**:

wherein Shore hardness of the resin forming the resin connector falls in a range of 35 through 75.

6. The endless retainer of a guide device according to any one of claim **1** or **2**:

wherein the resin forming the resin connector is any of polyamide-base elastomer, polyester-base elastomer, polyurethane-base elastomer, styrene-base elastomer and olefin-base elastomer.

7. The endless retainer of a guide device according to any one of claim **1** or **2**:

wherein the rolling body is a ball.

8. A method of fabricating an endless retainer of a guide device, said endless retainer comprising:

a number of rolling bodies arranged at predetermined intervals for rolling at an inside of an infinite track formed in the guide device;

a flexible resin connector having interposing portions interposed among the respective rolling bodies and connecting portions for connecting the respective interposing portions for holding the number of rolling bodies in an aligned state and rotatably, said method of fabricating the endless retainer comprising the steps of:

molding the resin connector holding the number of rolling bodies by an injection molding with the number of rolling bodies as cores by using a resin having a dimension change rate before and after an oil absorbing or a water absorbing treatment larger than a mold shrinkage rate; and

forming clearances between the resin connector and the respective rolling bodies for rotating the rolling bodies by subjecting the resin connector to the oil absorbing or the water absorbing treatment after having been removed from a mold.

9. The method of fabricating an endless retainer according to claim **8**:

wherein the oil absorbing or the water absorbing treatment is carried out by dipping the resin connector holding the rolling bodies into an oil or water.

10. The method of fabricating an endless retainer according to claim **8** or **9**:

wherein the oil used in the oil absorbing treatment is a mineral oil-base or a synthetic oil-base lubricant.

11. The method of fabricating an endless retainer according to claim **8**:

wherein the resin forming the resin connector is any of polyamide-base elastomer, polyester-base elastomer, polyurethane-base elastomer, styrene-base elastomer and olefin-base elastomer.

12. A guide device comprising:

a pair of bearing races;

a number of rolling bodies rolling at an inside of an infinite track formed between the pair of bearing races;

wherein the number of rolling bodies are formed in an endless retainer in a chain-like shape by being held in an aligned state and rotatably by a flexible resin connector having interposing portions interposed among the respective rolling bodies and connecting portions for connecting the respective interposing portions; and

wherein the resin connector is molded by an injection molding with the rolling bodies as cores by using a resin having a dimension change rate before and after an oil absorbing or a water absorbing treatment larger than a mold shrinkage rate and is provided with clearances between the resin connector and the rolling bodies formed by the oil absorbing or the water absorbing treatment.

* * * * *

US005957586A

United States Patent [19]

Okamoto et al.

[11] **Patent Number: 5,957,586**

[45] **Date of Patent: *Sep. 28, 1999**

[54] **ROLLING GUIDE UNIT**

[75] Inventors: **Isao Okamoto**, Higashi-Murayama; **Takeki Shirai**, Ichikawa, both of Japan

[73] Assignee: **THK Co. Ltd.**, Tokyo, Japan

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

This patent is subject to a terminal disclaimer.

[21] Appl. No.: **08/868,067**

[22] Filed: **Jun. 3, 1997**

Related U.S. Application Data

[62] Division of application No. 08/404,925, Mar. 15, 1995, Pat. No. 5,716,139.

[30] **Foreign Application Priority Data**

Mar. 18, 1994 [JP] Japan 6-72950

[51] **Int. Cl.**[6] **F16C 31/06**

[52] **U.S. Cl.** **384/45**

[58] **Field of Search** 384/43, 44, 45, 384/48, 49

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,898,273	2/1933	Stevens	384/48
2,047,868	7/1936	Harley	384/49
4,582,369	4/1986	Itoh	384/45 X
4,616,886	10/1986	Teramachi	384/45
5,240,331	8/1993	Ninomiya et al.	384/45
5,273,365	12/1993	Kondoh	384/45

FOREIGN PATENT DOCUMENTS

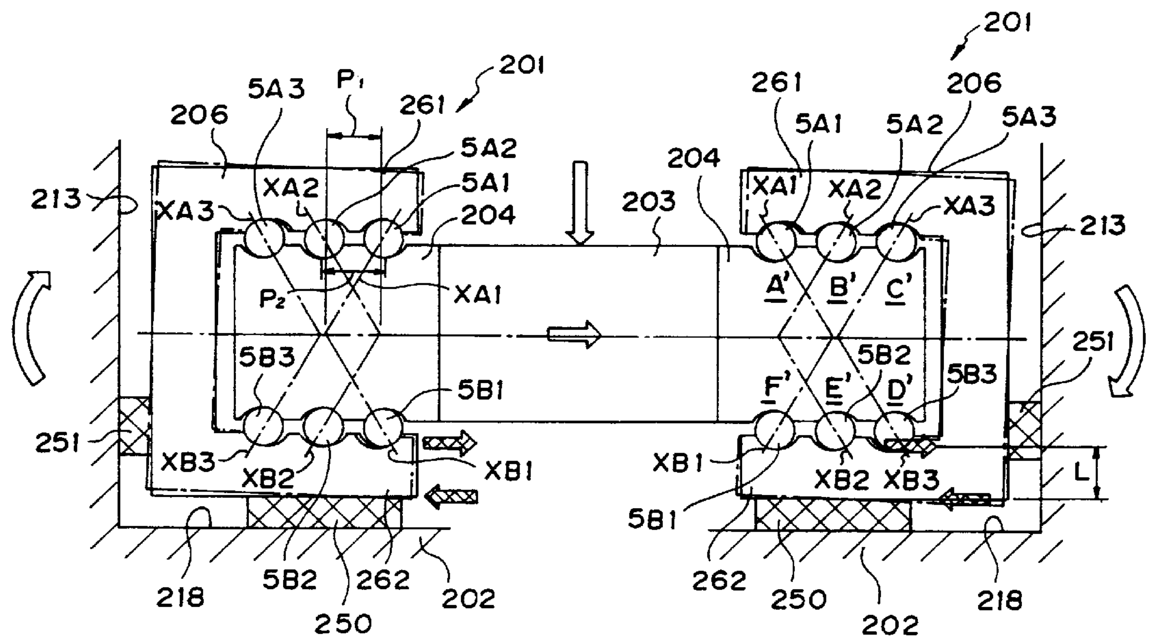
39 31 351 A1	3/1991	Germany .
41 32 320	4/1992	Germany .
41 34 864	4/1992	Germany .
42 09 824	3/1993	Germany .
102714	4/1992	Japan .
2 139 298	11/1984	United Kingdom .

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

A rolling guide unit comprises a movable member provided with a pair of support portions extending from lateral end portions of a main body portion so as to provide a recessed portion between the main body portion and both the support portions, a guide rail disposed in the recessed portion of the movable member so that side surfaces of the guide rail face the inner surfaces of the support portions, respectively, and a number of rolling members disposed to be rollable between corresponding rolling member rolling grooves formed to the guide rail and the support portions of the movable member so that each of the rolling members contact the rolling member rolling grooves at two contact points and the rolling members apply load to the rolling member rolling grooves, the movable member and the guide rail being relatively movable through the rolling of the rolling members. Each of the rolling member rolling grooves has an arcuate shape in section having radius of curvature larger than that of the rolling member and the contact points are displaceable along the arcuate shape of the rolling member rolling groove.

32 Claims, 17 Drawing Sheets



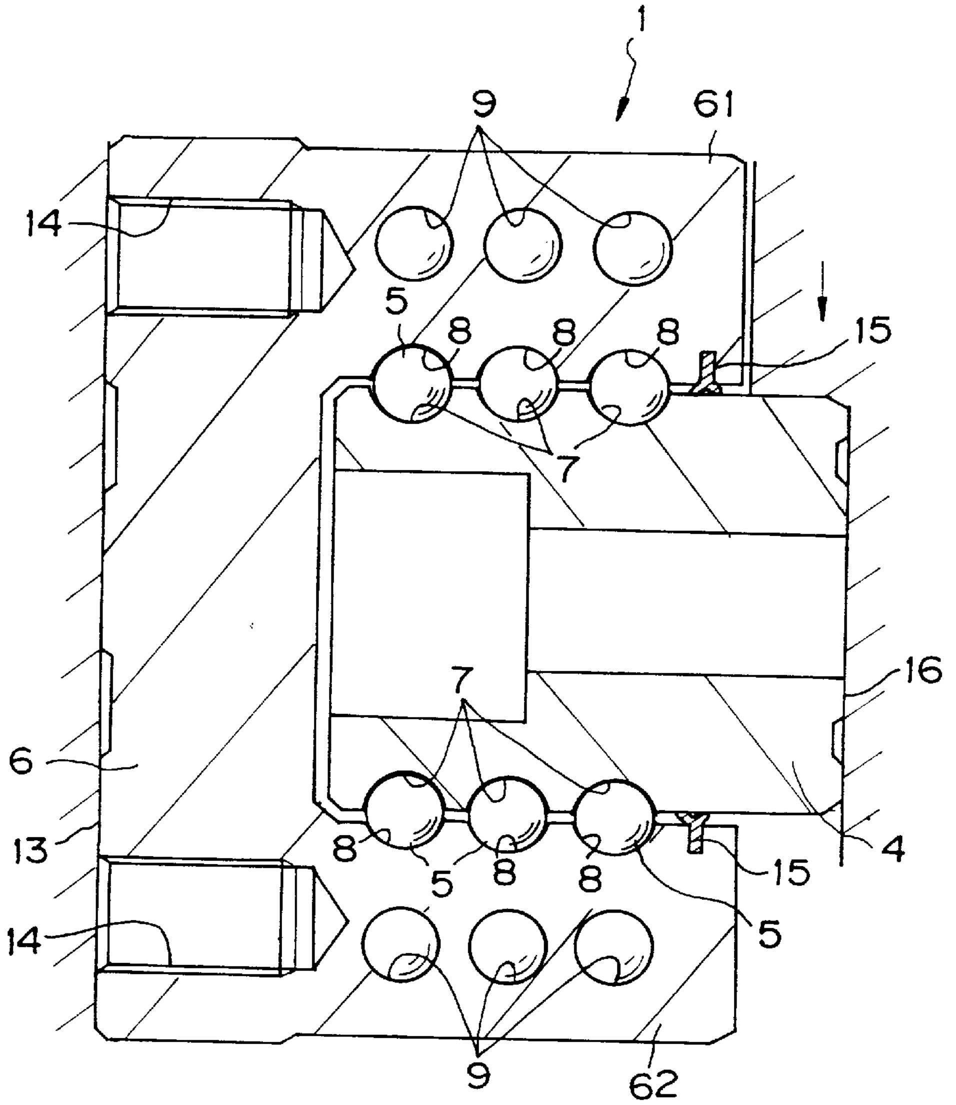


FIG. 1A

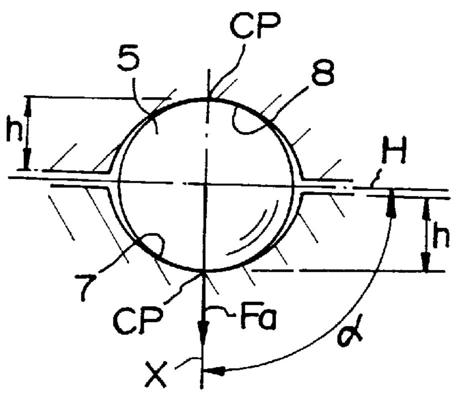


FIG. 1B

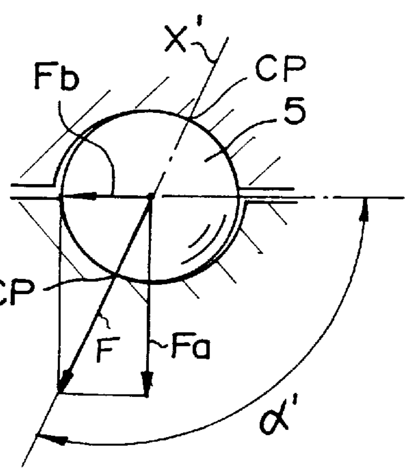


FIG. 1C

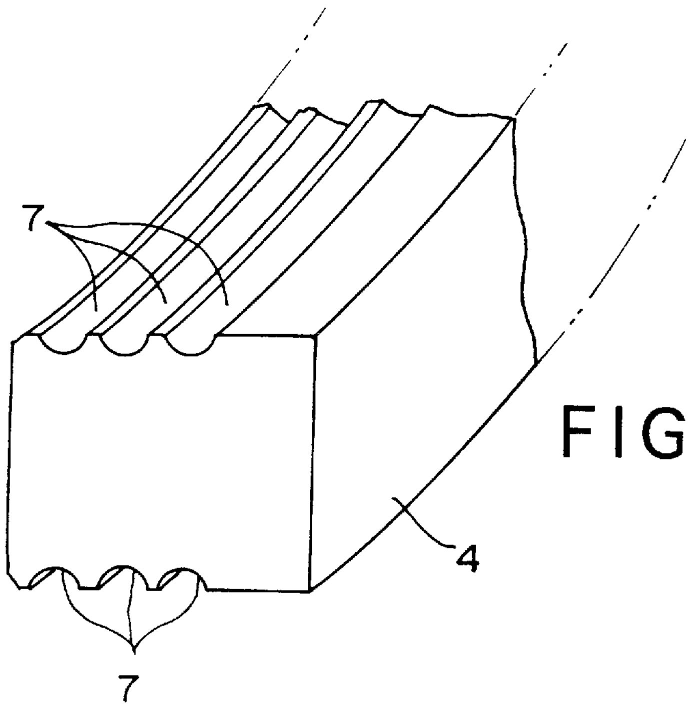


FIG. 2A

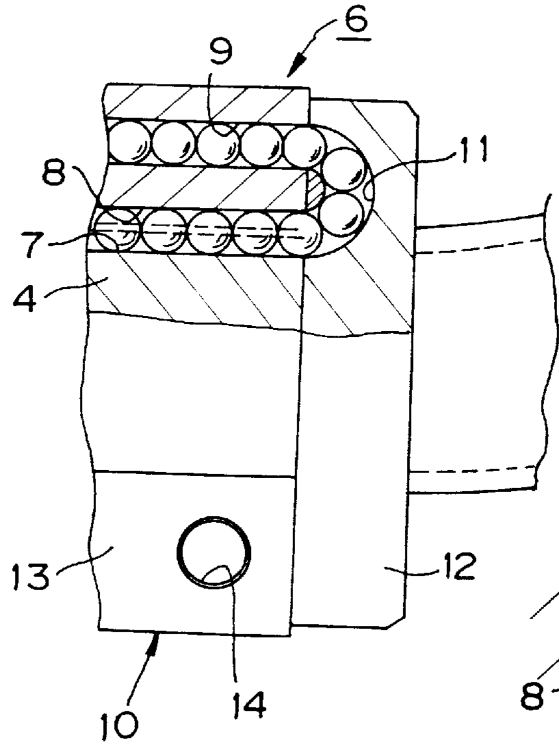


FIG. 2B

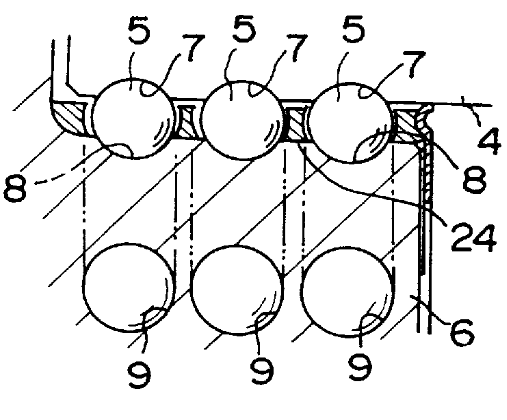


FIG. 2C

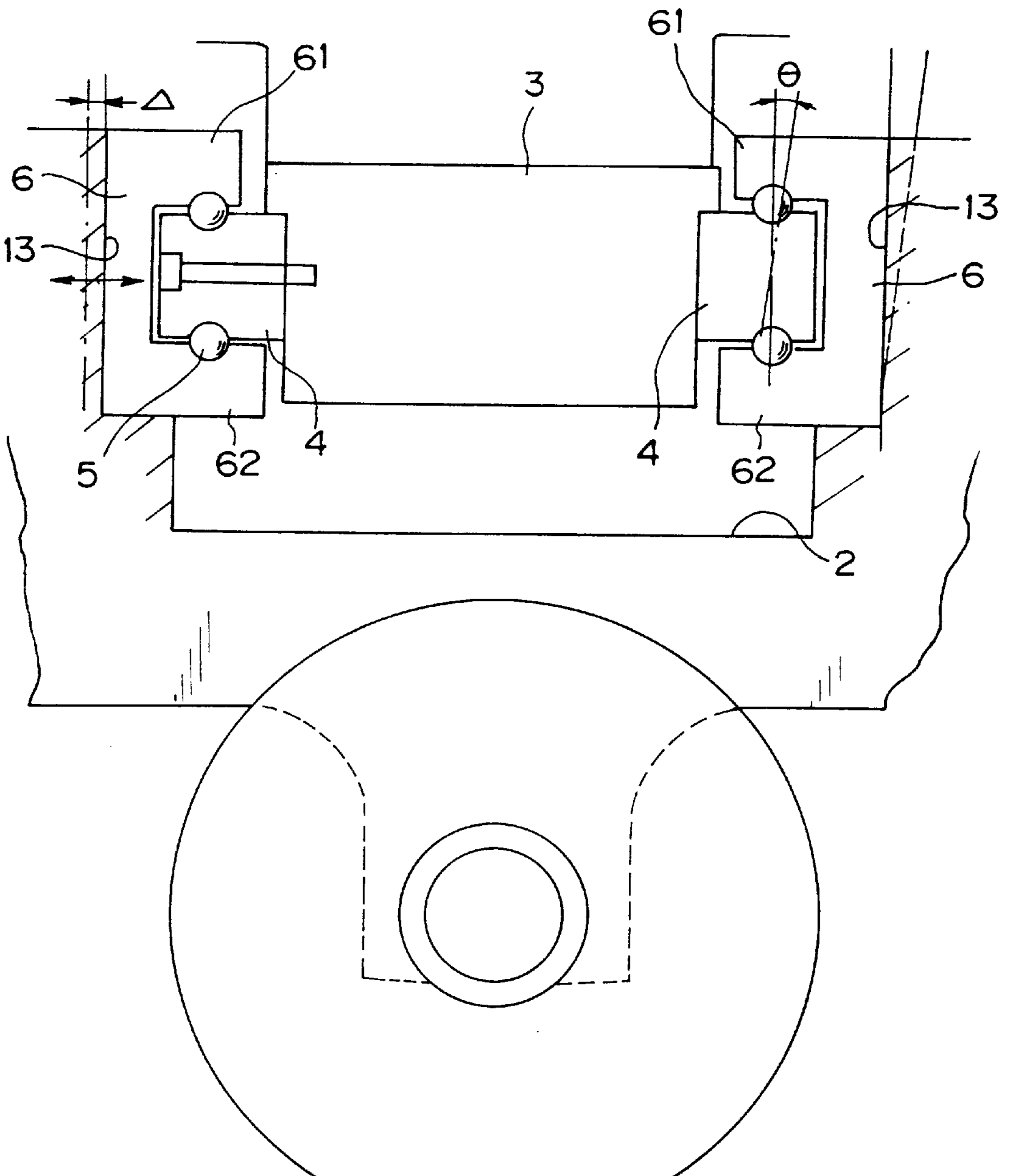


FIG. 3

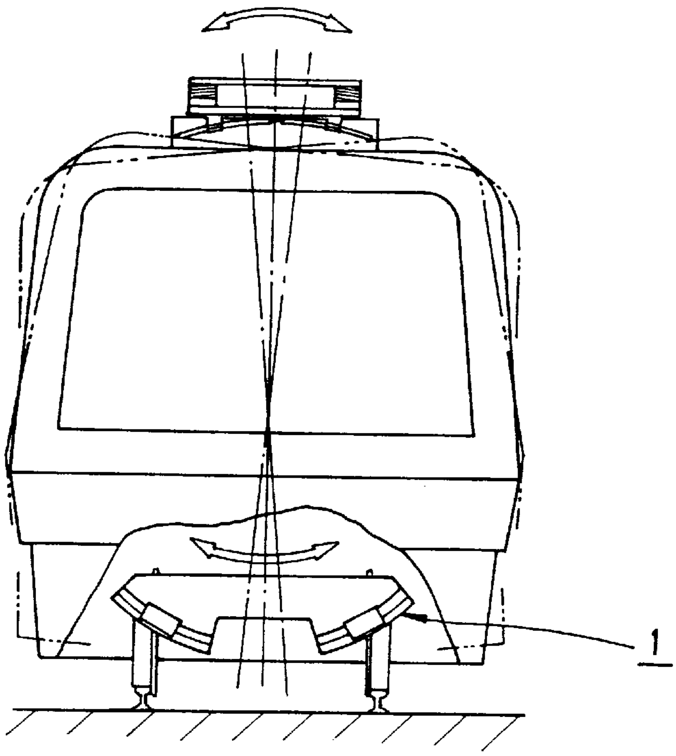


FIG. 4A

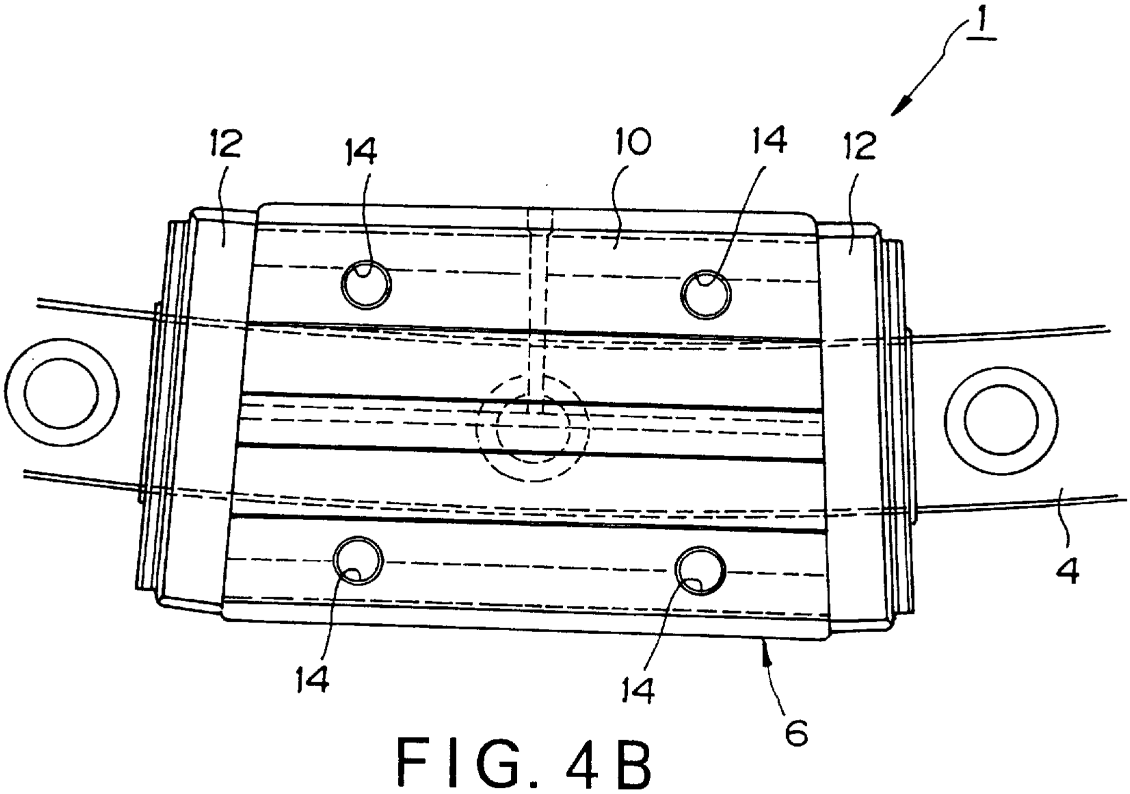


FIG. 4B

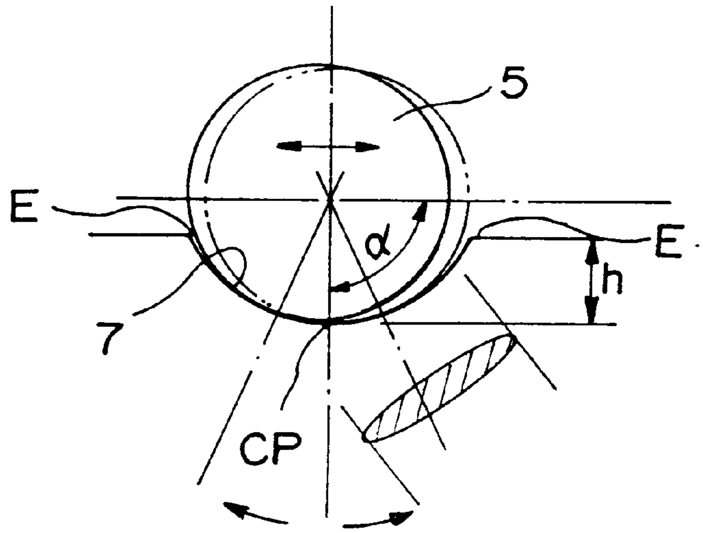


FIG. 5A

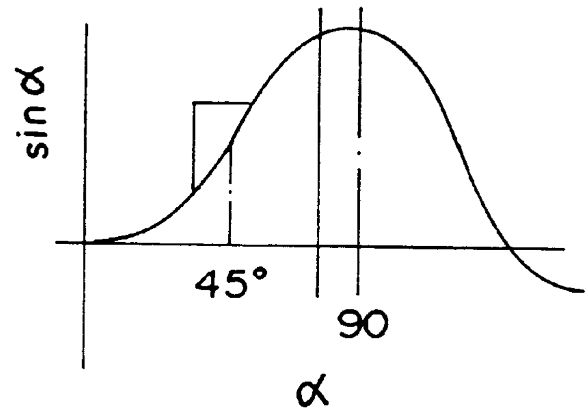


FIG. 5B

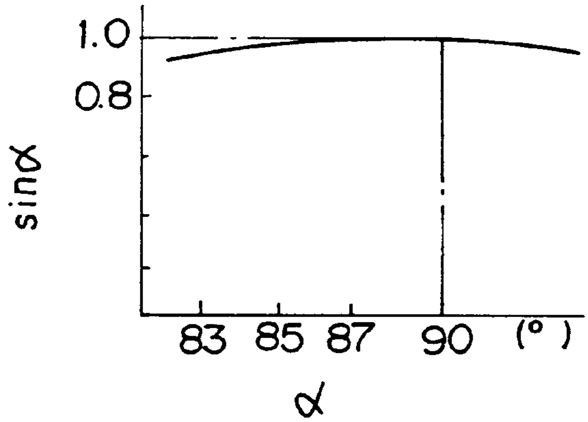


FIG. 5C

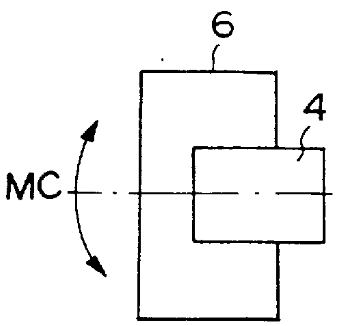


FIG. 6A

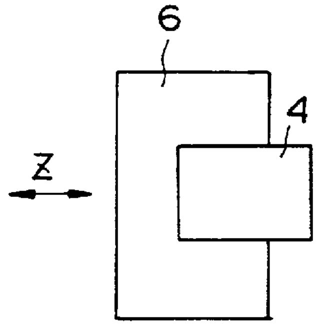


FIG. 6B

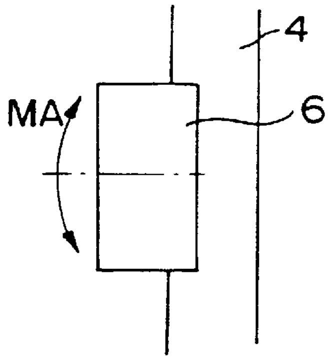


FIG. 6C

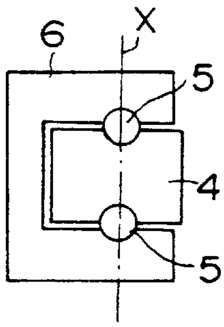


FIG. 6D

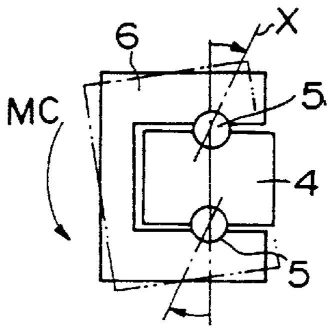


FIG. 6E

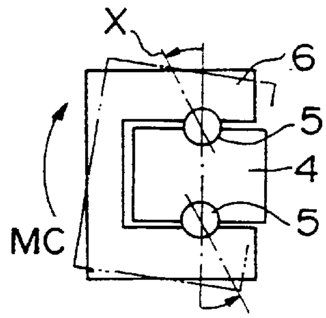


FIG. 6F

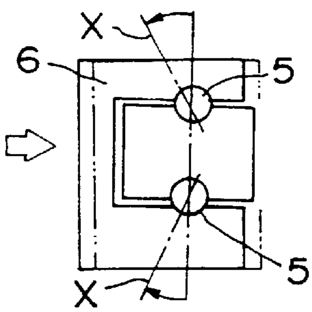


FIG. 6G

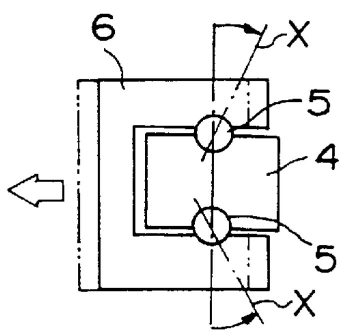


FIG. 6H

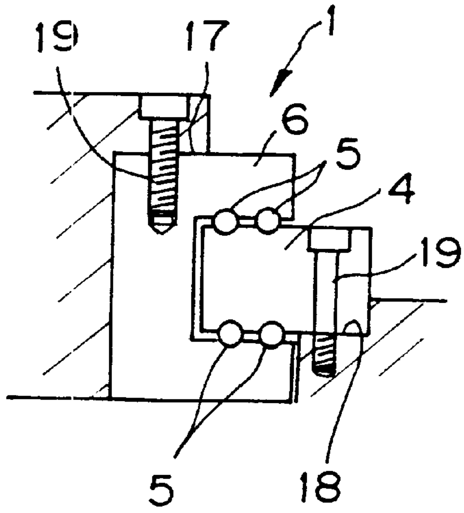


FIG. 7A

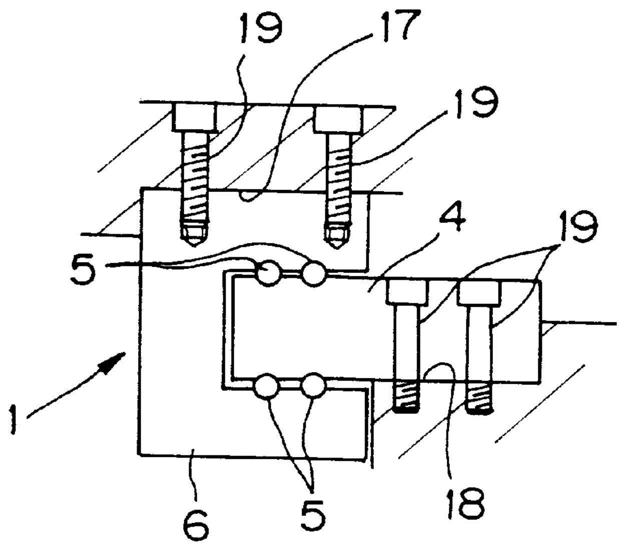


FIG. 7B

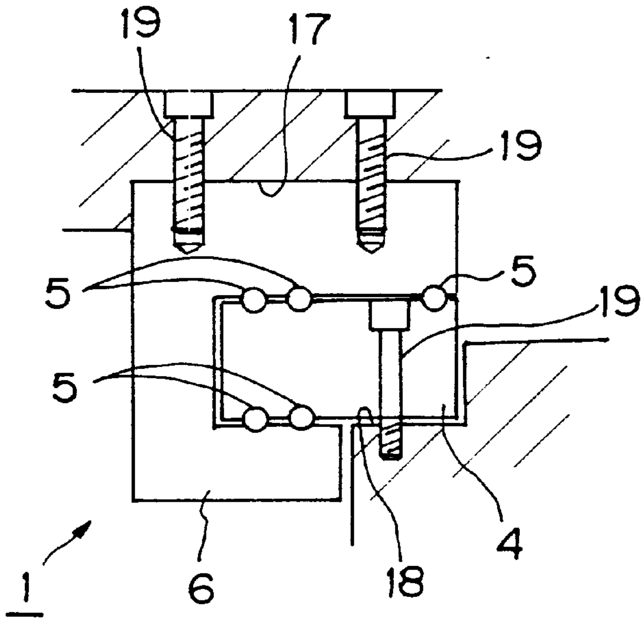


FIG. 7C

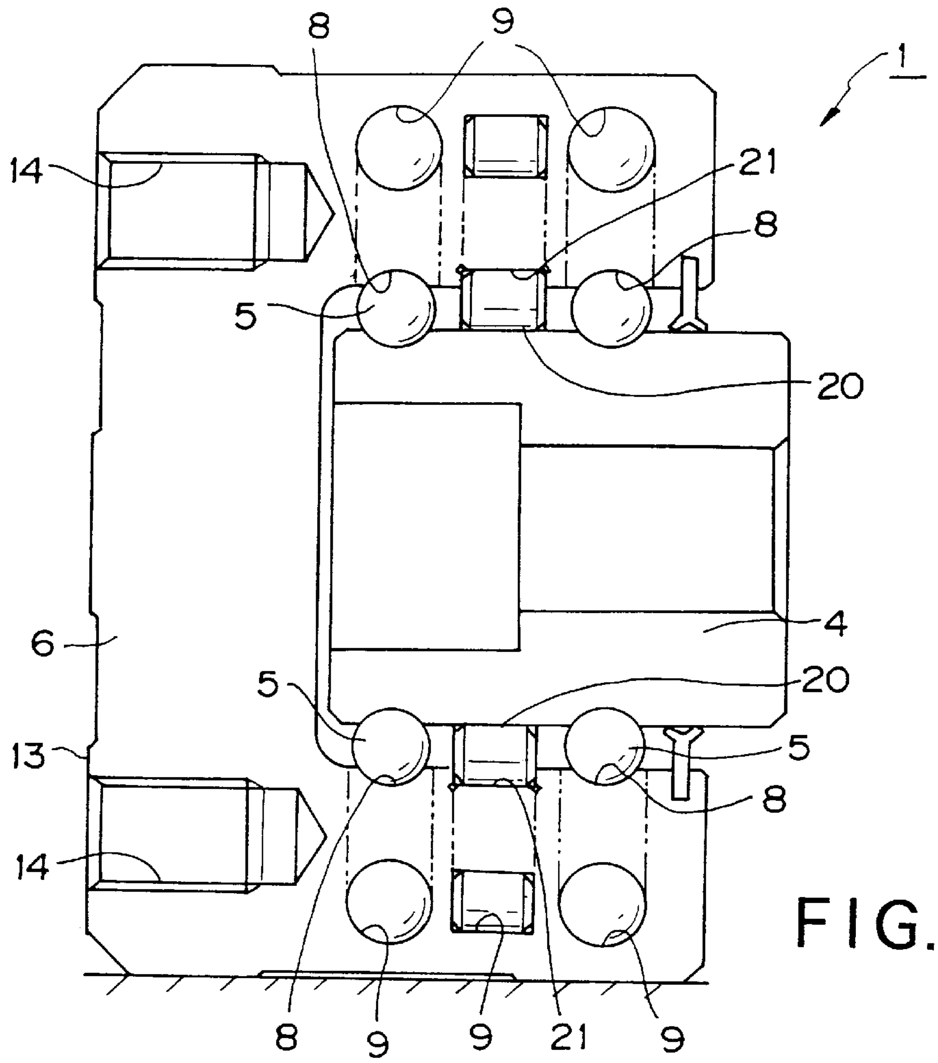


FIG. 8A

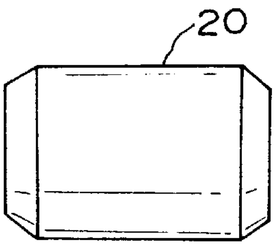


FIG. 8B

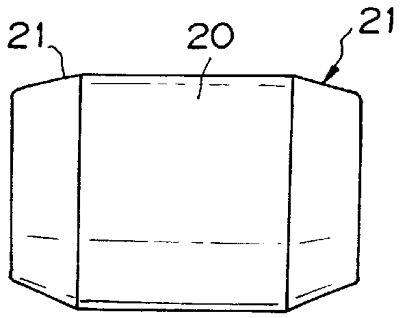


FIG. 8C

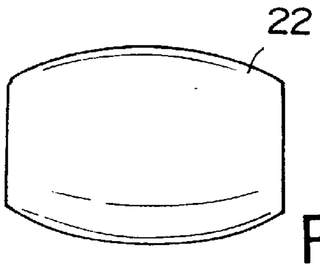


FIG. 8D

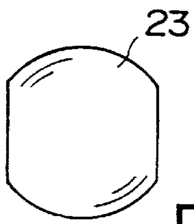


FIG. 8E

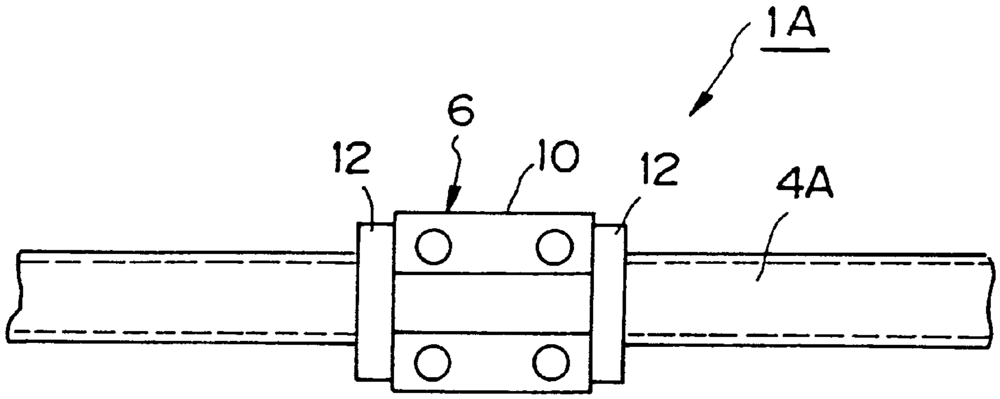


FIG. 9A

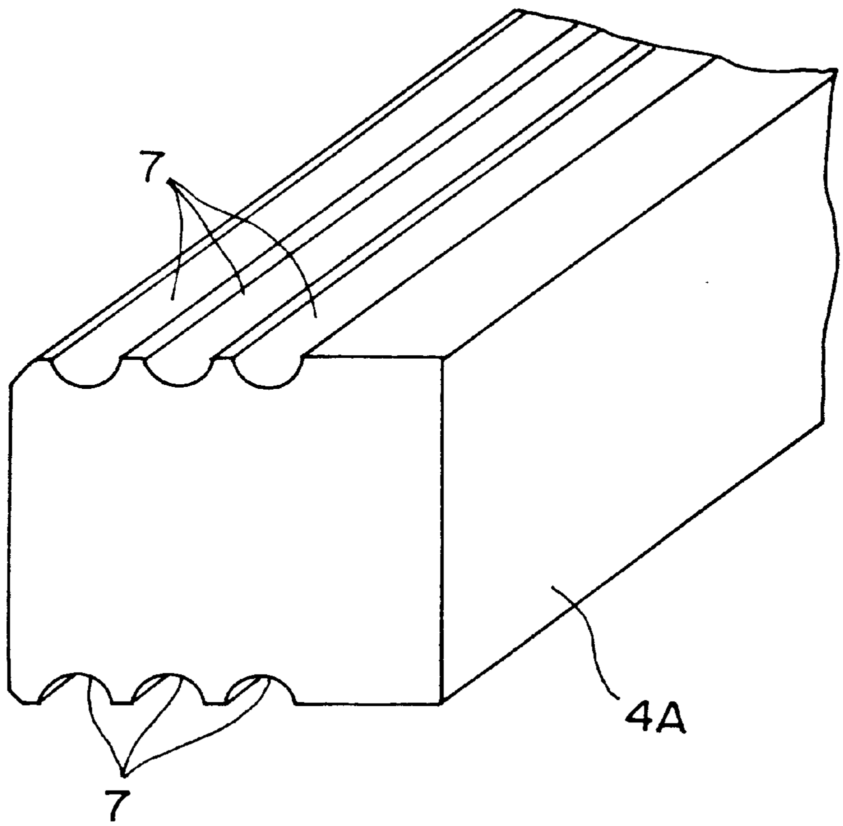


FIG. 9B

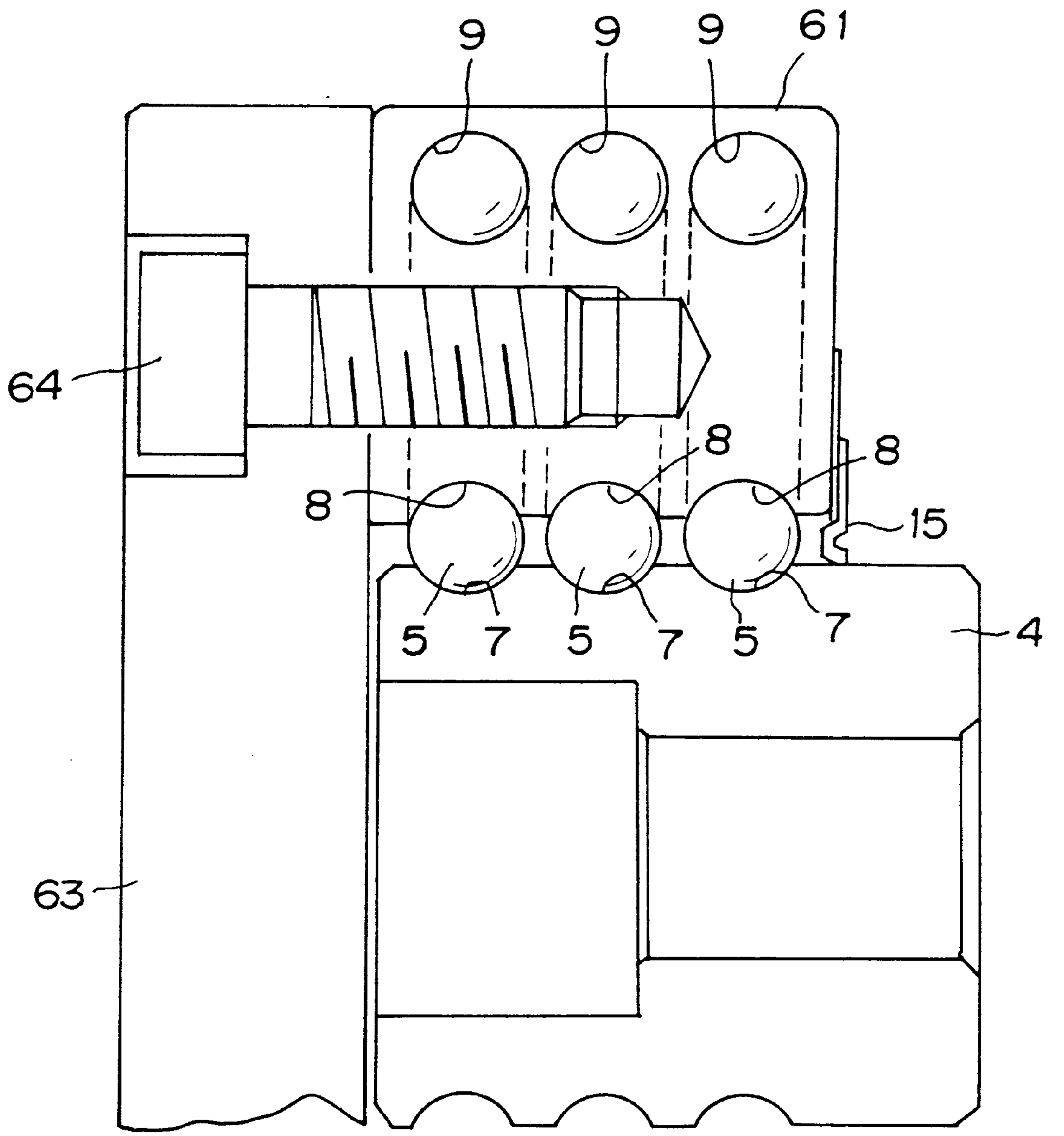


FIG.10

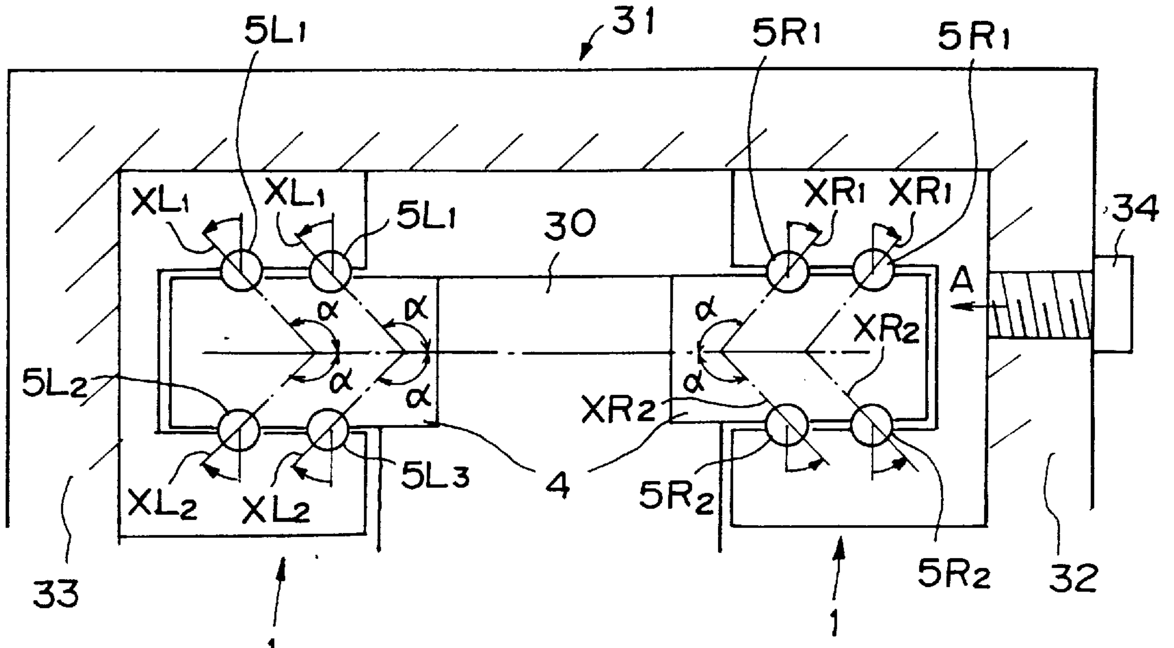


FIG. 11 A

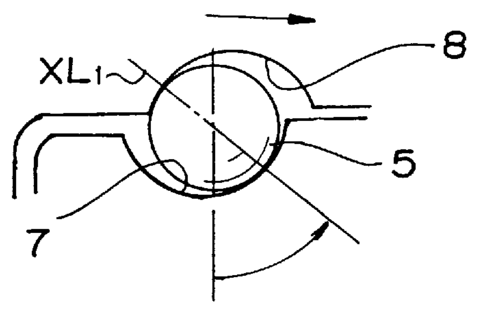
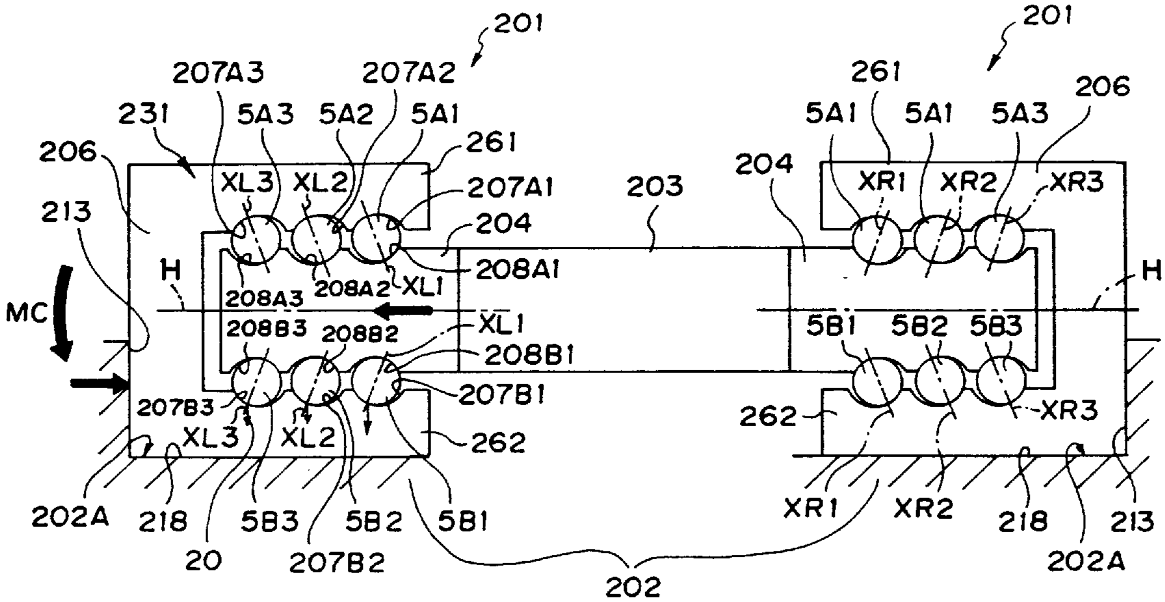
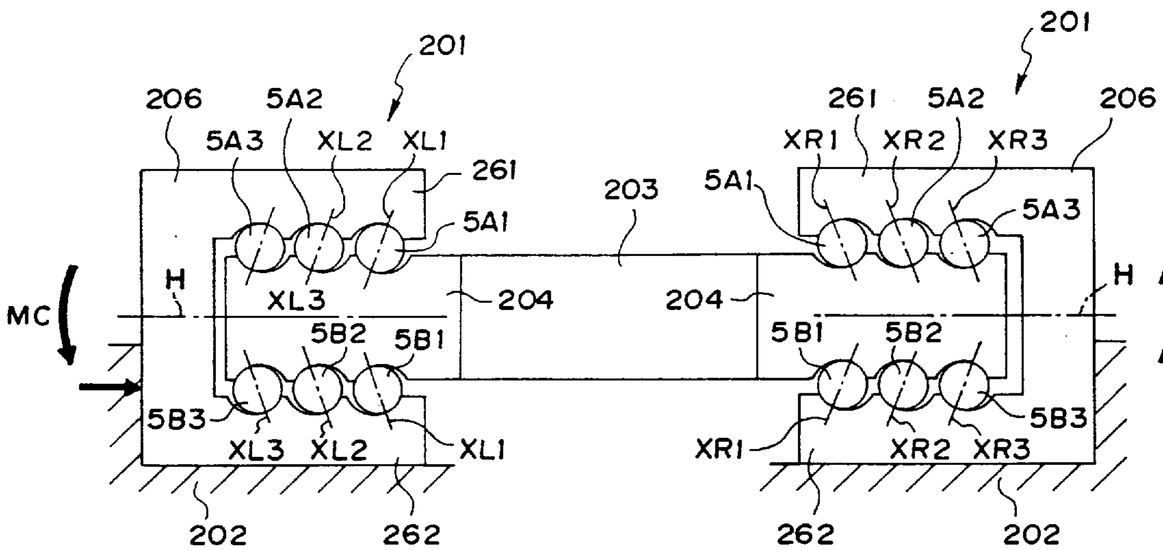


FIG. 11 B



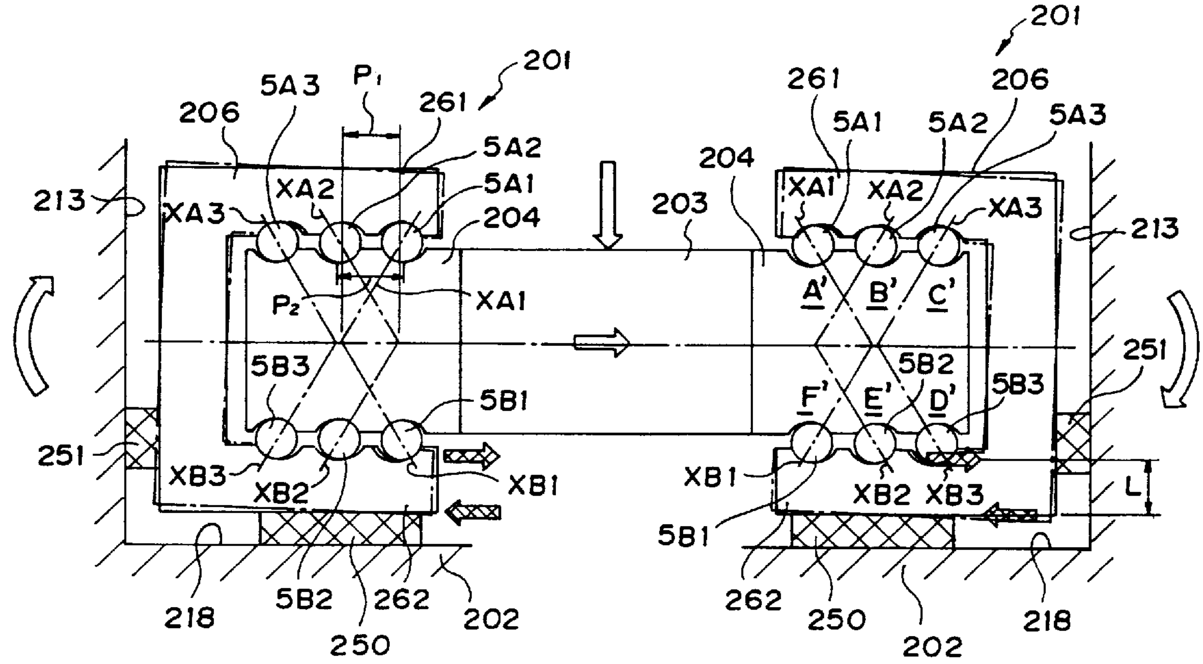
201
201
207A3
207A2
261
206
231
5A3
5A2
5A1
5A1
5A1
5A3
206
261
204
XR1
XR2
XR3
XL3
XL2
207A1
203
213
204
H
208A1
H
208A3
208A2
XL1
MC
208B3
208B2
XL1
5B1
5B2
5B3
208B1
207B1
207B3
262
XR3
XL3
XL2
262
202A
218
5B3
5B2
5B1
XR1
XR2
218
213
20
207B2
202A
202

FIG. 12



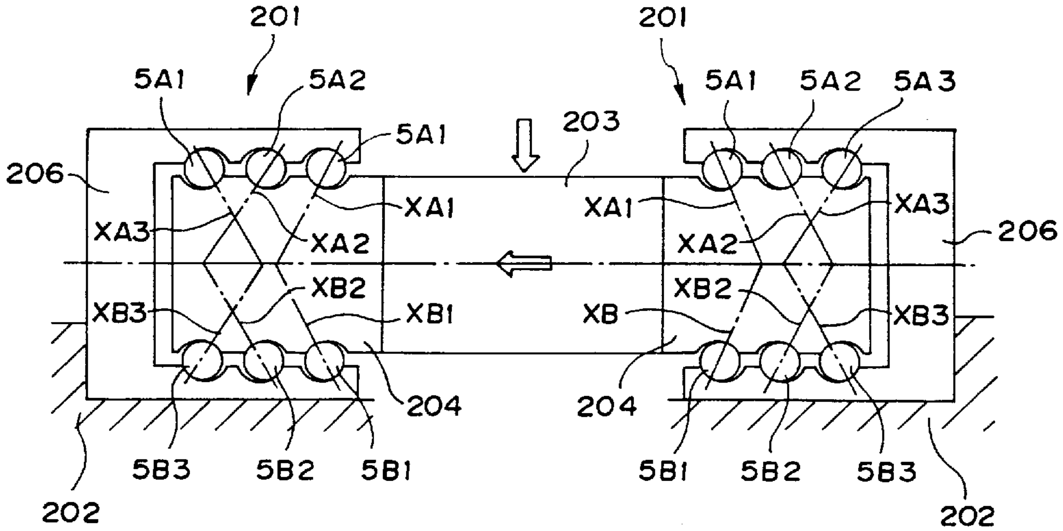
201
201
206
5A2
261
5A2
206
5A3
XL2
XL1
XR1
XR2
XR3
261
203
5A1
5A1
5A3
H
XL3
204
204
H
MC
5B2
5B1
5B1
5B2
5B3
5B3
XL3
XL2
XL1
XR1
XR2
XR3
202
262
262
202

FIG. 13



201
206
5A3
P1
261
5A2
5A1
204
203
213
XA3
XA2
XA1
P2
5B3
5B1
251
XB3
XB2
XB1
218
5B2
262
202
250
XA1'
A'
B'
C'
F'
E'
D'
5B2
5B3
L

FIG. 14



201
5A1
5A2
5A3
203
206
XA1
XA2
XA3
XB1
XB2
XB3
XB
204
5B1
5B2
5B3
202

FIG. 15

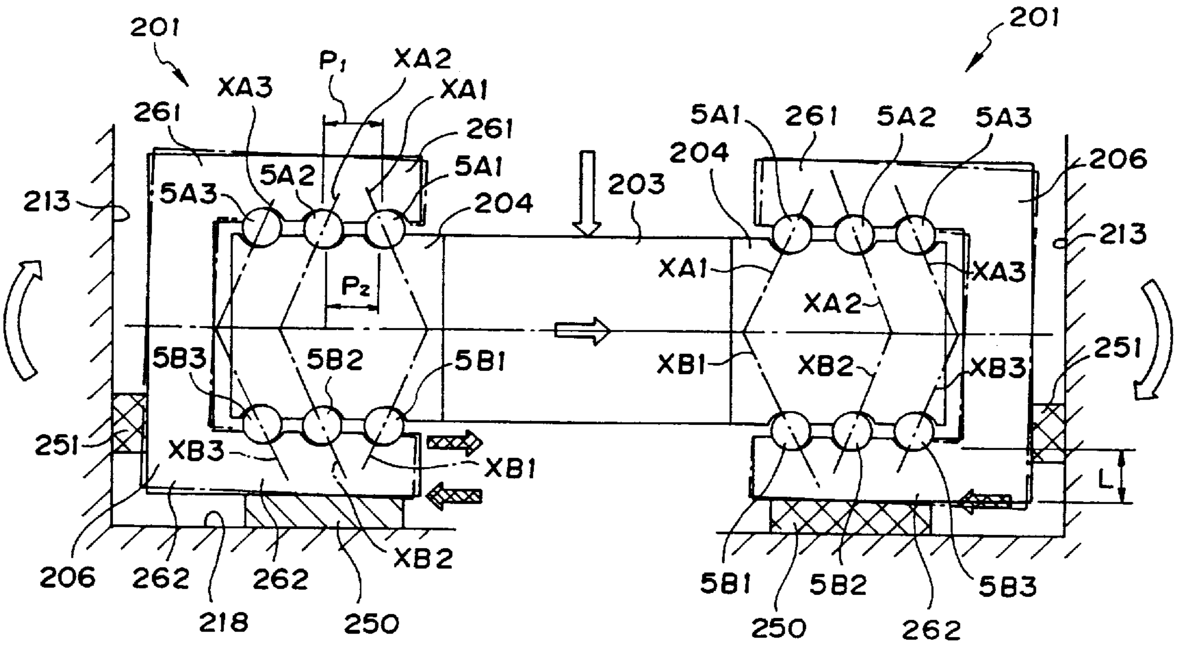

201
201
P1
XA2
XA3
XA1
261
261
5A1
261
5A2
5A3
5A1
204
206
5A2
5A3
203
213
204
213
XA1
XA3
P2
XA2
251
5B3
5B2
5B1
XB1
XB2
XB3
251
XB3
XB1
L
XB2
206
262
262
5B1
5B2
5B3
218
250
250
262

FIG. 16

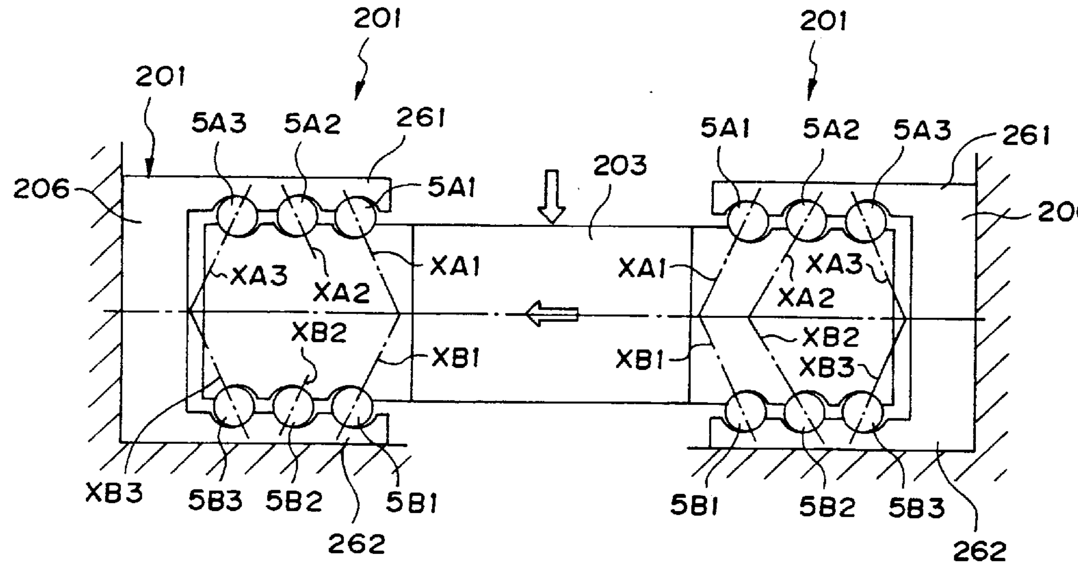

201
201
201
5A3
5A2
261
5A1
5A2
5A3
261
206
5A1
203
206
XA1
XA1
XA3
XA3
XA2
XA2
XB2
XB2
XB1
XB1
XB3
XB3
5B3
5B2
5B1
5B1
5B2
5B3
262
262

FIG. 17

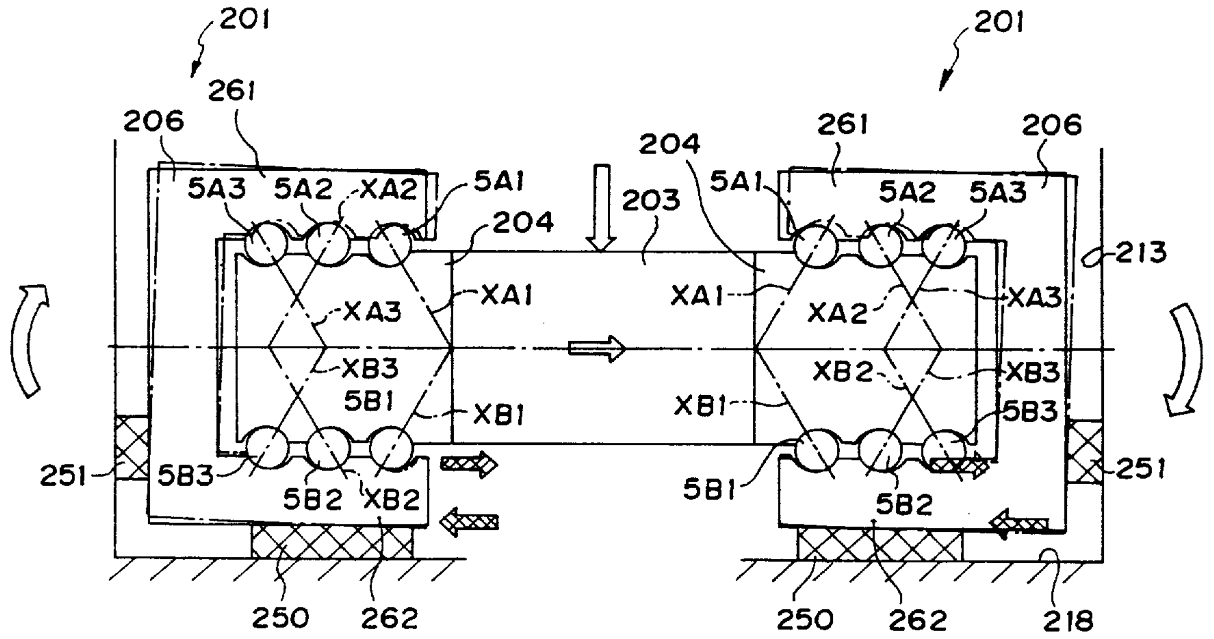

201
201
261
206
261
206
204
5A3
5A2
XA2
5A1
5A1
5A2
5A3
204
203
213
XA1
XA3
XA1
XA2
XA3
XB3
5B1
XB2
XB3
XB1
XB1
5B3
251
5B3
5B1
251
5B2
XB2
5B2
250
262
250
262
218

FIG.18

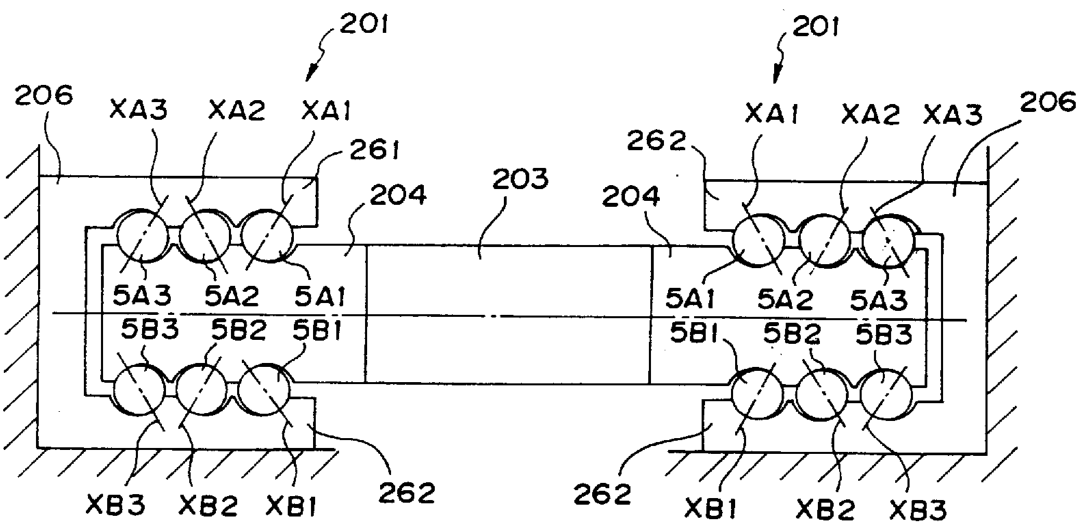

201
201
206
XA3
XA2
XA1
261
XA1
XA2
XA3
206
262
204
203
204
5A3
5A2
5A1
5A1
5A2
5A3
5B3
5B2
5B1
5B1
5B2
5B3
XB3
XB2
XB1
262
262
XB1
XB2
XB3

FIG.19

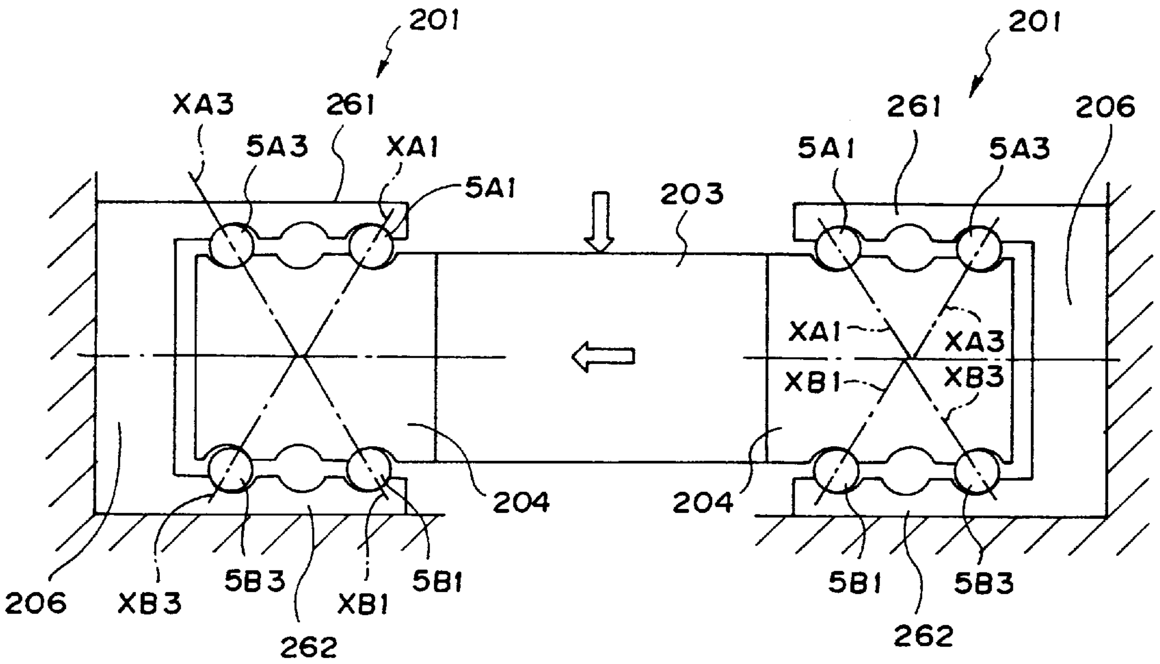

201
201
XA3
261
5A3
XA1
5A1
203
5A1
261
5A3
206
XA1
XA3
XB1
XB3
204
204
206
XB3
5B3
XB1
5B1
262
5B1
5B3
262

FIG. 20

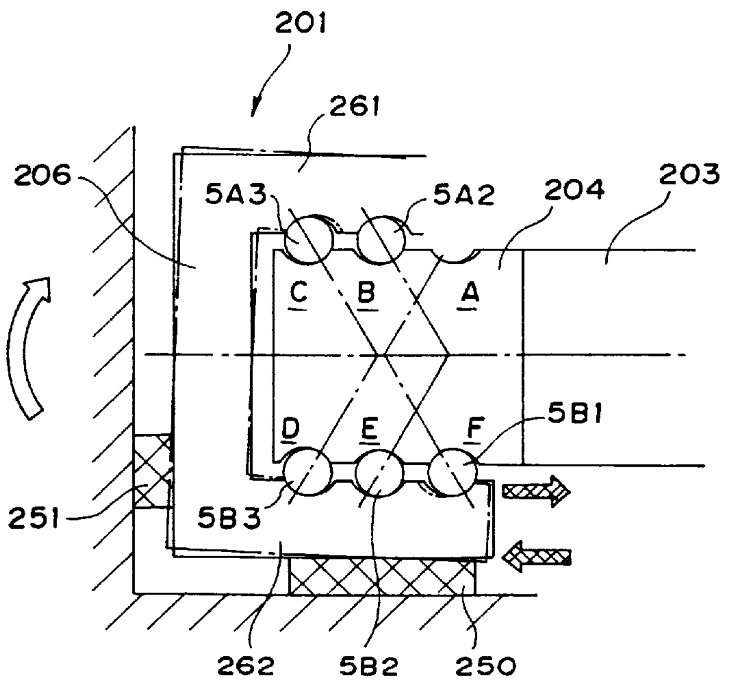

201
261
206
5A3
5A2
204
203
C
B
A
D
E
F
5B1
251
5B3
262
5B2
250

FIG. 21

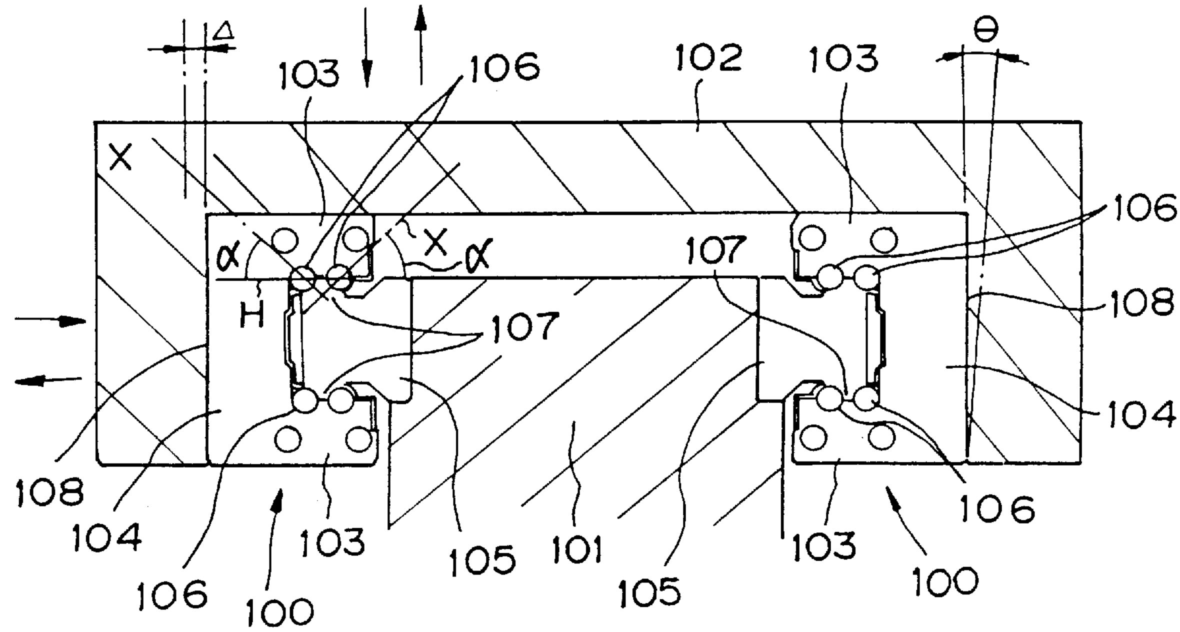


FIG. 22 PRIOR ART

ROLLING GUIDE UNIT

This is a divisional of application Ser. No. 08/404,925 filed Mar. 15, 1995, now U.S. Pat. No. 5,716,139.

BACKGROUND OF THE INVENTION

The present invention relates to a rolling guide unit of rolling contact type linear or curved, such as circular, guide passage, particularly capable of being excellent in misalignment adjustment performance.

As a known example of such rolling guide unit, there is provided an example shown in FIG. **22** in which a rolling guide unit **100** is disposed so as to guide a table **102** with respect to a fixed base **101**.

The rolling guide unit **100** is assembled in a manner that a movable member **104** having a U-shape in cross section is provided with a pair of upper and lower support portions **103** extending in a lateral direction, i.e. longitudinal direction of the movable member, and upper and lower surfaces of a guide rail disposed in the U-shaped hollow portion of the movable member **104** are supported by the support portions through upper and lower two rows of balls **106**. In general, high rigidity is required for such rolling guide unit, and in the known art, the rigidity in every direction including vertical and horizontal directions is made high by applying a preload to the balls **106** and forming projecting ribs **107** to the upper and lower side surfaces of the guide rail **105** so as to project therefrom thereby to clamp the ribs **107** by the respective two rows of the balls **106** from the upper and lower directions thereof. Particularly, in the illustrated example, in order to equally support the load in the every direction, a contact angle α of a line X connecting contacting points of the ball **106** to two ball rolling grooves with respect to a virtual horizontal line is set to 45°.

The known rolling guide unit of the type shown in FIG. **22**, however, has high rigidity, and accordingly, when a working error, for example, an angular error θ and a dimensional error Δ in the horizontal direction, is caused to a mounting surface of the movable member **104**, a misalignment is caused between the guide rail **105** and the movable member **104** at the time of clamping and fixing the rolling guide unit between the table **102** and the fixed base **101**. Such misalignment constitutes a cause of an application of excessive force to the movable member **104**, resulting in the increasing of a sliding resistance and abrasion of the balls **106** and the ball rolling groves, thus providing a problem.

Such misalignment will be avoided by increasing the working performance of the respective members of the rolling guide unit. However, the increasing of the working performance has a limit itself and involves cost increasing.

In the meantime, the misalignment will be somewhat reduced by making small the preload to be applied to the balls **106**, but the high rigidity of the rolling guide unit will be reduced by making small the preload to be applied. As mentioned above, the requirement of the high supporting rigidity is contrary to the reduction of the misalignment of the members, and hence, in the prior art construction, it is difficult to satisfy both the requirements for the realization of the high rigidity and the less misalignment.

SUMMARY OF THE INVENTION

An object of the present invention is to substantially eliminate defects or drawbacks encountered in the prior art described above and to provide a rolling guide unit capable of absorbing misalignment in a horizontal direction while

maintaining vertical rigidity of the unit and also maintaining an allowable load bearing ability.

This and other objects can be achieved according to the present invention by providing a rolling guide unit comprising:

a movable member provided with a main body portion and a pair of support portions extending from lateral end portions of the main body portion so as to provide a recessed portion between the central portion and both the support portions, the support portions having inner surfaces to which rolling member rolling grooves are formed;

a guide rail disposed in the recessed portion of the movable member so that side surfaces of the guide rail face the inner surfaces of the support portions, respectively, the side surfaces of the guide rail being formed with rolling member rolling grooves at portions corresponding to the rolling member rolling grooves of the support portions, respectively; and

a number of rolling members disposed to be rollable between the corresponding rolling member rolling grooves of the guide rail and the support portions of the movable member so that each of the rolling members contact the rolling member rolling grooves at two contact points and the rolling members apply load to the rolling member rolling grooves, the movable member and the guide rail being relatively movable through the rolling of the rolling members;

wherein each of the rolling member rolling grooves has an arcuate shape in section having radius of curvature larger than that of the rolling member and the contact points are displaceable along the arcuate shape of the rolling member rolling groove.

In preferred embodiments, the rolling member is a ball and each of the rolling member rolling grooves has a depth of approximately ¼ to ½ of a diameter of the ball.

A plurality of rolling member rolling grooves are formed at least one of the side surfaces of the guide rail and at least corresponding one inner surface of the support portion of the movable member.

An initial contact angle constituted by a line connecting the two contact points of the rolling members to the rolling member rolling grooves and a horizontal line passing a center of the rolling member is set substantially 90°.

A plurality of rolling member rolling grooves are formed at least one of the side surfaces of the guide rail and at least corresponding one inner surface of the support portion of the movable member, and an initial contact angle constituted by a line connecting the two contact points of the rolling members in at least one of the plurality of rolling member rolling grooves to this rolling member rolling groove and a horizontal line passing a center of the rolling member is set so as to have an inclination by a predetermined angle with respect to the angle of substantially 90°. All the rolling members disposed in the plurality of rolling member rolling grooves have contact angles inclined in the same direction or in directions reverse to each other.

A plurality of rolling member rolling grooves are formed at least one of the side surfaces of the guide rail and at least corresponding one inner surface of the support portion of the movable member, and the rolling members disposed in at least one of the plurality of rolling member rolling grooves are formed as tubular members and the rolling member rolling groove in which the tubular members are rolled is formed so as to provide a flat groove bottom. The rolling member rolling grooves for the tabular members are formed to the inner surfaces of the support portions so as to provide a groove bottom shape corresponding to an outer shape of the tubular member and the side surfaces of the guide rail for the tubular members are formed to be flat. Three rows of the rolling member grooves are formed and a central one is formed for the tubular members.

The guide rail has substantially rectangular cross section and is bent in a curved shape or has substantially linear shape.

Retainer means are disposed between the facing inner surfaces of the support portions of the movable member and the side surfaces of the rail guide.

The support portions are integrally formed with the main body portion of the movable member. The support portions may be independently formed with the main body portion of the movable member and the support portions are fixed to the main body portion of the movable member by means of bolts. The support portions have extending lengths different from each other and the numbers of rows of the rolling members of the respective support portions are different from each other.

According to the structures and characters of the rolling guide unit according to the present invention described above, the vertical load is born by the rolling members disposed between the upper and lower, as viewed in the illustrations of the drawings, support portions of the movable member and the guide rail. Particularly, in an arrangement in which the initial contact angle of the rolling member is set to approximately 90°, a vertical large load can be effectively born. When a horizontal load is applied, the contact points of the rolling member to the rolling member rolling groove are displaced to change the contact angle by the load balance between the vertical load and the horizontal, i.e. Lateral, load, thereby to effectively bear both the loads.

With respect to the misalignment in the horizontal direction, the contact points of the rolling members are displaced along the arcuate shape of the rolling member rolling groove thereby to absorb the misalignment.

Since the rolling member rolling groove has an arcuate shape in section, the allowable load is represented by a sine function with a contact angle being variable. According to the present invention, the contact angle is set to a value near **90**- about which the sine function shows a curve having a gentle variation, so that the allowable load varies small in amount even if the contact angle varies.

Since the depth of the rolling member rolling groove is set to a value approximately ¼ to ½ of the diameter of the rolling member such as ball, the ball does not contact the edge portions of the groove even if the contact points are displaced, and hence, the edge load is eliminated.

Furthermore, according to the present invention, the guide rail can be prevented from forming with a complicated cross section such as provided with projection ribs as in a conventional structure and the rolling member rolling grooves can be worked through a horizontal grinding working. Particularly, when the guide rail having a curved shape is formed, it can be formed so as to provide a simple rectangular shape, thus being uniformly bent.

In the case of contact angle of 90°, the contact points are displaced by the application of the horizontal load, and the variation of the contact points can be absorbed immediately by changing the initial contact angle in accordance with the load to be applied. The contact angle can be changed to an optional value by applying a horizontal load of predetermined amount, and for example, the horizontal load can be

born by setting the contact angle to, for example, 30° or 45° in accordance with the load to be applied. In such case, since the contact points of the rolling member to the rolling member rolling groove can be displaceable, the misalignment can be effectively absorbed.

The nature and further characters of the present invention will be made more clear through the following descriptions made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** represents one embodiment of a rolling guide unit according to the present invention, in which FIG. **1**A is a cross-sectional view of the guide unit, FIG. **1**B is a view showing a contacting condition of a ball to a ball rolling groove of FIG. **1**A in an enlarged scale, and FIG. **1**C is a view similar to FIG. **1**B at a time when loads are applied to the ball in both horizontal and vertical directions as viewed;

FIG. **2** includes FIGS. **2**A, **2**B and **2**C, in which FIG. **2**A is a perspective view of a portion of a guide rail of the guide unit in FIG. **1**A, FIG. **2**B is a side view, partially broken away, of FIG. **2**A, and FIG. **2**C is a partial sectional view showing an assembled arrangement of a retainer;

FIG. **3** is an illustration of a support portion for a railway rolling stock to which the rolling guide unit of the present invention is applicable;

FIG. **4** includes FIGS. **4**A and **4**B, in which FIG. **4**A is an illustration of an entire railway rolling stock to which the rolling guide unit of the present invention is applicable and FIG. **4**B is an enlarged view of the rolling guide unit of FIG. **4**A;

FIG. **5** includes FIGS. **5**A, **5**B and **5**C, in which FIG. **5**A is a view showing a condition of movement of a contacting point of the ball to the ball rolling groove, FIG. **5**B is a sine function graph with the contact angle of the ball being variable, and FIG. **5**C is a view in an enlarged scale at a point near the contact angle of 90° in FIG. **5**B;

FIG. **6** includes FIGS. **6**A to **6**H for the explanatory of steps for absorption of misalignment by means of the rolling guide unit according to the present invention in this order;

FIG. **7** includes FIGS. **7**A to **7**C representing structures of other embodiments of the rolling guide unit according to the present invention;

FIG. **8** represents a further embodiment of the rolling guide unit according to the present invention, in which FIG. **8**A is a side view thereof and FIGS. **8** to **8**E show various types of rolling members;

FIG. **9** represents an embodiment of a rolling guide unit of linear guide type according to the present invention, in which FIG. **9**A is a side view of the linear guide type rolling guide unit and FIG. **9**B is a perspective view of a guide rail to which the guide unit of FIG. **9**A is mountable;

FIG. **10** is a sectional view of a partial portion of another embodiment of the rolling guide unit in which a support structure is constructed as a separate member;

FIGS. **11**A and **11**B are schematic views showing the support structure of a movable member capable of increasing supporting rigidity both in the horizontal and vertical directions by utilizing the rolling guide unit according to the present invention;

FIG. **12** is a schematic view of the rolling guide unit representing one example of a tandem contact structure;

FIG. **13** is a schematic view, similar to that of FIG. **12**, representing another example of the tandem contact structure;

FIG. **14** is a schematic view of the rolling guide unit representing one example of a DF type compound contact structure;

FIG. **15** is a schematic view representing another example of the DF type compound contact structure;

FIG. **16** is a schematic view of the rolling guide unit representing one example of a DB type compound contact structure;

FIG. **17** is a schematic view representing another example of the DB type compound contact structure;

FIG. **18** is a schematic view of the rolling guide unit representing one example of a compound contact structure of both the DF type and DB type;

FIG. **19** is a schematic view representing another example of the compound contact structure of both the DF type and DB type;

FIG. **20** is a schematic view showing a further example of the contact structure;

FIG. **21** is a schematic view showing a still further example of the contact structure; and

FIG. **22** is a cross sectional view of a table moving apparatus utilizing a rolling guide unit of conventional structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

It is first to be noted that the terms "upper" and "lower" used herein for the following respective embodiments or examples are made with reference to the corresponding illustrations of the accompanying drawings.

FIGS. **1** and **2** represent one embodiment of the present invention, and this embodiment will be preferably described hereunder with reference to an example of a rolling guide unit for guiding on a curved line a pendulum type vehicle such as railway rolling stock such as shown in FIGS. **3** and **4**.

As shown in FIGS. **3** and **4**, the rolling guide unit **1** is one usable for the curve guide for a vehicle body such as railway rolling stock, and a pair of such rolling guide units **1**, **1** are oppositely arranged for supporting the vehicle body **3** swingably on a bogie **2**. Each of the rolling guide unit **1** comprises as shown in FIGS. **1** and **2**, a guide rail **4** and a movable member **6** assembled with the guide rail **4** so that the movable member **6** is movable along the guide rail **4** through rolling members **5** having a spherical outer shape such as balls.

The guide rail **4** has, as shown in FIG. **2**A, rectangular section and is bent in an arcuate shape so as to provide a predetermined radius of curvature. The guide rail **4** has upper and lower (as viewed) side surfaces to which ball rolling grooves **7** are formed entirely therealong. The ball rolling grooves **7** are formed in three rows in the illustrated example on the upper and lower sides as shown in FIG. **2**A. One row, two rows or more than three rows of the ball rolling grooves may be formed. The invention is not limited to the illustrated three-row arrangement.

Each of the ball rolling grooves **7** has an arcuate cross section having a radius of curvature larger than that of the ball **5** and has a depth of about ¼ to ½ of the diameter of the ball **5**.

The movable member **6** is formed of a block member provided with a pair of supporting portions **61** and **62** which extend sideway substantially perpendicularly from a central portion thereof so as to entirely provide a ⊐-shaped cross section, and as shown in FIG. **2**A, the movable member **6** is assembled with the guide rail **4** so that the supporting portions **61** and **62** are positioned on both the upper and lower sides of the guide rail **4** to be movable therealong. Each of the supporting portions **61** and **62** are formed with ball rolling grooves **8** corresponding to the ball rolling grooves **7** formed to the guide rail **4** in their positions and numbers. Each of the ball rolling grooves **8** also has an arcuate cross section having a radius of curvature larger than that of the ball **5** and has a depth of about ¼ to ½ of the diameter of the ball **5**.

When assembled, the balls **5** are disposed between these ball rolling grooves **7** and **8** each so as to contact at two points CP, in FIG. **1**B or **1**C, near groove bottoms thereof, and an angle α constituted by a line connecting these two contact points CP and a virtual horizontal line is set to approximately 90°. Accordingly, the contact points CP of the ball **5** is bilaterally displaceable with the position of contact angle α of 90° being the center of this displacement.

As shown in FIG. **2**B, the movable member **6** comprises a main body **10** of the movable member **6**, having the supporting portions **61** and **62**, and side covers **12** mounted to front and rear end portions of the main body **10**. The movable member main body **10** is provided with return passages **9** in an unloaded region for circulating the balls **5** in addition to the ball rolling grooves **8**, **8**, and each of the side covers **12** is formed with a ball turning passage **11** for changing the ball rolling direction.

The left side, as viewed in FIG. **1**A, surface of the movable member **6** is formed as a mounting surface **13** to which tap holes **14** for fixing bolts **13** are formed. The right side, as viewed in FIG. **1**A, surface of the guide rail **4** is formed as a mounting surface **16** which is fixed by means of bolts, not shown. Seal members **15** are disposed to the gaps between the inside surfaces of the upper and lower supporting portions **61** and **62** of the movable member **6** and the upper and lower side surfaces of the guide rail **4**, and retainers **24** for holding the balls **5** are also disposed between these gaps as shown in FIG. **2**C.

Preload is applied to the balls **5** by a suitable means.

In the rolling guide unit of the structure described above, load Fa applied in a vertical direction, as viewed in FIG. **1**C, is born by three row of balls **5** having the initial contact angle of 90°. On the other hand, when a load Fb from the horizontal direction is born by the balls **5** having the displaced contact angle of α' at which the line X' connecting the contact points CP of the balls **5** to the ball rolling grooves **7** and **8** substantially accords with a direction of composite vector F of the vertical load Fa and the horizontal load Fb. In the thus manner, the vertical and horizontal loads are applied to the balls **5** at the displaced contact angle α'.

In this embodiment, since the ball rolling grooves **7** and **8** are formed so as to provide the arcuate cross sections and the ball contact angle α is set to approximately 90°, variation of allowable load is small even if the contact angle α be changed.

That is, the allowable load will be expressed as follows.

$$Co=f(Da\cdot z\cdot i\cdot \sin\alpha)$$

Da: diameter of ball

z: number of balls

i: number of ball rows

α: contact angle (90° in the perpendicular case)

As shown in FIG. **5**B, the allowable load is expressed as sine function. A sine curve varies gently, as shown in FIG. **5**C, at a portion near 90°, and the sine function value is **1** at the contact angle α of 90°; 0.998 of 87°; 0.996 of 85°; and 0.992 even of 83°. This means that even if the contact angle varies in the range of 90°±7°, the reduction ratio of the allowable load is less than 1%, being very small, and of course, the displacement of the allowable contact angle can be properly selected.

In addition, since the depth h of the ball rolling grooves **7** and **8** are made deep as mentioned hereinbefore, the ball **5** does not contact the edge E of the ball rolling groove **7** as shown in FIG. **5**A even if the contact points CP are displaced, thus preventing the edge load from occurring. The depth h of the groove is determined in consideration of the edge load, but it is preferred to set the depth h to approximately ¼ to ½ oil the diameter of the ball **5**.

The misalignment absorbed according to the present invention basically corresponds to displacement of the guide rail and the movable member in the horizontal direction, and it is possible to absorb the following misalignments as shown in FIG. **6**: (1) a misalignment in the rotating direction about the central axis of the guide rail **4** (MC direction in FIG. **6**A); a misalignment in the rotating direction reversely changing the front and rear end portions of the movable member **6** (MA direction in FIG. **6**C); and a misalignment in the direction displacing the movable member **6** in the horizontal direction (Z direction in FIG. **6**B).

The above misalignments are caused by, for example, a working error of the mounting surface of the movable member **6** as shown in FIG. **3** and an error caused by an angular error θ or dimensional error Δ in the horizontal direction. In addition, an error in degree of parallelism of the bilateral guide rails **4**, **4** and an excessive clamping of the fastening bolt may also cause the misalignments.

FIGS. **6**D to **6**H represent the change of the contact angles in the absorption of the misalignments. FIG. **6**D represents a position at which the initial contact angle α of 90° being the reference value preliminarily set, FIGS. **6**E and **6**F represent a position at which the misalignment in the MC direction is absorbed and the contact angle is displaced in a direction reverse to the rotating direction, and FIGS. **6**G and **6**H represent a position at which the misalignment in the Z direction is absorbed and the contact angle is displaced in a direction reverse to the first displaced direction.

In the meantime, when the misalignment in the MC direction is absorbed, the front and rear end portions of the movable member **6** are displaced in the horizontal direction reverse to each other, and the contact angle of the ball **5** positioned at the front and rear end portions of the movable member **6** are displaced in directions reverse to each other as shown in FIGS. **6**G and **6**H.

As discussed above, since the contact angle is initially set to approximately 90°, it is not necessary as in the conventional technology for the guide rail to be formed with complicated structure having a projection, and since the ball rolling groove **7** can be ground by a horizontal grinding technique, the guide rail can be easily manufactured. In the case where a plurality of ball rolling grooves **7** are formed, they can be formed with high performance of a pitch between adjacent ones. Furthermore, since the grinding allowance is constant along the entire length of the guide rail **4** and hence is easily measured, the ball rolling grooves **7** can be worked so as to provide a smooth finishing surface with high performance.

Particularly, when the guide rail **4** is formed to provide a curved line shape, since it is not necessary to form the guide rail with the projected rib **107**, and the guide rail is formed so as to provide a simple rectangular shape, a plastical deformation in a bending working can uniformly progress with substantially no camber, thus being easily manufactured, and accordingly, the grinding allowance in the finishing working can be minimally suppressed, thus being effective in production.

FIG. **7** represents other embodiments of the present invention.

FIG. **7**A shows an embodiment, in which the upper end surface **17** of the movable member **6** and the lower end surface **18** of the guide rail **4** are formed as mounting surfaces of the movable member **6** and the guide rail **4**, respectively, and these members are fastened each by means of single fixing bolt **19** in the vertical direction as viewed. In the structure of FIG. **7**B, two fixing bolts **19** are utilized respectively for the movable member **6** and the guide rail **4**, respectively. In the embodiment of FIG. **7**C, two fixing bolts **19** are utilized for the movable member **6** and single fixing bolt **19** is utilized for the guide rail **4**. The numbers of rows of the balls **5** are different between the upper side surface and the lower side surface of the guide rail, and in the illustrated embodiment, three ball rows are formed on the upper side surface of the guide rail **4** and two ball rows are formed on the lower side surface thereof.

FIG. **8** represents a further embodiment of the present invention, which has a basic structure essentially identical to that of the embodiment shown in FIG. **1** and only has a different point that the balls rolling along the central ball rolling groove **7** in FIG. **1** are substituted with cylindrical rollers **20** rolling along a rolling groove **21**.

In accordance with this structural difference, the roller rolling groove **21** for the rollers **20** formed to the inside surfaces of the supporting portions **61** and **62** of the movable member **6** is formed so as to provide a rectangular cross section so as to accord with the shape or the cylindrical roller **20**. The bottom of the groove **21** is made flat accordingly. On the other hand, any roller rolling groove for the rollers **20** is not formed to the upper and lower side surfaces of the guide rail **4** and the upper and lower surfaces thereof are directly utilized for the roller rolling surface as they are.

According to this structure of the embodiment of FIG. **8**, the rollers **20** can move in the horizontal direction along the upper and lower side surfaces of the guide rail **4**, and hence, the misalignment in the horizontal direction can be absorbed by the embodiment of FIG. **1**. In addition, according to this embodiment of FIG. **8**, a larger load in the vertical direction can be born in comparison with the structure of the embodiment of FIG. **1**, thus being more advantageous.

Furthermore, the misalignments in the horizontal (Z) direction and the MA direction of the kind shown in FIGS. **6**B and **6**C can be absorbed in the same manner as described with reference to the embodiment of FIG. **1**, and the misalignment in the MC direction shown in FIG. **6**A does not constitutes a problem since the rollers **20** are positioned at the central portion of the guide rail side surface and the displacement of the roller **20** is hence small in comparison with the bilateral side ones.

However, since there may be a slight fear of causing the edge load at the end portion of the roller **20**, a crowning treatment will be effected to the edge portion **21** as shown in FIG. **8**C, or barrel shaped roller having a central portion swelled in section such as shown in FIG. **8**D may be utilized, as occasion demands. In the case where the barrel shaped rollers **20** are utilized, it: is necessary to form the roller rolling groove so as to provide an arcuate cross section having a radius of curvature larger than that of the barrel roller **20**.

In a modification, the barrel shaped rollers **20** or spherical, partially cut away, rollers **23** shown in FIG. **8**E may be utilized in substitution for the ball rollers **5**.

In the forgoing description, the embodiments of the curved line guiding structure were provided, the present invention is not limited to such curved line guiding structure and it can be applied as it is to the rolling guide units **1**A for the linear guiding structure as shown in FIG. **9**. That is, in comparison with the curved line guiding structure, the curved guide rail **4** is constructed to a linear guide rail **4**A and the respective ball rolling grooves are formed linearly so as to accord with the linear guide rail **4**A, and the other structure is the same as that of the former embodiment.

Furthermore, in the first described embodiment, the supporting portions **61** and **62** are formed integrally to the central portion of the movable member **6**, but these portions may be independently formed as shown in FIG. **10**, for example. That is, the supporting portion **61** is fixed to the main body **63** (FIG. **10**) of the movable member **6** by a fastening means **64** such as bolt. Both these portions or either one of these portions may be independently formed from the main body **63** of the movable member **6**.

In the present invention, the horizontal gap is formed between the ball and the ball rolling grooves for absorbing the misalignment of the ball. However, this gap may be eliminated by applying a horizontal preload, and in such arrangement, the horizontal supporting rigidity will be increased.

FIG. **11** shows an example increasing the horizontal supporting rigidity.

Referring to the example of FIG. **11**, a movable table **31** is movably supported by a fixed table **30** through a pair of opposing rolling guide units **1**, **1**, and the movable table **31** is formed with skirt portions **32** and **33**, as supporting portions, extending downward, as viewed, from both the bilateral ends thereof. The paired rolling guide units **1**, **1** are mounted between the inner surfaces of the skirt portions **32** and **33** and the outer side surfaces of the fixed table **30**.

In order to apply a preload to the structure shown in FIG. **11**A, in one example, a preload adjusting bolt **34** may be screwed to one of the skirt portion **32**, for example, thereby to push the side surface of one of the rolling guide unit **1** against the guide rail di fixed to the fixed table **30**, whereby the horizontal gap between the balls **5** and the ball rolling grooves **7** and **8** is eliminated, thus applying the horizontal preload in a state shown in FIG. **11**B. In a modification, a tapered wedge member, for example, not shown, may be inserted forcibly into the gap between the facing surfaces of the skirt portion **32** and the movable member **6** of the rolling guide unit **1**, thus also applying the horizontal preload.

That is, when one of the movable members **6** of the rolling guide unit **1** is pressed through one **32** of the skirt portions of the movable table **31** by, for example, the preload adjusting bolt **34**, a reaction force of the pressing force is transferred to the other one **33** of the skirt portions through the movable table **31**, and then, the other movable member **6** of the other rolling guiding unit **1** is pressed against the guide rail **4** fixed to the fixed table **30** through the other skirt portion **33**. Through this preload applying process, in the illustration of FIG. **11**A, the contact angles α of the upper and lower balls in the right rolling guide unit **1** are displaced such that the upper ball **5R1** is rotated clockwisely from the initial contact angle 90° position and the lower ball **5R2** is rotated counterclockwisely therefrom. On the other hand, the contact angles α of the upper and lower balls in the left rolling guide unit **1** are also displaced such that the upper ball **5L1** is rotated counterclockwisely from the initial contact angle 90° position and the lower ball **5L2** is rotated clockwisely therefrom. In the thus manner, the horizontal gap between the respective balls **5** can be eliminated.

In the assumption that lines connecting the contact points of the respective balls **5R1**, **5R2** **5L1** and **5L2** and the ball rolling grooves **7** and **8** into which theses balls disposed constitute contact angle lines XR**1**, XR**2**, XL**1** and XL**2**, upper and lower these contact angle lines in the right and left rolling guide units **1**, **1** are inclined outward of the guide units as shown in FIG. **11**A.

According to the arrangement of the ball contact angles, the supporting rigidity in the vertical direction can be improved as well as that in the horizontal direction.

Therefore, according to the rolling guide unit of the present invention, the supporting structure having improved load bearing performance in the vertical and horizontal directions, i.e. every direction, can be realized as well as achieving the misalignment absorbing performance.

FIGS. **12** to **21** represent various examples each having such a contact angle structure as mentioned above of a plurality of ball rows, typically through examples of the upper and lower three ball rows.

FIG. **12** shows an example of tandeim type, which has the respective upper and lower three rows, total six rows, of balls and the contact angles in the same directions as in the example of FIG. **11**.

That is, as like in FIG. **3**, a vehicle body **203** is movably supported by a bogie **202** through a pair of rolling guide units **201**, **201**. The paired rolling guide units **201**, **201** have guide rails **204**, **204** opposing to each other on the inner side, vehicle body side, thereof and movable members **206**, **206** opposing to each other on the outer side thereof such that the inner side surfaces of the guide rails **204**, **204** are fixed to the mounting surface of the vehicle body **203** and the outer side surfaces and the lower surfaces of the movable members **206**, **206** are fixed to stepped mounting portions **202**A, **202**A formed to the bogie **202**.

Each of the stepped portions **202**A, **202**A has an L-shaped cross section having a horizontal mounting surface **218** to which the lower side surface of the movable member **206** is fixed and a perpendicular mounting surface **213** to which the outer side surface of the movable member **206** is fixed.

Each of the movable members **206**, **206** has substantially a ⊐-shaped cross section having a pair of upper and lower supporting portions **261** and **262** extending in a horizontal direction as viewed in FIG. **12**, and each of the guide rails **204**, **204** having substantially rectangular cross section is fitted into a ⊐-shaped recessed portion of the corresponding movable member **206** from the horizontal direction.

The balls as rolling members in respectively three rows are rollably disposed between the facing surfaces of the upper and lower supporting portions **261** and **262** and the guide rails **204**, **204**. Supposing that the upper and lower respectively three rows of balls are referred to as upper first, second and third balls **5A1**, **5A2** and **5A3** and lower first, second and third balls **5B1**, **5B2** and **5B3** from the inner side to the outer side as in the illustration of FIG. **12**, these upper and lower balls have the same diameters and are arranged linearly symmetrically respectively with respect to a horizontal axis H passing the center of the guide rails **204**, **204**.

The upper first, second and third balls **5A1**, **5A2** and **5A3** and the lower first, second and third balls **5B1**, **5B2** and **5B3** are rollably disposed between upper first, second and third ball rolling grooves **207A1**, **208A1**; **207A2**, **208A2**; **207A3**, 208A3, and the lower first, second and third ball rolling grooves 207B1, 208B1; 207B2, 208B2; 207B3, 208B3 of the upper and lower supporting portions 261, 262 of the movable member 206 and the corresponding upper and lower side surfaces of the guide rails 204.

In such example of tandem type structure, the upper first, second and third ball rolling grooves 207A1, 208A1; 207A2, 208A2; 207A3, 208A3 formed to the upper supporting portion 261 and the upper side surface of the guide rail 204 are formed so as to provide the same phases and pitches as those of the lower first, second and third ball rolling grooves 207B1, 208B1; 207B2, 208B2; 207B3, 208B3 formed to the lower supporting portion 262 and the lower side surface of the guide rail 204. In a free arrangement of the balls, the initial contact angles of the upper first, second and third balls 5A1, 5A2 and 5A3 and lower first, second and third balls 5B1, 5B2 and 5B3 are made to substantially 90°.

In the illustrated example, the outer side surface of the movable member 206 of one of the rolling guide units 201 is pressed against the guide rail 204 mounted to the vehicle body side by means of a preload adjusting bolt such as shown in FIG. 6 or by using a tapered wedge member thereby to eliminate the horizontal gap between the balls 5A1—, 5B1—and the ball rolling grooves 207A1, 208A1; 207B1, 208B1—, whereby a horizontal preload is applied, thereby inclining the balls by a predetermined angle with respect to the initial contact angle 90° to the ball rolling grooves.

That is, the ball contact angles α of the upper first, second and third balls 5A1, 5A2 and 5A3 of the right side rolling guide unit 201 are displaced clockwisely in the illustration from the initial contact angle 90°, and the ball contact angles α of the lower first, second and third balls 5B1, 5B2 and 5B3 of the right side rolling guide unit 201 are displaced counterclockwisely in the illustration from the initial contact angle 90°. On the contrary, with respect to the upper and lower balls 5 of the left side rolling guide unit 201, the contact angles have linear symmetric arrangement with respect to the central perpendicular line between the right and left side rolling guide units 201, 201, and the contact angles of the upper first, second and third balls 5A1, 5A2 and 5A3 are displaced in the counterclockwisely in the illustration and the contact angles of the lower first, second and third balls 5B1, 5B2 and 5B3 are displaced clockwisely. In thus manner, the horizontal gaps of the respective balls can be eliminated, and the contact angle lines XR1, XR2, XR3 and XL1, XL2, XL3 of the upper and lower balls of the right and left side rolling guide units 201 are inclined to be opened outward.

As described above, the example of FIG. 12 represents the tandem type structure which has the respectively upper and lower three rows, total six rows, of balls having the contact angles in the same direction. In a modified example, as shown in FIG. 13, the inclination of the contact angle lines may be set in directions reverse to those of FIG. 12.

That is, referring to FIG. 13, the contact angle lines XR1, XR2, XR3 and XL1, XL2, XL3 of the upper and lower balls of the right and left side rolling guide units 201 are inclined to be opened inward. A structure having such contact angle arrangement will be easily realized by applying a force in the direction to outwardly draw out the movable member from the guide rail 204.

The basic structure of such tandem type example is identical to that shown in FIG. 6 in which the single row of balls are disposed at each of upper and lower sides, and accordingly, a moment load caused by the mounting error and eccentric load are not born, so that any inner load is not caused by such moment, thus being advantageous. That is, when the moment load MC acts, the movable member is moved in an inclined state in the direction of an arrow in FIG. 13.

Furthermore, according to this example, even in a case where the degree of parallelism between two axes of the respective guide rails are out of order, only the ball contact point varies and no forcible force acts on the balls, thus absorbing a geometric distortion of the parallelism between the axes of the guide rails.

Loads in the vertical and horizontal directions may be easily uniformly born.

According to the arrangement of the ball contact angles described above, the supporting rigidity in the horizontal direction can be improved as well as in the vertical direction. Accordingly, the rolling guide unit of these examples, the misalignment of the balls can be absorbed as well as realizing the support structure having high load bearing ability in the horizontal and vertical, i.e. every, directions in its use.

FIGS. 14 to 19 represent other examples of compound contact type structure in which the ball contact structure of respectively upper and lower three rows of balls is adapted such that at least one pair of balls of the upper or lower side rows have contact angles inclined reversely to each other. In such a compound contact type structure, the moment load caused by the mounting error or eccentric load can be born by one movable member.

As the basic structures of these examples are substantially identical to that of FIG. 12, the same reference numerals are added to members or portions corresponding to those of FIG. 12 and the descriptions thereof are omitted herein, and only the direction of the contact angle is referred to hereunder.

Elastic members 250 and 251 made of such as rubber material are interposed between the horizontal mounting surface 218 of the mounting stepped portion of the bogie and the lower side surface of the movable member 206, that is, between the perpendicular mounting surface 213 and the outer side surface of the movable member 206 for the purpose of absorbing the mounting error or the like. Of course, these mounting surfaces may be directly secured without interposing such elastic members 250 and 251.

In the example of FIG. 14, the contact angle lines are symmetrically inclined by predetermined angles with respect to the initial angle 90° so that the contact angle lines XA1 and XA2 of the upper first and second balls 5A1 and 5A2 are opened upward in the illustration and the contact angle lines XB1 and XB2 of the lower first and second balls 5B1 and 5B2 are opened downward. The contact angle line XA3 of the upper third ball 5A3 and the contact line XB3 of the lower third ball 5B3 are set in parallel to the contact angle lines XA2 and XB2 of the upper and lower second balls 5A2 and 5B2, respectively.

Such ball contact structure will be realized, for example, by setting a pitch P1 between the upper and lower first ball rolling grooves 207A1 and 207B1 and the upper and lower second ball rolling grooves 207A2 and 207B2 of the upper and lower supporting portions 261 and 262 to be smaller than a pitch P2 between the upper and lower first ball rolling grooves 208A1 and 208B1 and the upper and lower second ball rolling grooves 208A2 and 208B2 of the guide rails 204, and also setting a pitch between the upper and lower second ball rolling grooves 207A2 and 207B2 and the upper and lower third ball rolling grooves 207A3 and 207B3 of the upper and lower supporting portions **261** and **262** to be equal to a pitch between the upper and lower second ball rolling grooves **207**A**2** and **207**B**2** and the upper and lower third ball rolling grooves **207**A**3** and **207**B**3** of the guide rails **204**.

As described above, by adopting the ball contact structure of a pair of angular contact arrangement, the gap can be adjusted and the initial contact angle is made stable at the time of assembling the guide rail **204** and the movable member **206**.

FIG. **15** shows an example in which an angle between the upper and lower contact angle lines are opened outward, in which an angle of the contact angle lines XA**2** and XA**3** of the upper second and third balls **5**A**2** and **5**A**3** and an angle of the contact angle lines XB**2** and XB**3** of the lower second and third balls **5**B**2** and **5**B**3** are opened outward.

In the example of FIG. **16**, the contact angle lines are symmetrically inclined by predetermined angles with respect to the contact angle of 90° so that an angle between the contact angle line XA**1** and XA**2** of the upper first and second balls **5**A**1** and **5**A**2** is opened inward toward the inner guide rail **204**, and an angle between the contact angle line XB**1** and XB**2** of the lower first and second balls **5**B**1** and **5**B**2** is opened inward toward the inner guide rail **204**. On the other hand, the contact angle lines XA**3** and XB**3** of the upper and lower third balls **5**A**3** and **5**B**3** are set to be substantially parallel to the contact angle lines XA**2** and XB**2** of the upper and lower second balls **5**A**2** and **5**B**2**, respectively.

Such ball contact structure will be realized, for example, by setting a pitch P**1** between the upper and lower ball rolling grooves **207**A**1** and **207**B**1** and the lower second ball rolling grooves **207**A**2** and **207**B**2** of the upper and lower supporting portions **261** and **262** to be larger than a pitch P**2** between the upper and lower first ball rolling grooves **208**A**1** and **208**B**1** and the upper and lower second ball rolling grooves **208**A**2** and **208**B**2** of the guide rails **204**, and also setting a pitch between the upper and lower second ball rolling grooves **207**A**2** and **207**B**2** and the upper and lower third ball rolling grooves **207**A**3** and **207**B**3** of the upper and lower supporting portions **261** and **262** to be equal to a pitch between the upper and lower second ball rolling grooves **207**A**2** and **207**B**2** and the upper and lower third ball rolling grooves **207**A**3** and **207**B**3** of the guide rails **204**.

FIG. **17** shows an example in which an angle between the upper and lower contact angle lines are opened inward, in which an angle of the contact angle lines XA**2** and XA**3** of the upper second and third balls **5**A**2** and **5**A**3** and an angle of the contact angle lines XB**2** and XB**3** of the lower second and third balls **5**B**2** and **5**B**3** are opened inward.

Examples of FIGS. **18** and **19** shows an arrangement in which angles between respectively adjacent contact angle lines XA**1**, XA**2**, XA**3**, XB**1**, XB**2** and XB**3** are opened alternately outward and inward.

That is, FIG. **18** shows an example in which angles between the contact angle lines XA**1** and XA**2** of the upper first and second balls **5**A**1** and **5**A**2** and between the contact angle lines XB**1** and XB**2** of the lower first and second balls **5**B**1** and **5**B**2** are opened inward, and angles between the contact angle lines XA**2** and XA**3** of the upper second and third balls **5**A**2** and **5**A**3** and between the contact angle lines XB**2** and XB**3** of the lower second and third balls **5**B**2** and **5**B**3** are opened outward.

FIG. **19** shows an example in which angles between the contact angle lines XA**1** and XA**2** of the upper first and second balls **5**A**1** and **5**A**2** and between the contact angle lines XB**1** and XB**2** of the lower first and second balls **5**B**1** and **5**B**2** are opened outward, and angles between the contact angle lines XA**2** and XA**3** of the upper second and third balls **5**A**2** and **5**A**3** and between the contact angle lines XB**2** and XB**3** of the lower second and third balls **5**B**2** and **5**B**3** are opened inward.

In these examples, the numbers of ball rows, the numbers of the balls in each ball row, and the ball diameter are optionally selected in accordance with a load to be applied. For example, regarding the numbers of the ball rows, as shown in FIG. **20**, two ball rolling grooves corresponding to the upper and lower first and third balls **5**A**1**, **5**A**3** and **5**B**1**, **5**B**3**.

Furthermore, the contact structure of the respective balls of the upper and lower supporting portions **261** and **262** are made linearly symmetrical with respect to the horizontal axis, it is not always necessary to adapt the Linear symmetric structure, and as shown in FIG. **21**, in accordance with the load to be applied, an arrangement different in ball rows may be adapted such that two rows of the second and third balls **5**A**2** and **5**A**3** are formed on the upper side and three rows of the first, second and third balls **5**B**1**, **5**B**2** and **5**B**3** are formed on the lower side.

Further, it is to be noted that, in the above respective embodiments or examples, the rolling guide units are referred to for the guide support mechanism of a railway rolling stock, but the present invention is not limited to such specific utilization and many other applications may be adapted for guide mechanisms of, for example, various industrial robots or the like.

What is claimed is:

1. A rolling guide unit comprising:

a movable member provided with a main body portion and a pair of upper and lower support portions extending from lateral end portions of the main body so as to provide a recessed portion between the main body portion and both the support portions, said support portions having inner surfaces in which rolling member rolling grooves are formed;

a guide rail disposed in the recessed portion of the movable member so that upper and lower side surfaces of the guide rail face the inner surfaces of the support portions, respectively, the upper and lower side surfaces of said guide rail being formed with rolling member rolling grooves at positions cooperable with the rolling member rolling grooves of the upper and lower support portions, respectively, and the upper and lower side surfaces of said guide rail being substantially mutually parallel; and

a number of rolling members disposed to be rollable between the cooperating rolling member rolling grooves of said guide rail and said upper and lower support portions of the movable member so that each of the rolling members contact their associated rolling member rolling grooves at two contact points at which the rolling members apply load to the rolling member rolling grooves, said movable member and the guide rail being relatively movable through the rolling of the rolling members;

wherein each of said rolling member rolling grooves has an arcuate cross sectional shape having a radius of curvature larger than that of the rolling member and the contact points are displaceable along the arcuate shape of the respective rolling member rolling grooves and;

wherein an initial contact angle formed between a line connecting the two contact points on diametrally opposite sides of the rolling members to the rolling member rolling grooves and a line passing through a center of the rolling member and parallel to the facing surfaces containing said rolling member rolling grooves in said movable member and said guide rail is set to substantially 90°.

2. A rolling guide unit according to claim **1**, wherein the rolling member is a ball and each of said rolling member rolling grooves has a depth of approximately ¼ to ½ of a diameter of the ball.

3. A rolling guide unit according to claim **1**, wherein a plurality of rolling member rolling grooves are formed at least one of the side surfaces of the guide rail and at least corresponding one inner surface of the support portion of the movable member.

4. A rolling guide unit according to claim **1**, wherein a plurality of rolling member rolling grooves are formed at least on one of the side surfaces of the guide rail and at least on a corresponding one inner surface of the support portion of the movable member, and wherein an initial contact angle defined by a line connecting the two contact points of the rolling members in their associated rolling member rolling grooves and said line parallel to the facing surfaces containing said rolling member rolling grooves in said movable member and said guide rail passing a center of the rolling member is set to substantially 90°.

5. A rolling guide unit according to claim **4**, wherein lines connecting points of contact between all of said rolling members and their associated rolling member rolling grooves when said movable member and said guide rail are misaligned have contact angles inclined in the same direction.

6. A rolling guide unit according to claim **4**, wherein lines connecting points of contact between all of said rolling members and their associated rolling member rolling grooves when said movable member and said guide rail are misaligned have at least one pair of contact angles inclined in directions reverse to each other.

7. A rolling guide unit according to claim **1**, wherein a plurality of rolling member rolling grooves are formed at least on one of the side surfaces of the guide rail and at least corresponding to one inner surface of the support portion of the movable member, and the rolling members disposed in at least one of the plurality of rolling member rolling grooves are formed as cylindrical members and the rolling member rolling groove in which the cylindrical members are rolled is formed so as to provide a flat groove bottom.

8. A rolling guide unit according to claim **7**, wherein the rolling member rolling grooves for the cylindrical members are formed to the inner surfaces of the support portions so as to provide a groove bottom shape corresponding to an outer shape of the cylindrical member and the side surfaces of the guide rail for the cylindrical members are formed to be flat.

9. A rolling guide unit according to claim **7**, wherein three rows of the rolling member grooves are formed and a central one is formed for the cylindrical members.

10. A rolling guide unit according to claim **1**, wherein said guide rail has substantially rectangular cross section and is bent in a curved shape.

11. A rolling guide unit according to claim **1**, wherein said guide rail has substantially linear shape.

12. A rolling guide unit according to claim **1**, wherein retainer meals are disposed between the facing inner surfaces of the support portions of the movable member and the side surfaces of the rail guide.

13. A rolling guide unit according to claim **1**, wherein said support portions are integrally formed with the main body portion of the movable member.

14. A rolling guide unit according to claim **1**, wherein said support portions are independently formed with the main body portion of the movable member and the support portions are fixed to the central portion of the movable member by means of bolts.

15. A rolling guide unit according to claim **1**, wherein the numbers of rows of the rolling members of the respective support portions are different from each other.

16. A rolling guide unit assembly which comprises a first member, and a second member disposed in an opposing relation with respect to the first member, and relatively movable along the first member through a pair of rolling guide units arranged on bilateral side surfaces of said first member, said pair of rolling guide units comprising:

guide rails respectively secured to both side surfaces of said first member;

a movable member secured to said second member disposed so as to oppose bilateral side surfaces of said guide rails and having a pair of upper and lower support portions extending along lateral side portions thereof by which the guide rails are clamped at upper and lower side surfaces thereof; and

a number of rolling members rollably disposed in rolling member rolling grooves formed in the upper and lower side surfaces of the guide rails and opposing surfaces of the upper and lower support portions of the movable member in a mutually facing manner,

wherein each of said rolling member rolling grooves has an arcuate cross section having a curvature larger than a radius of each of the rolling members so that the rolling members are movable along the arcuate shape of the rolling member rolling grooves; and

wherein said guide rails are curved and each of said upper and lower side surfaces are parallel.

17. A rolling guide unit assembly according to claim **16**, wherein each of said rolling member rolling grooves has a depth of approximately ¼ to ½ of a diameter of the rolling member.

18. A rolling guide unit assembly according to claim **16**, wherein a plurality of rolling member rolling grooves are formed on at least one of the upper side surfaces and lower side surfaces of the guide rails.

19. A rolling guide unit assembly according to claim **18**, wherein a contact angle is determined by a line connecting contact points of the respective rolling members in the bilateral pair of the rolling guide units to the rolling member rolling grooves and a line passing through centers of the rolling members parallel to said guide rail side surfaces, and where contact point connecting lines of the respective rolling members have a symmetrical arrangement.

20. A rolling guide unit assembly according to claim **18**, wherein an initial contact angle constituted by a line connecting contact points of the rolling members to the rolling member rolling groove and a line parallel to said guide rail side surfaces and passing through a center of the rolling member is set to substantially 90°.

21. A rolling guide unit assembly according to claim **18**, wherein the contact angles of a plurality of rolling members disposed on the upper side surface or the lower side surface of the guide rails are bilaterally symmetrical and have inclinations in the same direction with respect to the rolling guide units, respectively.

22. A rolling guide unit assembly according to claim **18**, wherein a plurality of rows of the rolling members are disposed on at least one of the upper side surfaces and lower side surfaces of each of the guide rails, and further include cylindrical rolling members in at least one of said rows.

23. A rolling guide unit assembly according to claim **18**, wherein the lines connecting contact points of a plurality of rolling members disposed on the upper side surface or the lower side surface are bilaterally symmetrically inclined and have at least one pair of lines reversely inclined with each other with respect to the rolling guide units.

24. A rolling guide unit assembly according to claim **16**, wherein an elastic member is disposed between the movable member of the rolling guide unit and an attachment surface of the second member.

25. A rolling guide unit assembly according to claim **16** containing a plurality of movable members and wherein vertical mounting surfaces are formed on outer side surfaces of the movable members, each vertical mounting surface being respectively positioned opposite to one of the guide rails, and wherein horizontal mounting surfaces are formed on one of the upper and lower end surfaces of the movable members.

26. A rolling guide unit assembly according to claim **16**, wherein each of the guide rails of the paired rolling guide units has a substantially rectangular cross section and being bent along a longitudinal axis to provide an arcuate portion, and said guide rails relatively swingably supporting the first member with respect to the second member.

27. A rolling guide unit assembly according to claim **26**, wherein said first member is a pendulum type vehicle and said second member is a railway rolling stock which is swingably supported by the vehicle.

28. A rolling guide unit assembly according to claim **26**, wherein said first member is fixed to a pendulum type vehicle and said second member is fixed to a pantograph.

29. A rolling guide unit comprising:

a relatively movable member provided with a main body portion and a pair of upper and lower support portions extending from lateral end portions of the main body portion so as to provide a recessed portion between the main body portion and both the support portions, said support portions having inner surfaces in which rolling member rolling grooves are formed;

a guide rail disposed in the recessed portion of the movable member so that upper and lower side surfaces of the guide rail face the inner surfaces of the support portions, respectively, the upper and lower side surfaces of said guide rail being formed with rolling member rolling grooves at positions corresponding to the rolling member rolling grooves of the upper and lower support portions, respectively;

a number of rolling members disposed to be rollable between the corresponding rolling member rolling grooves of said guide rail and said upper and lower support portions of the relatively movable member so that each of the rolling members contact the rolling member rolling grooves at two contact points and the rolling members apply load to the rolling member rolling grooves associated therewith, said movable member and the guide rail being relatively movable through the rolling of the rolling members;

a transporting element, positioned in the vertical direction with respect to relatively movable member and the guide rail mounted to one of the relatively movable member and said guide rail;

wherein each of said rolling member rolling grooves has a cross section of arcuate shape and having a radius of curvature larger than that of the rolling members, and the contact points are displaceable along the arcuate shape of the rolling member rolling groove;

wherein an initial contact angle formed between a line connecting the two contact points on the rolling members to the rolling member rolling grooves and a horizontal line passing through a center of the rolling member is set to substantially 90°; and

wherein said horizontal line is perpendicular to said vertical direction and perpendicular to a direction of movement produced by said transportation element.

30. The rolling guide unit of claim **29**, wherein said transporting element is a wheel.

31. The rolling guide unit of claim **29**, wherein said transportation element is a bogie.

32. The rolling guide unit of claim **29**, wherein said relatively movable member is fixedly mounted to said bogie.

* * * * *

US005951168A

United States Patent [19]

Teramachi et al.

[11] **Patent Number: 5,951,168**

[45] **Date of Patent: Sep. 14, 1999**

[54] **ROLLING GUIDE APPARATUS**

[75] Inventors: **Hiroshi Teramachi**, Tokyo; **Takeki Shirai**, Chiba, both of Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **08/954,205**

[22] Filed: **Oct. 20, 1997**

Related U.S. Application Data

[62] Continuation of application No. 08/788,352, Jan. 27, 1997, Pat. No. 5,755,516, which is a continuation of application No. 08/569,125, filed as application No. PCT/JP95/00974, May 22, 1995.

[30] **Foreign Application Priority Data**

May 20, 1994 [JP] Japan 6-131266

[51] **Int. Cl.**[6] **F16C 31/06**

[52] **U.S. Cl.** **384/45**; 384/51

[58] **Field of Search** 384/43, 44, 45, 384/49, 51

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,932,067	6/1990	Pester et al.	384/45
4,932,279	6/1990	Kasuga	384/45 X
4,934,834	6/1990	Morita	384/45
4,944,607	7/1990	Jacob	384/44
5,082,374	1/1992	Narumiya	384/45

FOREIGN PATENT DOCUMENTS

63-225719	9/1988	Japan .	
64-25526	2/1989	Japan .	
1-112022	4/1989	Japan	384/43
4-132219	12/1992	Japan .	
5-52217	3/1993	Japan	384/49
149512	4/1955	Sweden	384/43

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

At least a ball escape hole (**10**) of a ball circulation passage (**7**) is formed of a molded body (**12**) and the molded body (**12**) is formed integrally with a block body (**13**) having high rigidity through an insert molding process, thereby eliminating a drilling working, possibly reducing assembling processes and reducing generation of noise.

It is preferred that the molded body (**12**) is provided with an inner peripheral portion of a direction changing passage (**11**) integrally connected with the ball escape hole (**10**) and joined with both end surfaces of the block body (**13**).

Furthermore, it is preferred that the molded body (**12**) is provided with a retainer (**17**) extending along a loaded ball passage (**8**) and integrally connected, at its both ends, with the inner peripheral portion of the direction changing passage (**11**), thereby providing a closed sectional shape surrounded by the ball escape hole portion (**10**), the direction changing portion (**11**) and the retainer portion (**17**).

4 Claims, 9 Drawing Sheets

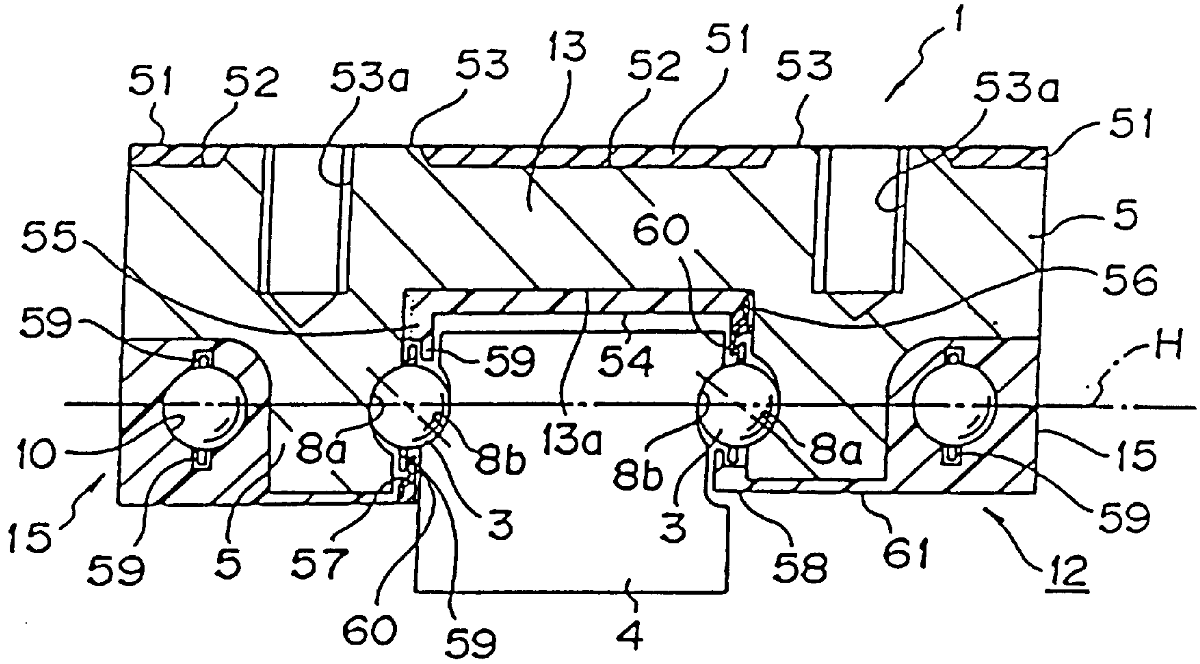


FIG. 1(a)

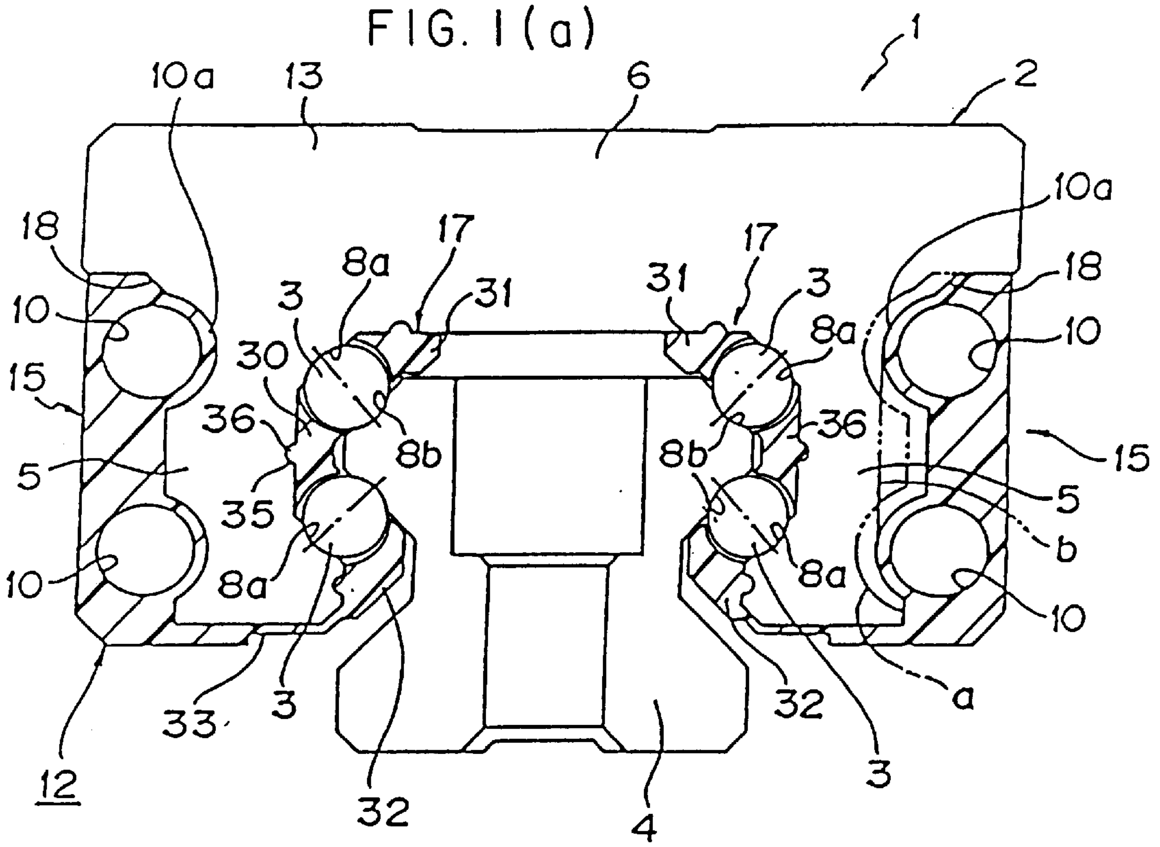


FIG. 1(b)

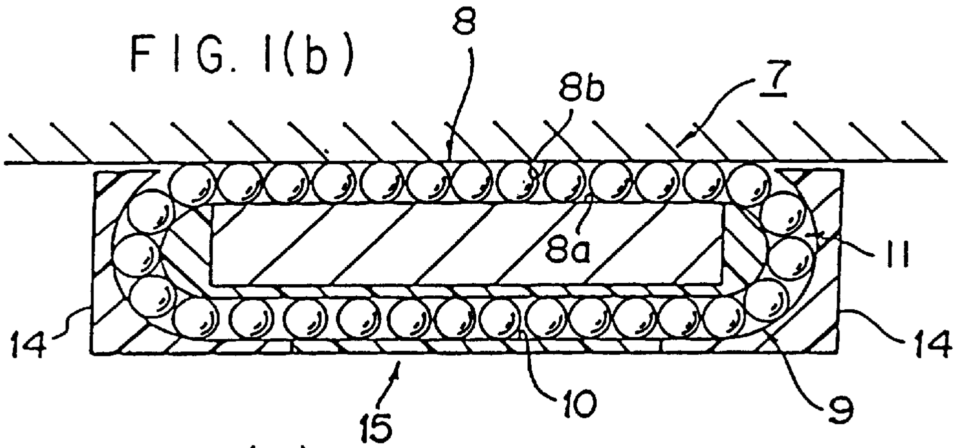


FIG. 1(c)

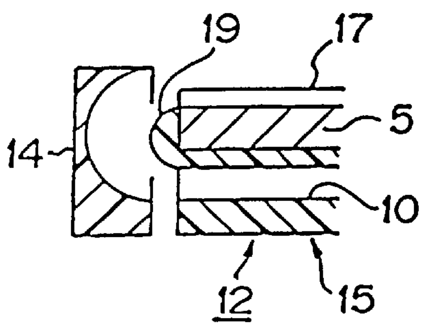


FIG. 1(d)

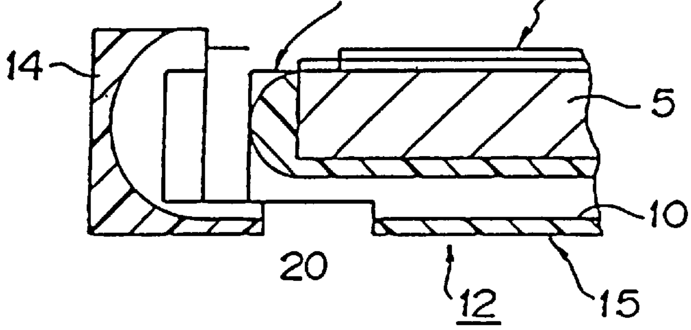


FIG. 2(a)

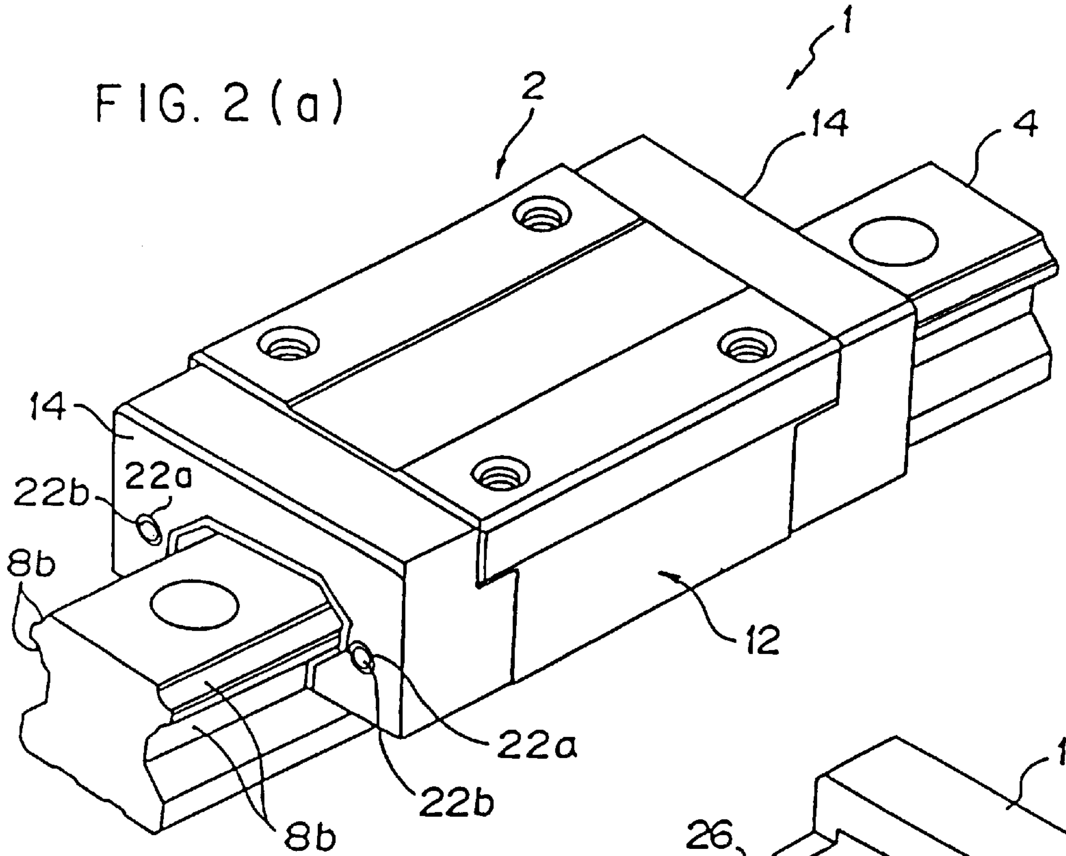

1
2
14
4
14
22b
22a
8b
22a
22b
8b
12

FIG. 2(b)

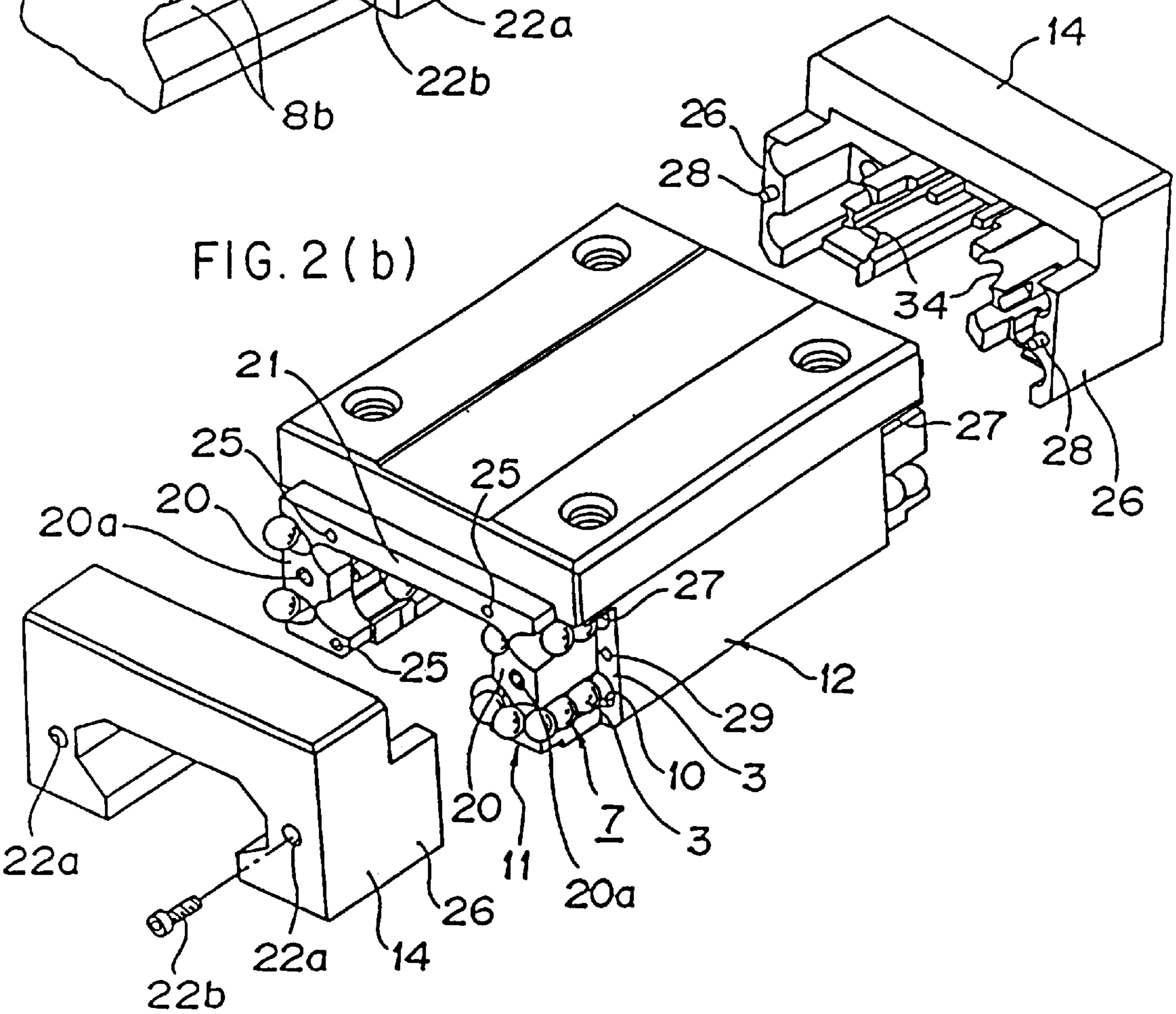

14
26
28
34
28
26
21
25
27
25
20
20a
25
27
12
29
25
3
10
20
3
11
7
20a
22a
26
22a
14
22b

FIG.3(a)

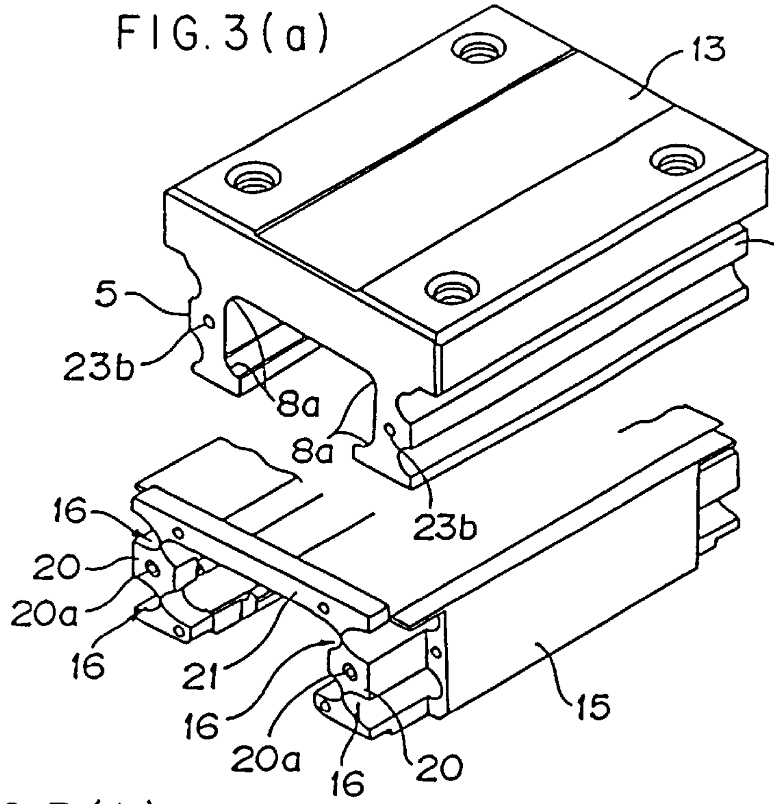


FIG.3(d)

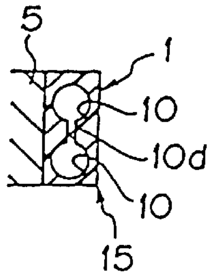


FIG.3(k)

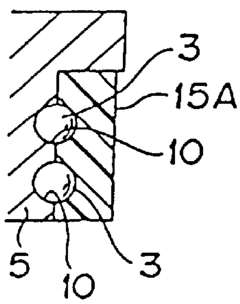


FIG.3(b)

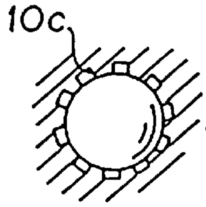


FIG.3(c)

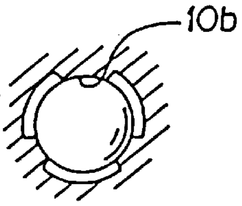


FIG.3(e)

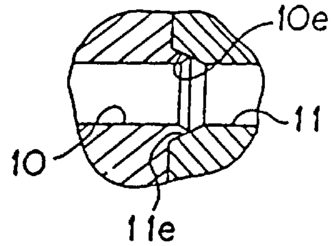


FIG.3(f)

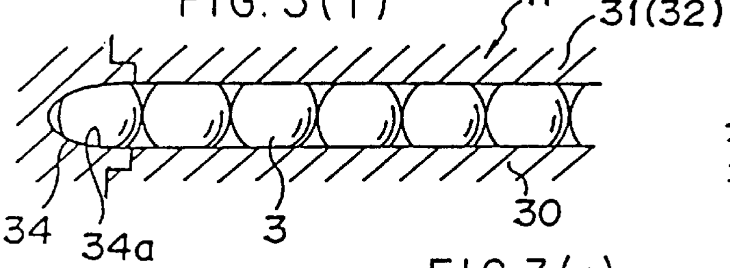


FIG.3(g)

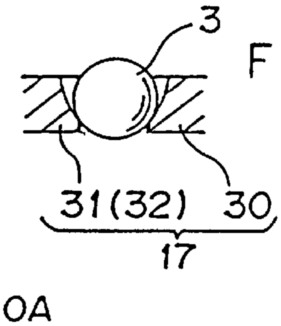
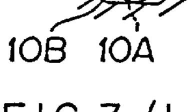
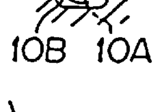


FIG.3(i)





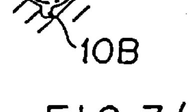
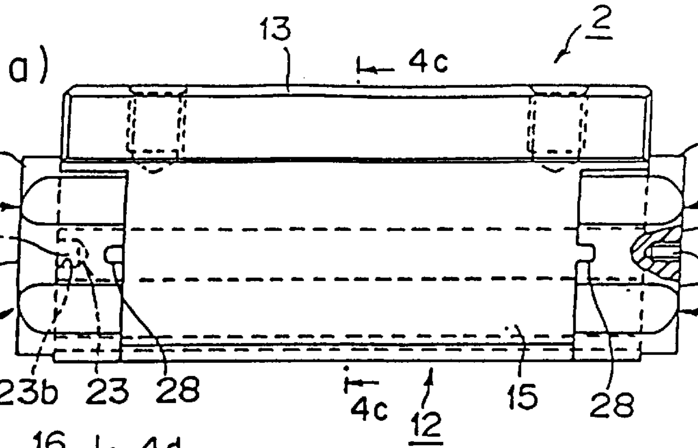


FIG.3(h)

FIG.3(j)

FIG.4(a)



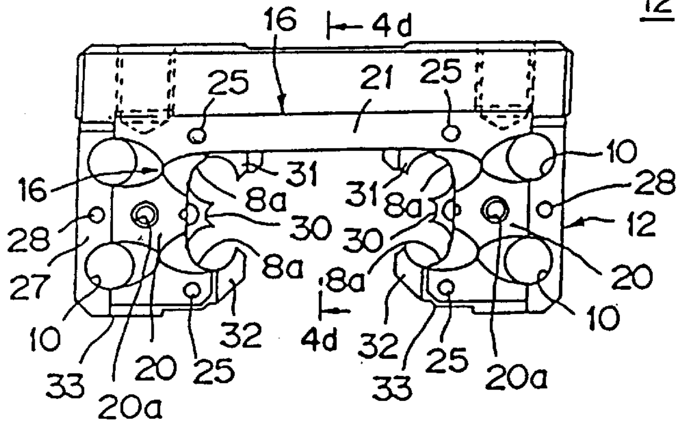


FIG. 4(b)

FIG.4(c)

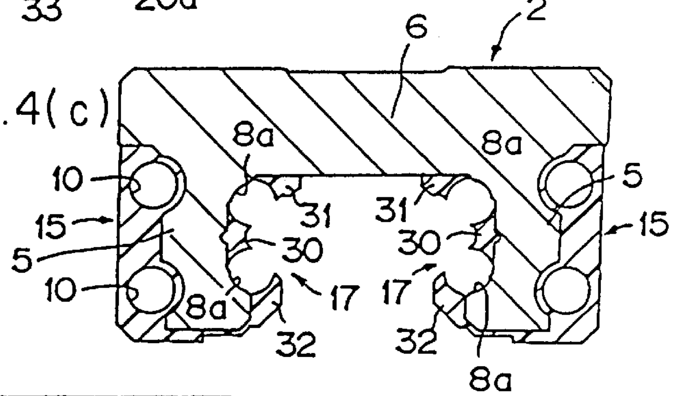


FIG. 4(d)

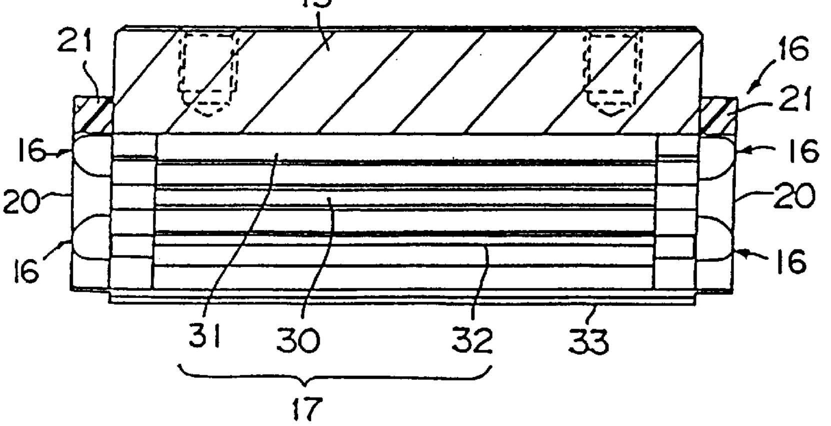


FIG.5(a)

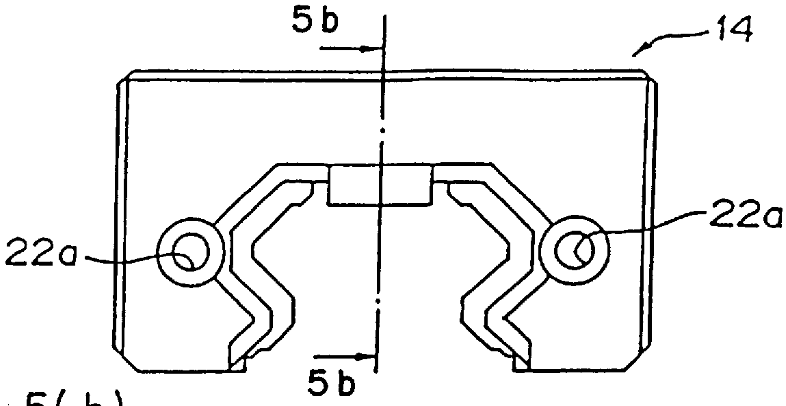


FIG.5(b)

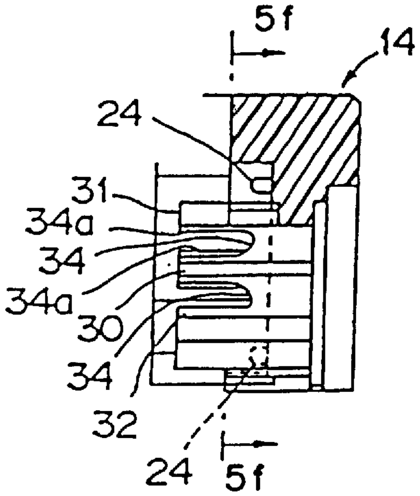


FIG.5(c)

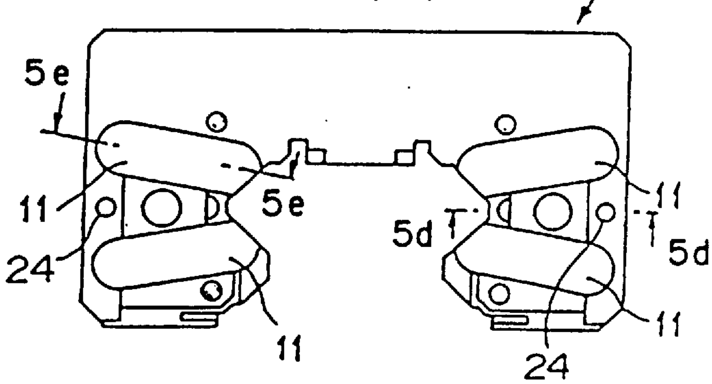


FIG.5(d)

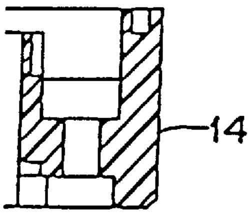
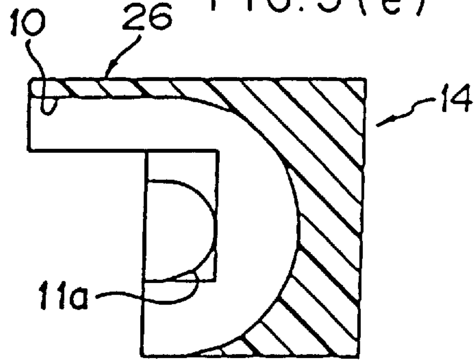


FIG.5(e)



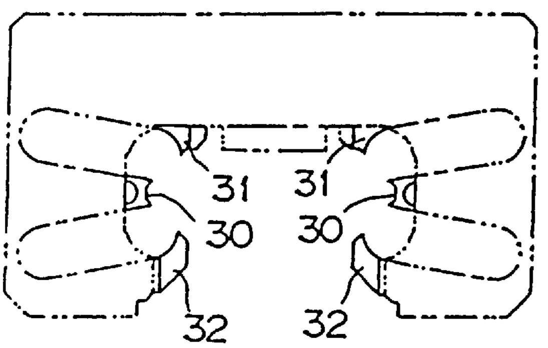


FIG.5(f)

FIG. 6(a)

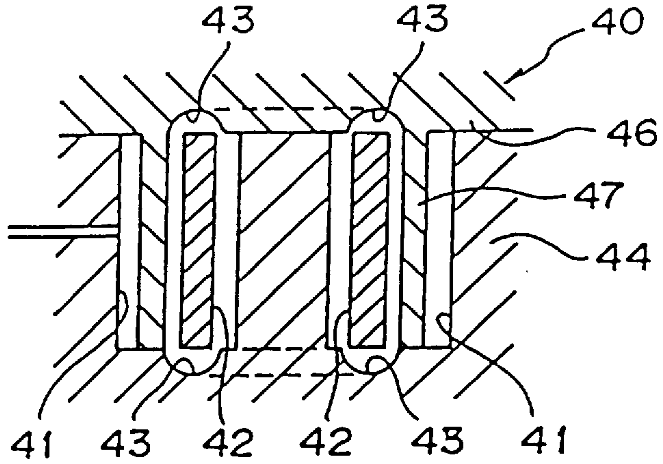


FIG. 6(b)

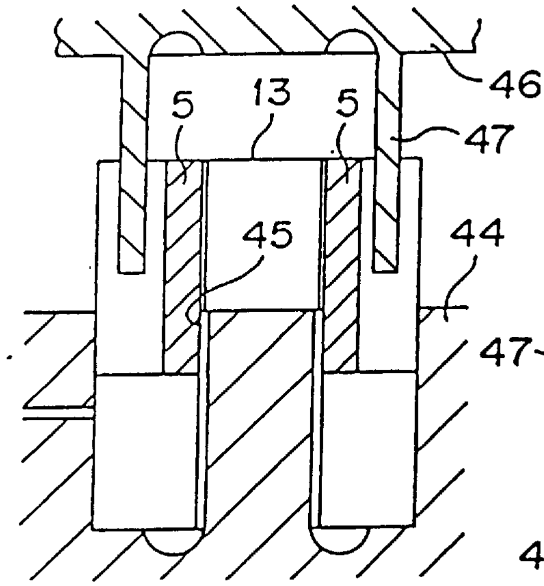


FIG. 6(c)

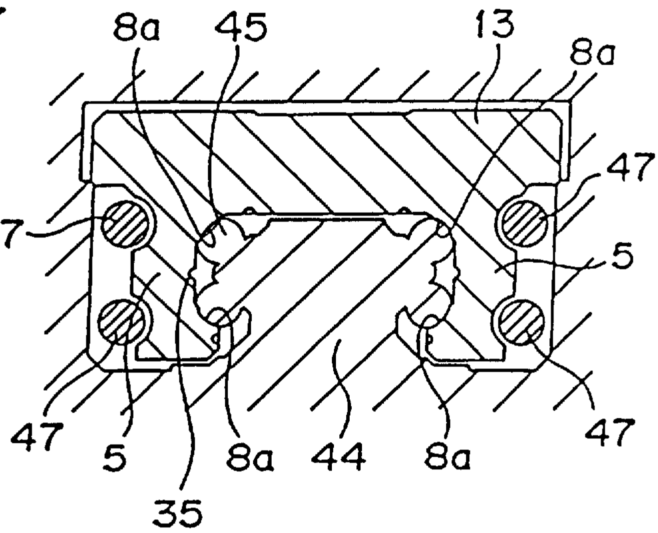


FIG. 7(a)

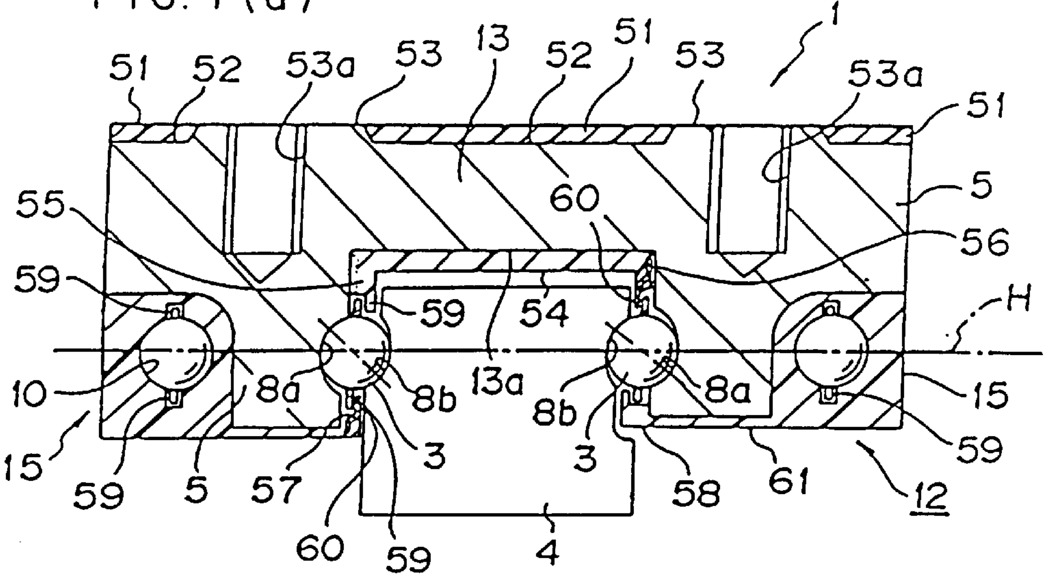


FIG. 7(b)

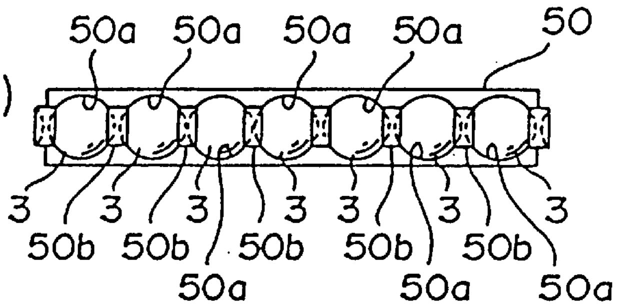


FIG. 7(c)

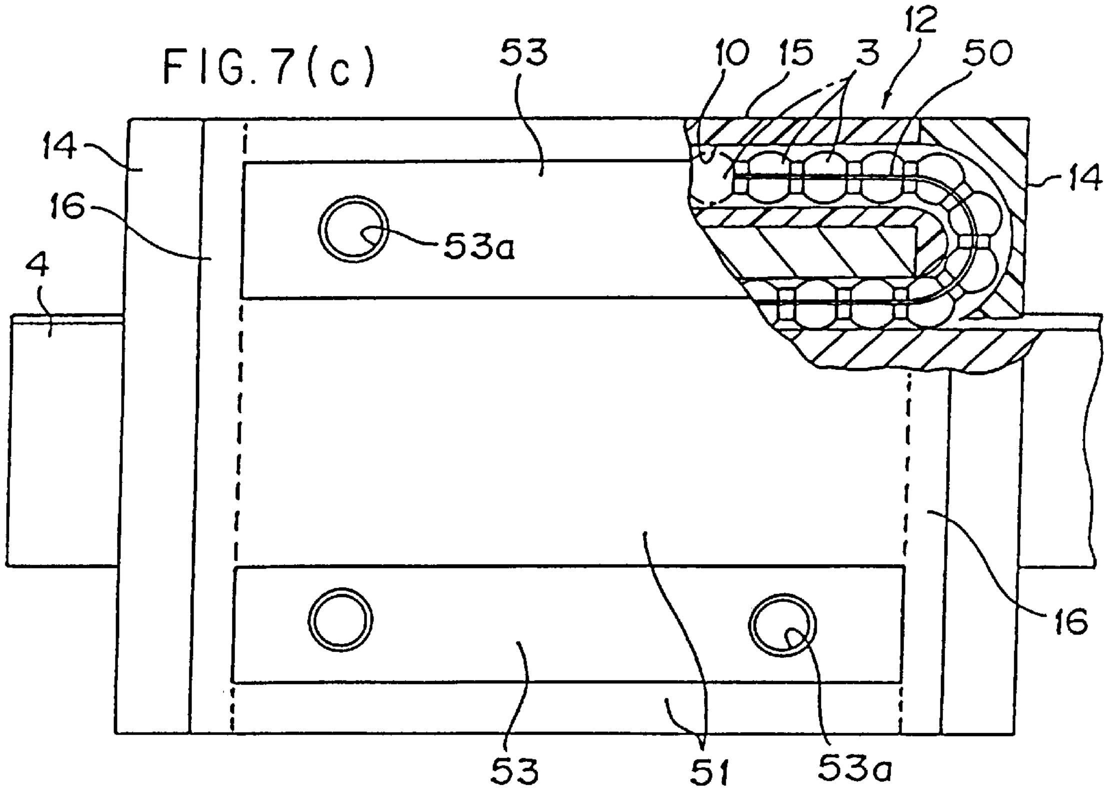


FIG. 8(a)

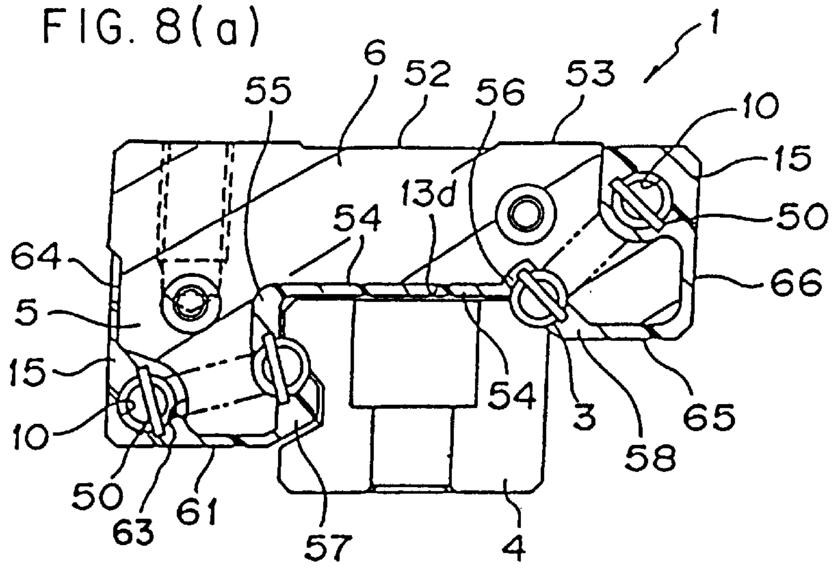
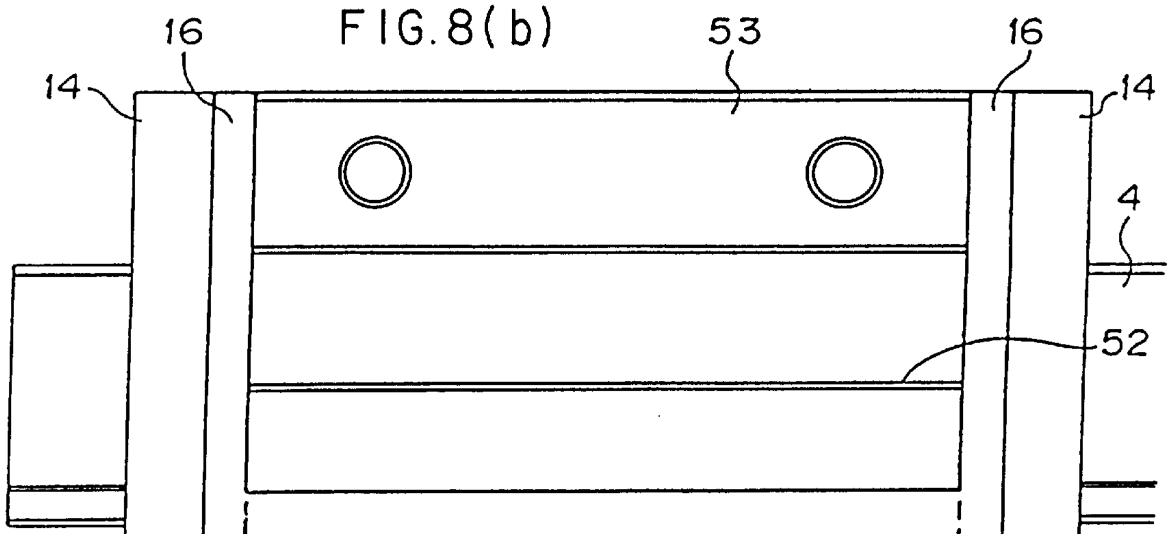


FIG. 8(b)



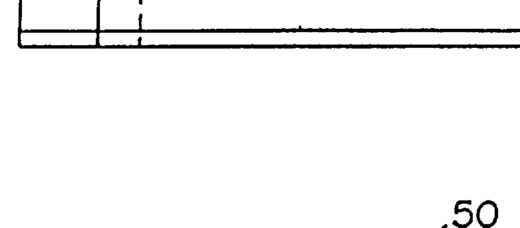


FIG. 8(c)

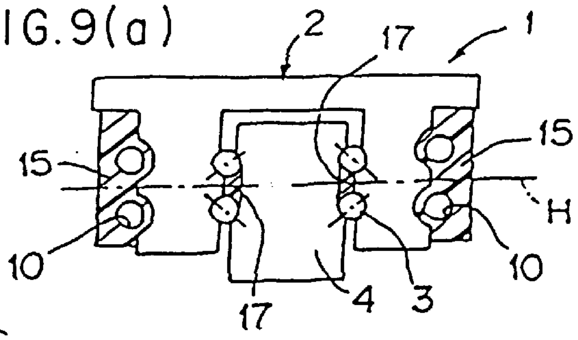


FIG.9(a)

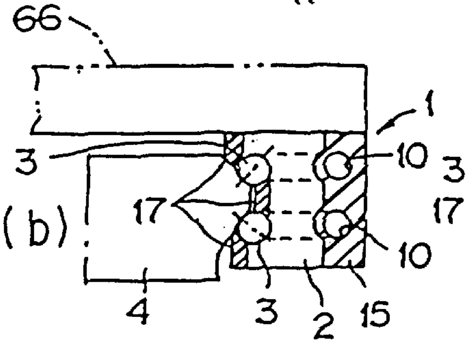


FIG.9(b)

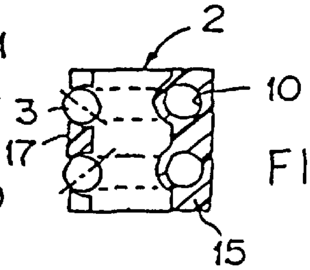


FIG.9(c)

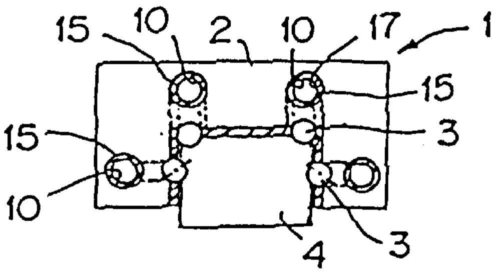


FIG.9(d)

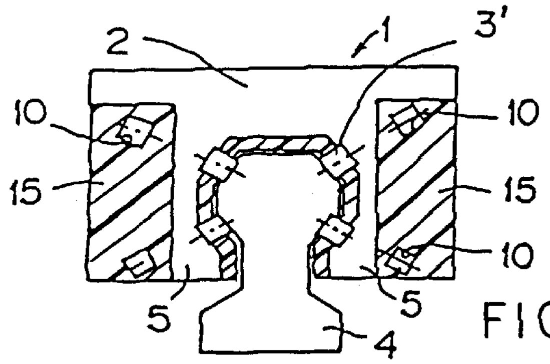


FIG.9(e)

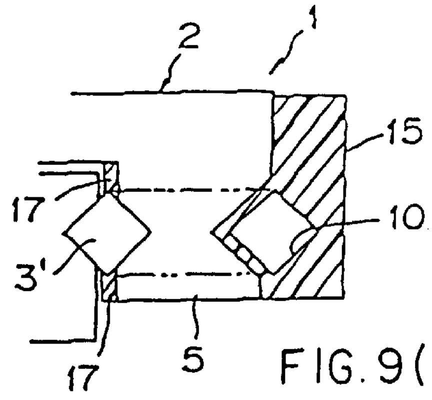


FIG.9(f)

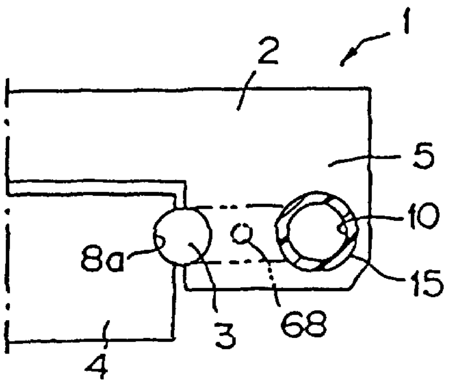


FIG.9(g)

ROLLING GUIDE APPARATUS

This is a continuation of application Ser. No. 08/788,352 filed Jan. 27, 1997 U.S. Pat. No. 5,755,516; which is a continuation of application Ser. No. 08/569,125 filed Apr. 3, 1996, now abandoned; which is a 371 of PCT/JP95/00974 filed May 22, 1995.

TECHNICAL FIELD

The present invention relates to a rolling guide apparatus of contact-type for guiding a rolling member along a linear passage or the like, more particularly, to a structure of a rolling member circulation passage and also relates to a method of manufacturing a movable block of the rolling guide apparatus.

Background Art

A conventional rolling guide apparatus of this type generally has a structure in which a movable block is supported to be movable along a guide rail through a number of rolling members, the movable block is provided with a circulation passage through which the rolling members are guided and circulated. The rolling member circulation passage is formed with a loaded rolling member rolling passage composed of loaded rolling member rolling grooves formed to oppose surfaces of the movable block and the guide rail, respectively, and is formed with a return passage formed to a non-loaded area and connected at their both end portions with the loaded rolling member rolling passage so that the rolling member circulates through the loaded rolling member rolling passage and the return passage. The return passage is composed of a rolling member escape hole extending in parallel to the loaded rolling member rolling passage and a direction changing passage connecting both end portions of the rolling member escape hole to both ends of the loaded rolling member rolling passage to change the rolling direction of the rolling member.

In the conventional structure, however, the rolling member escape hole is formed by drilling a block body so as to penetrate it vertically, which requires a troublesome working and involves a factor of cost increasing.

In order to obviate this defect, a conventional technology has provided a structure in which a rolling member escape hole in a non-loaded area is formed by cutting away a side surface of the block body and the cut-out portion is covered by a cover member formed of a resin material, for example. However, according to this conventional structure, it is difficult to assemble the rolling member circulation passage, and noise is generated due to an assembling error, thus providing a problem.

Furthermore, in the conventional rolling guide apparatus, it has been attempted to construct the block body to have a sufficient rigidity so as not to be deformed even if a heavy load is applied to the guide apparatus. On the contrary, in a case where there is caused a large misalignment between the guide rail and the movable block (for example, an error in degree of parallelism between a fixing surface of the guide rail and a fixing surface of a conveyer table fixed to the movable block), an unnatural force is applied to a contact surface between the rolling member and the rolling member rolling groove. This unnatural force obstructs smooth rolling of the rolling member and, hence, the rolling member and the rolling member rolling groove are easily worn, providing a problem.

In view of this point, in the case of the structure in which the rolling member escape hole is formed by cutting away

the outside surface of the block body, the block body has a reduced thickness portion corresponding to the cut-away portion and hence the rigidity thereof is lowered correspondingly. However, in this type of this structure, the rolling member contacts the cutout portion of the block body and then is covered by the cover member. Therefore, the thickness of the block body is not reduced to a thickness more than that corresponding to a gap between the rolling member escape hole and the loaded rolling member rolling groove and the rigidity is also not reduced correspondingly. However, the gap between the rolling member escape hole and the rolling member rolling groove is not so much reduced because of the smooth rolling direction changing of the rolling member. Thus, there is a limit which the thickness of the block body can be reduced.

The rolling member circulates through the circulation passage formed in the loaded and non-loaded areas, and as far as the positional relationship of the rolling member escape hole with respect to the loaded rolling member rolling groove is not accurately decided, the direction changing passage between the loaded rolling member passage and the rolling member escape hole is not also accurately positioned. Further, in a case where the loaded rolling member rolling passage is not smoothly and continuously connected with the direction changing passage, the rolling member is not smoothly rolled and circulated therein.

Furthermore, a retainer is also disposed on both sides of the loaded rolling member rolling passage for preventing the rolling member from falling off at a time when the movable block is disassembled from the guide rail. It is necessary to form a gap between the retainer and the rolling member rolling passage so that the rolling member does not interfere with the retainer at a time when the rolling member rolls in and along the rolling member rolling passage, and for this reason, it is necessary to accurately position the retainer with respect to the loaded rolling member rolling passage and it is also required for the passage to have an accurate linearity.

Still furthermore, in the conventional structure, respective members or elements assembled with the movable block body made of steel are often fastened by insufficient fastening force, and for this reason, these members, or elements, resonate and generate noises; thus, also providing a problem at a time of the rolling circulation of the rolling member particularly in the non-loaded area at which the rolling member is rolled with no load.

The present invention was conceived to solve the above problems and aims to provide a rolling guide apparatus, which does not require drilling to produce a rolling member escape hole and, instead, produces such a hole by integrally molding a block body and at least the rolling member escape hole through a molding process. As a result, the assembling process can be possibly reduced and generation of noise during the rolling of the rolling member is effectively reduced. A method of manufacturing the movable block is also provided.

In addition to the above object, it is aimed to change the rigidity of the block body without changing a gap between the rolling member escape hole and the loaded rolling member rolling groove.

Furthermore, in addition to the above objects, it is aimed to ensure smooth circulation of the rolling member by accurately positioning the rolling member circulation passage with respect to the rolling member rolling groove.

Disclosure of Invention

The present invention relates to a rolling guide apparatus in which a movable block is supported to be movable along a guide rail through a number of rolling members, a circulation passage for guiding circulation of the rolling members is formed to the movable block, the rolling member circulation passage being composed of a loaded rolling member rolling passage in a loaded area between loaded rolling member rolling grooves formed to opposing surfaces of the movable block and the guide rail and a non-loaded return passage for returning the rolling members in the loaded area from one end of the loaded rolling member rolling passage to another end thereof, the return passage being composed of a rolling member escape hole extending in parallel to the loaded rolling member rolling passage and a direction changing passage having inner and outer peripheral portions connecting both ends of the rolling member escape hole to both ends of the loaded rolling member rolling passage, and the rolling guide apparatus being characterized in that at least one of the rolling member escape hole, the inner peripheral portion of the direction changing passage and a retainer extending along the loaded rolling member rolling passage is formed of a molded body and the molded body is integrally formed with a block body having high rigidity.

The molded body may be composed of only the rolling member escape hole, only the inner peripheral portion of the direction changing passage or only the retainer, or composed of integral combination thereof.

That is, the molded body may be provided with the rolling member escape hole and the inner peripheral portion of the direction changing passage integrally connected to the rolling member escape hole and joined with both end surfaces of the block body.

The molded body may be provided with the rolling member escape hole and the retainer extending along the loaded rolling member rolling passage.

The molded body may be provided with the inner peripheral portion of the direction changing passage joined with both end surfaces of the block body and the retainer extending along the loaded rolling member rolling passage and integrally connected at its both ends with the inner peripheral portion of the direction changing passage.

The molded body may be provided with the rolling member escape hole, the inner peripheral portion of the direction changing passage integrally connected to the rolling member escape hole and joined with both end surfaces of the block body and the retainer extending along the loaded rolling member rolling passage and integrally connected at its both ends with the inner peripheral portion of the direction changing passage, the molded body having a closed sectional shape surrounded by the rolling member escape hole, the direction changing passage and the retainer.

Furthermore, a recess-protrusion engaging portion is formed to joining surfaces of the molded body and the block body.

The molded body is formed of a resin material, and a portion between the loaded rolling member rolling groove and the rolling member escape hole of the movable block is formed as one portion of the resin molded body so as to produce a reduced thickness in the block body having high rigidity to provide an elastic property.

It is effective that the rolling members rolling in the loaded rolling member rolling passage are scooped by a guide, each a two point contact state, extending in the loaded area of the direction changing passage from the loaded rolling member rolling groove to the direction changing passage in a manner of being separated gradually from each other.

It is further characterized that the movable block is provided with a pair of leg portions between which the guide rail is interposed and a connection portion connecting the leg portions, and the rolling member circulation passages are formed to the leg portions.

It is characterized that a covering portion is provided for covering at least one of upper and lower surfaces of the connection portion of the movable block and the covering portion is integrally formed with the inner peripheral portion of the direction changing passage joined with both the end surfaces of the block body.

The rolling member escape hole has a sectional shape having a rolling member passing section through which the rolling member passes and a lubrication agent storing section capable of storing a lubrication agent bled outward from the rolling member passing section.

In another aspect, the present invention relates to a method of manufacturing a movable block, which is supported to be movable with respect to a guide rail through a number of rolling members, of a rolling guide apparatus provided with loaded rolling member rolling grooves formed to opposing surfaces of the movable block and the guide rail, a rolling member escape hole extending in parallel to the loaded rolling member rolling grooves, and a direction changing passage having inner and outer peripheral portions connecting both ends of the rolling member escape hole with both ends of the loaded rolling member rolling passage, the manufacturing method being characterized in that the block body is placed in a mold, and at least one of the rolling member escape hole, the inner peripheral portion of the direction changing passage and a retainer extending along the loaded rolling member rolling passage is formed integrally with the block body through an insertion molding process.

The rolling member escape hole and the inner peripheral portion of the direction changing passage may be integrally formed together through the insertion molding process.

The rolling member escape hole and the retainer extending along the loaded rolling member rolling passage may be integrally formed together through the insertion molding process.

The inner peripheral portion of the direction changing passage and the retainer extending along the loaded rolling member rolling passage may be integrally formed together through the insertion molding process.

The rolling member escape hole, the inner peripheral portion of the direction changing passage, and the retainer extending along the loaded rolling member rolling passage may be integrally formed together through the insertion molding process.

The block body is positioned in the mold with reference to the rolling member rolling groove formed to the movable block.

According to the present invention, since the rolling member escape hole is integrally formed with the block body through the molding process, the drilling working can be eliminated to thereby easily form the, structure.

Particularly, since the rolling member escape hole forming portion is integrally formed in the non-loaded area with the molded body, noise which will be caused by an insufficient fastening force can be prevented from being generated.

The degree of integral formation can be increased by integrally forming the inner peripheral portion of the direction changing passage with the rolling member escape hole, making easy the assembling process.

Furthermore, by integrally forming the rolling member escape hole, the inner peripheral portion of the direction changing passage and the retainer, the tensile stress is applied, by the shrinkage of the molded portions, to the rolling member escape hole, so that the fastening force can be increased by the remaining tensile stress, thus remarkably reducing the generation of the noise.

Particularly, with respect to the retainer, the degree of straightness can be made high by the function of the remaining tensile stress, so that the retainer is made parallel and straight with respect to the loaded rolling member rolling passage, and as a result, when the loaded rolling member is rolled and moved, the retainer does not contact and interfere with the rolling member and the rolling member is hence rolled smoothly and the movable block is also smoothly moved along the guide rail.

Furthermore, since the retainer is firmly secured to the block body through the tensile stress, no resonance is caused by the rolling vibration of the rolling member, thus remarkably reducing the noise.

Further, the thickness of the block constituting material, such as metal, constituting the block body at its portion between the loaded rolling member rolling groove to the rolling member escape hole which affects rigidity thereof can be made thin so as to provide an elastic property without changing the dimension between the rolling member rolling groove and the rolling member escape hole, in other words, with the dimension suitable for the smooth direction changing operation being maintained, by forming the rolling member escape hole by the molded resin body.

Accordingly, if an assembling error between the guide rail and the movable block (for example, misalignment such as an assembling error due to an error in parallelism between the fixing surface of the guide rail and the fixing surface of a conveyer table to be fixed to the movable block) is caused, such error can be absorbed through the flexibility of the thin portions of the block body and the contact portion between the rolling member and the rolling member rolling groove is prevented from being applied with an excessive force.

The rolling member escape hole is formed so as to provide a sectional shape having a rolling member passing section along which the rolling members roll and a lubrication agent storing section capable of storing lubrication agent bleed outward from the rolling member passing section, and according to such structure of the rolling member escape hole, since the lubrication agent can be retained without obstructing the circulating motion of the rolling member, the smooth circulating motion thereof can be surely maintained for the long time operation with no substantial maintenance. Furthermore, the escape hole having such complicated sectional shape can be easily formed through the molding process.

The positioning of the block body inserted into the mold is performed with reference to the rolling member rolling groove through the insertion molding process, and accordingly, since the position of the rolling member escape hole and the position of the retainer can be determined with reference to the rolling member rolling groove, the relative positional relationship among the loaded rolling member rolling passage, the direction changing passage and the escape hole constituting the rolling member circulation passage can be exactly determined. Accordingly, no staged portion is formed on the connection portion between the loaded rolling member rolling passage, the inner peripheral portion of the direction changing passage and the rolling member escape hole, thus smoothly circulating the rolling members.

Furthermore, when the position of the block body in the mold is determined, the contacting portion of the mold with the block body is minimally limited to the rolling member rolling groove by positioning it with reference to the rolling member rolling groove, and the other portions of the mold can be maintained with a non-contact state, which requires no precise working, thus easily performing the manufacturing process.

BRIEF DESCRIPTION OF DRAWINGS

FIGS. **1** through **5** show a rolling guide apparatus according to one embodiment of the present invention, in which: FIG. **1**(*a*) is a vertical sectional view and FIGS. **1**(*b*) to (show structures of a ball circulation passage;

FIG. **2**(*a*) s a perspective view of an outer appearance of the rolling guide apparatus of FIG. **1** and FIG. **2**(*b*) is a disassembled perspective view of a movable block;

FIG. **3***a*–**3***k* shows a disassembled perspective view of the block body and a molded body of the movable block of the rolling guide apparatus of FIG. **1**;

FIG. **4***a*–**4***d* shows the movable block body of the rolling guide apparatus of FIG. **1**, in which FIG. **4**(*a*) is a front view, FIG. **4**(*b*) is a side view, FIG. **4**(*c*) is a sectional view taken along the line C—C of FIG. **4**(*a*) and FIG. **4**(*d*) is a sectional view taken along the line D—D of FIG. **4**(*b*); and

FIG. **5** shows a side cover of the rolling guide apparatus of FIG. **1**, in which FIG. **5**(*a*) is a front view, FIG. **5**(*b*) is a sectional view taken along the line B—B of FIG. **5**(*a*), FIG. **5**(*c*) is backside view, FIG. **5**(*d*) is a sectional view taken along the line D—D of FIG. **5**(*c*), FIG. **5**(*d*) is a sectional view taken along the line E—E of FIG. **5**(*e*) and FIG. **5**(*f*) is a end view along the line F—F of FIG. **5**(*b*).

FIG. **6***a*–**6***c* is a view showing a manufacturing process of the movable block of the rolling guide apparatus of the present invention.

FIG. **7** shows a rolling guide apparatus according to another embodiment of the present invention, in which FIG. **7**(*a*) is a vertical sectional view, FIG. **7**(*b*) is a view showing an endless type retainer and FIG. **7**(*c*) is a plan view partially broken away.

FIG. **8** shows a structure of a further rolling guide apparatus utilizing the endless type retainer of FIG. **7**, in which FIG. **8**(*a*) is a vertical sectional view, FIG. **8**(*b*) is a plan view and FIG. **8**(*c*) is a view showing the retainer.

FIGS. **9**(*a*) to (*g*) represent structures of various types of the rolling guide apparatus of the present invention.

BEST MODE FOR THE INVENTION

The present invention will be described hereunder by way of the embodiments shown in the accompanying drawings.

FIGS. **1** and **2** represent a rolling guide apparatus of one embodiment according to the present invention.

The rolling guide apparatus **1** has a structure in which a movable block **2** is supported, through a plurality of balls as rolling members, by a guide rail **4** to be movable therealong.

The movable block **2** has a U-shape in section and is provided with a pair of leg portions **5**, **5** between which the guide rail **4** is interposed and a horizontal portion **6** to which the leg portions **5**, **5** are rigidly connected.

Four ball circulation passages **7** for guiding a number of balls **3** are formed in the movable block **2**. In the illustrated example, two pairs of upper and lower circulation passages **7** are formed in the bilateral leg portions **5**, **5**, respectively.

Each of the respective ball circulation passages **7** is composed of a loaded ball rolling passage **8** defined by loaded ball rolling grooves **8***a*, **8***b* respectively formed in the opposing surfaces of the movable block **2** and the guide rail **4** and a return passage **9**, formed in a non-loaded area, for returning the balls **3** from one end of the loaded ball rolling passage **8** to the other end thereof.

Contact lines showing directions of contact angles of the four rows of the loaded balls incline in directions to be closed with respect to horizontal line towards the center of the guide rail **4**. In such structure, the contact line means a line connecting contact portions of the balls contacting the ball rolling grooves of the movable block and the guide rail, and the term “contact line” used hereinafter means the same content.

The return passage **9** formed in the non-loaded area is composed of a ball escape hole **10** extending in parallel to the loaded ball rolling passage **8** and a ball rolling direction changing passage **11** connecting both ends of the ball escape hole **10** to both the ends of the loaded ball rolling passage **8**. The direction changing passage **11** is composed of an end surface cover portion **16** integrally joined with the end surface of a high rigid movable block body **13**, to which the loaded ball rolling passage is formed, and a side cover **14** as an outer periphery constituting member.

In the illustrated embodiment, an escape hole forming portion **15** to which the ball escape hole **10** of the ball circulation passage, the end surface cover portion **16** and a retainer **17** extending along the loaded ball rolling passage are formed with a resin molded body **12** integrally with the high rigid block body **13**.

The escape hole forming portions **15** are joined integrally with cutouts **18**, substantially rectangular in section, formed in the bilateral side surfaces of the metallic block body **13**, and the two rows of the upper and lower ball escape holes **10** are independently formed with space. Each of the ball escape holes **10** is entirely peripherally surrounded by the escape hole forming portion **15**. In the illustrated embodiment, an inside portion **10***a* of the ball escape hole **10** is formed in arc shape, and this inside portion **10***a* is integrally connected with the end surface cover portion **16** integrally joined to the end surface of the block body **13**.

The most simple structure of the end surface cover portion **16** is shown in FIG. **1**(*c*) and comprises only an inner peripheral portion **19** of each of the direction changing passages which is connected with the inside portion **10***a* of the ball escape hole **10**, but in the present embodiment, a staged protruded portion **20** fitted to the side cover **14** is formed, and an inner periphery guide surface **11***a* of the direction changing passage is formed in the shape of a recess in the staged protruded portion **20**. Further, a central staged protruded portion **21** is formed in the end surface of the horizontal portion **6** of the block body **13** so as to connect the bilateral staged protruded portions **20**, **20**.

Recess-protrusion engaging portions **23** are formed in surfaces of the bilateral staged protruded portions **20** and the end surface of the block body **13** to be joined for preventing the mold forming member and the block body from positionally shifting from each other through their recess-protrusion engagement. Each of these recess-protrusion engaging portions **23** is composed of a recess **23***a* formed in the end surface of the block body **13** and a protrusion **23***b* fitted to the recess **23***a*.

Screw tap holes **20***a* are formed to the end surfaces of the bilateral staged protruded portions **20** for fastening the side covers **14**. These screw tap holes **20***a* are formed to the end surfaces of the molded body **12**, and on the other hand, tap prepared holes each having a diameter smaller than that of the tap hole **20***a* are formed, through resin formation, to the end surfaces of the block body **13** to positions corresponding to the screw tap holes **20***a*, respectively, and screw tap holes **20***a* are also formed in these prepared holes. The side covers **14** are formed with bolt insertion holes **22***a* through which bolts **22** are inserted and screw-engaged with the screw tap holes **20***a*, thereby fastening the side covers **14**.

The staged protruded portions **20** and the central protruded portion **21** are both formed with positioning holes **25** at their end faces at portions near the ball rolling direction changing portions **11**, and the side covers **14** are formed with positioning projections **24**, at their end surfaces, at portions near the ball rolling direction changing portions **11** corresponding to the positioning holes **25**. These positioning projections **24** and holes **25** are engaged with each other when these members are joined together, whereby the outer peripheral side of the ball rolling direction changing portion **11** on the side cover side and the inner peripheral side of the ball rolling direction changing portion **11** on the mold forming member side of the block body **13** can be surely positioned.

The inner periphery of the ball escape hole **10** may have a simple circular section having a diameter slightly larger than that of the rolling ball, but a guide projection **10***b* as shown in FIG. **3**(*c*) will be provided for constituting three-point contact structure, or a spline shape guide projection **10***c* as shown in FIG. **3**(*b*) may be provided. Since the position of the ball is determined by three point support structure, it is desired to provide the guide projections contacting the ball at more than three points and portions other than the projections **10***b* and **10***c* may be formed. It is desired that the gap between the ball outer periphery and a virtual circle connecting the tip ends of the projections **10***b* and **10***c* is made small so as to be approximately equal to the diameter of the ball.

According to this structure, the balls **3** are guided by the tip ends of these projections, thus preventing meandering motion of the balls **3**.

Furthermore, a lubrication agent, such as grease, in the ball escape hole **10** stays in a portion between the guide projections **10***b* and **10***c*, and accordingly, resistance caused by the lubrication agent during the rolling motion of the balls **3** through the escape holes **10** can be made small, thus the balls **3** being smoothly rolled with less obstruction of the lubrication agent.

Still furthermore, as shown in FIG. **3**(*d*), a structure in which parallel two rows of the ball escape holes **10**, **10** are connected with each other to prevent the balls **3** from clogging due to the presence of the lubrication agent. In this arrangement, the connection groove **10***d* acts as a lubrication agent stay position so that the lubrication agent staying in front of the balls does not obstruct the rolling of the balls **3**.

The ball escape hole **10** is formed so as to provide other various shapes in its section, such as shown in FIGS. **3**(*h*), (*i*) and (*j*) showing triangular shape, square shape and grooved circular shape, respectively. That is, in other words, it will be said that it is desired for the ball escape hole to have a non-circular section provided with a virtual circular section **10**A as a rolling member passing section for passing the ball **3** as rolling member and a lubrication agent staying section **10**B capable of storing the lubrication agent bled out from the virtual circular section **10**A.

In the conventional drilling technology, it is impossible to form the ball escape hole having such section, as mentioned above, and such drilling working can be realized by the integral molding method according to the present invention.

Further, in order to make large the rotation radius of the ball in the direction changing passage **11**, the both end portions of the ball escape hole forming portion is cut away at the outer peripheral portion of the ball escape hole **10** by a predetermined length, and according to the ball escape hole forming portion **15** of the above structure provided for the side cover **14,** the cutout portion **27** is covered to thereby connect the end portion of the ball escape hole **10** with the end portion of the direction changing passage **11**. That is, since the balls **3** can be circulated more smoothly by making possibly large the rotation radius of the direction changing passage, it will not be desired to adopt the structure having a small curvature.

The escape hole outer periphery forming portion **26** of the side cover **14** is formed with positioning projections **28** and the end surfaces of the cutout portions **27** formed to both the ends of the escape hole forming portions **15** of the mold forming member **12** are formed with positioning holes **29,** which engage with the projections **28**. According to this structure, the ball escape holes **10** and the ball direction changing passages **11** are surely positioned at their outer peripheral and inner peripheral sides, providing no staged portion at the joined portions. Since the connection portions between the ball escape holes **10** and the direction changing passages **11** are formed as continuous guide surfaces with no staged portion, the smooth circulation of the balls **3** can be ensured. Particularly, as shown in FIG. **3**(*e*), it is desired for the ball escape hole **10** to have an annular tapered projection **10***e* and desired for the direction changing passage **11** to have a taper received portion **11***e* which is circumferentially entirely engaged with the tapered projection **10***e* as a faucet joint engagement. The tapered projection **10***e* and the taper receiving portion **11***e* are formed at the connection portion of the ball escape hole **10** and the direction changing passage **11**. According to this structure, the ball escape hole **10** and the direction changing passage **11** can be substantially completely joined together.

The retainer **17** acts to hold the balls **3** to prevent the balls **3** from falling off from the movable block **2** when the guide rail **4** is drawn out from the movable block **2**, and in the assembling state of the guide rail **4** and the movable block **2**, the retainer **17** is designed in its dimension so that a gap is formed between the retainer **17** and the balls **3** so as not to obstruct the rolling motion of the balls rolling in the loaded ball passage **8**.

In the described embodiment, the retainer **17** is disposed between the upper and lower two rows of loaded balls **3** formed in the bilateral leg portions **5, 5** and includes a first retainer section **30** for holding the lower edge portion of the ball **3** in the upper row of balls **3** and the upper edge portion of the ball **3** in the lower row of balls **3**, a second retainer section **31** for holding the upper edge portion of the ball **3** of the upper row of balls **3** and a third retainer section **32** for holding the lower edge portion of the ball **3** of the lower row of balls **3**. The upper ball row is held by the first and second retainer sections **30** and **31** and the lower ball row is held by the first and third retainer sections **30** and **32**. The portions of the balls **3** are exposed between these first to third retainer sections **30, 31** and **32** and contact the ball rolling groove **8***b* on the guide rail side to be capable of freely rolling.

These retainer sections **30, 31** and **32** are integrally connected, at their both ends, with the end surface cover portion **16**, and in the illustrated embodiment, the third retainer section **32** is integrally connected with the ball escape hole forming portions **15** of the bilateral leg portions **5, 5** of the block body **13** through the lower surface cover portion **33** covering the lower side surfaces of the leg portions **5, 5**.

The connection between the ball direction changing passage **11** and the loaded ball passage **8** is done by the manner such that each of the balls **3** is scooped gradually at two bilateral points by a tongue piece **34** having a boat shape serving as a guide suitable for scooping the ball **3** by invading the loaded area, the tongue piece **34** being provided at the outer peripheral end portion of the direction changing passage of the side cover **14**, thereby smoothly transferring the balls **3** to the direction changing passage **11** from the loaded ball passage **8**. That is, as shown in FIG. **3**(*f*), the tongue piece **34** is provided with a groove **34***a* having a width gradually reduced towards both the end portions, and as shown in FIG. **3**(*g*), the ball **3** is supported at two points and the loaded ball **3** then rolls apart from the ball rolling groove **8***b* of the guide rail **4**.

Accordingly, the ball **3** circulates to the direction changing passage **11** from the non-loaded ball hole **10** through the tapered projection and receiving portions **10***e* and **11***e*, then, to the loaded ball passage **8** in the loaded area through the boat shaped tongue piece **34**, to the direction changing passage **11** at the end portion of the tongue piece **34** and again to the ball escape hole **10** through the tapered projection and receiving portions **10***e* and **11***e*, thus the balls **3** being circulated in a rolling state through this circulation route. Thus, the connection portions of these portions are not formed with a staged portion to thereby smoothly perform the circulation of the balls **3**.

According to this structure, in which, as shown in FIG. **3**(*b*), the ball escape hole **10** has at least three point contact structure by providing the guide projections **10***b*, **10***c*, the balls **3** roll from the two point contact state in the scooping operation of the boat bottom shaped tongue piece **34** to the three point contact structure, and an ideal ball rolling route can be established throughout the entire ball circulation passage, so that the balls **3** can be smoothly rolled therealong, and hence, generation of noise caused by unbalanced rolling of the balls **3** can be also minimized. In addition, since the idle ball rolling is also reduced, the noise can be minimized.

The movable block **2** of the rolling guide apparatus according to the present invention of the structure described above will be manufactured in the following manner.

A loaded ball rolling groove **8***a* is preliminarily formed to the block body **13**, and the block body **13** is inserted into the mold **40** to integrally form the rolling member escape hole **10** in the block body **13** through the insertion molding process.

FIG. **6** shows a structure of the mold, which is formed with a cavity **41** for forming ball escape hole forming portions **15** outside the leg portions **5, 5**, a cavity **42** for forming the retainers **17** inside the leg portions **5, 5** and a cavity **43** for forming the inner peripheral portions of the direction changing passages **19** at both longitudinal ends of the leg portions **5, 5**. A stationary mold half **44** is provided with a protruded portion **45** to be fitted to the ball rolling groove **8***a* to position the same and a movable mold half **46** is provided with a pin **47** for forming the ball escape hole **10**.

At the time of the insertion molding process, as shown in FIG. **6**(*c*), the positioning inside the mold **40** is made with reference to the ball rolling groove **8***a* of the block body **13**. According to this manner, when the insertion molding process is performed with reference to the ball rolling groove **8***a*, since the positioning of the ball escape hole **10** and the retainer **17** can be done, relative positional relationship among the loaded ball rolling passage **8**, the direction changing passage **11** and the ball escape hole **10** can be accurately established.

In addition, at the time of the positioning in the mold **40** for the block body **13**, if the positioning is performed with reference to the ball rolling groove **8***a*, the contact point to the block body **13** is minimally made to the ball rolling groove **8***a* and the other portions of the mold **40** are allowed to take non-contact arrangement and an accurate working is hence not required to these portions of the mold **40**, resulting in easy manufacture thereof.

Furthermore, the inner peripheral portion **19** of the direction changing passage can be integrally formed with the block body **13** together with the ball escape hole **10** through the insertion molding process.

The retainer **17** can be also integrally formed with the block body **13** together with the ball escape hole formation portion **15** and the end surface covering portion **16** through the insertion molding process.

Thereafter, the direction changing passage **11** can be completed at both the end portions of the loaded ball rolling groove **8***a* by assembling the side covers **14**.

According to the rolling guide apparatus of the structure described above, the ball escape hole forming portion **15** is integrally formed with the block body **13** as the mold forming body **12** through the insertion molding process, so that the drilling working to produce the ball escape hole **10** can be eliminated, thus making simple the manufacturing process.

Furthermore, since the integral molding can be realized through the molding process, any assembling process can be eliminated, thus reducing the assembling working.

Still furthermore, according to the present embodiment, the ball escape hole forming portion **15**, the end surface covering portion **16** and the retainer **17** are integrally formed as the mold forming body **12**, thus making more simple the manufacturing process.

According to the structure for enclosing the outer periphery of the block body **13**, a tensile stress is applied by the shrinkage of the mold forming body **12** to the retainer **17**, the escape ball forming portion **15** and the end surface covering portion **16**, and hence, the ball escape hole forming portion **15** and the retainer **17** are formed with high degree of straightness. Particularly, the ball **3** and the respective retainer sections are not contacted by the application of the tensile stress to the thin retainer sections for the upper side loaded ball and the lower side loaded ball, thus realizing smooth circulation of the balls **3**.

However, in a case where the retainer **17** is formed of a resin material, there is a case of causing a shifting in position by temporary lowering of the tensile stress by a creeping phenomenon, and for such case, the joining surfaces of the first retainer section **30** of the retainer **17** and the block body **13** are formed with recesses and protrusions so as to be firmly joined together through the engagement of these recesses and protrusions. This engagement structure is composed of an engaging groove **35** formed to the joining surface of the block body **13** so as to extend entirely along the axial direction of the block body **13** and an engaging protrusion **36** fitted to the engaging groove **35**. This engaging protrusion **36** is formed by invading the forming material into the groove **35** at the molding time. It will be of course noted that substantially the same engagement is realized in the joining surfaces between the second and third retainer sections **31**, **32** and the block body **13**.

Furthermore, according to the present embodiment, the thickness of the block constituting material, such as metal, constituting the block body **13** at its portion between the loaded ball rolling groove **8***a* to the ball escape hole **10** which affects on rigidity thereof can be made thin so as to provide an elastic property without changing the dimension between the ball rolling groove **8***a* and the ball escape hole **10**, in other words, with the dimension suitable for the smooth direction changing operation being maintained, by forming the ball escape hole **10** by the resin molded body **12**. The thin thickness of the block body will be performed by making large the thickness of the circular portion as shown with two-dot chain line a in FIG. **1**(*a*) or by performing a linear cutting as shown with two-dot chain line b in FIG. **1**(*a*).

Accordingly, if an assembling error between the guide rail **4** and the movable block **2** (for example, misalignment such as assembling error due to an error in parallelism between the fixing surface of the guide rail **4** and the fixing surface of a conveyer table to be fixed to the movable block **2**) will be caused, such error can be absorbed through the flexibility of the thin leg portions of the block body **13** and the contact portion between the ball **3** and the ball rolling groove **8***a* is prevented from being applied by an excessive force.

The ball escape hole may be formed in a structure in which half of the ball escape hole **10** is integrally formed as shown in FIG. **3**(*k*). In such case, an effect due to the thin thickness of the block body will be expected in comparison with the drilling working to the metal block though this effect may be small in comparison with the above embodiment.

FIG. **7** represents another embodiment according to the present invention, in which like reference characters are added to elements or portions corresponding to those of the first mentioned embodiment and explanations thereof are omitted hereunder.

In this embodiment, one ball row is formed in each of the bilateral leg portions **5** of the movable block **2**, and the balls **3** are held by means of an endless retainer **50**, as shown in FIG. **7**(*b*).

The endless retainer **50** is a flexible belt-shaped member formed of a resin, or like material, and a number of ball retaining holes **50***a* are formed with predetermined space from each other. The ball **3** is held by the inner peripheral surface of the respective ball retaining holes **50***a* to be freely rollable and slidable to thereby guide the balls along the entire periphery of the ball circulation passage **7**. Spacers **50***b*, each having a recess of spherical crown shape corresponding to an outer spherical shape of the ball, are disposed between adjacent ball retaining holes **50***a* so as to squeeze the ball **3** from both axial sides of the retainer **50**.

Since the endless retainer **50** is vibrated during the rolling motion of the balls **3**, retainer support members **55** to **58** are disposed linearly along the loaded ball rolling passage **8** to suppress the vibration thereof, and a guide groove **59** is also formed to the ball escape hole **10** for guiding both side edges of the endless retainer **50**.

In this embodiment of FIG. **7**, the ball escape hole forming portion **15**, the end surface covering portion **16** and the retainer support members **55** to **58** are formed integrally as the molded body members **12**. The contact line of the left side ball **3** is inclined downward towards the central portion of the guide rail **4** by a predetermined angle with respect to the horizontal line H, and the contact line of the right side ball **3** is inclined upward towards the central portion of the guide rail **4** by a predetermined angle with respect to the horizontal line H. Thus, these contact lines are substantially in parallel with each other. In an arrangement of a certain contact angle case, there may appear a case wherein each of the retainer support members has a portion having insufficient thickness, so that a reinforcing member **60**, such as a metal plate, may be embedded to such portion as occasion demands. In the illustrated embodiment, the reinforcing members **60**, such as metal plates, are embedded in the right upper retainer support member **56** and the left lower retainer support member **57**.

An upper surface covering portion **51** for covering the upper surface of the block body **13** and an inner peripheral surface covering portion **54** for covering the upper surface of the inner periphery of the central recessed portion **13***a* of the block body **13** are provided on the block body **13**. These covering members **51** and **54** are formed integrally through the end surface covering portion **16** to thereby achieve the reinforcement of the block body **13** and the resin portion formed integrally with the block body **13**. The inner peripheral surface covering portions **54** are formed integrally with the left upper retainer support member **55** and the right upper retainer support member **56**. Lower surface covering portions **61** for covering the lower surfaces of the leg portions **5**, **5** of the block body **13** are also integrally provided on the block body **13** and formed integrally with the left and right lower retainer support members **57** and **58** to define jaw portions which cooperatively engage complementary surfaces on the guide rail **4** to hold the horizontal portion **6** thereon. As shown in FIG. **8**(*a*), each jaw portion is formed of resin having a thickness less than the diameter of the rolling members.

The upper surface of the block body **13** has a low level surface portion **52** and a high level surface portion **53** having a surface level higher than that of the lower level surface portion **52**, and the high level surface portion **53** is formed as a bearing surface formed with bolt holes **53***a* through which fixing bolts are inserted for clamping, whereby the upper surface covering portion **51** is covered over the lower level surface portion **52** to make equal the surface level to that of the high level surface portion **53**, providing a flat surface of the block body **13**. In this embodiment, two high level surface portions **53** are provided in correspondence to the left and right leg portions **5**, **5** of the block body **13**, and three low level surface portions **52** are provided at an intermediate portion between the two high level surface portions **53** and at bilateral both end portions of the block body **13**.

FIG. **8** shows an example of a structure which utilizes the endless retainer **50** described above.

In this example, the levels in arrangements of the left and right balls **3** are made different in a manner such that one of the ball rows is arranged to the right side edge of the upper surface of the guide rail **4** and the other of the ball rows is arranged to the intermediate portion of the left side surface of the guide rail **4**. The block body **13** is formed to have substantially an L-shape in section having one leg portion **5**, and one of the ball escape holes **10** is formed to the right side portion of the upper surface of the horizontal portion **6** of the block body **13** and the other of the ball escape holes **10** is formed to the leg portion **5**. That is, a cutout **62**' is formed in the right edge portion of the upper surface of the horizontal portion **6** of the block body **13**, and the ball escape hole forming portion **15** formed of the resin material is integrally joined with the cutout **62** and the other ball escape hole forming portion **15** is integrally joined with a cutout **63** formed in the lower surface of the leg portion **5** and the corner portion of the left side surface thereof.

The left side surface covering portion **64** of the leg portion **5** and the left upper retainer support member **55** disposed at the inner periphery of the leg portion **5** are formed integrally through the front and rear end surface covering portions **16** so as to surround the leg portion **5**. The inner side edge portion of the lower surface covering portion **61** for covering the lower surface of the leg portion **5** is integrally joined with the retainer support member **57** at the left side ball lower side edge portion. The ball escape hole forming portion **15** formed in the horizontal portion **6** and the lower surface covering portion **65** of the horizontal portion **6** are integrally joined together through the front and rear end surface covering portions **16** so as to vertically surround the horizontal portion **6**. The lower surface covering portion **65** and the ball escape hole forming portion **15** are integrally formed through the right side surface covering portion **65** of the block body **13**, and the inner side edge portion of the lower surface covering portion **65** is joined with the retainer support member **58** for the right lower ball row.

As described above, with the structure of the block body **13**, only the portions necessary for the positioning are exposed and portions not required to form with high precision are covered with resin materials, so that portions of the block body **13** requiring cut working or the like, are reduced, thus reducing manufacturing cost. As shown in the drawing figure, the molded body member forming the support may, in addition to guiding the edges of the retainer, also support the rolling members.

FIG. **9** shows a further example of an arrangement of the present invention, in which like reference numerals are added to elements or portions corresponding to those of the former examples and explanations thereof are omitted herein.

FIG. **9**(*a*) shows a structural example of the linear motion guide apparatus provided with four rows of ball circulation passages **7** as like the above first embodiment, in which the ball escape hole **10**, the inner peripheral portion of the direction changing passage and the retainer **17** are integrally formed. This example differs from the former one in that the contact angle lines to the bilateral upper and lower two ball rows are opened towards the guide rail **4** with respect to the horizontal line.

In the illustrated embodiment, one retainer **17** is disposed between each of the bilateral upper and lower ball rows.

An example shown in FIG. **9**(*b*) has a structure in which the left and right leg portions, such as shown in the embodiment of FIG. **1**, are independently separated and which is utilized for conveying and guiding a table **66**, or the like, by using a pair of linear motion guide apparatus. In this structure, the ball escape hole **10**, the direction changing passage inner peripheral surface **19** and the retainer **17** are also integrally formed.

An example shown in FIG. **9**(*c*) has a structure in which the left and right leg portions **5** of the linear motion guide apparatus, such as shown in FIG. **9**(*b*), are independently separated. In this structure, the ball escape hole **10**, the direction changing passage inner peripheral portion **19** and the retainer **17** are also integrally formed.

An example shown in FIG. **9**(*d*) represents a structure of a linear motion guide apparatus provided with four ball rows including two rows formed to the upper surface of the guide rail **4** and respective one row formed to left and right side surfaces thereof, and in this arrangement, the ball escape hole **10**, the direction changing passage inner peripheral portion **19** and the retainer **17** are integrally formed together.

In this example, the ball escape hole forming portion **15** of the molded body **12** is fitted in a lower hole **67** formed through the block body **13**.

In such arrangement, however, high precision is not basically required with respect to the lower hole **67** to be formed to the block body **13**, thus easily forming the same.

FIG. **9**(*g*) is an example employing the structure of the lower hole **67** to the left and right two ball rows, and particularly, in this example, no retainer is provided and an engaging portion **68** performing recess-protrusion engagement for preventing the positional shifting is formed to the end surface of the block body **13** at the direction changing passage inner peripheral portion.

FIGS. **9**(*e*) and **9**(*f*) show examples of arrangements of the linear motion guide apparatus in which rollers **3**' are used instead of the balls **3**, and FIG. **9**(*e*) shows a linear motion guide apparatus provided with four roller rows and FIG. **9**(*f*) shows a linear motion guide apparatus provided with two roller rows.

With respect to the above examples, it is to be noted that the present invention is described with reference to the linear motion guide apparatus, but it is of course applicable to a linear guide rail slidably assembled with a curved motion guide rail, and as the molded body, a die cast product, sintered metal or the like other than resin material may be utilized.

According to the present invention having the structures and functions mentioned hereinbefore, since the rolling member escape holes are integrally formed with the block body through the molding process, the drilling working can be eliminated to thereby easily form the structure.

In addition, since the integral structure can be provided through the molding process, the assembling process can be reduced.

The degree of integral formation can be increased by integrally forming the inner peripheral portion of the direction changing passage with the ball escape hole, making easy the assembling process.

By integrally forming the rolling member escape hole, the inner peripheral portion of the direction changing passage and the retainer to surround the periphery of the block body, the tensile stress is applied, by the shrinkage of the molded portions, to the rolling member escape hole, the inner peripheral portion of the direction changing passage and the retainer, so that the degree of straightness of the rolling member escape hole and the retainer can be made high, and the generation of resonance noise, at the time of rolling member circulation, to the respective parts of the guide apparatus by residual tensile stress can be prevented.

The low noise frequency due to the rolling member circulation can be prevented from being caused by the increasing of vibration frequency including mass of the block body.

Furthermore, the thickness of the block constituting material, such as metal, constituting the block body at its portion between the loaded rolling member rolling groove to the rolling member escape hole which affects rigidity thereof can be made thin so as to provide an elastic property without changing the dimension between the rolling member rolling groove and the rolling member escape hole, in other words, with the dimension suitable for the smooth direction changing operation being maintained, by forming the rolling member escape hole by the molded resin body. Accordingly, if an assembling error between the guide rail and the movable block (for example, misalignment such as an assembling error due to an error in parallelism between the fixing surface of the guide rail and the fixing surface of a conveyer table to be fixed to the movable block) is caused, such error can be absorbed through the flexibility of the thin portions of the block body and the contact portion between the rolling member and the rolling member rolling groove is prevented from being applied with an excessive force.

The rolling member escape hole is formed so as to provide a sectional shape having a rolling member passing section along which the rolling members roll and a lubrication agent storing section capable of storing lubrication agent bled outward from the rolling member passing section, and according to such structure of the rolling member escape hole, since the lubrication agent can be retained without obstructing the circulating motion of the rolling member, the smooth circulating motion thereof can be surely maintained for a long time operation with no substantial maintenance. Furthermore, the escape hole having such complicated sectional shape can be easily formed through the molding process.

The positioning of the block body inserted into the mold is performed with reference to the rolling member rolling groove through the insertion molding process, and accordingly, since the position of the rolling member escape hole and the position of the retainer can be determined with reference to the rolling member rolling groove, the relative positional relationship among the loaded rolling member rolling passage, the direction changing passage and the escape hole constituting the rolling member circulation passage can be exactly determined. Accordingly, no staged portion is formed to the connection portion between the loaded rolling member rolling passage, the inner peripheral portion of the direction changing passage and the rolling member escape hole, thus smoothly circulating the rolling members.

Furthermore, when the position of the block body in the mold is determined, the contacting portion of the mold to the block body is minimally limited to the rolling member rolling groove by positioning it with reference to the rolling member rolling groove, and the other portions of the mold can be maintained with a non-contact state, which requires no precise working, thus easily performing manufacturing process.

We claim:

1. A rolling guide apparatus in which a movable block is supported to be movable along a guide rail through a number of rolling members, a circulation passage for guiding circulation of the rolling members is formed in the movable block, said rolling member circulation passage being composed of a loaded rolling member rolling passage in a loaded area between loaded rolling member rolling grooves formed in opposing surfaces of the movable block and the guide rail, and a non-loaded return passage for returning the rolling members in the loaded area from one end of the loaded rolling member rolling passage to another end thereof, said rolling guide apparatus further including a continuous belt-shaped retainer extending about the length of said circulation passage formed in said movable block, said retainer being formed of flexible material and having mutually spaced holes operative to rollably mount said rolling members therein, and retainer support means defined by a molded body member integrally formed on said movable block and extending along said circulation passage thereof, said molded body member defining said retainer support means containing means to supportively engage said belt-shaped retainer for sliding movement along said movable block circulation passage.

2. A rolling guide apparatus according to claim **1**, wherein said molded body member defining said retainer support means contains means operative to also support the rolling members.

3. A rolling guide apparatus according to claim **2** wherein said retainer support member is formed with jaw portions adapted to support the retainer against the loaded ball rolling groove.

4. A rolling guide apparatus according to claim **3**, wherein each of said jaw portion is formed of resin having a thickness smaller than a diameter of each of the rolling members.

* * * * *

US005947605A

United States Patent [19]

Shirai

[11] **Patent Number: 5,947,605**

[45] **Date of Patent: Sep. 7, 1999**

[54] **LINEAR MOTION GUIDE APPARATUS EQUIPPED WITH A PLURALITY OF ROWS OF BALL CHAINS**

[75] Inventor: **Takeki Shirai**, Ichikawa, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **09/011,699**

[22] PCT Filed: **Jun. 18, 1997**

[86] PCT No.: **PCT/JP97/02096**

§ 371 Date: **Apr. 13, 1998**

§ 102(e) Date: **Apr. 13, 1998**

[87] PCT Pub. No.: **WO97/48913**

PCT Pub. Date: **Dec. 24, 1997**

[30] **Foreign Application Priority Data**

Jun. 18, 1996 [JP] Japan 8-177388

[51] **Int. Cl.**[6] **F16C 29/06**

[52] **U.S. Cl.** **384/45**

[58] **Field of Search** 384/45, 44, 43, 384/49

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,059,037 10/1991 Albert 384/45
5,755,516 5/1998 Teramachi et al. 384/45

FOREIGN PATENT DOCUMENTS

126149 5/1993 Japan .
317762 12/1995 Japan .

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Armstrong, Wsterman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

A linear motion guide device provided with a plural ball row chain capable of achieving easy assembling working and realizing an improved smooth ball circulation.

It is characterized that ball retainer members **23**, **23** to which one sides of the respective two ball rows **3**, **3** arranged along loaded ball rolling grooves **10**, at a time of removing a movable block **4** from a track rail **1**, are formed to the movable block **4**, the falling-off of the balls in the ball rows can be prevented by the assembling of the ball retainer members **23**, **23** and a plural ball row chain **20**, and the hanging-down of an end portion of the plural ball row chain **20** can be also prevented.

5 Claims, 3 Drawing Sheets

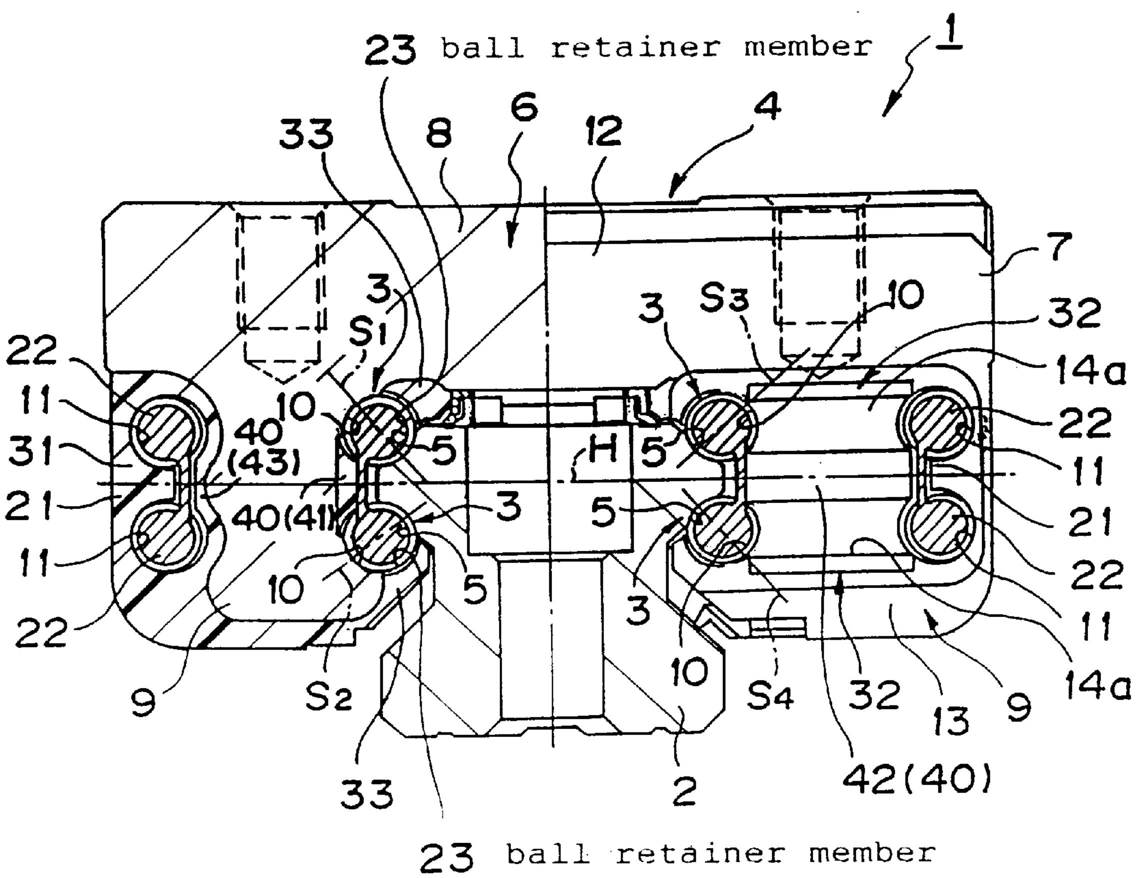
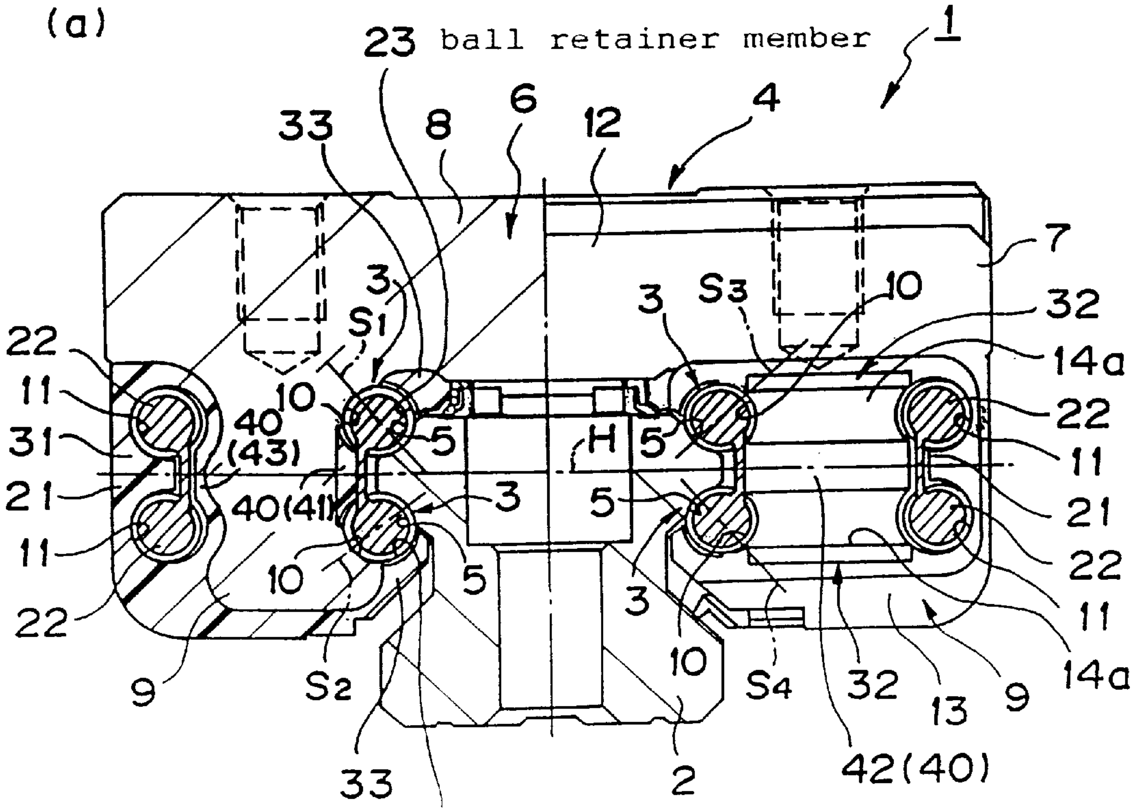


FIG. 1


(a)
23 ball retainer member
1
33
8
6
12
4
7
3
S3
10
32
3
S1
14a
22
22
11
10
5
H
5
11
31
40
21
(43)
21
40(41)
3
5
22
11
10
5
3
22
10
11
9
S2
S4
32
13
9
14a
33
2
42(40)
23 ball retainer member

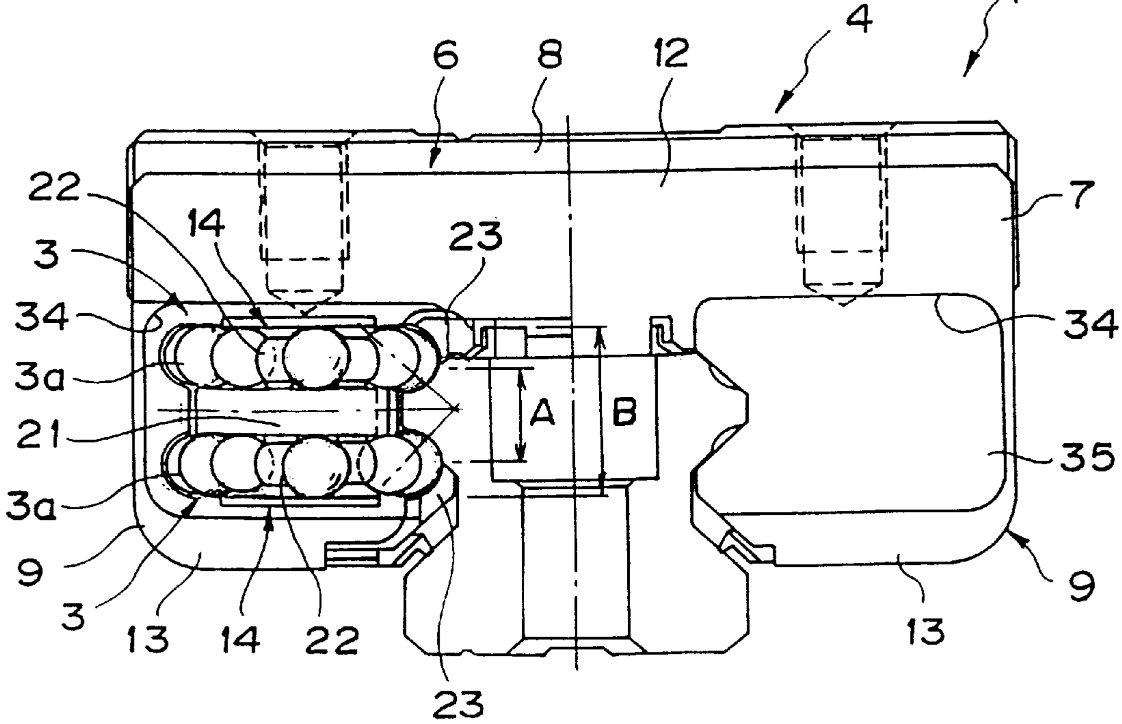

(b)
1
4
6
8
12
22
7
14
23
3
34
34
3a
A
B
21
35
3a
9
9
3
13
14
22
13
23

FIG. 2

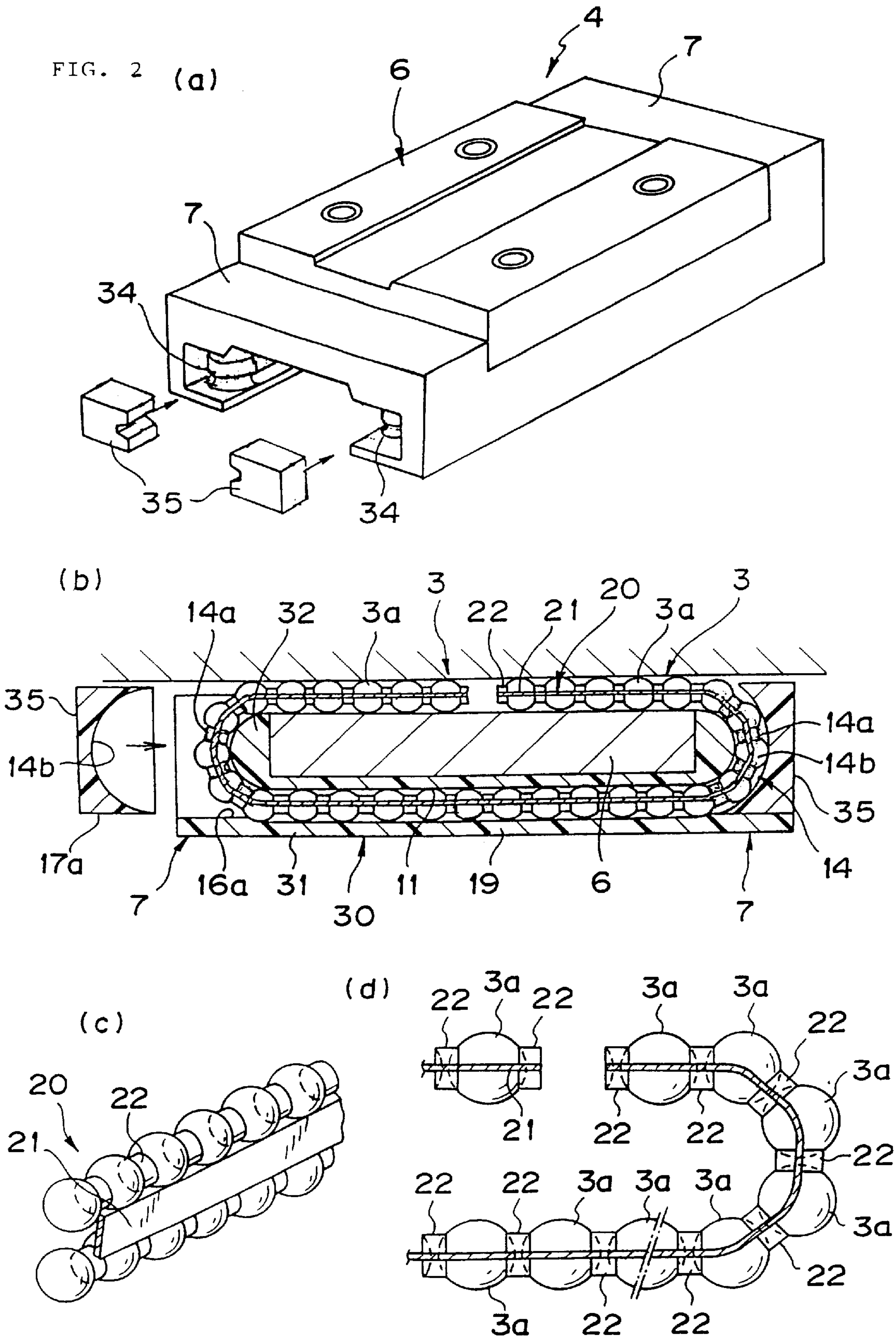
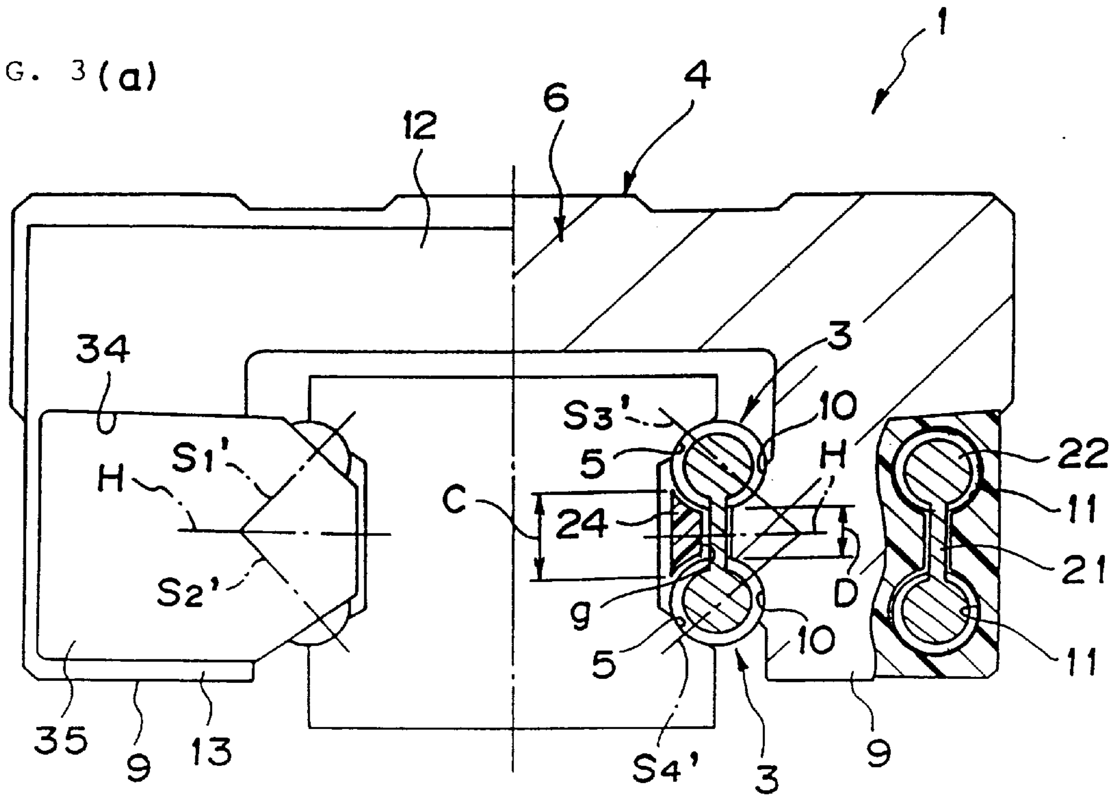
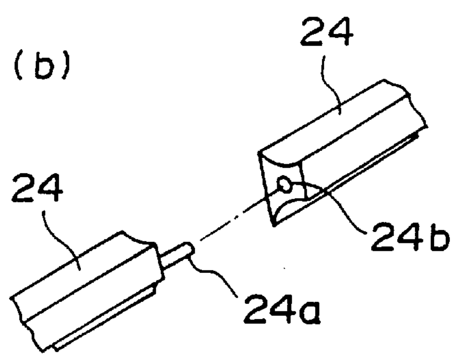

(a)
4
7
6
7
34
35
34
(b)
3
20
3
14a
32
3a
22
21
3a
35
14b
14a
14b
35
17a
16a
31
11
19
6
14
7
30
7
(c)
20
22
21
(d)
22
3a
22
21
3a
3a
22
3a
22
22
22
22
3a
3a
3a
3a
3a
22
3a
22
22
22

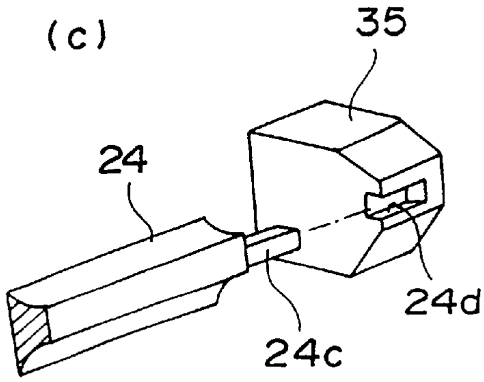
FIG. 3(a)


1
4
6
12
34
3
S3'
10
5
H
22
11
C
24
H
D
21
S1'
S2'
g
5
10
11
35
9
13
S4'
3
9

(b)


24
24
24b
24a

(c)


35
24
24d
24c

LINEAR MOTION GUIDE APPARATUS EQUIPPED WITH A PLURALITY OF ROWS OF BALL CHAINS

TECHNICAL FIELD

The present invention relates to a linear motion guide device, particularly, having a plural ball row chain holding two rows of balls.

BACKGROUND ART

In a conventional art, as a linear motion guide device of this kind, the same applicant as that of the present invention had already proposed a linear motion guide device assembled with a chain for holding plural rows of balls in which two ball rows are held by one ball chain (see Japanese Patent Laid-open Publication No. HEI 5-126149). That is, this linear motion guide device is provided with a track rail and a movable block mounted to the track rail to be movable through a number of balls.

The movable block is composed of a movable block body having a loaded ball rolling groove corresponding to a loaded ball rolling groove formed to the track rail and a non-loaded ball return passage formed in parallel thereto and end plates disposed to both ends of the movable block body and adapted to form an endless ball circulation passage communicating the loaded ball rolling groove and the rolling member return passage.

The balls constitute two ball rows separated from each other with a predetermined distance and in parallel to each other, and these two ball rows are held by a plural ball row chain to thereby circulate in the endless circulation passage. The plural ball row chain has a structure composed of a flexible connection member disposed between two ball rows and spacer members located at both side edge portions of the connection member and adapted to be inserted into balls of the respective ball rows so as to smoothly perform the circulation of the balls.

However, in the conventional technique mentioned above, because the plural ball row chain is formed from a belt-shaped member having a cut end portion, the end portion of the ball chain hangs down at a time when the movable block is removed from the track rail.

In a state that the end portion of the chain hangs down, when only the movable block is assembled with a table or the like, the hung end portion of the chain may be engaged with the table, which may result in that the plural row ball chain is withdrawn from the movable block or, otherwise, is twisted or clamped thereby, thus providing a troublesome working problem and, in a certain case, damaging the ball chain.

Further, although the respective ball rows are circulated in alignment through the spacer members of the ball chain, the smooth circulation movement of the ball may be blocked in the presence of stepped portions, caused by, for example, assembling error, at connection portions between the loaded ball rolling groove and a direction changing passage inner periphery guide portion and between the direction changing passage and the non-loaded ball return passage.

Furthermore, there may easily be caused a positional error of an outer periphery guide portion with respect to the inner periphery guide portion of the movable block body by an assembling error at the time of clamping the end plates or self-deformation of the end plates. Since the end portion of the outer periphery portion approaches the loaded ball rolling groove of the track rail and constitutes a scooping

portion for scooping the balls, it is necessary to make such error as small as possible in order to perform further smooth circulation of the balls. Particularly, in the case of two ball rows, it is necessary to exactly set a pitch between the direction changing passage outer periphery guide portions of the end plates corresponding to two rows of loaded ball rolling grooves. However, in the conventional technology, the end plates have been formed through a molding process, so that it is extremely difficult to exactly perform a molding working because of deformation due to burr of a material in the molding process, and there is a limit for enhancing a mounting performance.

The present invention has been proposed to solve such problems in the conventional technique mentioned above and an object thereof is to provide a linear motion guide device having a plural ball row chain capable of being easily assembled and achieving an improved circulation of balls.

DISCLOSURE OF THE INVENTION

To achieve the above objects, according to the present invention, there is provided a linear motion guide device, provided with a plural ball row chain, which comprises a track rail and a movable block mounted to the track rail to be movable through a number of balls, the movable block comprising a movable block body provided with a loaded ball rolling groove corresponding to a loaded ball rolling groove formed to the track rail and a non-loaded ball return passage disposed in parallel to the loaded ball rolling groove of the movable block body and also provided with a direction changing passage forming members formed at both the ends of the movable block body and constituting ball direction changing passages forming an endless ball circulation passage communicating the loaded ball rolling groove and the rolling member return passage, the balls being composed of at least one set of two ball rows in parallel to each other with a predetermined space and the two ball rows being supported by a belt-shaped plural ball row chain enabling the balls to circulate the endless ball circulation passage, the plural ball row chain being composed of a flexible connection member disposed between the two ball rows and spacers disposed at both side edges of the connection member and adapted to be inserted into adjacent balls,

wherein a ball retainer portion is disposed to the movable block body so that the balls in respective ball rows along the loaded ball rolling groove are engaged at a time of removing the movable block from the track rail and the balls are prevented from falling off through an assembling of the ball retainer portion and the plural ball row chain.

According to the present invention, the assembling of the balls in the movable block is done by holding predetermined numbers of balls by the plural ball row chain, which is then inserted into the movable block body, now not assembled with the track rail, through the end portion of the plural ball row chain. Accordingly, by assembling the balls into the movable block through the plural ball row chain, the assembling working of the necessary numbers of balls can be done accurately and quickly without falling-off of the balls and the assembling workability can be also improved.

Furthermore, at the time when the assembling of the plural ball row chain has been completed, the balls of two ball rows exposed to the loaded ball rolling groove of the movable block to which the track rail is not assembled are supported by the spacers of the plural ball row chain positioned between the adjacent balls. One side of the ball row supported by the plural ball row chain is engaged with the ball retainer, and the balls are hence prevented from falling off by means of the plural ball row chain, and furthermore, the hanging-down of the end portion of the plural ball row chain can also be prevented.

Accordingly, in a case where the movable block is assembled to a table with the track rail being not inserted, there is no fear of falling-off of the plural ball row chain from the movable block and the assembling working can be hence quickly performed.

Furthermore, the ball retainer portion includes two retainer members disposed to side edge portion opposing to the location of the connection member of the plural ball row chain and an opening width of the retainer member is set smaller than a maximum width between balls of the respective ball rows.

According to this structure, two ball rows supported by the plural ball row chain can be held together with the plural ball row chain by the two ball retainer members positioned outside the plural ball row chain.

This structure is preferred for a contact angle structure in which a contact angle line connecting contact points of two ball rows to the loaded ball rolling grooves of the movable block and the track rail is inclined in a direction closed towards the track rail.

Furthermore, the ball retainer members are disposed between the two ball rows, a maximum width between the retainer members is set larger than a minimum width of two ball rows and a gap through which the connection member of the plural ball row chain passes is formed between the ball retainer portion and the movable block body.

In this structure, two ball rows held by the plural ball row chain are held together with the plural ball row chain by both the side edges of the ball retainer portion positioned inside the plural ball row chain.

This structure is preferred for a contact angle structure in which a contact angle line connecting contact points of two ball rows to the loaded ball rolling grooves of the movable block and the track rail is inclined in a direction opened towards the track rail.

Furthermore, a return passage forming portion constituting the non-loaded ball returning passage corresponding to the two ball rows, a direction changing inner periphery guide portion forming portion constituting an inner periphery guide portion of the ball direction changing passage, and a ball retainer forming portion constituting ball retainer members are constituted by a circulation passage forming portion integrally formed by inserting the movable block body into a mold.

According to this structure, the connected portions between the non-loaded ball return passage and the direction changing passage inner periphery guide portion and between the direction changing passage inner periphery guide portion and the loaded ball rolling groove can be formed as continuous surfaces with no stepped portion, thus performing smooth ball circulation. Furthermore, since the ball retainer portion can be exactly positioned, the balls do not contact the retainer portion at the ball rolling time and the balls can hence roll smoothly.

Furthermore, the direction changing passage inner periphery guide portion forming portion is composed of an end surface forming portion integrally formed with an end surface of the movable block body inclusive of the direction changing passage guide portion and an area in the vicinity thereof, a recessed portion exposing the direction changing passage inner periphery guide portion corresponding to ball rows is formed to the end surface forming portion, a deflector formed with an outer periphery guide portion of a rolling member rolling direction changing passage is engaged with the recessed portion, and the rolling member rolling direction changing passage is composed of the inner periphery guide portion and the outer periphery guide portion.

According to this structure, the deflector can be positioned by the recessed portion formed to the end surface forming portion integrally formed to the movable block body, and the outer periphery guide portion of the ball direction changing passage can be also positioned by the end surface forming portion. Since the recessed portion is integrally formed with the movable block body, the positional relationship to the loaded ball rolling groove can be exactly set.

Furthermore, the assembling working of the plural ball row chain can be easily done by inserting the same through the recessed portion, reducing the chain assembling working time.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view showing a linear motion guide device according to one embodiment of the present invention, in which FIG. **1**(*a*) is a half elevational section and

FIG. **1**(*b*) is a half cross section showing an end face portion.

FIG. **2**(*a*) is a schematic perspective view showing an inserting state of a deflector of a movable block,

FIG. **2**(*b*) is a sectional view of an endless circulation passage,

FIG. **2**(*c*) is a perspective view showing a portion of a chain for plural ball row chain, and

FIG. **2**(*d*) is a partial plan view.

FIG. **3**(*a*) is a sectional view of a linear motion guide device according to another embodiment of the present invention, and

FIGS. **3**(*b*) and **3**(*c*) are views showing connection structures of a ball holding portion.

BEST MODE FOR EMBODYING THE INVENTION

Hereunder, the present invention will be described through exemplary embodiments with reference to the accompanying drawings.

FIGS. **1** and **2** represent a linear motion guide device provided with plural ball row chain according to the present invention.

Referring to FIG. **1**, reference numeral **1** denotes an entire structure of a linear motion guide device, and the linear motion guide device **1** is generally composed of a track rail **2** and a movable block **4** disposed to be movable, through a number of balls **3***a* as rolling members, with respect to the track rail **2**.

The track rail **2** is formed of a member having a long length in its longitudinal direction and forming so as to provide a]-shape in section. The track rail **2** has bilateral left and right side surfaces along which the movable block **4** is guided through a pair of two ball rows, totally four ball rows **3**, **3**, **3**, **3**, and the bilateral side surfaces are formed with four rows of loaded ball rolling grooves **5**, **5**, **5**, **5** along the longitudinal length of the track rail at positions corresponding to the four ball rows **3**, **3**, **3**, **3**, respectively. Each pair of these ball rolling grooves **5**, **5** and **5**, **5** are formed in an vertical arrangement, in an illustrated state, at each of the bilateral side surfaces of the track rail **2** with a projected portion, projecting sideaway at an upper portion of each side surface, being interposed therebetween.

The movable block **4** is composed of a movable block body **6** and end plates **7**, as direction changing passage constituting members, to be disposed at both ends of the movable block body **6**. The movable block body **6** is a block member providing a]-shape in section having a horizontal portion **8** facing an upper surface of the track rail **2** and a pair of supporting leg portions **9, 9** facing the right and left side surfaces of the track rail **2**. The supporting leg portions **9, 9** have inner side surface portions formed with loaded ball rolling grooves **10, 10, 10, 10** corresponding, in locations, to the loaded ball rolling grooves **5, 5, 5, 5** formed to the bilateral side surfaces of the track rail **2**. Four ball return passages **11, 11, 11, 11** are linearly formed to solid portions of the respective supporting leg portions **9, 9**, in parallel to the corresponding loaded ball rolling grooves **10, 10, 10, 10**, respectively.

The end plate **7** also provides a]-shape in section as like the movable block body **6** and is composed of a horizontal portion **12** corresponding to the horizontal portion **8** of the movable block body **6** and skirt portions **13, 13** corresponding to the supporting leg portions **9, 9** of the movable block body **6**. The skirt portions **13, 13** of the end plate **7** is formed with ball direction changing passages **14, 14, 14, 14** communicating the loaded ball rolling grooves **10, 10, 10, 10** and the ball returning passages **11, 11, 11, 11**, thus constituting the endless ball circulating passages at both ends of the movable block body **6**.

Contact angle lines S1, S2, S3, S4 connecting contact points of bilateral two, totally four, ball rows **3, 3** and **3, 3** to the corresponding ball rolling grooves **5, 5, 5, 5** and **10, 10, 10, 10** have inclinations bilaterally symmetrically in directions narrowing distances towards the track rail side with respect to the horizontal line H passing the central portion of the upper and lower vertical ball rows so as to provide outwardly opened contact structure. Contact angles constituted by these contact angle lines S1, S2, S3 and S4 and the horizontal line H are set to about 45°, thus providing a load supporting property for substantially equally supporting the load from vertical and horizontal directions, i. e. substantially every direction.

The respective right and left two rows of balls **3, 3** and **3, 3** are circulated through the endless circulation passage with being supported by two plural ball row chains **20**, and each of plural ball row chain **20** is composed of a flexible connection member **21** disposed between two rows of balls **3, 3** and spacer members **22** attached to both side edges of the connection member **21** and adapted to be inserted into adjacent two balls **3*a*** in each ball row **3**. The plural ball row chain **20** is formed from a flexible linear belt-shaped member and both the ends thereof are not connected and are separated.

Two ball retainer members **23, 23** for preventing the balls **3*a*** from falling off at a time of removing the movable block **4** from the track rail **1** are disposed to a side edge portions, i. e. upper and lower side edge portions in the illustrated embodiment, opposing to the connection member **21** of the plural ball row chain **20** for the ball rolling grooves **10, 10, 10, 10** of the movable block side through which two ball rows **3, 3** are rolled. According to the combination of the two ball retainer members **23, 23** and the plural ball row chain **20** prevents the balls **3*a*** in the respective ball rows from falling down. An opening width between the respective ball retainer members **23, 23** is set to a value smaller than the maximum width between the respective ball rows **3, 3**.

According to the present invention, the assembling working of the respective ball rows **3, 3** in the movable block **4** is performed by supporting predetermined numbers of the balls **3*a*** by the plural ball row chain **20** and inserting the balls **3*a*** into the movable block **4**, to which the track rail **1** has not been assembled, through the end portion of the plural ball row chain **20**. According to the manner that the balls **3*a*** are assembled into the movable block **4** through the plural ball row chain **20**, the necessary numbers of the balls **3*a*** can be assembled acurately and promptly without falling off, thus improving the workability in the assembling working.

Furthermore, in the state that the assembling of the plural ball row chain **20** has been completed, the balls in the bilateral two rows exposed in the loaded ball rolling grooves **10, 10, 10, 10** of the movable block **4**, which has not been assembled with the track rail, are supported by the spacer members of the plural ball row chain **20** disposed between the adjacent balls, respectively. One side portions of the respective two rows **3, 3** and **3, 3** of balls **3*a*** supported by the plural ball row chain **20** are engaged with the ball retainer members **23, 23** and **23, 23** disposed at both the upper and lower side edge portions of the respective loaded ball rolling grooves **10, 10**, and the balls **3*a*** can hence be prevented from falling off by means of the plural ball row chain **20**. Furthermore, the hang-down of the end portions of the plural ball row chain **20** can be also prevented.

Accordingly, in a case where the movable block **4** is assembled with a table with the track rail **1** being not inserted, there is no fear of falling off of the plural ball row chain **20** from the movable block **4**, thereby smoothly performing the assembling working.

Furthermore, a pair of bilateral return passage forming portions **31, 31** forming the non-loaded ball return passages **11, 11** and **11, 11** corresponding to the respective bilateral two ball rows **3, 3** and **3, 3**; a pair of bilateral direction changing passage inner periphery guide portion forming portions **32, 32** forming the inner periphery guide portions **14*a*, 14*a*** and **14*a*, 14*a*** of the ball direction changing passages **14, 14** and **14, 14**; and bilateral two rows of ball retainer member forming portions **33, 33** and **33, 33** forming the ball retainer members **23, 23** and **23, 23**, are formed by a circulation passage forming member **30** which is formed integrally with the movable block body **6** by inserting the same into a mold. The circulation passage forming member **30** may be formed as a product of resin molding or aluminium die casting.

According to the manner mentioned above, the connected portions between the non-loaded ball return passages **11, 11** and **11, 11** and the direction changing passage inner periphery guide portions **14*a*, 14*a*** and **14*a*, 14*a*** and between the direction changing passage inner periphery guide portions **14*a*, 14*a*** and **14*a*, 14*a*** and the loaded ball rolling grooves **10, 10** and **10, 10** can be formed so as to provide substantially continuous surfaces with no stepped portion, enabling the ball rows **3, 3** and **3, 3** to smoothly circulate. Furthermore, since the ball retainer members **23, 23** and **23, 23** can be exactly positioned, the ball rows **3, 3**, and **3, 3** can smoothly roll without contacting the ball retainer members **23, 23** and **23, 23** at the ball row moving time.

Still furthermore, according to the present embodiment, there are also formed chain guide portions **40, 40** for limiting deviation of the respective bilateral two ball rows **3, 3** and **3, 3** at a time when the ball rows are guided through the endless circulation passage by the connection members **21** of the plural ball row chains **20, 20**.

The chain guide portions **40, 40** are provided with a loaded area guide portion **41** formed between the bilateral loaded ball rolling grooves **10, 10** and **10, 10**; a direction changing area guide portion **42** formed between the direction changing inner periphery guide portions **14***a*, **14***a* and **14***a*, **14***a*; and a return area guide portion **43** formed between the ball return passages **11, 11** and **11, 11**, the chain guide portions being integrally formed with the circulation passage forming member **30**.

According to the structure mentioned above, since the plural ball row chains **20, 20** can be guided along the chain guide portions in the ball row circulation operation, the deviation or swinging of the ball row chains **20, 20** can be prevented and the ball circulation can be further smoothly performed.

Further, the direction changing passage guide portion forming portion **32, 32** is composed of the end plates **7** as end surface forming portions integrally formed to the end surfaces of the movable block body **6** inclusive of the direction changing passage inner periphery guide portions **14***a*, **14***a* and **14***a*, **14***a* and an area in the vicinity thereof. These end plates **7** are formed with recessed portions **34, 34** exposing the direction changing inner periphery guide portions **14***a*, **14***a* and **14***a*, **14***a*, and bilateral one deflectors **35, 35** respectively formed with the outer periphery guide portions **14***b*, **14***b* and **14***b*, **14***b* of the ball direction changing passages **14, 14** and **14, 14** are engaged with these recessed portions **34, 34**, whereby the rolling member rolling direction changing passages **14, 14** and **14, 14** are constituted by the inner periphery guide portions **14***a*, **14***a* and **14***a*, **14***a* and the outer periphery guide portions **14***b*, **14***b* and **14***b*, **14***b*. It will be preferred to form the deflectors **35, 35** by a resin having wearproof property, large attenuation and large specific gravity.

According to the structure described above, the deflectors **35, 35** are positioned by the recessed portions **34, 34** formed to the end plates **7, 7** integrally formed with the movable block body **6**, and moreover, the outer periphery guide portions **14***b*, **14***b* and **14***b*, **14***b* of the ball direction changing passages **14, 14** and **14, 14** can be also exactly positioned by means of the end plates **7**. Since the recessed portions **35, 35** are formed integrally with the movable block body **6**, the positional relationship between the recessed portions **35, 35** and the loaded ball rolling grooves **10, 10** and **10, 10** can be exactly set.

Furthermore, in the assembling working of the plural ball row chains **20, 20**, the chains can be easily inserted from the recessed portions **34, 34**, reducing the chain assembling working time. That is, by inserting the plural ball row chains **20, 20** preliminarily holding the necessary numbers of balls into the movable block **4** through the recessed portions **34, 34**, the necessary numbers of balls can be quickly inserted without falling off.

[Another Embodiment]

FIG. **3** represents another embodiment of the present invention. In the former embodiment described above, the contact angle lines S1, S2, S3 and S4 constitute outwardly opened structure inclined bilaterally symmetrically in directions narrowing the distance therebetween towards the track rail side with respect to the horizontal line H passing the central portion between the upper and lower ball rows. However, in this embodiment, there is adopted a structure in which the contact angle lines S1, S2, S3 and S4 constitute inwardly opened structure inclined bilaterally symmetrically in directions widening the distance therebetween towards the track rail side with respect to the horizontal line H passing the central portion between the upper and lower ball rows.

In this embodiment, the ball retainer member **24** is disposed between the two ball rows **3, 3**, and the maximum width C of the ball retainer member **24** is set to a value larger than the minimum width D of the two ball rows **3, 3** to thereby form a gap g between the retainer member **24** and the movable block **4** through which the connection member **21** of the plural ball chain **20** passes.

Accordingly, the two ball rows **3, 3** supported by the plural ball row chain **20** are held together with the plural ball row chain **20** by both the side edge portions of the ball retainer member **24** positioned inside the chain **20**.

Both the ends of the ball retainer member **24** may be fixed to the deflector **35**, and as shown in FIG. **3**(*b*), both may be connected at the central portions thereof through the engagement between an engaging projection **24***a* and an engaging hole **24***b*, and otherwise, may be connected to the deflector **35**, as shown in FIG. **3**(*c*), at the end portion of the ball retainer member **24**. Further, as the connection structure, there may be adopted a structure, for example, in which a projection **24***c* having a trapezoidal section, which is engaged with a dovetail groove **24***d* formed to the deflector **35**, is formed to the end portion of the ball retainer member **24**, and many other connection structures may be further adopted.

Since structures of this embodiment other than the above structures are substantially the same as those mentioned with reference to the former embodiment, the same reference numerals are added to members or portions corresponding to those in the former embodiment and the details thereof are not mentioned herein.

Further, in the case of the parallel contact angle lines of the above two ball rows, it may be possible to locate two ball retainer members **23, 23** outside the two ball rows **3, 3** as shown in FIG. **1** or to locate the ball retainer member **24** between the two ball rows **3, 3** as shown in FIG. **2**.

Furthermore, in the above embodiment, although there is described the case of the linear motion guide device provided with two sets of two ball rows, the present invention is of course applicable to a case of single set of two ball rows.

As mentioned hereinabove, according to the present invention, the falling-off of the balls can be prevented by the combined structure of the ball retainer member and the plural ball row chain, and the hanging-down of the end portion of the plural ball row chain can be also prevented, so that the assembling working can be done without paying specific attention to the falling-off of the balls, thus improving the assembling workability.

Furthermore, according to the present invention, the return passage forming portion constituting the non-loaded ball returning passage corresponding to the two ball rows, the direction changing inner periphery guide portion forming portion constituting the inner periphery guide portion of the ball direction changing passage, and the ball retainer forming portion constituting the two ball retainer members positioned outside the plural ball row chain are constituted by the circulation passage forming portion integrally formed by inserting the movable block body into the mold. Accordingly, the connected portions between these portions are made continuous with no stepped portion, thus realizing the smooth ball circulation.

Still furthermore, since the ball retainer portion can be exactly positioned, the balls never contact the retainer portion at the time of the ball rolling movement and the balls can be smoothly rolled.

Still furthermore, the recessed portion exposing the direction changing passage inner periphery guide portion corresponding to the two ball rows are formed to the end surface forming portion formed to the end surface of the movable block body and the recessed portion is engaged with the deflector to thereby constitute the rolling member rolling direction changing passage, so that the deflector can be positioned by the recessed portion formed to the end surface forming portion integrally formed with the movable block body, and the outer periphery guide portion of the ball rolling direction changing passage can be also exactly positioned through the end surface forming portion, so that the positional relationship to the loaded ball rolling groove can be also exactly set, thus further achieving the smooth ball circulation.

Furthermore, in the assembling working of the plural ball row chain, the chain can be easily inserted through the recessed portion, thus reducing the chain assembling working.

Field of Industrial Usage

As mentioned above, the linear motion guide device provided with the plural ball row chain according to the present invention is usable for linear motion guide mechanisms for machine tools, industrial robots, measuring devices, etc.

I claim:

1. A linear motion guide device, provided with a plural ball row chain, which comprises a track rail and a movable block mounted to the track rail to be movable through a number of balls, said movable block comprising a movable block body provided with a loaded ball rolling groove corresponding to a loaded ball rolling groove formed to the track rail and a non-loaded ball return passage disposed in parallel to the loaded ball rolling groove of the movable block body and also provided with a direction changing passage forming members formed at both ends of the movable block body and constituting ball direction changing passages forming an endless ball circulation passage communicating the loaded ball rolling groove and the rolling member return passage, said balls being composed of at least one set of two ball rows in parallel to each other with a predetermined space and said two ball rows being supported by a belt-shaped plural ball row chain enabling the balls to circulate the endless ball circulation passage, said plural ball row chain being composed of a flexible connection member disposed between the two ball rows and spacers disposed at both side edges of the connection member and adapted to be inserted into adjacent balls,

wherein a ball retainer portion is disposed to the movable block body so that the balls in respective ball rows along the loaded ball rolling groove are engaged at a time of removing the movable block from the track rail and the balls are prevented from falling off through an assembling of the ball retainer portion and the plural ball row chain.

2. A linear motion guide device provided with a plural ball row chain according to claim **1**, wherein said ball retainer portion includes two retainer members disposed to side edge portion opposing to the location of the connection member of the plural ball row chain and an opening width of the retainer member is set smaller than a maximum width between balls of the respective ball rows.

3. A linear motion guide device provided with a plural ball row chain according to claim **1**, wherein said ball retainer members are disposed between said two ball rows, a maximum width between the retainer members is set larger than a minimum width of two ball rows and a gap through which the connection member of the plural ball row chain passes is formed between the ball retainer portion and the movable block body.

4. A linear motion guide device provided with a plural ball row chain according to any one of claims **1** to **3**, wherein a return passage forming portion constituting the non-loaded ball returning passage corresponding to the two ball rows, a direction changing inner periphery guide portion forming portion constituting an inner periphery guide portion of the ball direction changing passage, and a ball retainer forming portion constituting ball retainer members are constituted by a circulation passage forming portion integrally formed by inserting the movable block body into a mold.

5. A linear motion guide device provided with a plural ball row chain according to claim **4**, wherein the direction changing passage inner periphery guide portion forming portion is composed of an end surface forming portion integrally formed with an end surface of the movable block body inclusive of the direction changing passage guide portion and an area in a vicinity thereof, a recessed portion exposing the direction changing passage inner periphery guide portion corresponding to ball rows is formed to said end surface forming portion, a deflector formed with an outer periphery guide portion of a rolling member rolling direction changing passage is engaged with the recessed portion, and the rolling member rolling direction changing passage is composed of said inner periphery guide portion and said outer periphery guide portion.

* * * * *

US005911509A

United States Patent [19]

Kawaguchi et al.

[11] Patent Number: 5,911,509

[45] Date of Patent: Jun. 15, 1999

[54] **SLIDER FOR LINEAR GUIDE UNIT**

[75] Inventors: **Takahiro Kawaguchi**; **Tadashi Hirokawa**, both of Tokyo, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **09/043,585**

[22] PCT Filed: **Aug. 5, 1997**

[86] PCT No.: **PCT/JP97/02719**

§ 371 Date: **Mar. 27, 1998**

§ 102(e) Date: **Mar. 27, 1998**

[87] PCT Pub. No.: **WO98/05877**

PCT Pub. Date: **Feb. 12, 1998**

[30] **Foreign Application Priority Data**

Aug. 6, 1996 [JP] Japan 8-206910

[51] **Int. Cl.**[6] **F16C 29/06**

[52] **U.S. Cl.** **384/45**

[58] **Field of Search** 384/43, 44, 45

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,755,516 5/1998 Teramachi et al. 384/45

FOREIGN PATENT DOCUMENTS

248433 9/1993 Japan .

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Nikaido, Marmelstein, Murray & Oram LLP

[57] **ABSTRACT**

The present invention concerns a slider of a rectilinear guide unit for guiding a movable body such as a work table of a machine tool, an industrial robot or the like by moving along a track rail arranged on a stationary section such as a bed or a column while bearing a load. Such type of slider is manufactured by injection-molding a synthetic resin over a metallic block main body having ball load rolling surfaces. Further, the block main body is provided on the outer side surfaces thereof with synthetic resin side surface molded portions with ball return holes formed by padding and on the front and rear end surfaces thereof with end surface molded portions with change direction paths for balls formed by padding. Further, simultaneously with the padding of the side surface molded portions and the end surface molded portions, there is formed by padding an upper surface molded portion on the upper surface of the block main body so as to connect the end surface molded portions formed on both end surfaces of the block main body, respectively.

2 Claims, 14 Drawing Sheets

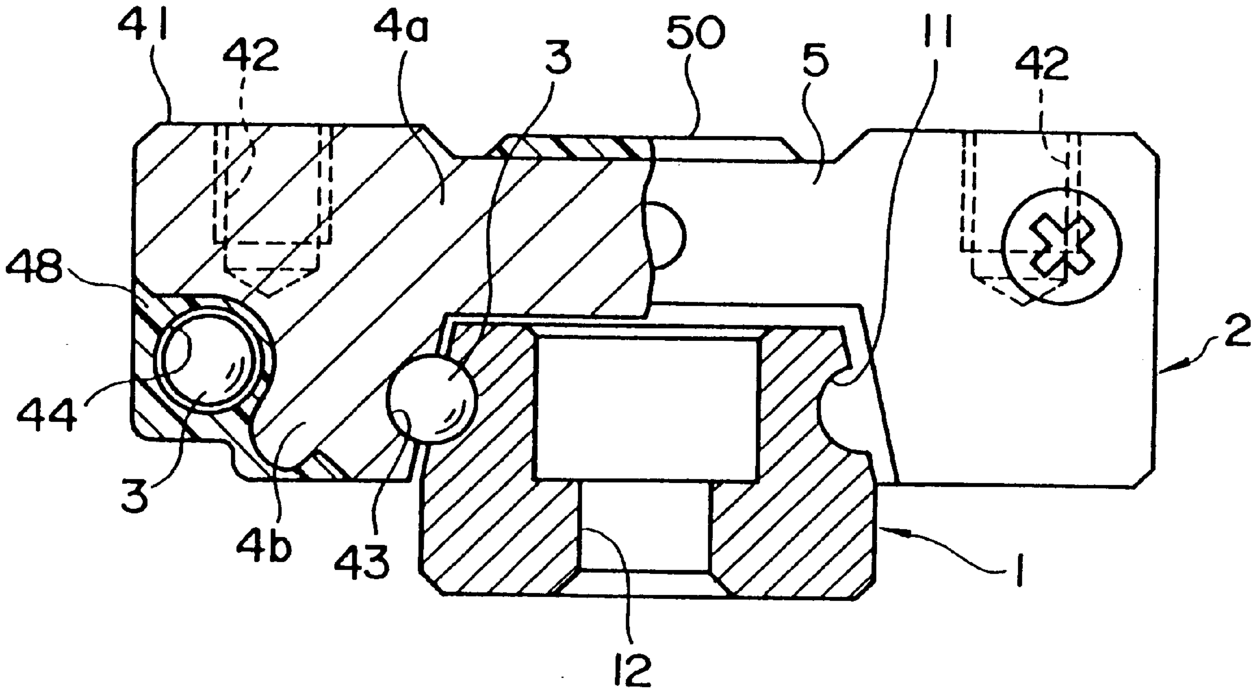


Fig. 1

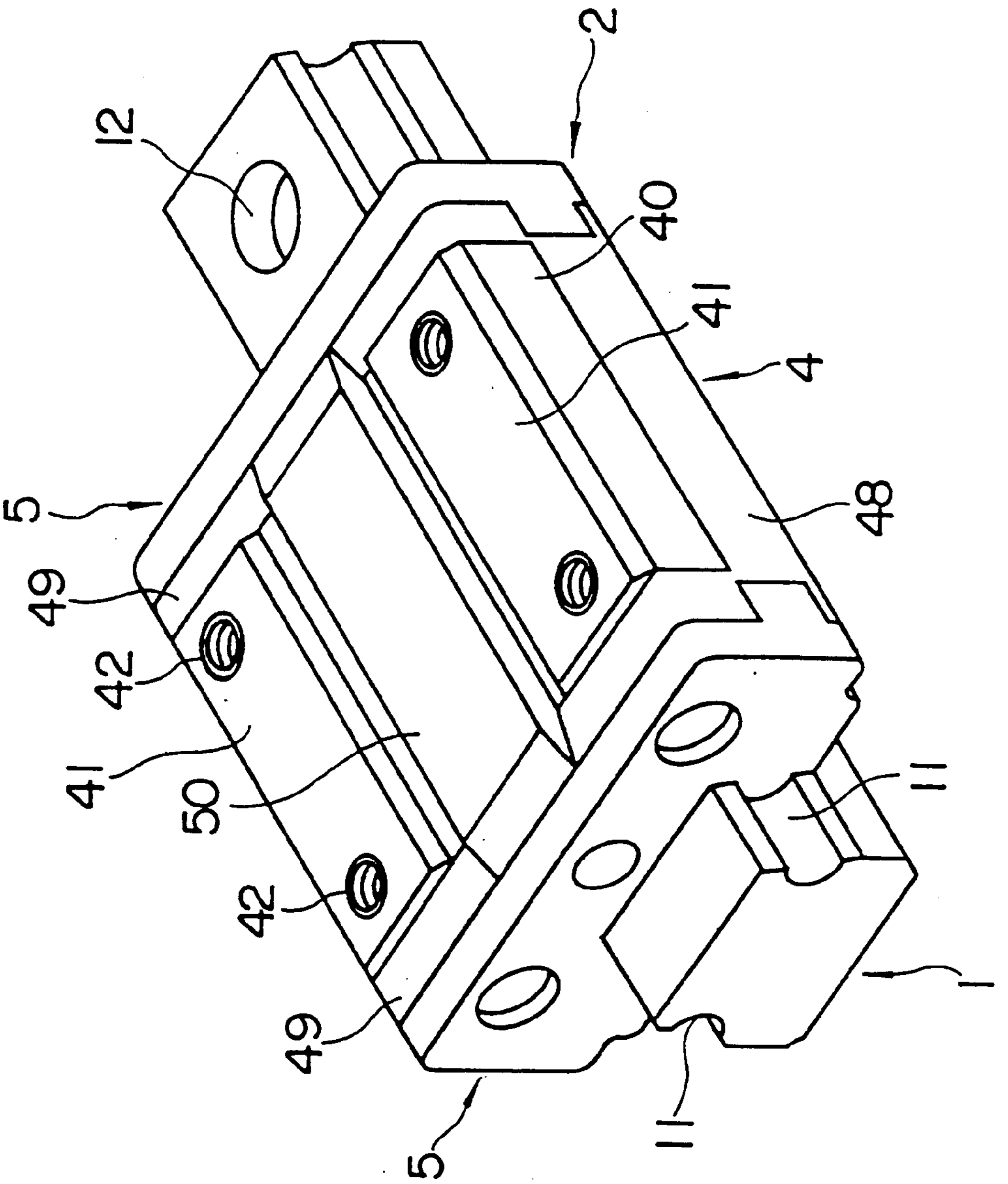
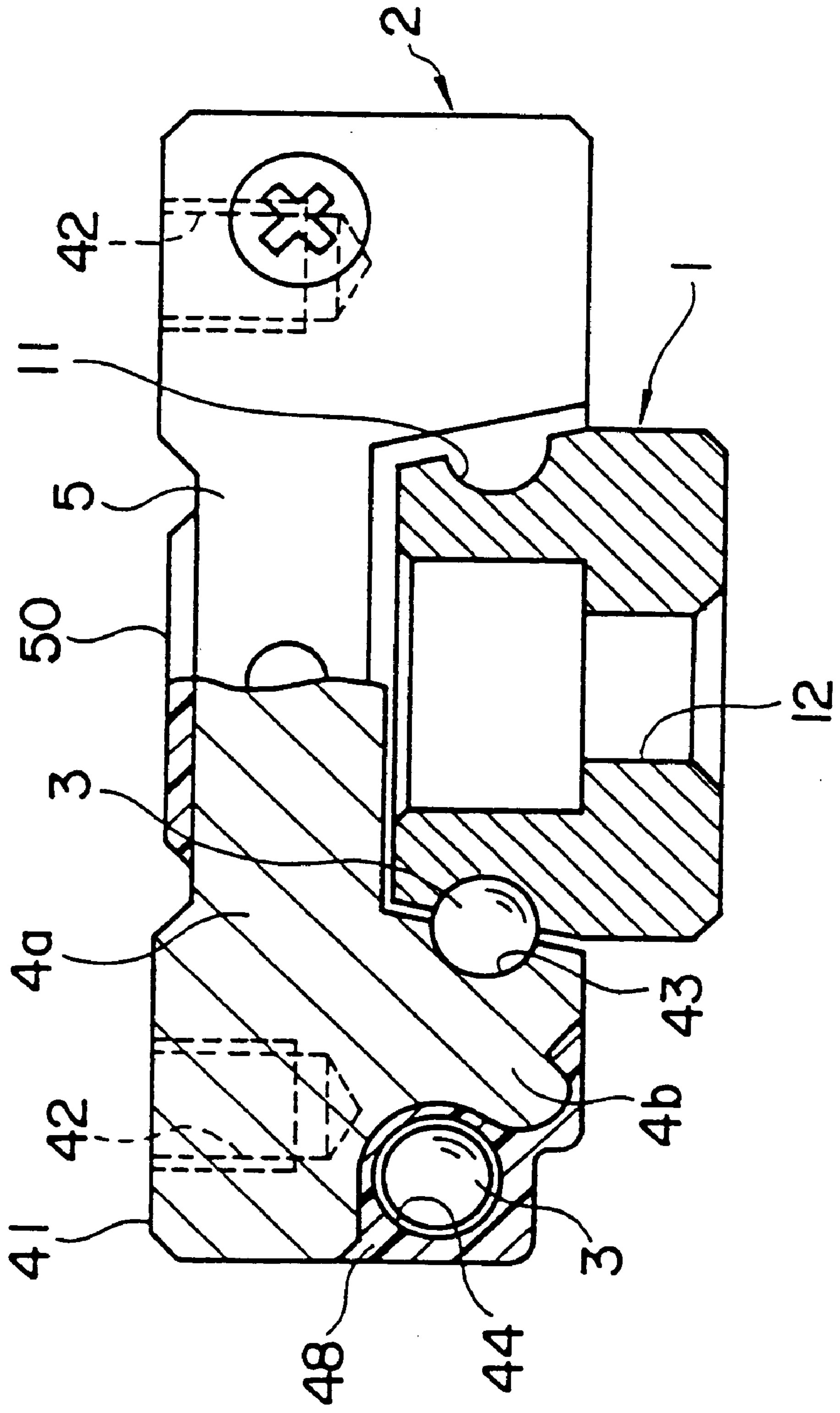


Fig. 2



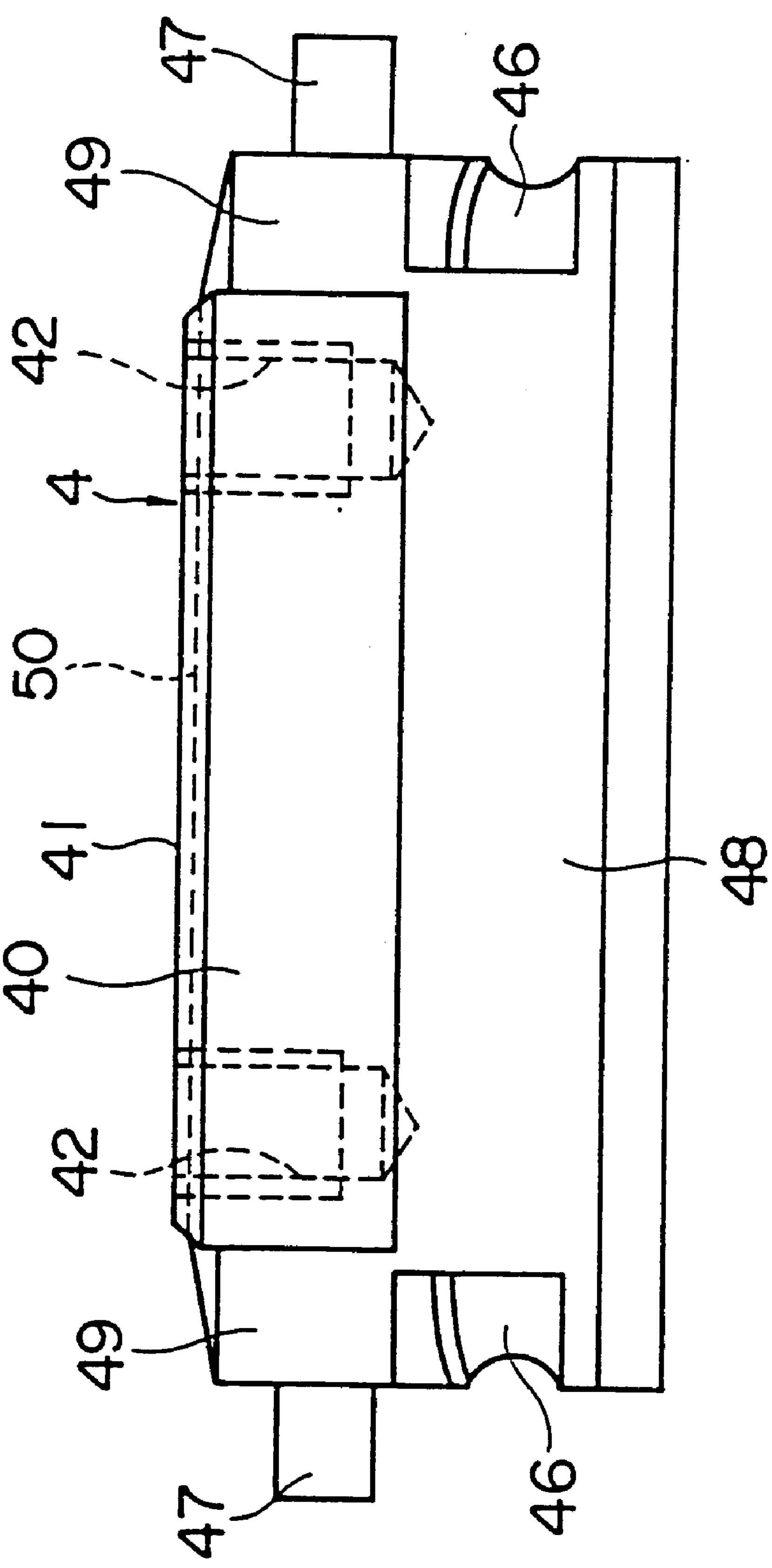


Fig. 3

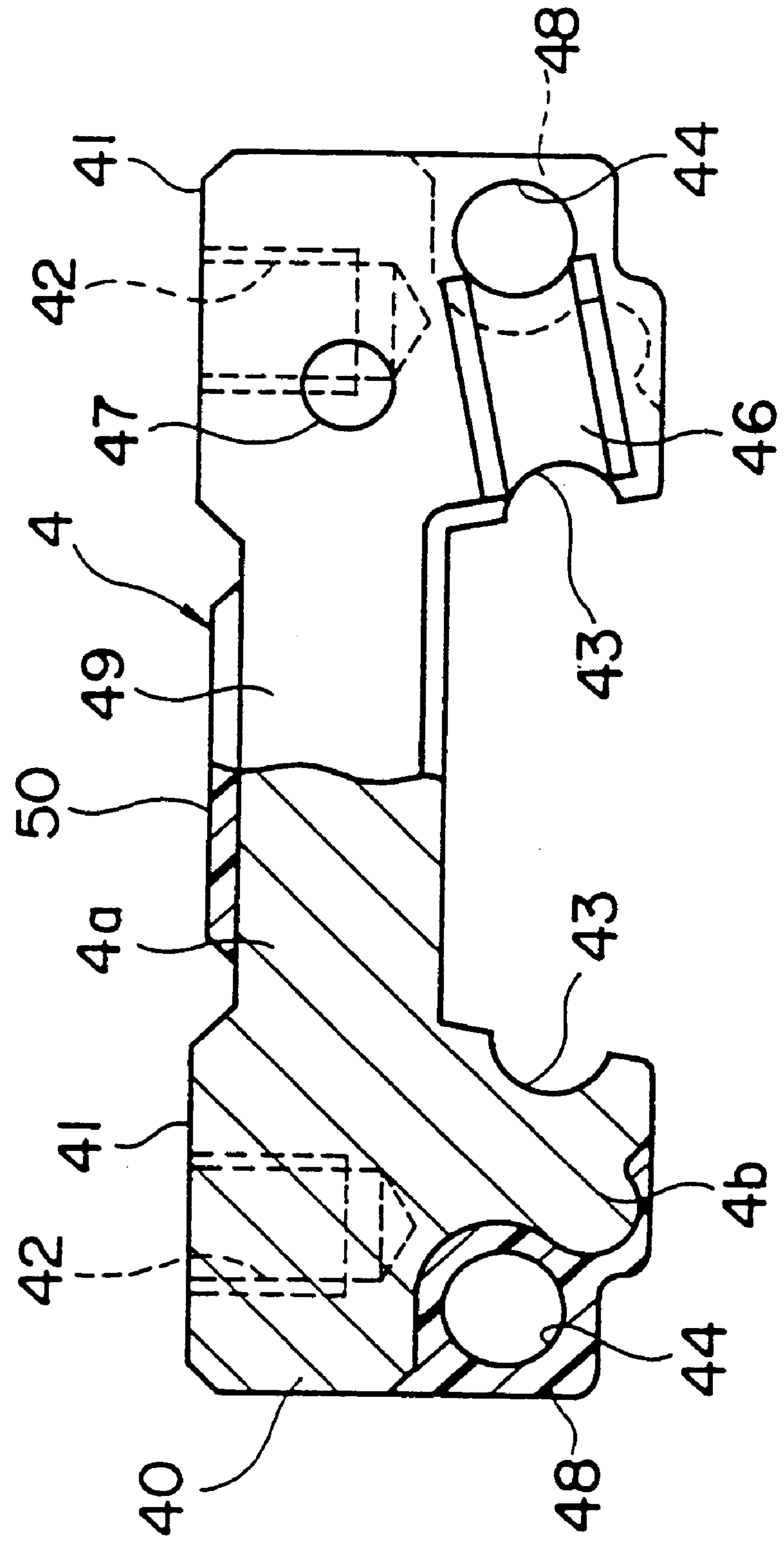


Fig. 4

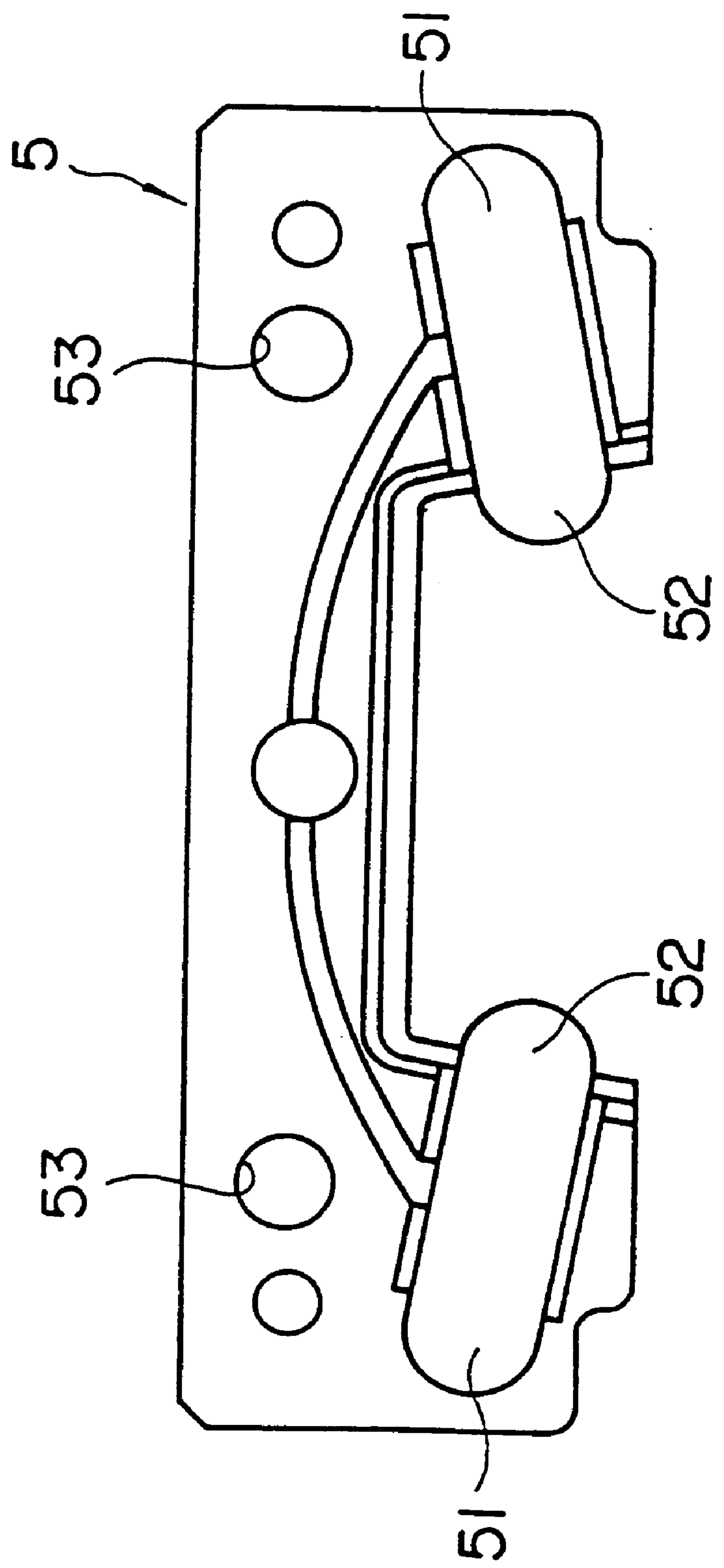


Fig. 5

Fig. 6

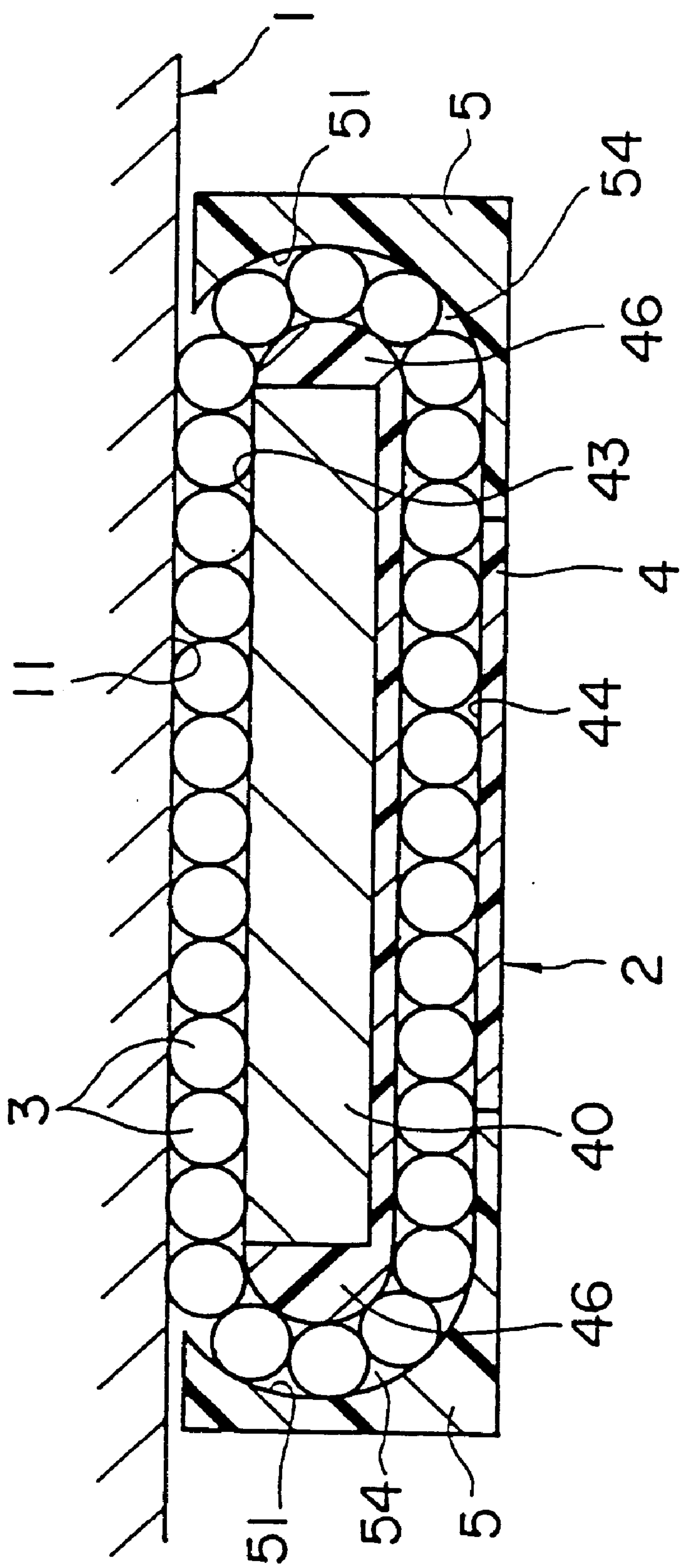


Fig. 7

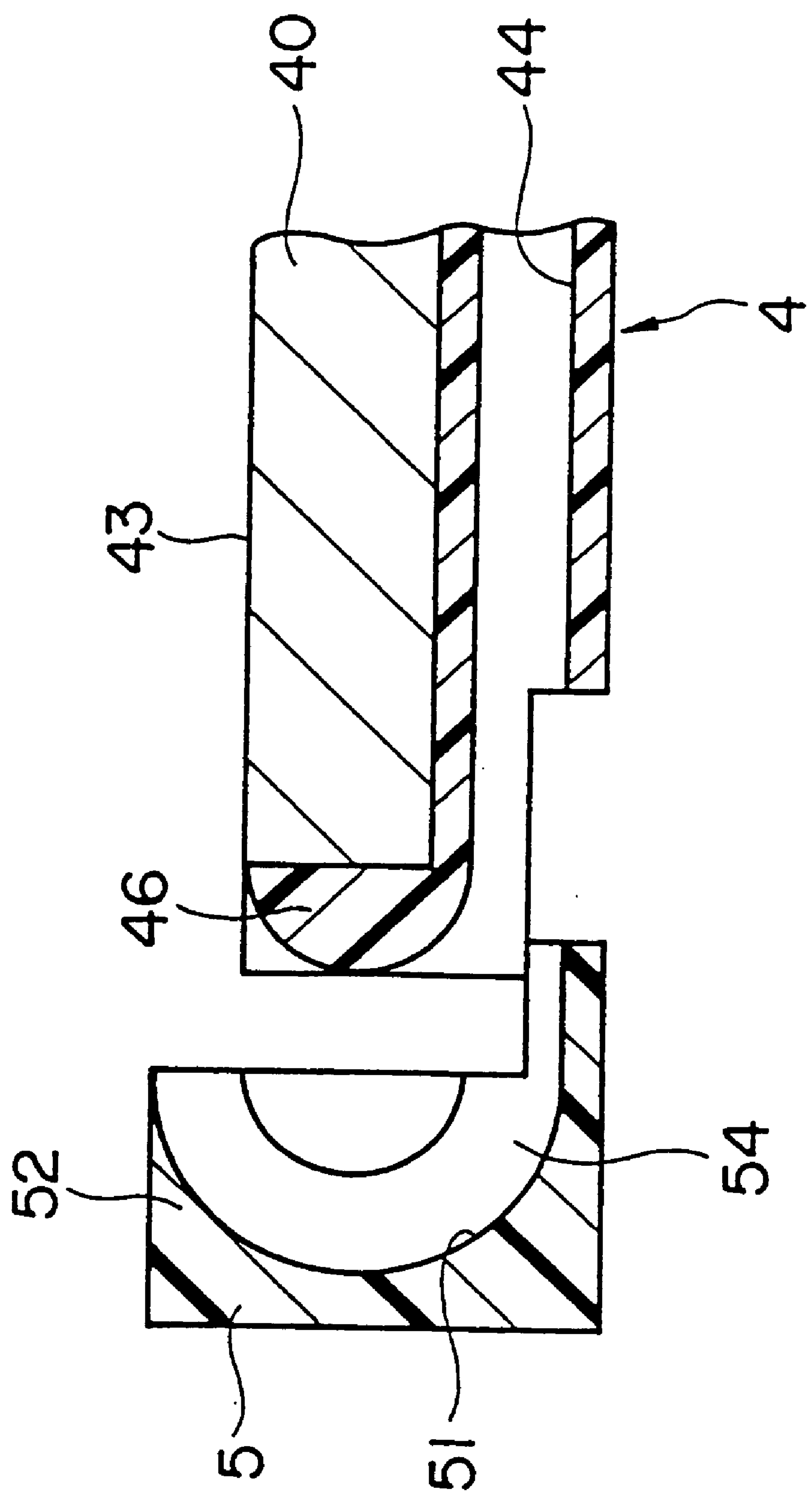


Fig. 8

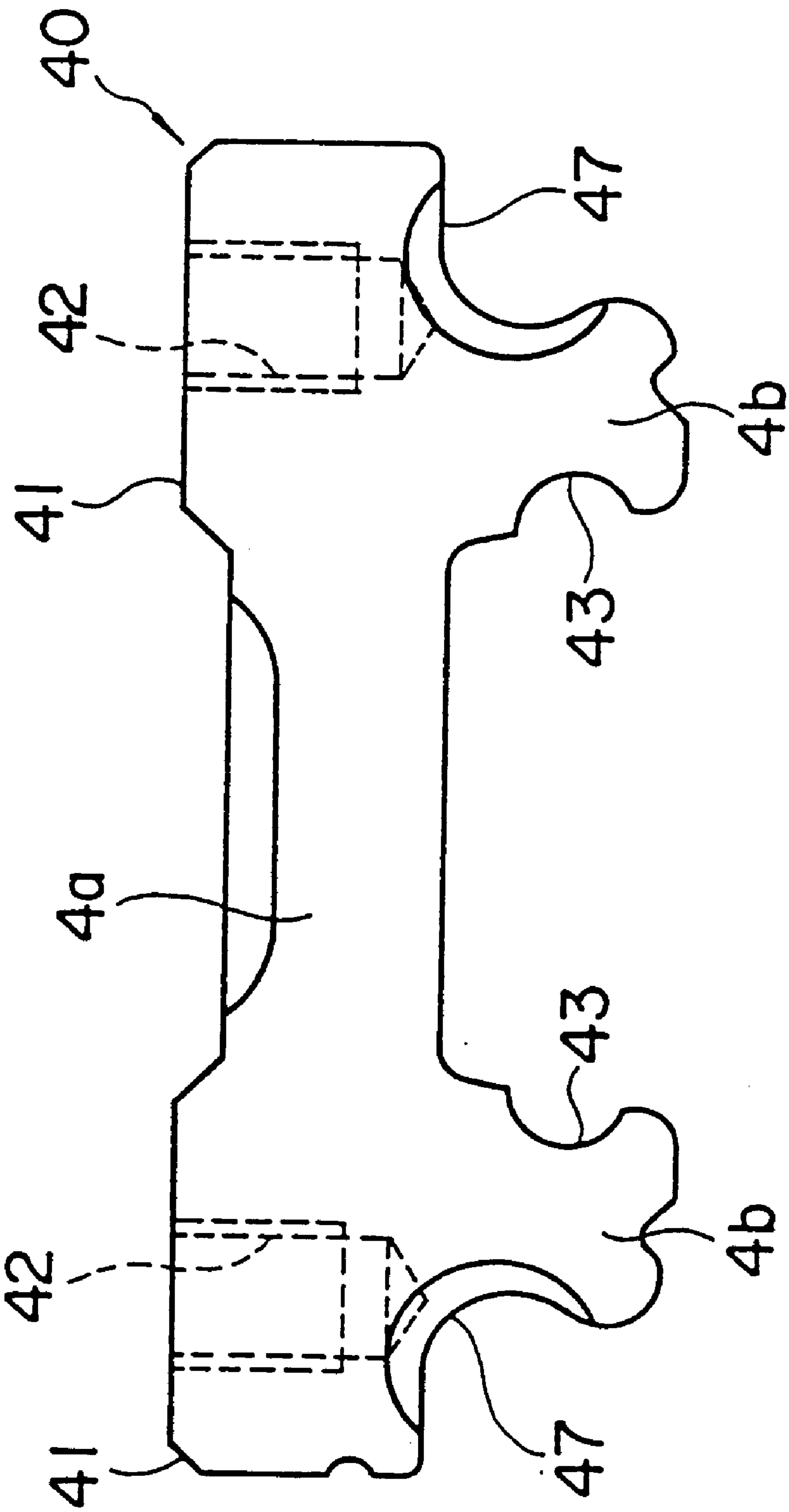


Fig. 9

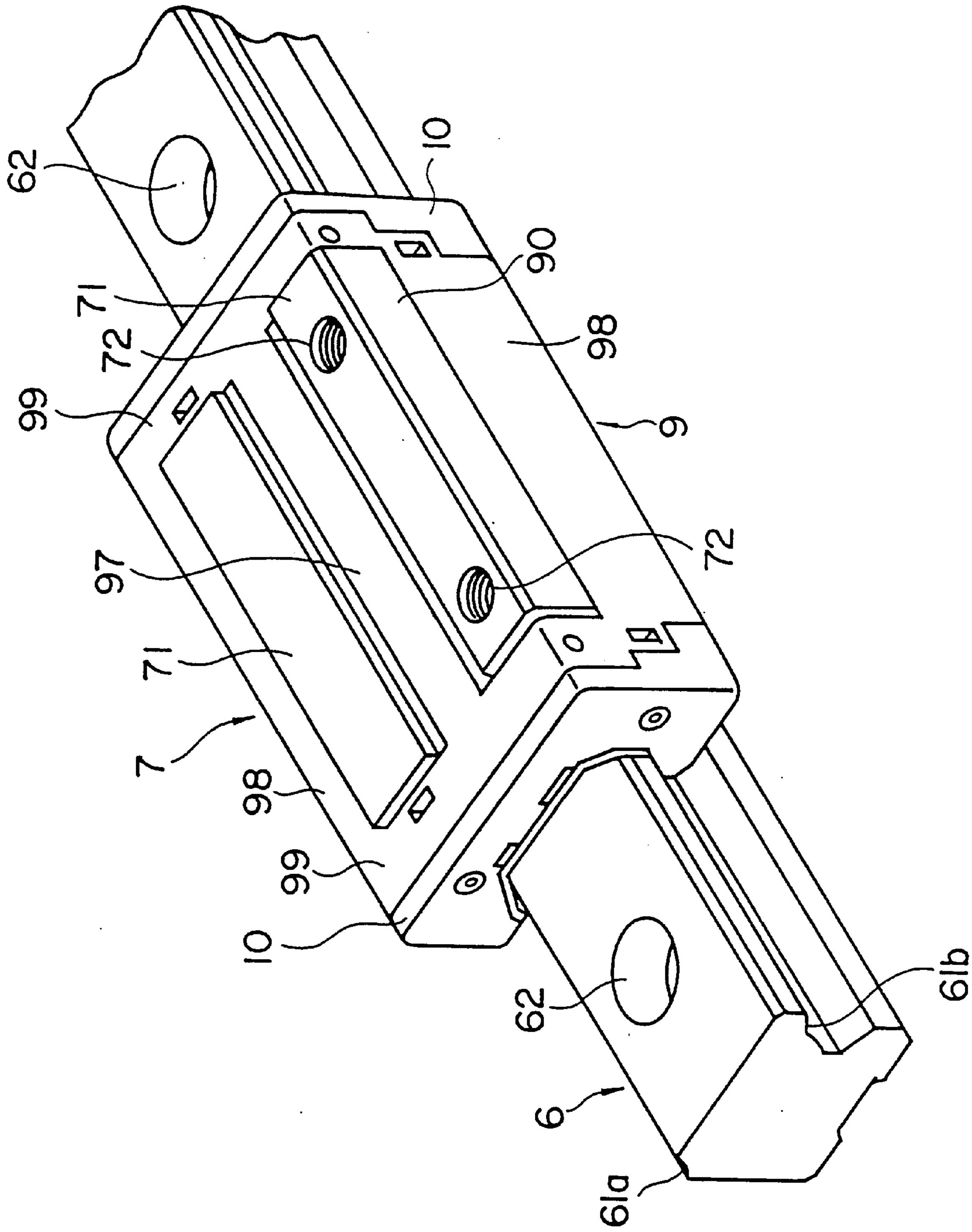


Fig. 10

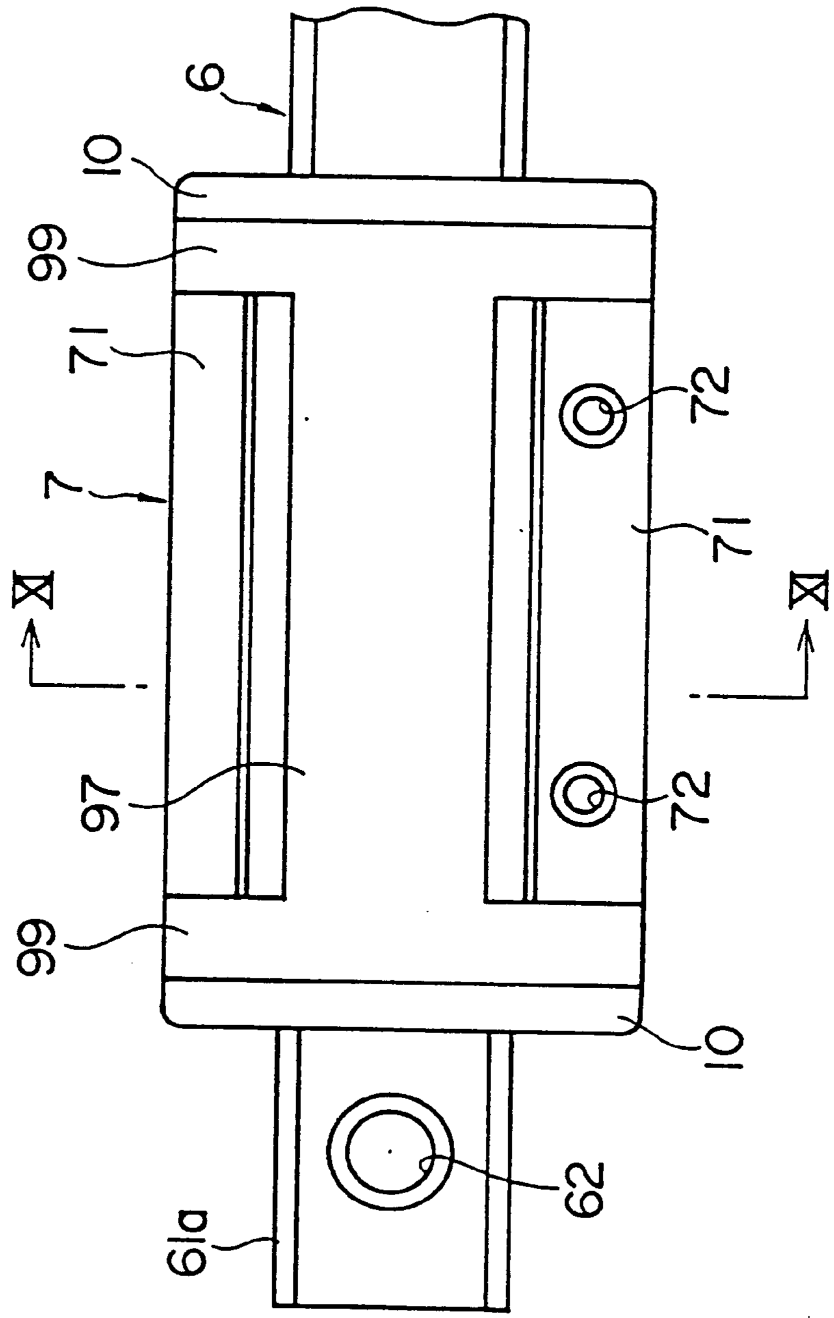


Fig. 11

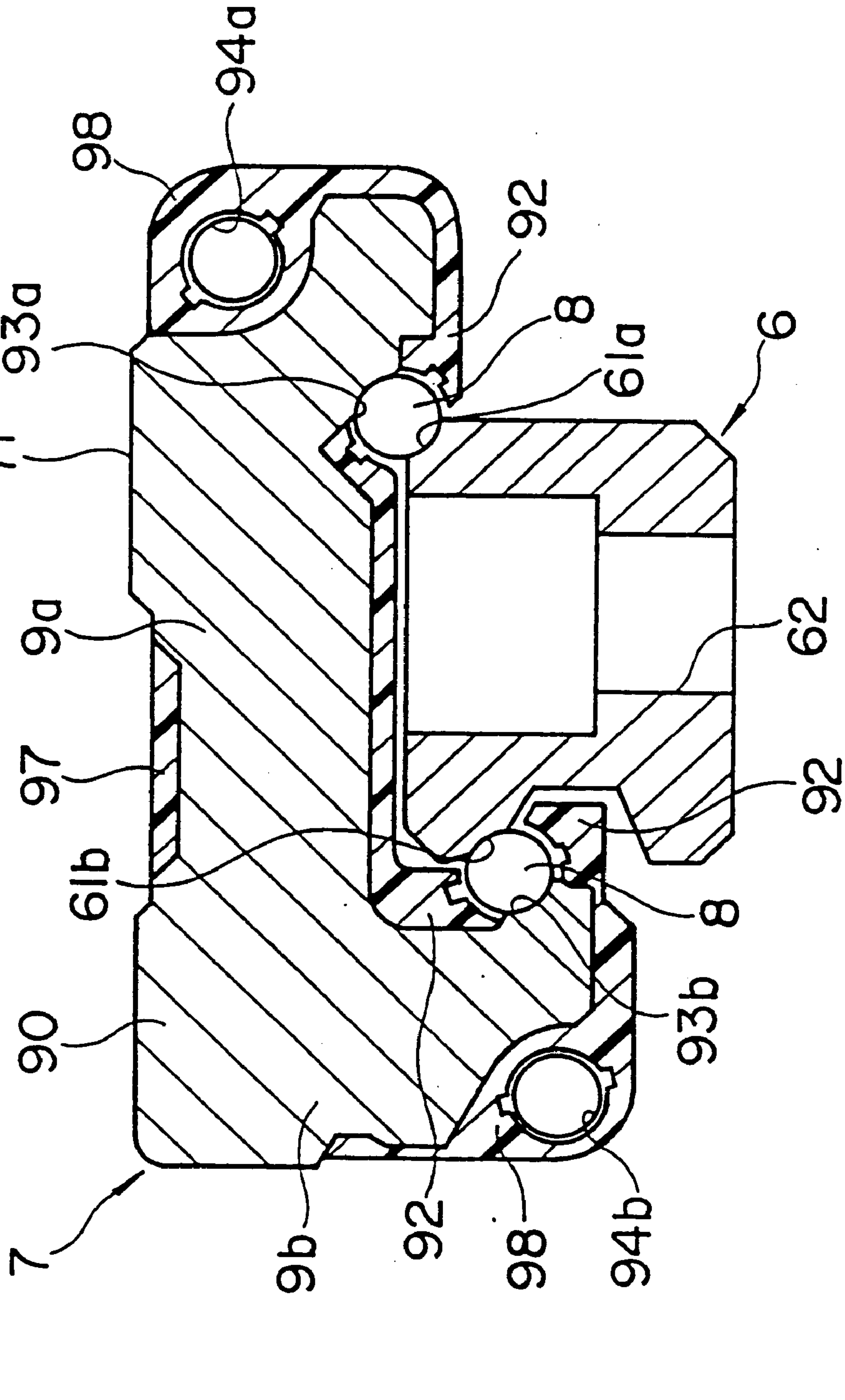


Fig. 12

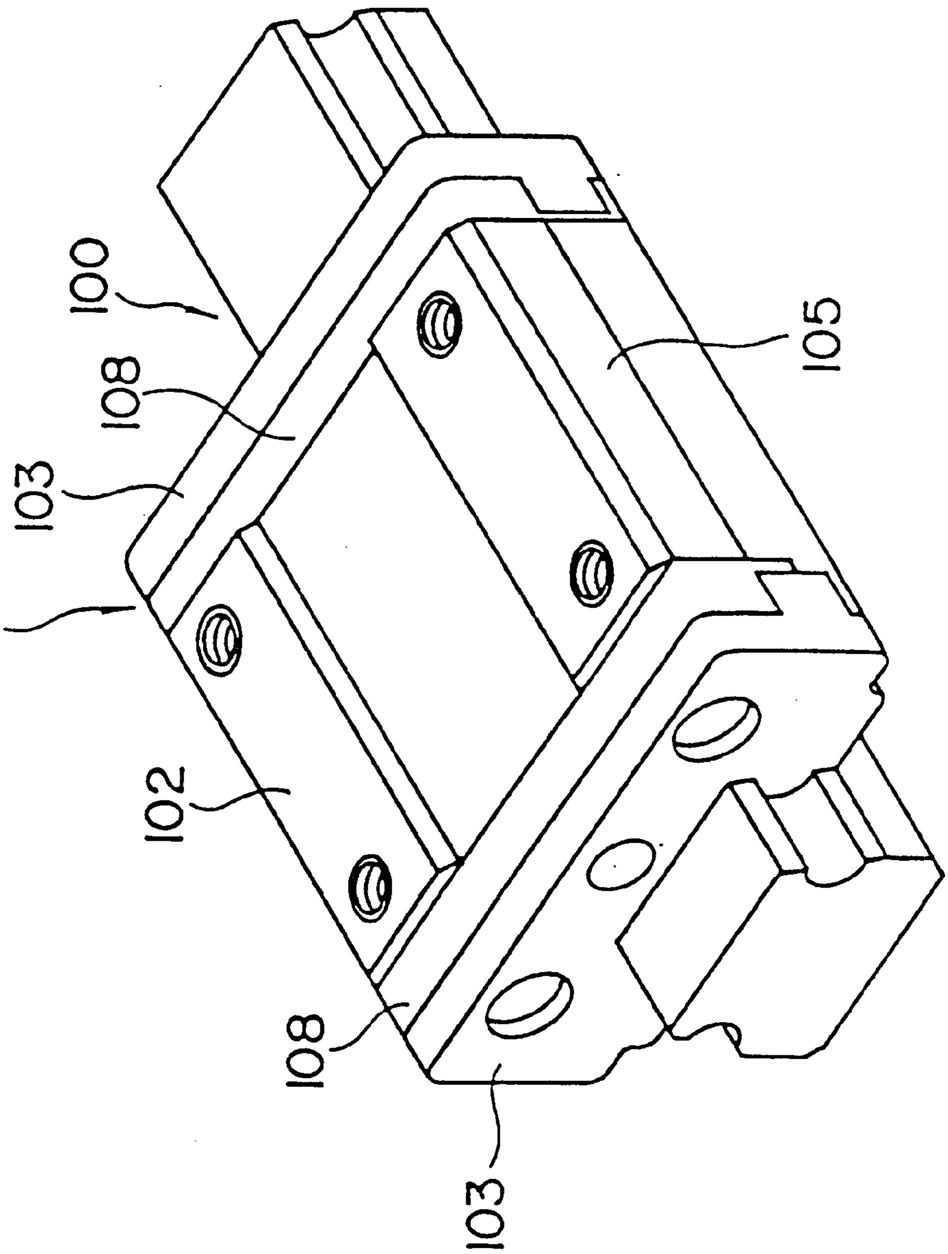


Fig. 13

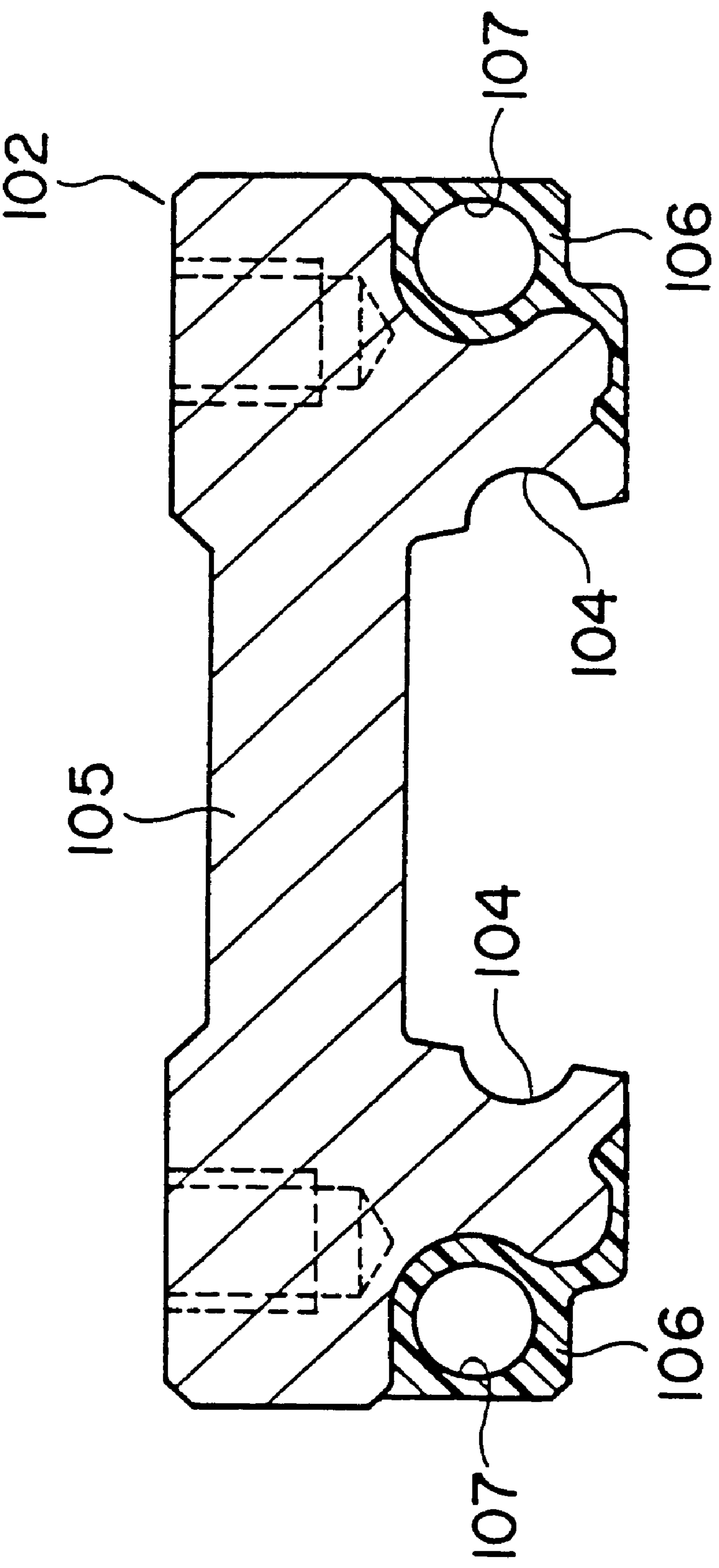
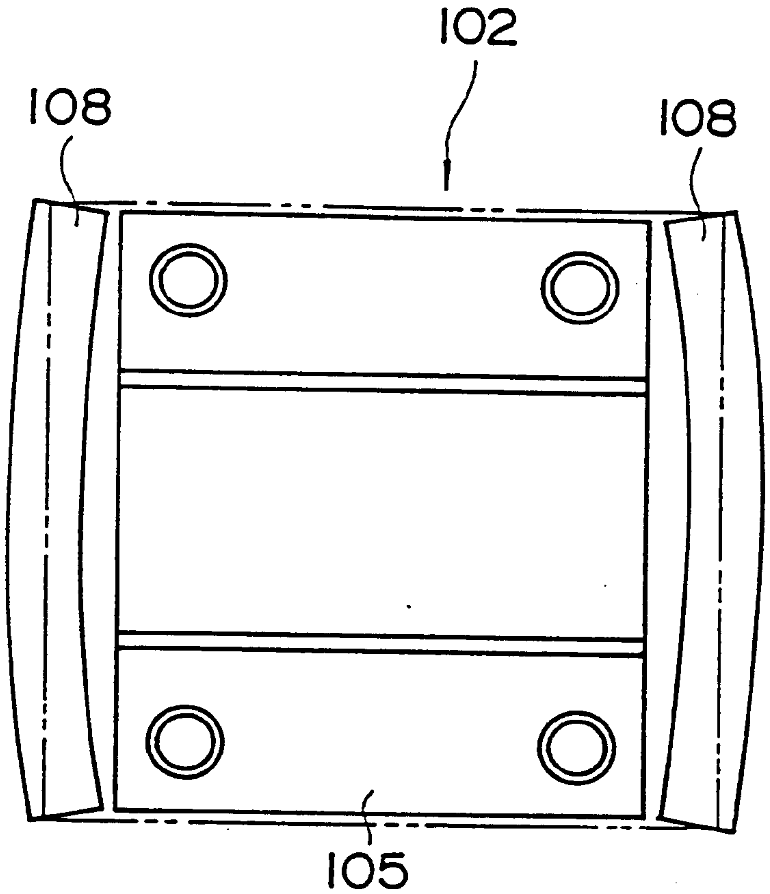
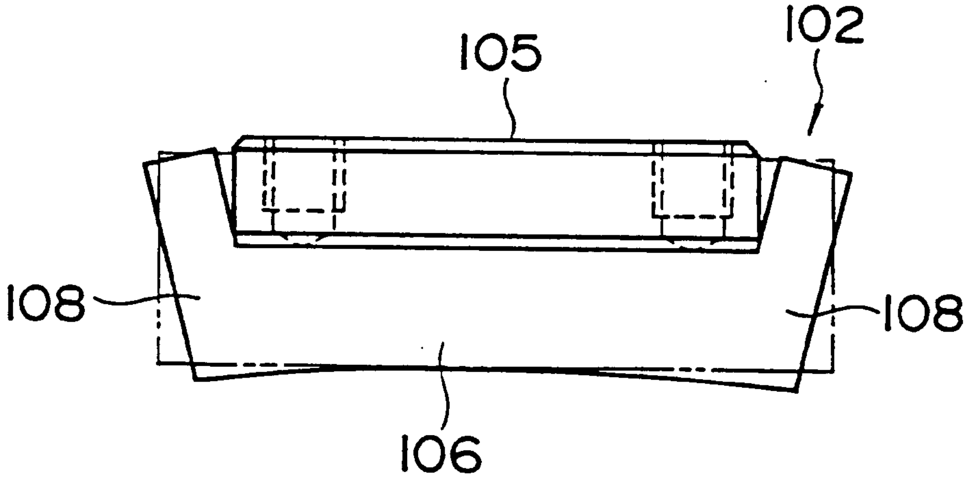


Fig. 14





SLIDER FOR LINEAR GUIDE UNIT

TECHNICAL FIELD

The present invention relates to a slider of a rectilinear guide unit adapted to guide a movable body such as a work table of a machine tool, an industrial robot and etc. and more particularly to an improvement in a slider which is formed by padding a synthetic resin over a metallic block main body.

BACKGROUND TECHNOLOGY

Conventionally, as a rectilinear guide unit of the above type, there is known the one that has a structure comprising a track rail arranged on a stationary portion such as a bed and having ball rolling surface and a slider fastened to the track rail through a number of balls and movable along the rail while supporting a movable body such as a table.

Further, the slider comprises a movable block having ball load rolling surfaces opposing to the ball rolling surfaces of the track rail through the balls and ball return holes parallel to the ball load rolling surfaces and capable of moving along the track rail following the rolling of the balls and a pair of covers having change-direction paths for establishing communication between the ball load rolling surfaces and the ball return holes, and by fixing the covers to both front and rear end surfaces of the movable block, respectively, the load rolling surfaces and the ends of the ball return holes are respectively connected by the change direction paths thereby completing in the slider an endless circulation path for the balls.

In the case of the slider of the conventional rectilinear guide unit having the above-described structure, the process of drilling the ball return holes and the fixing of the ball retainers to the movable block becomes necessary resulting in taking much time and labor for its manufacture so that the present applicant provided such slider by making use of extrusion molding of a synthetic resin (refer to Unexamined Published Japanese Patent Application No. 7-317762).

FIG. **12** shows one example of a slider of a rectilinear guide unit manufactured according to the above-described method wherein the slider **101** fastened to a track rail **100** also comprises a movable block **102** and a pair of covers **103**, **103** such that the movable block **102** comprises a metallic block main body **105** having load rolling surfaces **104** and padded with a synthetic resin by an injection-molding method and as shown in FIG. **13**, ball return holes **107** corresponding to the load rolling surfaces **104** are formed in a pair of side surface molded portions **106** padded to the outer lower side surfaces of the block main body **105**, respectively. Further, to simplify the shape of each of the covers **13**, there are padded to the front and rear end surfaces of the block main body **105** a pair of end surface molded portions **108** which are continuous with the side surface molded portions **106**, respectively, as shown in FIG. **14** and these molded portions **108** are provided with semicircular ball guide sections (not shown) for guiding the balls which have rolled the load rolling surfaces **104** to the ball return holes **107**.

According to such slider manufacturing method making use of the injection molding of synthetic resin material, it is possible to manufacture in a simple manner the movable block **102** of a complicated shape by merely padding a synthetic resin over the block main body **105** and to continuously form the ball return holes **107** and the change direction paths through which unloaded balls roll with the advantage that the circulation of the balls is smoothed and the noise level at the time of rolling of the balls is reduced.

Now, due to the fact that the synthetic resin mold produced by injection-molding contracts in the direction of the large thickness portion thereof, when the side surface molded portions **106** are padded to the outer side surfaces of the block main body **105** so as to form the above-mentioned ball return holes **107** in the side surface molded portions **106**, the portions **106** contract in the longitudinal direction thereof, that is, in a direction parallel to the ball return holes **107**.

However, since both end surfaces of the block main body **105** are also provided with the synthetic resin end surface molded portions **108** padded by injection-molding and formed integral with the side surface molded portions **106** respectively, when the molded portions **106** contract for the above-described reason, the forces of such contraction of the molded portions **106** act unevenly upon the end surface molded portions **108**.

Consequently, there has arisen a problem that as shown in FIG. **14**, after a little while from the completion of injection-molding, the end surface molded portions **108** are pulled by the side surface molded portions **106** to become deformed and float up from the end surfaces of the block main body **105** so that gaps are formed between the block main body **105** and the end surface molded portions **108**, respectively.

Further, there has also arisen a problem that although the covers **103** are respectively fixed to the end surface molded portions **108** to allow the slider **101** to have the change direction paths for the balls, when each of the end surface molded portions **18** deforms, the covers **103** can no more be fixed tightly to the end surface molded portions **108** failing to accurately form the change direction paths so that the balls rolled on the load rolling surface **104** can not be smoothly guided with respect to the ball return holes **107**.

DISCLOSURE OF THE INVENTION

The present invention has been made in view of the above-described problems and an object of the present invention is to provide a slider of a rectilinear guide unit provided with ball return holes and change direction paths for balls formed by padding a synthetic resin to a metallic block main body, which slider is capable of preventing the deformation of the end surface molded portions padded onto the front and rear end surfaces of the block main body so that the change direction paths are formed accurately to thereby realize a smooth circulation of balls.

In order to achieve the above-described object, the present invention provides the following two types of sliders of a rectilinear guide unit.

That is, a first aspect of the present invention is characterized by the provision of a slider of a rectilinear guide unit, which comprises: a metallic block main body substantially in the shape of a saddle in section including a horizontal section and a pair of skirts drooping from the horizontal section and having ball load rolling surfaces on the inner surfaces thereof, respectively; synthetic resin side surface molded portions padded to the outer side surfaces of each of the pair of skirts of the block main body by injection molding and having ball return holes corresponding to the load rolling surfaces, respectively; and synthetic resin end surface molded portions padded to both longitudinal end surfaces of the block main body, respectively, by injection-molding so as to become continuous with the side surface molded portions, respectively, and having circular arc-shaped ball guide sections for guiding balls rolled on the load rolling surfaces to the ball return holes and operating such that it comes into engagement with a track rail through the balls rolling on the load rolling surfaces and moves along the track rail, wherein the block main body is provided on an upper surface of the horizontal section thereof with a synthetic resin upper molded portion which is injection-molded simultaneously with the side surface molded portions and the end surface molded portions and adapted to connect the end surface molded portions on both end surfaces of the block main body.

Further, a second aspect of the present invention is characterized by the provision of a slider of a rectilinear guide unit, which comprises: a metallic block main body substantially in the shape of the letter "L" including a horizontal section and a skirt drooping from one end of the horizontal section and having ball load rolling surfaces on the lower surface of the horizontal section and on the inner surface of the skirt, respectively; synthetic resin side surface molded portions padded to the top end of the horizontal section and the outer side surface of the skirt of the block main body by injection-molding and having ball return holes corresponding to the load rolling surfaces; and synthetic resin end surface molded portions padded to both longitudinal end surfaces of the block main body by injection-molding so as to become continuous with the side surface molded portions, respectively, and having circular arc-shaped ball guide sections adapted to guide the balls rolled on the load rolling surfaces to ball return holes, and operating such that it comes into engagement with a track rail through the balls rolling on the load rolling surfaces and moves along the track rail, wherein the block main body is provided on the upper surface of the horizontal section thereof with a synthetic resin upper molded portion which is injection-molded simultaneously with the side surface molded portions and the end surface molded portions and adapted to connect the end surface molded portions formed on both end surfaces of the block main body.

According to these technical means, even when the side surface molded portions forming the ball return holes contract and the force of such contraction acts on the end surface molded portions on both end surfaces of the block main body, since the upper surface molded portion is padded to the upper surface of the horizontal section of the block main body by injection-molding so as to connect the pair of end surface molded portions on both end surfaces of the block main body, the upper surface molded portion pulls the end surface molded portions against the force of contraction of the side surface molded portions so that the end surface molded portions are closely adhered to the end surfaces of the block main body without floating up from the latter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a linear guide unit with a slider according to a first embodiment of the present invention;

FIG. **2** is a front view (partly in section) of the linear guide unit shown in FIG. **1**;

FIG. **3** is a side view of a movable block according to the first embodiment of the present invention;

FIG. **4** is a front view (partly in section) of the movable block shown in FIG. **3**;

FIG. **5** is a rear view of a cover according to the first embodiment of the present invention;

FIG. **6** is a sectional view of an endless ball circulation path attached to the slider of the linear guide unit according to the first embodiment of the present invention;

FIG. **7** is an exploded sectional view showing how the cover and the movable block are brought into engagement with each other;

FIG. **8** is a front view of a block main body according to the first embodiment of the present invention;

FIG. **9** is a perspective view of a linear guide unit according to a second embodiment of the present invention;

FIG. **10** is a plan view of the linear guide unit shown in FIG. **1**;

FIG. **11** is a sectional view taken along the XI—XI line of FIG. **10**;

FIG. **12** is a perspective view of a conventional linear guide unit;

FIG. **13** is a sectional view of a slider of the conventional linear guide unit shown in FIG. **12**; and

FIG. **14** is a plan view and a side view showing how end surface molded portions of a slider of the conventional rectilinear guide unit are deformed.

DESCRIPTION OF REFERENCE SYMBOLS

1: Track rail **2**: Slider **40**: Block main body **48**: Side surface molded portion **49**: End surface molded portion **50**: Upper surface molded portion

BEST MODE FOR CARRYING OUT THE INVENTION

The slider of the linear guide unit according to the present invention will be described with reference to the accompanying drawings.

FIGS. **1** and **2** show a rectilinear guide unit comprising a combination of a slider and a track rail according to a first embodiment of the present invention.

In the figures, reference numeral **1** designates the track rail to be arranged in the stationary section such as a bed of a machine tool, reference numeral **2** designates a slider for guiding a movable body such as a table along the track rail **1** and reference numeral **3** designates balls which roll between the track rail **1** and the slider **2** while applying road on the rail and endlessly circulate in the slider **2**.

First, the track rail **1** is substantially rectangular in section and on both side surfaces thereof there are formed two lines of ball rolling surfaces **11** for allowing the balls **3** to roll thereon along the longitudinal direction (vertical direction in FIG. **2**). The track rail **1** is provided with bolt fitting holes **12** at suitable intervals in the longitudinal direction of the rail so that the track rail **1** is fixed to a stationary section by means of fixing bolts (not shown) to be inserted into the bolt fitting holes **12**.

Further, the slider **2** comprises a movable block **4** having fitting surfaces **41** for a movable body such as a table and tapped holes **42** into which fixing bolts of the movable body are screw-fitted and a pair of covers **5**, **5** to be fixed to the front and rear end surfaces of the movable block **4**. Thus, by fixing the covers **5**, **5** to the movable block **4**, an endless circulation path for the balls **3** is formed within the slider.

The movable block **4** is substantially in the shape of a saddle in section and is provided with a horizontal section **4***a* on which the movable body fitting surface **41** is formed and a pair of skirts **4***b*, **4***b* drooping from the horizontal section **4***a*. On the inner surface of each of the skirts **4***b* there is formed a load rolling surface **4** opposing to the ball rolling surface **11** of the track rail **1**. Further, each of the skirts **4***b* is provided with a ball return hole **44** corresponding to each of the load rolling surfaces **43** so that each of the balls **3** released from its load after having rolled on the load rolling surface **43** rolls in a direction reverse to the rolling direction of the balls on the load rolling surface **43**.

On both front and rear end surfaces of the movable block **4** there are provided semicircular ball guide sections **46**, respectively, as shown in FIGS. **3** and **4** so as to form change direction paths for the balls **3** together with U-shaped groove **51** of each of the covers **5** to be described later thereby guiding the balls **3** coming into, and leaving away from, the ball return holes **44**. Further, on both front and rear end surfaces of the movable block **4** there are provided positioning bosses **7**, respectively, for the covers **5**.

FIG. **5** shows a contact surface of each of the cover **5** coming into contact with the movable block **4**. This contact surface is provided with a pair of the above-mentioned U-shaped grooves **51** for forming the change direction paths for the balls **3** and each of the grooves **51** is provided at one end thereof with a projection **52** which scoops up each of the balls **3** which has rolled on the ball rolling surface **11** of the track rail **1**. Further, the cover **5** has positioning holes **53** into which positioning bosses **47** of the movable block **4** are fitted, respectively.

FIG. **6** is a sectional view of an endless ball circulation path attached to the slider **2**. As shown in FIG. **7**, this endless circulation path is completed by fixing the covers **5** to both end surfaces of the movable block **4**, respectively. That is, when each of the covers **5** is fixed to the movable block **4**, the ball guide section **46** of the movable block **4** fits in the U-shaped groove **51** to thereby complete the U-shaped change direction path **54** and by this change direction path **54** the load rolling surface **43** of the movable block **4** and the above-mentioned ball return hole **44** are connected together.

With the above structure, when each of the balls **3** which has been bearing a load between the ball rolling surface **11** of the track rail **1** and the load rolling surface **43** of the movable block **4** has finished rolling on the load rolling surface **43** with the movement of the slider **2**, it is released from its load to enter the change direction path **54** of one of the covers **5** and begins to roll through the ball return hole **44** of the movable block **4** toward a direction reverse to its rolling direction on the load rolling surface **43** under no load condition. Further, each of the balls **3** having finished rolling through the ball return hole **44** again enters between the track rail **1** and the movable block **4** through the change direction path **54** in the other cover **5** and rolls on the load rolling surface **43** as it bears a load.

In the linear guide unit according to the instant embodiment, the movable block **4** forming the slider **2** is manufactured by injection-molding a synthetic resin material. That is, the movable block **4** is so formed that a metallic block main body **40** produced by mechanical machining is padded with a synthetic resin by injection-molding in such a manner that the portions such as the above-mentioned movable body fixing surface **41** and the load rolling surface **43** for the balls **3** where a mechanical strength is required are formed on the block main body **40** while the portions such as the ball return holes **44**, the ball guide holes **46** and positioning bosses **47** where not so great mechanical strength is required are formed of a synthetic resin material thereby making the weight of the movable block as small as possible.

FIG. **8** shows the block main body **40** before it is padded with the synthetic resin material. Such block main body **40** is first drawn to have a horizontal section **4***a* and a pair of skirt sections **4***b*, **4***b* and in this case, the outer side surface of each of the skirt sections **4***b* is formed to have a concave portion **47** for padding a synthetic resin thereto later. Further, the block main body **40** formed to its predetermined shape by drawing is ground whereby the above-mentioned movable body fitting surface **41** and the load rolling surface **43** are formed with a predetermined accuracy.

The block main body **40** finished to the predetermined shape is padded with a synthetic resin by injection-molding and in the case of such injection-molding, side surface molded portions **48** are padded to the concave portions **47** formed on the skirts **4***b* while end surface molded portions **49** are padded to the front and rear end surfaces of the block main body **40** so that the side surface molded portions **48** provide the above-mentioned ball return holes **44**, respectively, while the end surface molded portions **49** provide the above-mentioned ball guide sections **46** and the positioning bosses **47**, respectively.

On the other hand, where the amount of contraction of the synthetic resin after the completion of the injection-molding is taken into consideration, in the instant embodiment, the amount of contraction of each of the side surface molded portions **48** padded along the longitudinal direction of the block main body **40** is considered larger than that of each of the end surface molded portions **49** padded along the cross direction of the block main body **40** so that if the movable block **4** manufactured by the above-mentioned injection-molding is left as it is, there is a possibility that the end surface molded portions **49** are pulled by the side surface molded portions **48** to become deformed as shown in FIG. **14**.

Therefore, in the instant embodiment, an upper surface molded portion **50** is padded between the pair of movable body fitting surfaces **41** simultaneously with the injection-molding of the above-mentioned end surface molded portions **49** and the side surface molded portions **48** so that the pair of end surface molded portions **49** located at both end surfaces of the block main body **40** are connected by the upper surface molded portion **50**.

Consequently, the deformation of the end surface molded portions **49** is prevented by the upper surface molded portion **50** so that the end surface molded portions **49** can adhere to the block main body **40** without leaving any gaps therebetween thereby effectively preventing the aging of the movable block **4** manufactured by injection-molding. Further, since the deformation of the end surface molded portions **49** can be prevented, the covers **5** can be tightly fixed to the end surface molded portions **49**, respectively, so that change direction paths **54** for the balls **3** which are completed by the fixation of the covers **5** thereto (refer to FIGS. **6** and **7**) are accurately formed thereby achieving a smooth endless circulation of the balls.

Next, FIGS. **9** through **11** show a rectilinear guide unit according to a second embodiment of the present invention wherein a slider is combined with a track rail.

Like the above-described first embodiment, this rectilinear guide unit also comprises a track rail **6** and a slider **7** fastened to the track rail through balls **8** and adapted to guide a movable body along the track rail wherein the slider **7** comprises the movable block **9** having movable body fitting surfaces **71** and tapped holes **72** for receiving fitting bolts and a pair of covers **10** to be fixed to both front and rear end surfaces of the movable block **9**, respectively.

Further, like the above-described first embodiment of the present invention, on both side surfaces of the track rail **6** there are formed two ball rolling surfaces **61***a* and **61***b*, respectively, of which the ball rolling surface **61***a* is formed to face upward at an angle of 45° (with respect to the horizontal direction) while the ball rolling surface **61***b* is formed to face downward at an angle of 12.5° (with respect to the horizontal direction). Further, the track rail **6** is provided with bolt fitting holes **62** in spaced apart relationships with one another in the longitudinal direction thereof so that it is fixed to a stationary section by fixing bolts (not shown) to be inserted into these bolt fitting holes **62**.

The movable block **9** is substantially in the shape of L and comprises a horizontal section **9***a* provided with the above-mentioned movable body fitting surfaces **71** and a skirt **9***b* drooping from one end of the horizontal section **9***a* and into a concave portion formed by the horizontal section **9***a* and the skirt **9***b*, the upper half of the track rail **6** enters. On the side of the lower surface of the horizontal section **9***a* there is formed a load rolling surface **93***a* opposing to the upward facing ball rolling surface **61***a* of the track rail **6** and on the side of the inner surface of the skirt **9***b* there is a load rolling surface **93***b* opposing to the downward facing ball rolling surface **61***b* so that balls **8** supporting the slider **7** moving on the track rail **6** roll in the state of being sandwiched between the ball rolling surfaces **61***a*, **61***b* and the load rolling surfaces **93***a*, **93***b*.

Further, on both sides of the load rolling surfaces **93***a* and **93***b* of the movable block **9** there are formed retainers **92**, respectively, so that when the slider **7** is removed from the track rail **6**, the balls **8** on the load rolling surfaces **93***a* and **93***b* are prevented from falling down from the slider **7**.

Further, the horizontal section **9***a* and the skirt **9***b* are provided with ball return holes **94***a* and **94***b*, respectively, in correspondence to the above-mentioned load rolling surfaces **93***a* and **93***b* so that the balls **8** released from their loads after having rolled on the load rolling surfaces **93***a* and **93***b* roll in a direction reverse to the direction of rolling thereof on the load rolling surfaces **93***a* and **93***b*.

Further, also in this embodiment, on the front and rear end surfaces of the movable block **9**, there are provided semi-circular ball guide sections (not shown) for guiding the balls **8** from the load rolling surfaces **93***a* and **93***b* to the ball return holes **94***a* and **94***b* and by fixing the covers **10** to the movable block **9**, an endless circulation path for the balls **9** is completed as in the case of the first embodiment.

Also in the case of the rectilinear guide unit according to this embodiment having the above-described structure, the movable block **9** forming the slider **7** comprises a metallic block main body **90** with a synthetic resin pad formed by injection-molding. The injection-molding is performed such that side surface molded portions **98** are padded to the top end of the horizontal section and the side surface of the skirt **9***b* of the block main body **90**, respectively, with the formation of the above-mentioned ball return holes **94***a* and **94***b* and end surface molded portions **99** are padded to both front and rear end surfaces of the block main body **90**, respectively, with the formation of the above-mentioned ball guide sections.

Also, in the case of the movable block **9** according to this embodiment thus manufactured, when the contraction of the side surface molded portions **98** and that of the end surface molded portions **99** are taken into consideration after completion of injection-molding, since there is a possibility that each of the end surface molded portions **99** is pulled by the contraction of each of the side surface molded portions **98** to become deformed with the generation of a gap between the two portions, the same countermeasure is taken as in the case of the first embodiment.

That is, an upper molded portion **97** is padded between the pair of movable body fitting surfaces on the upper surface of the block main body **90** simultaneously with the injection-molding of the end surface molded portions **99** and the side surface molded portions **98** so that the pair of end surface molded portions **99** of the block main body **90** are connected by this upper molded portion **97**.

Consequently, also in the case of this embodiment, the upper surface molded portion **97** prevents the deformation of the end surface molded portions **99** so that the end surface molded portions **99** closely adhere to the block main body **90** without leaving any gap therebetween and since the end surface molded portions **99** are prevented from becoming deformed, it is possible to tightly fix the covers to these portions **99**, respectively.

INDUSTRIAL AVAILABILITY

As described above, according to the slider of the rectilinear guide unit of the present invention, where the slider is manufactured by padding a synthetic resin to the metallic block main body, the upper molded portion is padded on the horizontal section of the block main body so as to connect the pair of end surface molded portions padded to both end surfaces of the block main body so that the end surface molded portions are prevented from becoming deformed after their padding and can be tightly adhered to the end surfaces of the block main body.

Further, even when the endless ball circulation path is formed by fixing the covers to the end surface molded portions, the deformation of the end surface molded portions is controlled according to the present invention so that it is possible to tightly fix the covers to the end surface molded portions, respectively, thereby achieving a smooth endless circulation of balls.

What is claimed is:

1. A slider of a rectilinear guide unit, which comprises: a metallic block main body substantially in the shape of a saddle in section including a horizontal section and a pair of skirts drooping from the horizontal section and having ball load rolling surfaces on the inner surfaces thereof, respectively; synthetic resin side surface molded portions padded to outer side surfaces of each of said pair of skirts of said block main body by injection-molding and having ball return holes corresponding to said load rolling surfaces, respectively; and synthetic resin end surface molded portions padded to both longitudinal end surfaces of said block main body, respectively, by injection molding so as to become continuous with said side surface molded portions, respectively, and having circular arc-shaped ball guide sections for guiding each of balls rolled said load rolling surfaces to said ball return holes and operating such that it comes into engagement with a track rail through the balls rolling on said load rolling surfaces and moves along said track rail, wherein said block main body is provided on the upper surface of the horizontal section thereof with a synthetic resin upper molded portion injection-molded simultaneously with said side surface molded portions and said end surface molded portions and adapted to connect said end surface molded portions formed on both end faces of said block main body.

2. A slider of a rectilinear guide unit, which comprises: a metallic block main body substantially in the shape of the letter “L” including a horizontal section and a skirt drooping from one end of the horizontal section and having ball load rolling surfaces on the lower surface of the horizontal section and on the inner surface of said skirt, respectively; synthetic resin side surface molded portions padded to the top end of said horizontal section and the outer side surface of the skirt of said block main body by injection-molding and having ball return holes corresponding to said ball load rolling surfaces; and synthetic resin end surface molded portions padded to both longitudinal end surfaces of said block main body by injection-molding so as to become continuous with said side surface molded portions, respectively, and having circular arc-shaped ball guide sections adapted to guide the balls rolled on the load rolling surfaces to ball return holes, and operating such that it comes into engagement with a track rail through the balls rolling on said load rolling surfaces and moves along said track rail, wherein the block main body is provided on the upper surface of said horizontal section thereof with a synthetic resin upper molded portion which is injection-molded simultaneously with said side surface molded portions and said end surface molded portions and adapted to connect said end surface molded portions respectively formed on both end surfaces of said block main body.

* * * * *

US005829883A

United States Patent [19]

Kawaguchi et al.

[11] **Patent Number: 5,829,883**

[45] **Date of Patent: Nov. 3, 1998**

[54] **ROLLING MOTION GUIDE APPARATUS**

[75] Inventors: **Takahiro Kawaguchi**, Tokyo; **Tadashi Hirokawa**, Moroyama-machi, both of Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **947,159**

[22] Filed: **Oct. 8, 1997**

[30] **Foreign Application Priority Data**

Oct. 9, 1996 [JP] Japan 8-287544

[51] **Int. Cl.**[6] **F16C 29/06**

[52] **U.S. Cl.** **384/45**; 384/43

[58] **Field of Search** 384/43, 44, 45, 384/13

[56] **References Cited**

U.S. PATENT DOCUMENTS

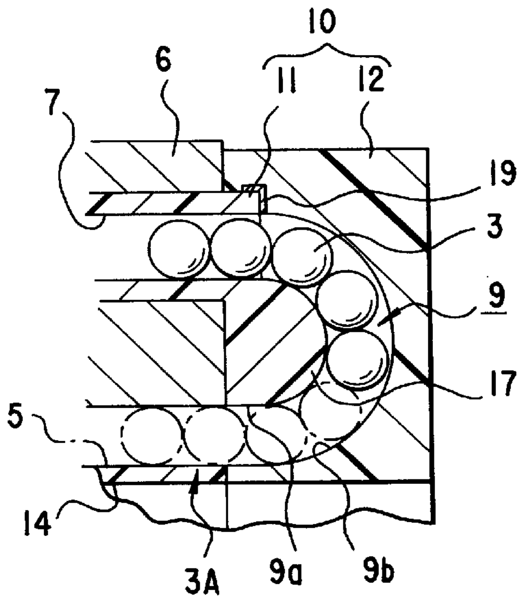
4,545,626	10/1985	McCloskey	384/43
4,934,834	6/1990	Morita	384/43 X
5,051,001	9/1991	Jacob	384/43
5,139,347	8/1992	Hattori	384/45 X

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

A rolling motion guide apparatus comprises a guide rail formed with a loaded rolling member rolling passage and a movable member disposed to be movable with respect to the guide rail through a number of rolling members, in which the rolling direction changing passage structure is composed of an end surface forming portion which is formed with a rolling direction changing passage inner periphery guide portion integrally formed with the movable member main body and an end plate which is formed with a rolling direction changing passage outer periphery guide portion separately formed from the end surface forming portion. The rolling direction changing passage outer periphery guide portion of the end plate and a rolling direction changing passage inner periphery guide portion thereof have peripheral portions respectively which are joined and welded so as to provide joining surfaces as a welding portion.

10 Claims, 3 Drawing Sheets



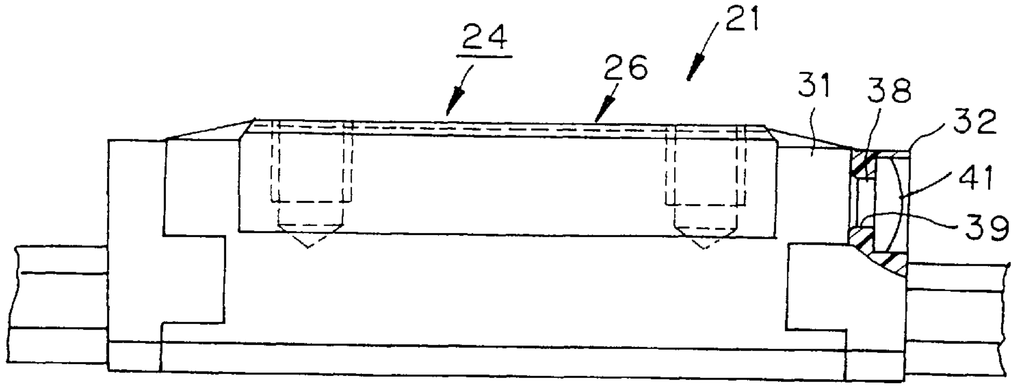


FIG.1A

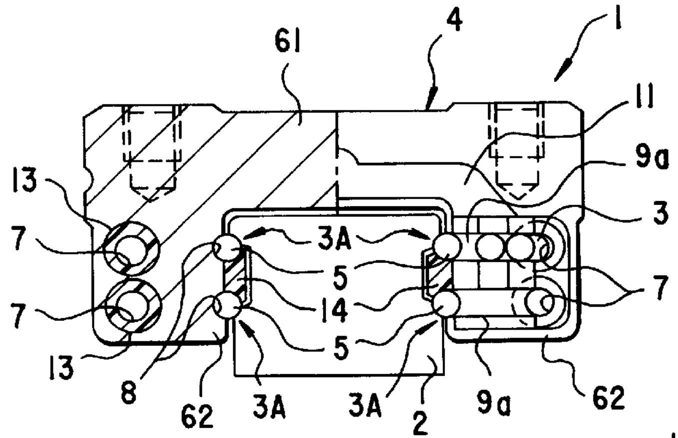


FIG.1B

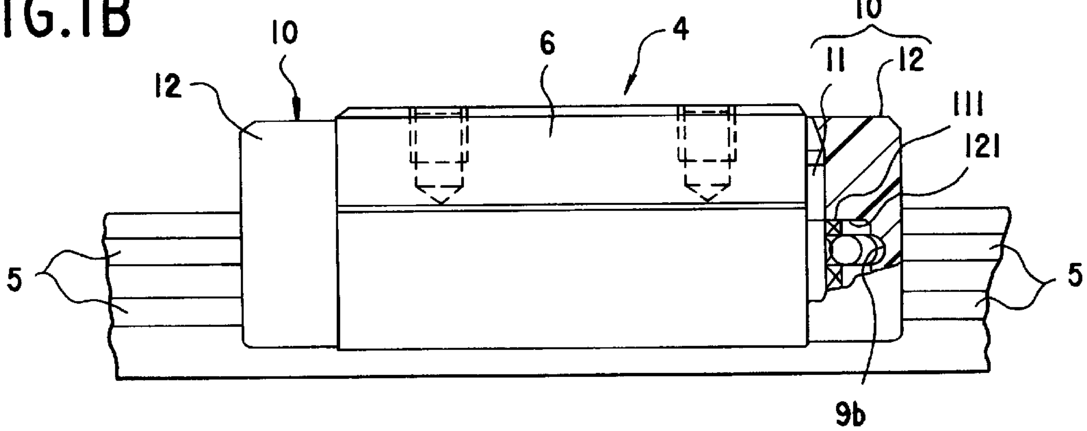


FIG.1D

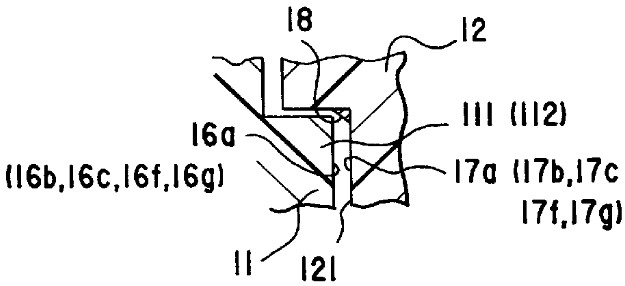


FIG.1C

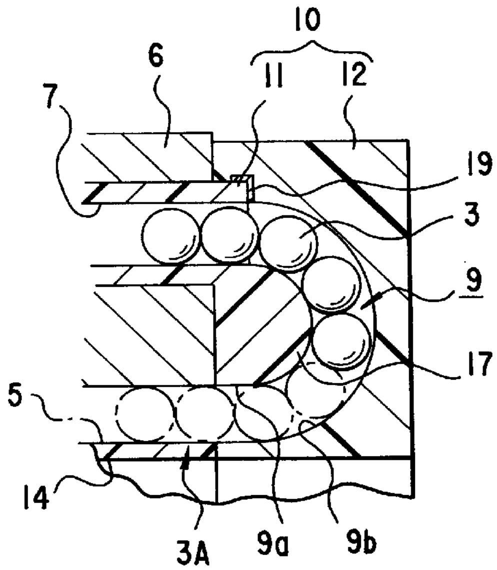


FIG.1E

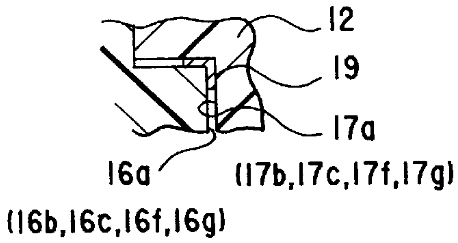


FIG.2A

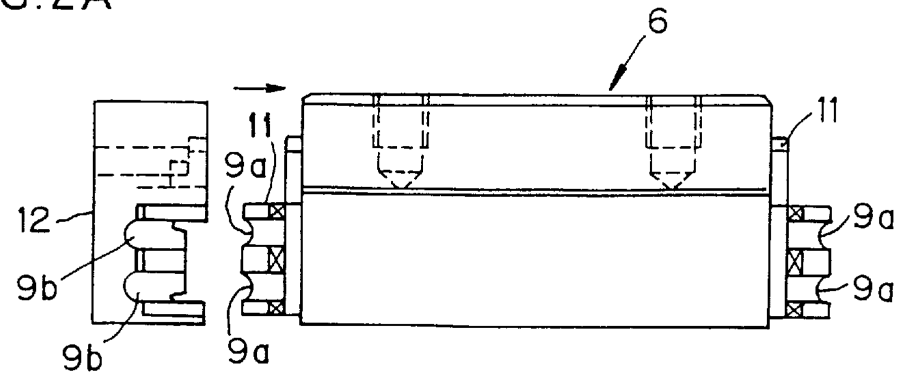


FIG.2B

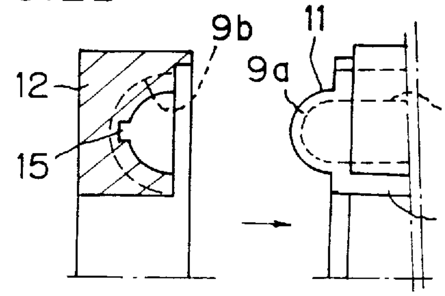


FIG.2C

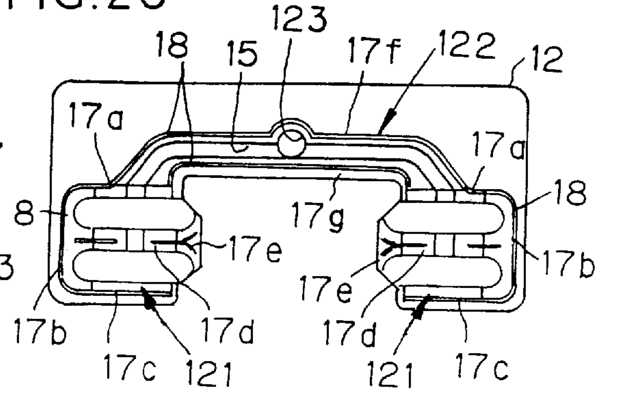


FIG.2D

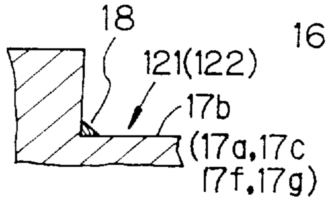


FIG.2E

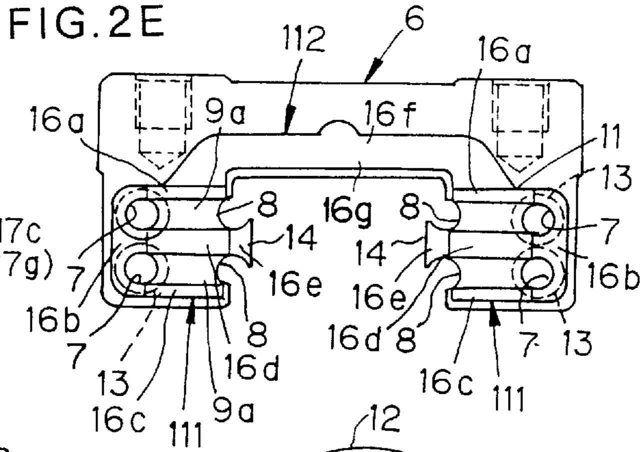


FIG.2F

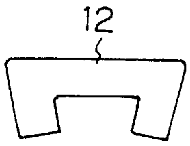


FIG.2G

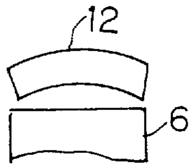


FIG.2H

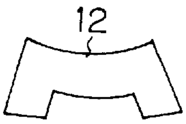


FIG.2I

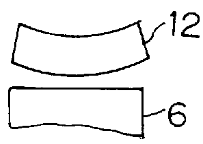


FIG.3A

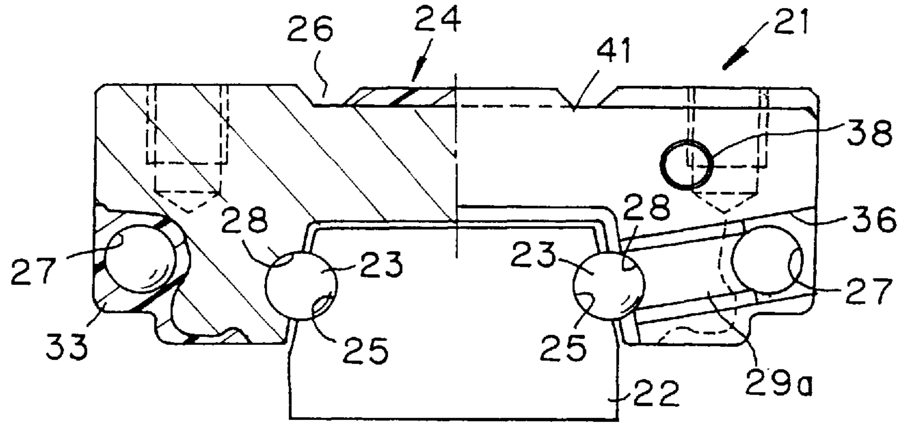


FIG.3B

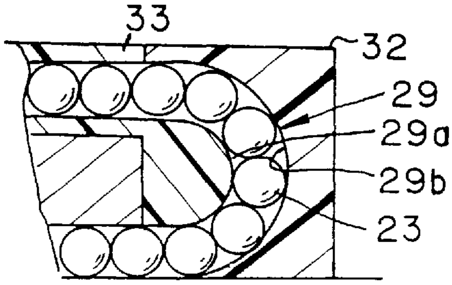


FIG.3C

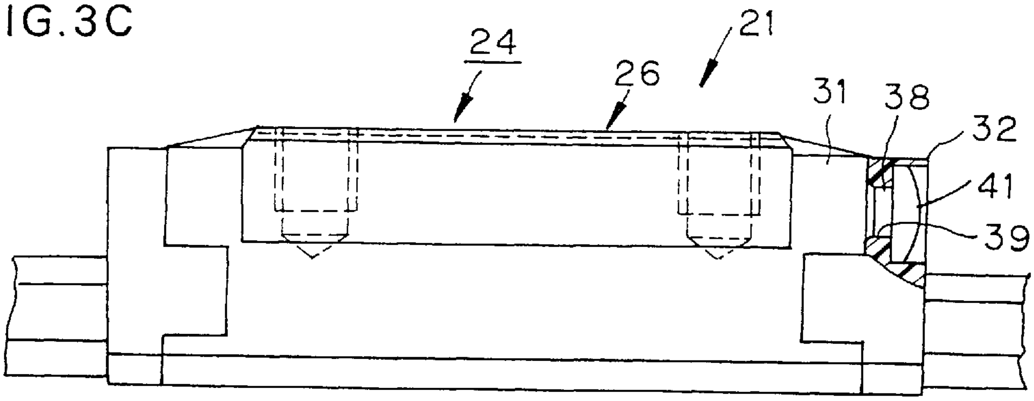


FIG.3D

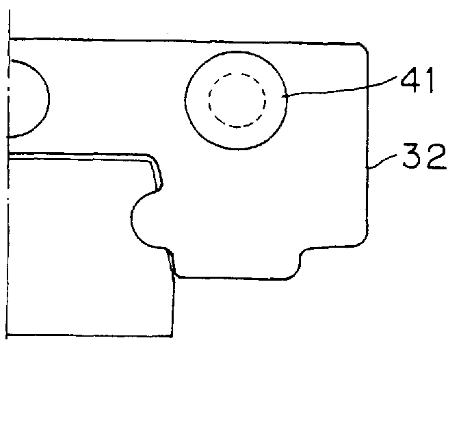
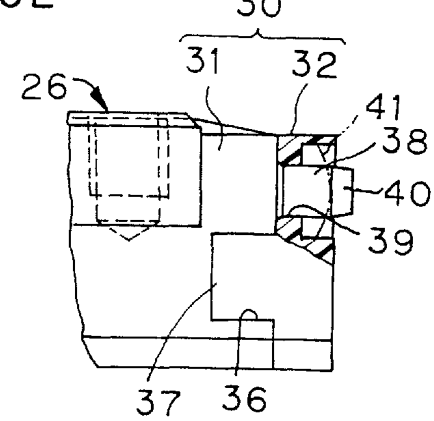


FIG.3E



ROLLING MOTION GUIDE APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a rolling motion guide apparatus, particularly having a rolling direction changing passage structure, adapted for such as linear motion guide apparatus, ball spline, ball bush, ball screw and the like, in which a movable member is assembled to a guide shaft to be movable through rolling members.

In a known art, there is provided a rolling motion guide apparatus of the kind mentioned above in which a movable member is assembled to a guide shaft to be movable through a plurality of rolling members. The movable member is composed of a movable member main body provided with a loaded rolling member rolling passage corresponding in position to a loaded rolling member rolling passage formed to the guide shaft and a rolling member returning passage for returning the rolling members from one end of the loaded rolling member rolling passage to another end thereof and also composed of a structure constituting a rolling direction changing passage disposed at both ends of the main body of the movable member and constituting rolling member rolling direction changing passages for scooping the rolling members from the loaded rolling member rolling passage and guiding the same to the rolling member returning passage.

In order to prevent a staged portion from occurring at the connection between the loaded rolling member rolling passage and the rolling member rolling direction changing passage to thereby smoothly roll the rolling members, in the known art, an inner peripheral guide portion of the rolling member direction changing passage is formed integrally with the main body of the movable member such as disclosed in the Japanese Patent Laid-open Publication No. HEI 7-317762.

Although there is provided an end plate, generally formed of resin, as a member constituting the rolling direction changing passage structure for constituting an outer periphery guide portion of the loaded rolling member rolling direction changing passage (herein called merely rolling direction changing passage), the end plate is formed of a different member from the main body of the movable member, and the end plate is positioned and then fastened to the movable member main body by means of bolt. The rolling direction changing passage is composed of such outer periphery guide portion of the end plate and the inner periphery portion integrally formed with the movable member main body.

In the above known structure, there is a problem of fastening the end plate to the movable member main body by means of bolt, involving a troublesome assembling working.

In the case of the bolt fastening, the fastening bolt is screwed into a tap hole formed to an end surface of the movable member main body through a bolt insertion hole formed to the end plate. However, in this assembling, there may cause an alignment error to the end plate assembling portion due to a working error in the tap hole formation or a play between the bolt insertion hole and the bolt inserted. The occurrence of such error will result in the formation of the staged portion between the direction changing passage outer periphery guide portion of the end plate and the end portion of the rolling member rolling passage in a loaded area, disturbing the smooth circulation of the rolling members.

Furthermore, even if such assembling working can be made accurately, the end plate formed of the resin material has contraction strain of the resin at the cooling and curing time of the end plate. Such contraction strain may cause the staged portion to occur between the end portion inside the direction changing passage outer periphery guide portion and the end portion of the rolling member rolling passage in the loaded area, thus also disturbing the smooth circulation of the rolling members.

Still furthermore, in a known structure, an oil groove for feeding a lubricant to the direction changing passage is formed between joining surfaces of the end plate and the movable member main body so as to tightly contact the joining surfaces by means of the fastening bolt to prevent the lubricant from leaking through the joined surface. However, as mentioned above, since the end plate has the contraction strain at the cooling time, the end plate cannot tightly contact the movable member main body and there is a fear of the leakage of the lubricant through the not-tightly contacting portion. Although the complete tight contacting can be achieved by strongly fastening the bolt, such strong fastening may damage or deform the end plate, resulting in the deformation of the direction changing passage outer periphery guide portion and further resulting in the deformation of the end position of the direction changing passage outer peripheral guide portion, causing the staged portion between it and the end portion of the loaded rolling member rolling passage and, hence, disturbing the smooth circulation of the rolling members.

SUMMARY OF THE INVENTION

An object of the present invention is to substantially eliminate defects or drawbacks encountered in the prior art described above and to provide a rolling motion guide apparatus having an improved mounting structure of an end plate of a movable member of the apparatus particularly for ensuring a stable and smooth circulation of rolling members with high reduced working process and with high assembling performance.

This and other objects can be achieved according to the present invention by providing a rolling motion guide apparatus which comprises a guide shaft formed with a loaded rolling member rolling passage and a movable member disposed to be movable with respect to the guide shaft through a number of rolling members, the movable member being composed of a movable member main body provided with a loaded rolling member rolling passage corresponding in position to the loaded rolling member rolling passage formed to the guide shaft and a rolling member returning passage for returning the rolling members from one end of the loaded rolling member rolling passage of the movable member main body to another end thereof and also composed of a rolling direction changing passage structure constituting a rolling member direction changing passage for guiding the rolling member scooped from the loaded rolling member rolling passage of the movable member main body to the rolling member returning passage, wherein the rolling direction changing passage structure is composed of an end surface forming portion which is formed with a rolling direction changing passage inner periphery guide portion integrally formed with the movable member main body and an end plate which is formed with a rolling direction changing passage outer periphery guide portion separately formed from the end surface forming portion, and wherein the rolling direction changing passage outer periphery guide portion of the end plate and a rolling direction changing passage inner periphery guide portion thereof have peripheral portions respectively which are joined and welded so as to provide joining surfaces as a welding portion.

In preferred examples of the present invention, the end surface forming portion of the movable member main body is formed of a resin material through an insertion molding process.

The guide shaft is a guide rail and the movable member is composed of a central horizontal portion and side portions extending downward in a mounted state from both end portions of the horizontal portion so that the guide rail is disposed between the side portions of the movable member.

The movable member main body is provided with axial forming portions which are integrally formed with the end surface forming portions formed at both ends of the movable member main body. Each of the axial forming portions is provided with at least either one of a return hole constituting member forming a non-loaded rolling member returning hole and a rolling member retainer member for preventing the rolling member from falling down at a time when the guide shaft is withdrawn from the movable member.

The rolling direction changing passage outer periphery guide portion and the rolling direction changing passage inner periphery guide portion of the rolling direction changing passage structure have peripheral portions respectively which are joined so as to provide joining surfaces, and a welding portion is continuously formed between the joining surfaces.

A lubricant groove is formed between the joining surfaces of the end surface forming portion and the end plate to communicate with the rolling direction changing passage structure and the welding portion is formed continuously so as to surround the rolling direction changing passage structure and the lubricant groove.

A recessed portion and a protruded portion, which is faucet fitted to the recessed portion, are formed to the peripheral portions of the rolling direction changing passage inner periphery guide portion of the end surface forming portion of the movable member main body and the rolling direction changing passage outer periphery guide portion of the end plate, the protruded and recessed portions having flat portions as joining surfaces to be joined together, and a welding width portion, which is fused at a welding time, is formed between the joining surfaces.

A projection is formed to the joining surface of the end surface forming portion of the movable member main body and the end plate is formed with a hole at the joining surface thereof through which the projection is inserted, and a front end portion of the projection penetrating over the hole is fused to a peripheral edge portion of the hole.

According to the characters and structures of the rolling motion guide apparatus of the present invention mentioned above, the following functions and/or effects will be attained.

The direction changing passage inner periphery guide portion of the end surface forming portion integrally formed with the end surface of the movable member main body through the insertion molding process is accurately formed to the predetermined position of the movable member main body with the predetermined shape. In the formation mold, the movable member main body is positioned by a support portion contacting the rolling member rolling passage, and the direction changing passage inner periphery guide portions can be accurately positioned with reference to the rolling member rolling passage and, after the positioning, the molding process is carried out.

The peripheral portions of the direction changing passage inner periphery guide portion and the direction changing passage outer periphery guide portion of the end plate and the movable member main body are fused and welded. Accordingly, even if the end plate is deformed, the rolling direction changing passage outer periphery guide portion is fixed with the corrected deformation along the rolling direction changing passage inner periphery guide portion of the end surface forming portion of the movable member main body molded with high performance, thereby forming the passage constituting the rolling direction changing passage with high accuracy. That is, in the rolling direction changing passage, the respective rolling members are changed in their rolling directions with pushing force being applied to each other and the rolling members collide repeatedly with the inner peripheral surface of the direction changing passage. In order to prevent the rolling members from irregularly circulating due to the collision, it is necessary to form uniform play passage. According to the structure of the direction changing passage of the present invention, this can be achieved.

Furthermore, the direction changing passage outer periphery guide portion of the end plate can be exactly positioned with respect to the movable member main body along the rolling direction changing passage inner periphery guide portion of the end surface forming portion of the movable member main body. Accordingly, there can be accurately achieved the positional alignment of both the end portions of the direction changing passage outer periphery guide portion with the rolling member rolling passage on the guide shaft side and with the end portion of the rolling member return passage.

Further, in the direction changing passage, although noise will be likely generated due to the mutual collision of the rolling members, such noise can be substantially eliminated by forming the rolling direction changing passage through the welding process.

Furthermore, the apparatus is formed with the return hole constituting member as the axial forming portion and the ball retainer member, and accordingly, the end surface forming portion of the movable member main body can be further firmly fixed to the end surface of the movable member main body due to the axial contraction of these portions, so that the positional accuracy of the direction changing passage inner periphery guide portion can be enhanced at the welding time of the end plate.

The most high positional accuracy is required for both the end portions of the direction changing passage inner periphery guide portion which are to be connected to the non-loaded ball returning hole and the ball retainer member. The position of the direction changing passage inner periphery guide portion can be accurately determined by providing the return hole constituting member as the axial forming portion and the ball retainer member through which the axial contraction force is applied to both the end portions of the direction changing passage inner periphery guide portion. Accordingly, both the end portions of the direction changing passage outer periphery guide portion of the end plate which is welded along such direction changing passage inner periphery guide portion can be also accurately positioned.

The welded portion is formed continuously along the entire length between the joining surfaces at the peripheral portions of the rolling direction changing passage inner periphery guide portion and the rolling direction changing passage outer periphery guide portion. Accordingly, the rolling direction changing passage outer periphery guide portion on the end plate side can be more precisely positioned with respect to the rolling direction changing passage inner periphery guide portion, so that the direction changing passage can be further accurately manufactured.

Furthermore, the portions between the joining surfaces at the peripheral portions of the direction changing passage inner periphery guide portion and the direction changing passage outer periphery guide portion can be substantially completely sealed, so that the leakage of the lubricant to be supplied to the direction changing passage can be substantially prevented and the noise suppressing function can also be enhanced.

Still furthermore, since the joining surfaces are formed respectively to the recessed portions of the end plate and the protruded portions which are to be faucet fitted to those recessed portions, the direction changing passage outer periphery guide portion of the end plate can be further accurately positioned with respect to the movable member main body. The fused resin is filled up in the gaps between the fitted surface portions of the protruded portions and the recessed portions as well as the portions of the joining surfaces mentioned above, thereby further increasing the fixing strength. The filling and fusing of the fused resin in the gap between the protruded portions and the recessed portions can further contribute the maintenance of the accurate performance. The welding performed from the faucet fitting portion to the direction changing passage peripheral portion can contributes to increase the welding strength and prevent the fused resin from entering into the direction changing passage and the lubricant groove.

Still furthermore, according to a further preferred example, the joining surfaces of the end surface forming portion of the movable member main body and the end plate are not directly welded, and the fitted portions of the projection and the hole are welded, so that although the continuous welding is not performed, and the end plate is firmly fixed at the peripheral portion of the direction changing passage inner periphery guide portion, whereby the direction changing passage outer periphery guide portion can be precisely fixed with respect to the direction changing passage inner periphery guide portion.

The nature and further characteristic features of the present invention will be made more clear from the following descriptions with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** represents a linear motion guide apparatus according to a first embodiment of the present invention, in which FIG. **1**A is a front view, left half being in section, of the apparatus from which an end plate is removed, FIG. **1**B is a side view thereof partially cut away, FIG. **1**C is a sectional view in an enlarged scale of a portion of a rolling direction changing passage of the apparatus, and FIGS. **1**D and **1**E are schematic views showing welding sequence applied to the apparatus;

FIG. **2** represents a movable block of the linear motion guide apparatus of FIG. **1**, in which FIG. **2**A is a disassembled side view of the apparatus having end plate shown in section, FIG. **2**B is a partial bottom view of the end plate and an end surface portion of the movable block body in a disassembled state, FIG. **2**C is a view showing an end surface of the end plate to be joined to the end surface of the movable block body, FIG. **2**D shows a welding overlap width portion, FIG. **2**E shows an end surface of the movable block body, and FIGS. **2**F to **2**I show deformed states (strains) of the end plate in an exaggerated manner; and

FIG. **3** represents a linear motion guide apparatus according to a second embodiment of the present invention, in which FIG. **3**A is a front view, left half being in section, of the apparatus from which an end plate is removed, FIG. **3**B is a partial sectional view in an enlarged scale of a portion of a rolling direction changing passage of the apparatus, FIG. **3**C is a side view of the apparatus partially cut away, FIG. **3**D is a half front view showing a state that the end plate is assembled, and FIG. **3**E is a view showing a state of engagement of a projection of the movable block body with an engaging hole of the end plate before welding.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will be described hereunder by way of preferred embodiments with reference to the accompanying drawings.

[First Embodiment]

FIGS. **1** and **2** represents the first embodiment of a linear motion guide apparatus as a rolling motion guide apparatus according to the present invention.

Referring to FIGS. **1** and **2**, reference numeral **1** denotes an entire structure of the linear motion guide apparatus, which is provided with a guide (track) rail **2** as a guide shaft and a movable block **4** as a movable member mounted to the guide rail **2** to be movable through a number of balls **3** as rolling members.

The guide rail **2** is composed of a long member having a rectangular cross section, and the movable block **3** is guided at the lateral, left and right, side of the guide rail **2**, through four ball rows, two rows at each lateral side, **3**A, **3**A, **3**A, **3**A. The left and right side surfaces of the guide rail **2** is formed each with two, totally four, loaded ball rolling grooves **5**, **5**, **5**, **5** as loaded rolling member rolling passage corresponding in positions to the four ball rows **3**A, **3**A, **3**A, **3**A, respectively, along the entire longitudinal length of the guide rail **2**.

The movable block **3** is composed of a movable block body **6** as the main body of the movable member and rolling direction changing passage constituting members **10**, **10** disposed to both end sides of the movable block body **6**. The movable block body **6** is a member having a]-shaped section an d is provided with a horizontal portion **61** opposing to the upper surface of the guide rail **2** and a pair of support leg (skirt) portions **62**, **62** corresponding in positions to the left and right side surfaces of the guide rail **2**. Furthermore, two loaded ball rolling grooves **8**, **8**, as loaded rolling member rolling passages, are formed respectively to the inner side surfaces of the paired left and right support leg portions **62**, **62** of the movable block body **6**, and the loaded ball rolling grooves **8**, **8**, **8**, **8** correspond in position to the loaded ball rolling grooves **5**, **5**, **5**, **5**, respectively, formed to the left and right side surfaces of the guide rail **2**. Furthermore, the support leg portions **62**, **62** are also formed with ball returning passages **7**, **7**, **7**, **7** as the rolling member returning passages for returning the balls from one end of each loaded ball rolling groove **8** to another end thereof.

The each rolling direction changing passage constituting member **10** is composed of an end surface forming portion **11** made of resin and an end plate **12** also made of resin. The end surface forming portion **11** is formed with an inner periphery guide portion of the rolling member direction changing passages (herein called merely direction changing passage inner periphery guide portion) **9***a*, **9***a*, **9***a*, **9***a* integrally formed with the movable block body **6** through an insertion molding process in which the movable block body **6** is inserted into a formation mold to carry out the molding. The end plate **12** is formed with an outer periphery guide portion of the rolling member direction changing passages (herein merely called direction changing passage outer periphery guide portion) **9***b*, **9***b*, **9***b*, **9***b* independently formed from the end surface forming portion **11**. Joining surfaces of the peripheral portions of the direction changing passage inner periphery guide portion **11** and the direction changing passage outer periphery guide portion **12** are welded to thereby constitute a direction changing passage **9** having a curved U-shape.

The movable block body **6** is formed integrally with an axial forming portion, which is composed of a return hole constituting members **13** forming a non-loaded ball return holes **7** and connected to the end surface forming portions **11** at both the ends of the movable block body **6** and ball retainer members **14** preventing the balls **3** from falling down at the time when the guide rail **2** is withdrawn from the movable block body **6**.

Each of the end surface forming portions **11** is composed of first protruded portions **111**, each having substantially rectangular shape, formed to the end surfaces of the left and right leg (skirt) portions **62**, **62** of the movable block body **6** and second protruded portions **112** formed to the end surface of the horizontal portion **61** so as to connect the right and left first protruded portions **111** to each other. Each of the left and right first protruded portions **111** is formed with upper and lower rows of the direction changing passage inner periphery guide portions **9***a*, **9***a*, **9***a*, **9***a* projecting in half-moon shape.

The end plate **12** has left and right skirt (leg) portions, to which first recessed portions **121** into which the first protruded portions **111** of the end surface forming portion **11** are fitted in a faucet manner, and second recessed portions **122** into which the second protruded portions are fitted in a faucet manner. These first and second protruded portions **111** and **112** of the end surface forming portion **11** constitute a staged protruded portion according to the structure of the present invention.

The first recessed portion **121** is formed with the direction changing passage outer periphery guide portions **9***b*, **9***b*; **9***b*, **9***b* which are circularly recessed in correspondence to the half-moon shaped direction changing passage inner periphery guide portion and constitutes the rolling direction changing passages **9**, **9**; **9**, **9** in combination of the direction changing passage inner periphery guide portion **9***a*, **9***a*; **9***a*, **9***a*.

A second recessed portion **122**, into which the second protruded portion **112** is fitted, is formed to the horizontal portion of each of the end plate **12**, and the second recessed portion **122** has a bottom portion to which an oil groove **15** is formed so as to be communicate with the left and right direction changing passage outer periphery guide portion **9***b*, **9***b*; **9***b*, **9***b* from an oil supply port **123** opened at a central portion thereof. A grease nipple, not shown, is mounted to the oil supply port **123**.

Joining surfaces **16***a* to **16***e* and **17***a* to **17***e* are formed between a peripheral portion of the direction changing passage inner periphery guide portion **9***a* of the left and right first protruded portions **111** of the movable block body **6** and a peripheral portion of the direction changing passage outer periphery guide portion **9***b* of the first recessed portions **121** of the end plate **12**. These joining surfaces extend each with a predetermined width and are joined together, respectively. Joining surfaces **16***f*, **17***g* and **17***f*, **17***g*, which are joined together through the oil groove **15**, are formed between the second protruded portions **112** and the first recessed portions **121** of the end plate **12**. These joining surfaces **16***f*, **16***g* and

17*f*, **17***g* are formed with welding width portions **18** which are welded together in the fusing process. Although such welding width portions **18** may be formed either one of the joining surfaces **17***a* to **17***g* on the side of the end plate **12** and the joining surfaces **16***a* to **16***g* on the side of the first and second protruded portions **111** and **112** of the movable block body **6**, in the present embodiment, the welding width portions **18** are formed on the side of the joining surfaces **17***a* to **17***g* of the first and second recessed portions **121** and **122** of the end plate **12**.

Furthermore, the welding width portions **18** are formed continuously so as to surround the oil groove **15** as well as the bilateral direction changing passage outer periphery guide portions **9***b* of the end plate **12**. The joining surfaces **17***a*, **17***b* and **17***c*, which are positioned at upper edge, outside edge and lower edge portions of the first recessed portion **121** of the end plate **12**, are formed continuously so as to surround the two rows of upper and lower direction changing passage outer periphery guide portions **9***b*, **9***b*. The joining surface **17***d* constituting the boundary portion between the upper and lower direction changing passage outer periphery guide portion **9***b* and the joining surface **17***e* facing the end surface of the ball retainer portion **14** are formed at the intermediate portions therebetween.

The joining surface **17***b* of the outside edge portion of the first recessed portion **121** is formed to be flat, and the joining surfaces **17***a* and **17***c* of the upper and lower edge portions have partial flat portions at their outer end portions continuous to the outside edge portion and circular portions along the direction changing passage outer periphery guide portion **9***b*. The circular portions of the joining surfaces **17***a* and **17***c* may not be welded as occasion demands. Further, the joining surface **17***d* at the boundary portion between the upper and lower direction changing passage inner periphery guide portions **9***b*, **9***b* may not also be welded as occasion demands.

Furthermore, the joining surfaces **17***e* and **17***f* of the upper and lower edge portions of the second recessed portion **122** are continuously trimmed between the joining surfaces of the second protruded and recessed portions **112** and **122** surrounding the oil groove **15**.

The joining surfaces **17***a*, **17***b*, **17***c* of the upper, outside and lower edge portions of the first recessed portion **121** and the welding width portions **18** trimming the joining surfaces **17***f*, **17***g* of the upper and lower edge portions of the second recessed portion **122** are formed respectively at the corner portions of the first and second recessed portions **121** and **122** to make maximum the thickness of the corner portions, the thickened portions being reduced in their thicknesses towards the direction changing passage **9** and the oil groove **15** so as to each provide a triangular shape in section and extend continuously with uniform width. Although, the welding width portions **18** may be formed to intermediate portions of the respective joining surfaces **17***a*, **17***b*, **17***c*, **17***f*, **17***g*, it will be desired to form them at portions apart by a predetermined distance from the rolling direction changing passage **9** or the oil groove **15** for preventing the fused resin material from entering into the rolling direction changing passage **9** or the oil groove **15**.

In the described embodiment of the present invention, the direction changing passage inner periphery guide portion **9***a* of the end surface forming portion **11** integrally formed with the end surface of the movable block body **6** through the insertion molding process is accurately formed to the predetermined position of the movable block body **6** with the predetermined shape. In the formation mold, the movable block body **6** is positioned by a support portion contacting the loaded ball rolling grooves **8**, **8**, **8**, **8**, and the direction changing passage inner periphery guide portions **9***a*, **9***a*, **9***a*, **9***a* are accurately positioned with reference to the loaded ball rolling grooves **8**, **8**, **8**, **8**, and after the positioning, the molding process is carried out.

In the described embodiment, the peripheral portions of the direction changing passage inner periphery guide portion **9***a* and the direction changing passage outer periphery guide portion **9***b* of the end plate **12** and the movable block body **6** are fused and welded. Accordingly, even if the end plate is deformed as shown in FIGS. **2**F to **2**I in an exaggerative manner, the direction changing passage outer periphery guide portion **9***b* is fixed with the corrected deformation along the direction changing passage inner periphery guide portion **9***a* of the end surface forming portion **11** of the movable block body **6** molded with high performance, thereby forming the the passage constituting the rolling direction changing passage **9** with high accuracy. That is, in the rolling direction changing passage **9**, the respective balls **3** are changed in their rolling directions with pushing force being applied to each other and the balls **3** collide repeatedly with the inner peripheral surface of the direction changing passage **9**. In order to prevent the balls **3** from irregularly circulating due to the collision, it is necessary to form uniform play passage. According to the present invention, this can be achieved.

Furthermore, according to the embodiment of the present invention, the direction changing passage outer periphery guide portion **9***b* of the end plate **12** can be exactly positioned with respect to the movable block body **6** along the direction changing passage inner periphery guide portion **9***a* of the end surface forming portion **11** of the movable block body **6**. Accordingly, there can be accurately achieved the positional alignment of both the end portions of the direction changing passage outer periphery guide portion **9***b* with the loaded ball rolling groove **5** on the guide rail side and with the end portion of the rolling ball return passage **7**.

Further, in the direction changing passage **9**, although noise will be likely generated due to the mutual collision of the rolling balls **3**, such noise can be substantially eliminated by forming the direction. changing passage through the welding process.

Furthermore, in the present embodiment, the apparatus is formed with the return hole constituting member **13** as the axial forming portion and the ball retainer portion **14**, and accordingly, the end surface forming portion **11** of the movable block body **6** can be further firmly fixed to the end surface of the movable block body **6** due to the axial contraction of these portions **13** and **14**, so that the positional accuracy of the direction changing passage inner periphery guide portion **9***a* at the welding time of the end plate **12**.

The most high positional accuracy is required for both the end portions of the direction changing passage inner periphery guide portion **9***a* which are to be connected to the non-loaded ball returning hole **7** and the ball retainer portion **14**. The position of the direction changing passage inner periphery guide portion **9***a* can be accurately determined by providing the return hole constituting member **13** as the axial forming portion and the ball retainer portion **14** through which the axial contraction force is applied to both the end portions of the direction changing passage inner periphery guide portion **9***a*. Accordingly, both the end portions of the direction changing passage outer periphery guide portion **9***b* of the end plate **12** which is welded along such direction changing passage inner periphery guide portion **9***b* can be also accurately positioned.

The welded portion **19** is formed continuously along the entire length portions between the joining surfaces **16***a* to **16***g* and **17***a* to **17***g* at the peripheral portions of the direction changing passage inner periphery guide portion **9***a*, the direction changing passage outer periphery guide portion **9***b* and the oil groove **15**. Accordingly, the direction changing passage outer periphery guide portion **9***b* on the end plate side can be more precisely positioned with respect to the direction changing passage inner periphery guide portion **9***a*, so that the rolling direction changing passage **9** can be further accurately manufactured.

Furthermore, the portions between the joining surfaces **16***a* to **16***g* and **17***a* to **17***g* at the peripheral portions of the direction changing passage inner periphery guide portion **9***a*, the direction changing passage outer periphery guide portion **9***b* and the oil groove **15** can be substantially completely sealed, so that the leakage of the oil to be supplied to the rolling direction changing passage **9** can be completely prevented and the noise suppressing function can also be enhanced.

Particularly, since the joining surfaces **16***a*, **16***b*, **16***c*, **16***f*, **16***g* and **17***a*, **17***b*, **17***c*, **17***f*, **17***g* are formed respectively to the first and second recessed portions **121**, **122** of the end plate **12** and the first and second protruded portions **111**, **112** which are to be faucet fitted to those recessed portions, the direction changing passage outer periphery guide portion **9***b* of the end plate **12** can be further accurately positioned with respect to the movable block body **6**.

Still furthermore, the fused resin (welding portion) is filled up in the gaps **19** between the fitted surface portions of the first and second protruded portions **111**, **112** and the first and second recessed portions **121**, **122** as well as the portions of the joining surfaces mentioned above, thereby further increasing the fixing strength. The filling and welding of the fused resin in the gaps **19** between the first and second protruded portions **111**, **112** and the first and second recessed portions **121**, **122** can further contribute the maintenance of the accurate performance.

The welding process of the rolling motion guide apparatus of the structure mentioned above will be performed in the following manner.

At the first step, the end plates **12** are mounted to both the ends of the movable block body **6** in a manner that the first and second protruded portions **111**, **112** of the end surface forming portions **11** of the movable block body **6** are faucet fitting to the first and second recessed portions **121**, **122** of the end plates **12**, respectively.

In the next step, the movable block body **6** is supported by an ultrasonic plastic welder, not shown, while the back surface, to which the welding width portion **18** of the end plate **12** is formed, is uniformly pressed by a honing head, not shown, so that corner portions of the first and second protruded portions of the end surface forming portion **11** of the movable block body **6** abut against the welding width portion **18**. Under the state, ultrasonic vibration is applied to thereby fuse and weld the welding width portions by friction force caused between the joining surfaces of the welding width portions **18** and the corner portions of the first and second protruded portions **111**, **112**.

At the initial stage of the welding, the most front end portion of the corner portion of the welding width portion **18** is first fused and, in an intermediate stage thereof, fused resin flows into the gap between the fitting portions of the first and second protruded portions **111**, **112** and the first and second recessed portions **121**, **122** and the joining surfaces **16***a* to **16***g* and **17***a* to **17***g* therebetween. In the final stage, the fusing at the welding width portion **18** has been completed by the pressing of the welder, and the joining surfaces **16***a* to **16***g* and **17***a* to **17**g of the first and second protruded portions **111, 112** and the first and second recessed portions **121, 122** are contacted respectively and subjected to the pressing vibration. Thereafter, the fused resin is solidified, thus completing the welding process.

FIG. **3** represents a second embodiment of a linear motion guide apparatus as a rolling motion guide apparatus of the present invention.

Referring to FIG. **3**, reference numeral **21** denotes an entire structure of a linear motion guide apparatus **21** which is essentially composed of a guide rail **22** as a guide shaft and a movable block **24** as a movable member which is mounted to the guide rail **22** through a number of balls **23** as rolling members.

The guide (track) rail **22** of this embodiment is composed of a long member having a rectangular cross section, and the movable block **24** is guided at the lateral, left and right, side of the guide rail **2**, through two ball rows, one row at each lateral side, **23**A, **23**A. The left and right side surfaces of the guide rail **22** are formed with two loaded ball rolling grooves **25, 25** as loaded rolling member rolling passage corresponding in position to the two ball rows **23**A, **23**A, respectively, along the entire longitudinal length of the guide rail **22**.

The movable block **24** is composed of a movable block body **26** as the main body of the movable member and rolling direction changing passage constituting members **30** disposed to both end sides of the movable block body **26**. The movable block body **26** is a block member having a]-shaped section and is provided with a horizontal portion **261** opposing to the upper surface of the guide rail **22** and a pair of support leg (skirt) portions **262, 262** corresponding in positions, i.e. opposing, to the left and right side surfaces of the guide rail **22**. Furthermore, loaded ball rolling grooves **28, 28**, as loaded rolling member rolling passages, are formed respectively to the inner side surfaces of the paired left and right support leg portions **262, 262** of the movable block body **26**, the loaded ball rolling grooves **28, 28** corresponding in position to the loaded ball rolling grooves **25, 25**, respectively, formed to the left and right side surfaces of the guide rail **22**. Furthermore, the support leg portions **262, 262** are also formed with ball returning passages **27, 27** as the rolling member returning passages for returning the balls from one end of each loaded ball rolling groove **8** to another end thereof. Each of the respective balls **23** of the ball row **23**A has a diameter larger than a diameter of the loaded ball rolling groove **25** to thereby apply a preload to the balls **23**.

The rolling direction changing passage constituting member **30** is composed of an end surface forming portion **31** made of resin and an end plate **32** also made of resin. The end surface forming portion **31** is formed with a direction changing passage inner periphery guide portion **29***a*, **29***a* integrally formed with the movable block body **26** through an insertion molding process in which the movable block body **26** is inserted into a formation mold to carry out the molding. The end plate **32** is formed with a direction changing passage outer periphery guide portion **29***b*, **29***b* independently formed from the end surface forming portion **31**. Peripheral portions of the direction changing passage inner periphery guide portion **29***a* of the movable block body **26** and the direction changing passage outer periphery guide portion **29***b* of the end plate **32** are welded to thereby constitute a rolling direction changing passage **29** having a curved U-shape.

The movable block body **26** is formed integrally with an axial forming portion, which is composed of a return hole constituting member **33** forming a non-loaded ball return hole **27** and connected to the end surface forming portions **31** at both the ends of the movable block body **26**.

To the peripheral portions of the direction changing passage guide portion **29***a* of the end surface forming portion **31** of the movable block body **26** and the direction changing passage outer periphery guide portion **29***b* of the end plate **32**, there are formed a recessed portion **36** and a protruded portion **37** which is faucet fitted to the recessed portion **36**.

In the structure of the second embodiment, a projection **38** is formed to the joining surface at the peripheral portion of the direction changing passage **29** of the end surface forming portion **31** of the movable block body **26**, and the end plate **32** is formed at its joining surface with a hole **39** through which the projection **38** is inserted. The front end portion **40** of the projection **38** extending over the hole **38** is fused to thereby form an engaging portion **41** which is engageable with the peripheral edge portion of the hole **39**.

According to such structure, the joining surfaces of the end surface forming portion **31** of the movable member **26** and the end plate **32** are not directly welded and the fitted portions of the projection **38** and the hole **39** are welded. Accordingly, although the continuous welding is not carried out, the end plate **32** is firmly fixed at the peripheral portion of the direction changing passage inner periphery guide portion **29***a*, so that the direction changing passage outer periphery guide portion **29***b* can be precisely fixed with respect to the direction changing passage inner periphery guide portion **29***a*.

The welding process in this second embodiment will be performed in the following manner.

First, the front end portion **41** of the projection **38** of the movable block body **26** is pressed and crushed by a jig, not shown, under the application of the ultrasonic vibration to form the engaging portion **41** having a bevel shape having a diameter larger than that of the hole **39**.

In the initial stage of the welding, the projection **38** is fused first at its front end portion, and in the intermediate stage, a shank portion **38***a* of the projection **38** inserted into the hole **39** is swelled by the compressing force, whereby a gap between the shank portion **38***a* and the inner peripheral surface of the hole **39** vanishes.

In the final stage of the welding, the engaging portion **41** of the front end portion of the projection **38** is pressed by a plastic welder, not shown, to thereby provide a semi-circular shape such as head portion of a rivet, and the end plate **32** is fixed to the movable block body **26** upon the completion of the pressing and vibrating processes.

Through the processes mentioned above, the positional performance between the direction changing passage inner periphery guide portion **29***a* and outer periphery guide portion **29***b* can be ensured, the balls **23** are fitted into the direction changing passage **29** while maintaining a suitable gap therebetween, and hence, the balls **23** can be smoothly circulated.

Furthermore, the positional precision of the direction changing passage inner periphery guide portion **29***a* formed to the end surface of the movable block body **26** can be ensured by forming the movable block body **26** through the insertion molding process. That is, since the direction changing passage inner periphery guide portion **29***a* of the movable block body **26** having high rigidity and the peripheral portion thereof are further tightly fixed through the axial contraction of the non-loaded rolling member return hole **27**, the precision of the direction changing passage inner periphery guide portion **29***a* of the movable block body **26** can be ensured.

According to the present embodiment, since the positioning projection **38** is fused and then fixed at the peripheral portion of the direction changing passage **29**, the direction changing passage outer periphery guide portion **29***a* of the end plate **23** can be also fixed in accordance with the direction changing passage inner periphery guide portion **29***b* of the movable block body **26** formed precisely, and accordingly, the rolling direction changing passage **29** can be formed with high precision and performance.

It is further to be noted that the present invention is not limited to the embodiments described above and many other changes or modifications may be made without departing from the scope of the appended claims. For example, in the embodiments mentioned above, either one of the end plate and the end surface forming portion may be formed of a thermoplastic resin. Although it is described above that the plastic welding (fusing) process is performed by using ultrasonic welding method, the present invention is not limited thereto and a heat welding process may be applicable, and a laser welding process or other welding processes may be also applicable.

What is claimed is:

1. A rolling motion guide apparatus comprising:

a guide shaft formed with a loaded rolling member rolling passage; and

a movable member disposed to be movable with respect to the guide shaft through a number of rolling members, said movable member being composed of a movable member main body provided with a loaded rolling member rolling passage corresponding in position to the loaded rolling member rolling passage formed to the guide shaft and a rolling member returning passage for returning the rolling members from one end of the loaded rolling member rolling passage of the movable member main body to another end thereof and a pair of rolling direction changing passage structures respectively constituting a rolling member direction changing passage for guiding the rolling member scooped from the loaded rolling member rolling passage of the movable member main body to the rolling member returning passage,

wherein said each rolling direction changing passage structure is composed of an end surface forming portion which is formed with a rolling direction changing passage inner periphery guide portion integrally formed with the movable member main body and an end plate which is formed with a rolling direction changing passage outer periphery guide portion separately formed from the end surface forming portion, and

wherein the rolling direction changing passage outer periphery guide portion of the end plate and a rolling direction changing passage inner periphery guide portion thereof have peripheral portions respectively which are joined and welded.

2. A rolling motion guide apparatus according to claim **1**, the peripheral portions respectively is provided with the joining surfaces as a welding portion.

3. A rolling motion guide apparatus according to claim **1**, wherein the end surface forming portion of the movable member main body is formed of a resin material through an insertion molding process.

4. A rolling motion guide apparatus according to claim **1**, wherein said guide shaft is a guide rail and said movable member is composed of a central horizontal portion and side portions extending downward in a mounted state from both end portions of the horizontal portion, said guide rail being disposed between the side portions of the movable member.

5. A rolling motion guide apparatus according to claim **1**, wherein the movable member main body is provided with axial forming portions which are integrally formed with the end surface forming portions formed at both ends of the movable member main body.

6. A rolling motion guide apparatus according to claim **5**, wherein each of said axial forming portion is provided with at least either one of a return hole constituting member forming a non-loaded rolling member returning hole and a rolling member retainer member for preventing the rolling member from falling down at a time when the guide shaft is withdrawn from the movable member.

7. A rolling motion guide apparatus according to claim **1**, wherein the rolling direction changing passage outer periphery guide portion and the rolling direction changing passage inner periphery guide portion of the rolling direction changing passage structure have peripheral portions respectively which are joined so as to provide joining surfaces, and a welding portion is continuously formed between the joining surfaces.

8. A rolling motion guide apparatus according to claim **1**, wherein a lubricant groove is formed between joining surfaces of the end surface forming portion and the end plate to communicate with the rolling direction changing passage structure and the welding portion is formed continuously so as to surround the rolling direction changing passage structure and the lubricant groove.

9. A rolling motion guide apparatus according to claim **1**, wherein a recessed portion and a protruded portion which is faucet fitted to the recessed portion are formed to peripheral portions of the rolling direction changing passage inner periphery guide portion of the end surface forming portion of the movable member main body and the rolling direction changing passage outer periphery guide portion of the end plate, said protruded and recessed portions having flat portions as joining surfaces to be joined together and a welding width portion, which is fused at a welding time, is formed between the joining surfaces.

10. A rolling motion guide apparatus according to claim **1**, wherein a projection is formed to the joining surface of the end surface forming portion of the movable member main body and the end plate is formed with a hole at the joining surface thereof through which the projection is inserted and a front end portion of the projection penetrating over the hole is fused and welded to a peripheral edge portion of the hole.

* * * * *

US005755516A

United States Patent [19]

Teramachi et al.

[11] **Patent Number: 5,755,516**

[45] **Date of Patent: May 26, 1998**

[54] **ROLLING GUIDE APPARATUS AND METHOD OF MANUFACTURING MOVABLE BLOCK OF ROLLING GUIDE APPARATUS**

[75] Inventors: **Hiroshi Teramachi**, Tokyo; **Takeki Shirai**, Chiba, both of Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **788,352**

[22] Filed: **Jan. 27, 1997**

Related U.S. Application Data

[63] Continuation of Ser. No. 569,125, filed as PCT/JP95/00974 May 22, 1995, abandoned.

[30] **Foreign Application Priority Data**

May 20, 1994 [JP] Japan 6-131266

[51] **Int. Cl.**^{6} **F16C 29/06**; F16C 43/04

[52] **U.S. Cl.** **384/45**; 29/898.03

[58] **Field of Search** 384/45, 43, 49; 29/898.03

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,932,067	6/1990	Pester et al.	384/45
4,932,279	6/1990	Kasuga	384/45 X
4,934,834	6/1990	Morita	384/45
5,082,374	1/1992	Narumiya	384/45

FOREIGN PATENT DOCUMENTS

63-225719	9/1988	Japan .
64-25526	2/1989	Japan .
4-132219	12/1992	Japan .

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

At least a ball escape hole (**10**) of a ball circulation passage (**7**) is formed of a molded body (**12**) and the molded body (**12**) is formed integrally with a block body (**13**) having high rigidity through an insert molding process, thereby eliminating a drilling working, possibly reducing assembling processes and reducing generation of noise.

It is preferred that the molded body (**12**) is provided with an inner peripheral portion of a direction changing passage (**11**) integrally connected with the ball escape hole (**10**) and joined with both end surfaces of the block body (**13**).

Furthermore, it is preferred that the molded body (**12**) is provided with a retainer (**17**) extending along a loaded ball passage (**8**) and integrally connected, at its both ends, with the inner peripheral portion of the direction changing passage (**11**), thereby providing a closed sectional shape surrounded by the ball escape hole portion (**10**), the direction changing portion (**11**) and the retainer portion (**17**).

17 Claims, 9 Drawing Sheets

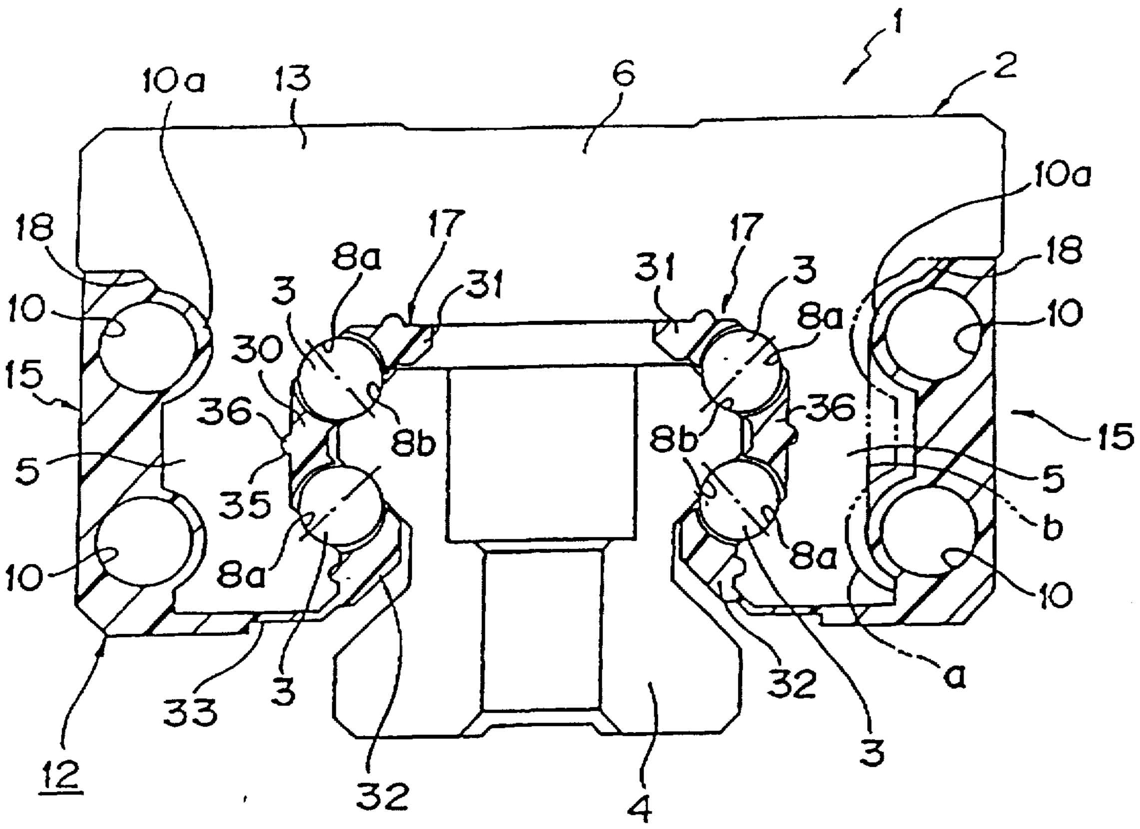


FIG. 1(a)

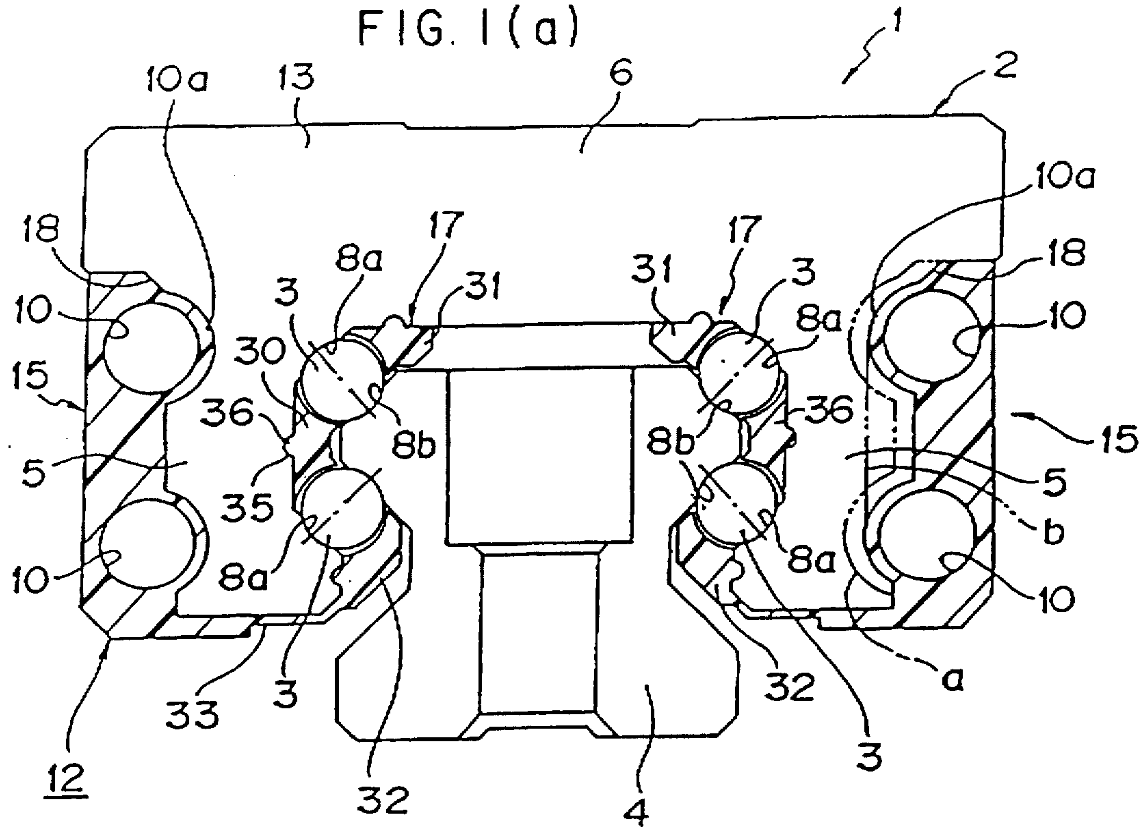


FIG. 1(b)

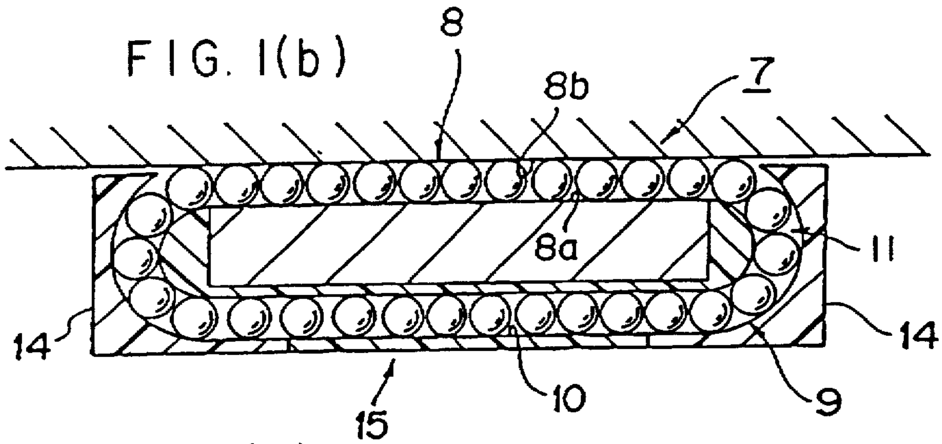


FIG. 1(c)

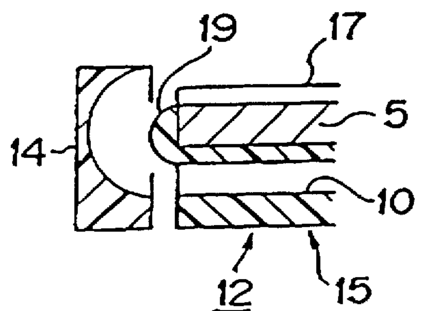


FIG. 1(d)

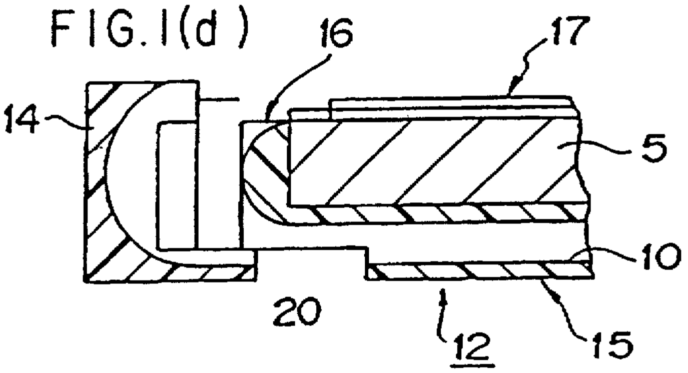


FIG. 2(a)

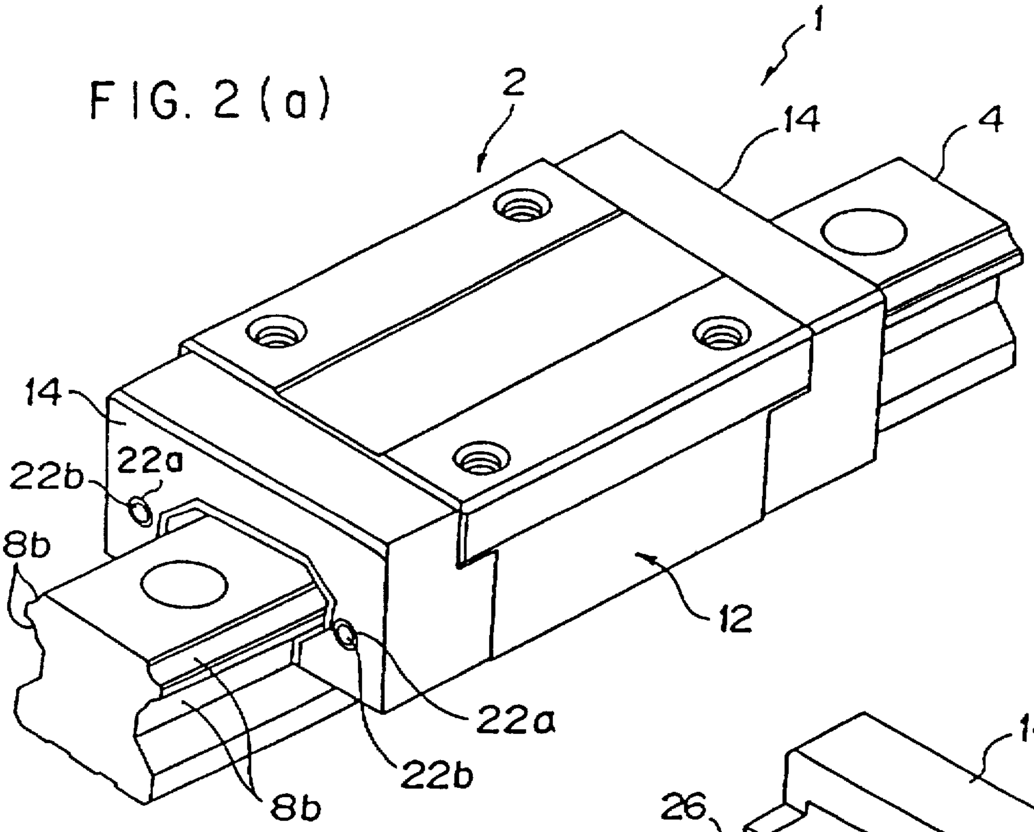

1
2
14
4
14
22b
22a
8b
12
22a
22b
8b

FIG. 2(b)

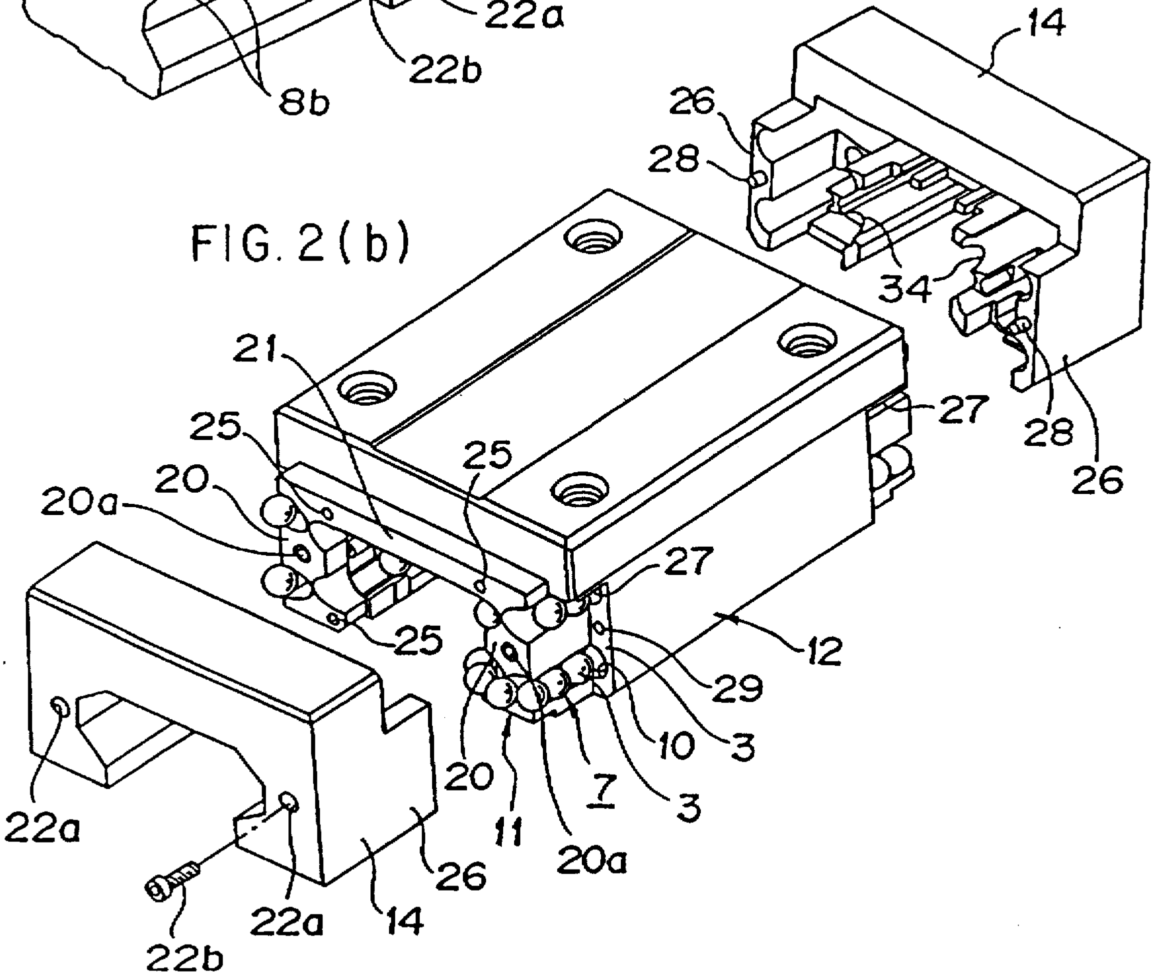

14
26
28
34
28
26
21
25
20
20a
25
27
27
25
12
29
20a
3
10
3
20
7
11
20a
22a
22a
22b
14
26

FIG. 3(a)

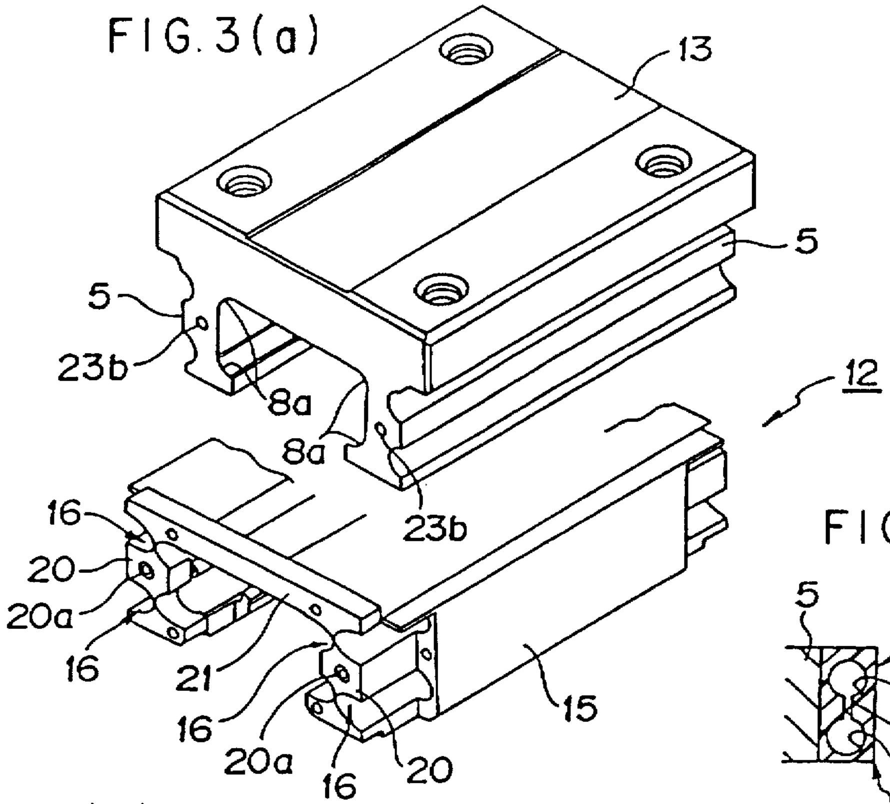


FIG. 3(d)

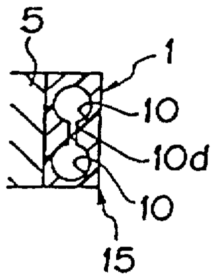


FIG. 3(k)

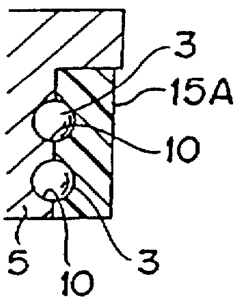


FIG. 3(b)

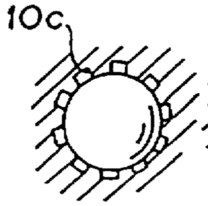


FIG. 3(c)

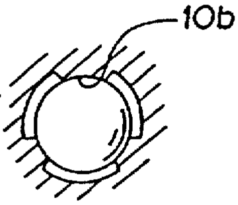


FIG. 3(e)

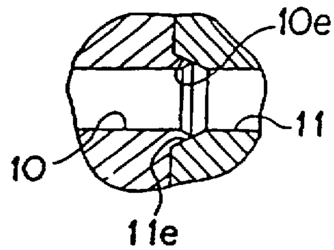
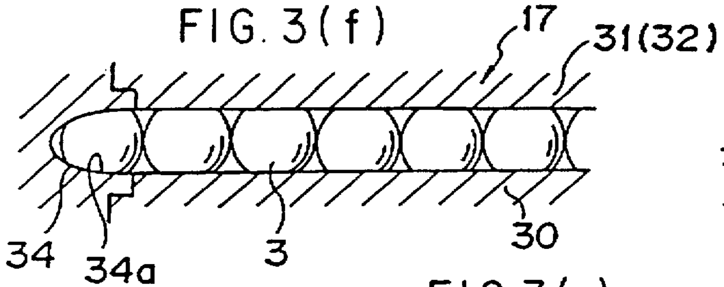


FIG. 3(f)



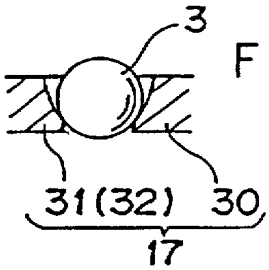
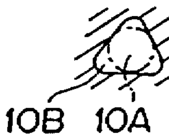
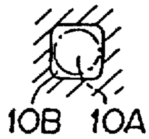


FIG. 3(g)

FIG. 3(i)





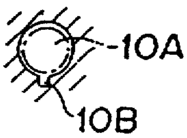


FIG. 3 (h)

FIG. 3(j)

FIG.4(a)

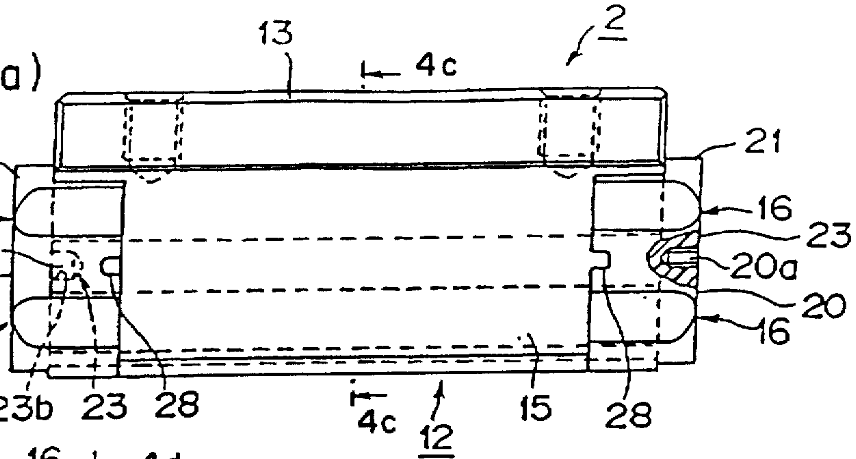


FIG. 4(b)

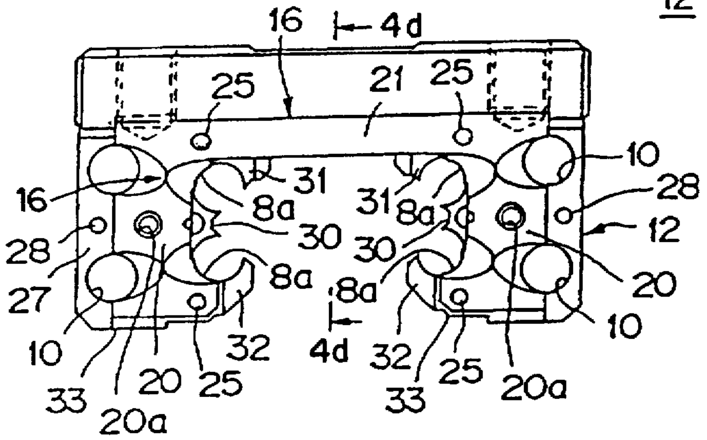


FIG.4(c)

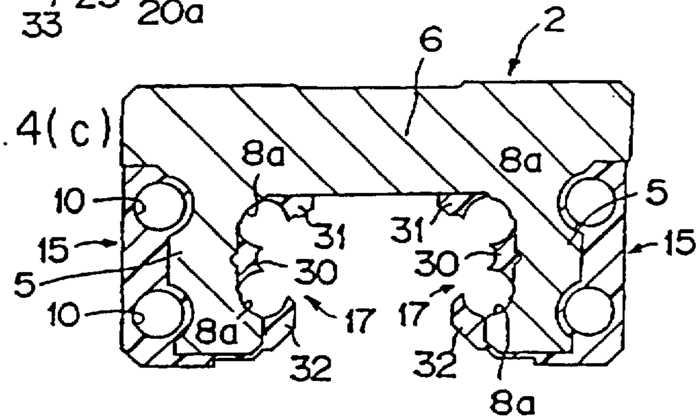


FIG. 4(d)

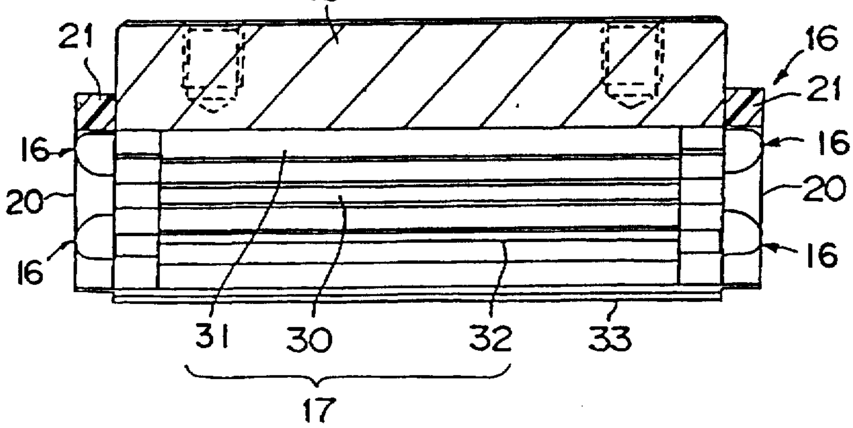


FIG. 5(a)

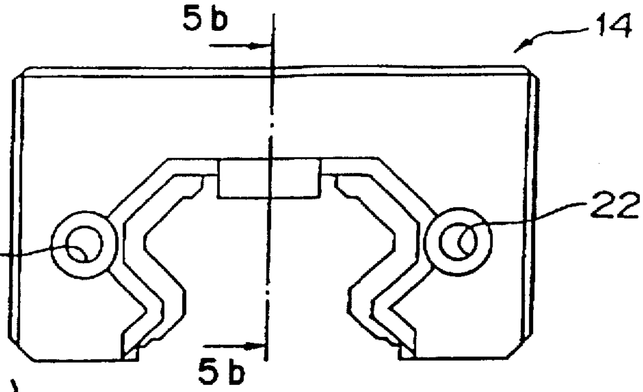


FIG. 5(b)

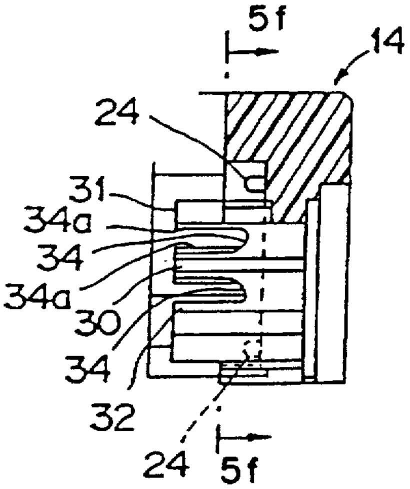


FIG. 5(c)

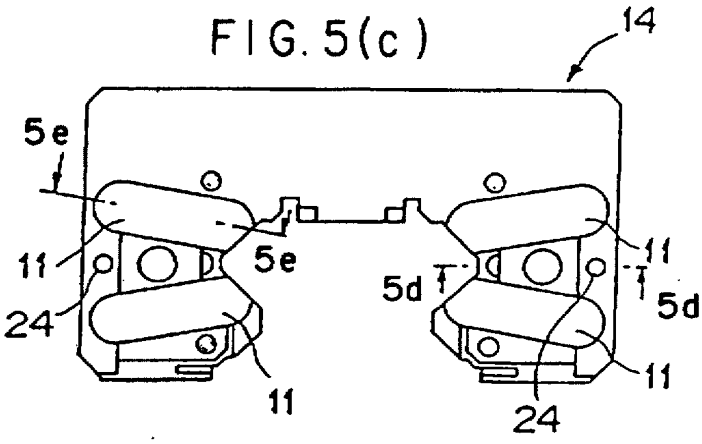


FIG. 5(d)

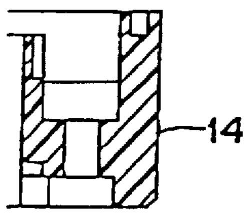
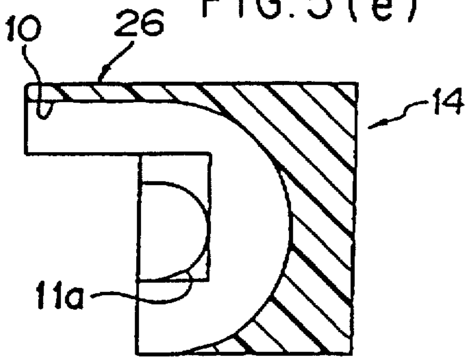


FIG. 5(e)



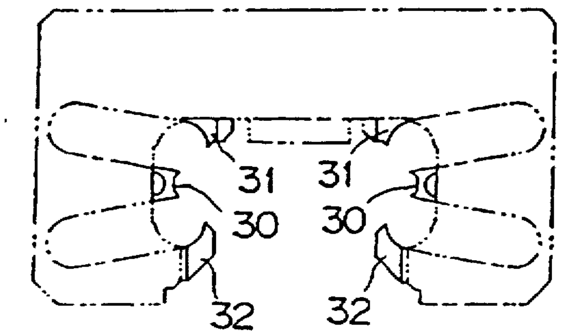


FIG. 5(f)

FIG. 6(a)

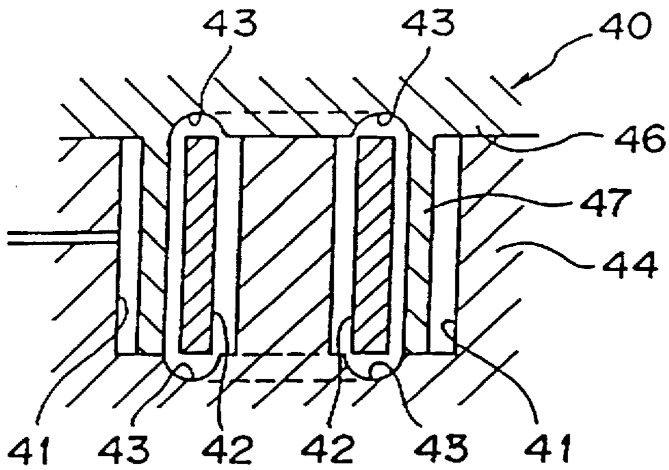


FIG. 6(b)

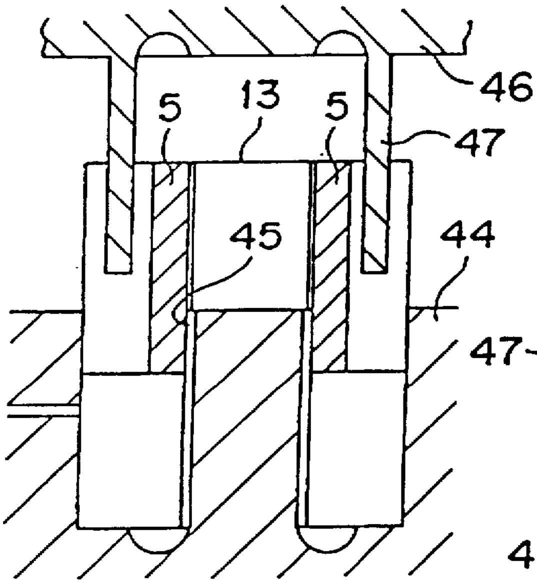


FIG. 6(c)

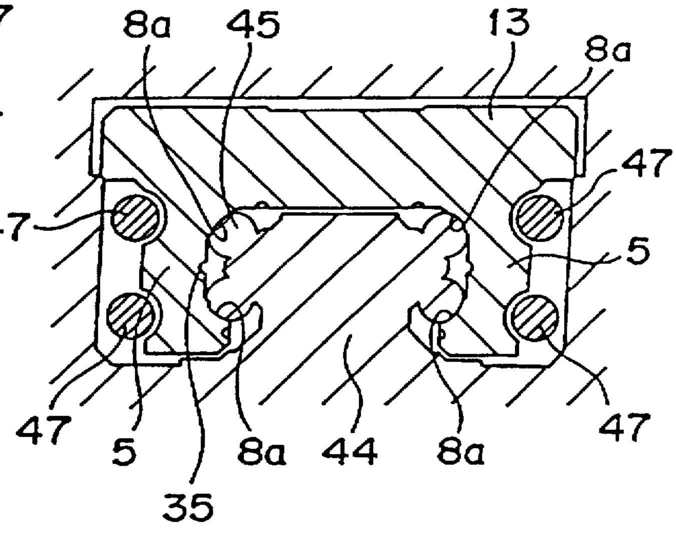


FIG. 7(a)

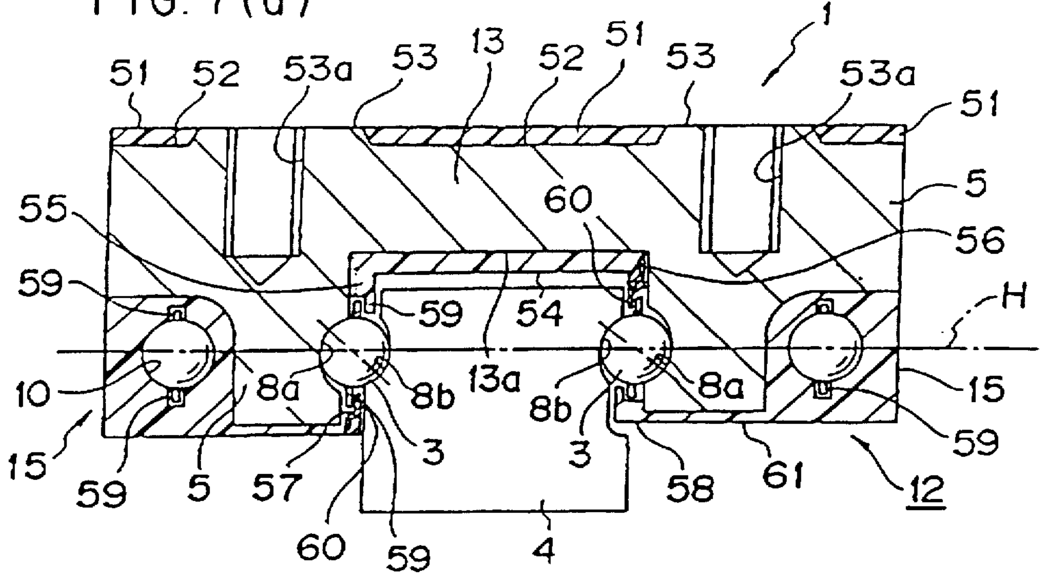


FIG. 7(b)

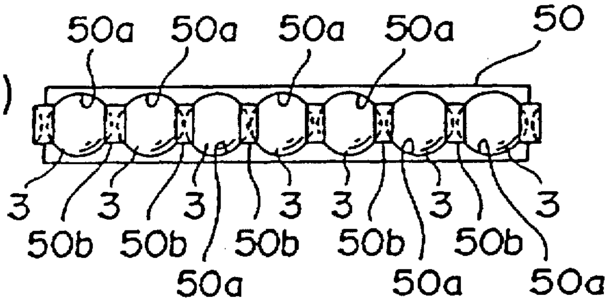


FIG. 7(c)

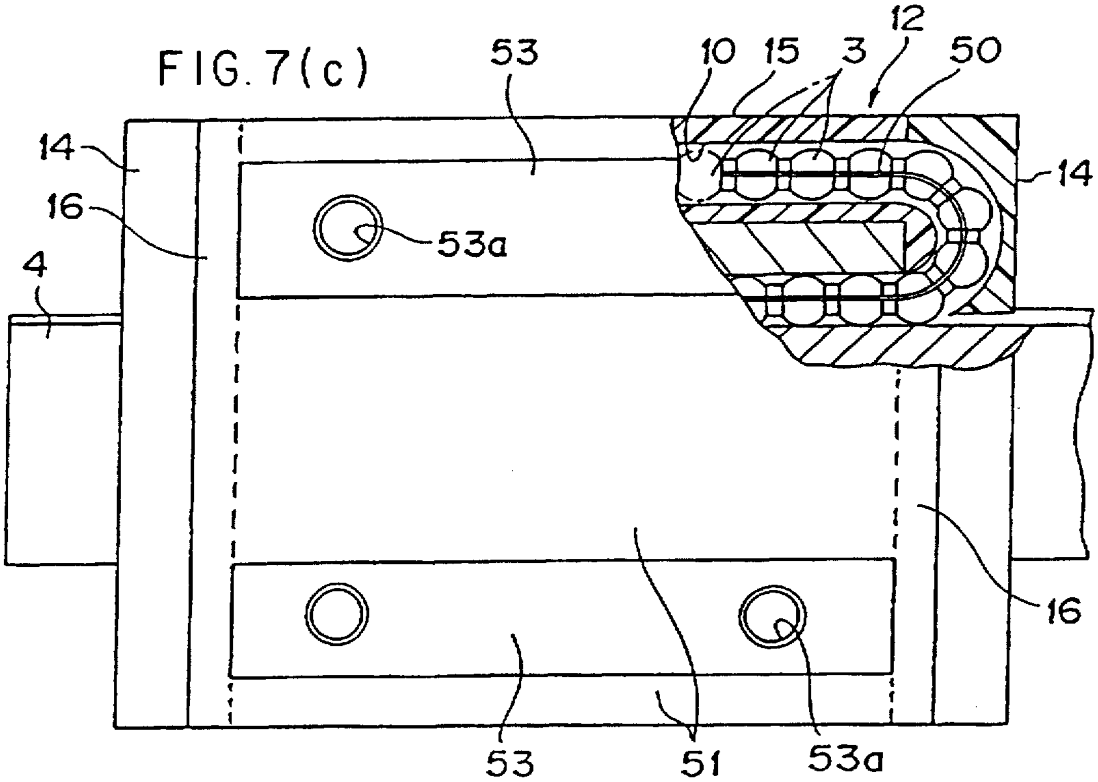


FIG. 8(a)

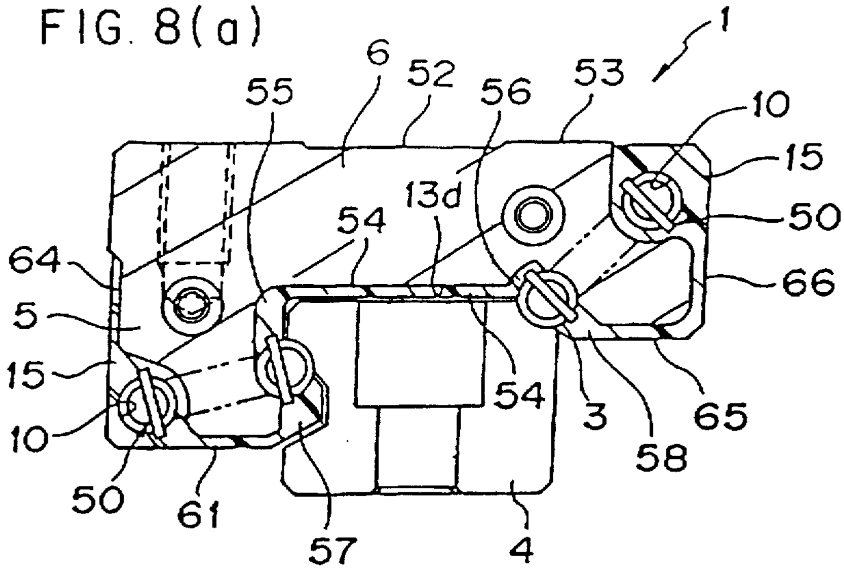
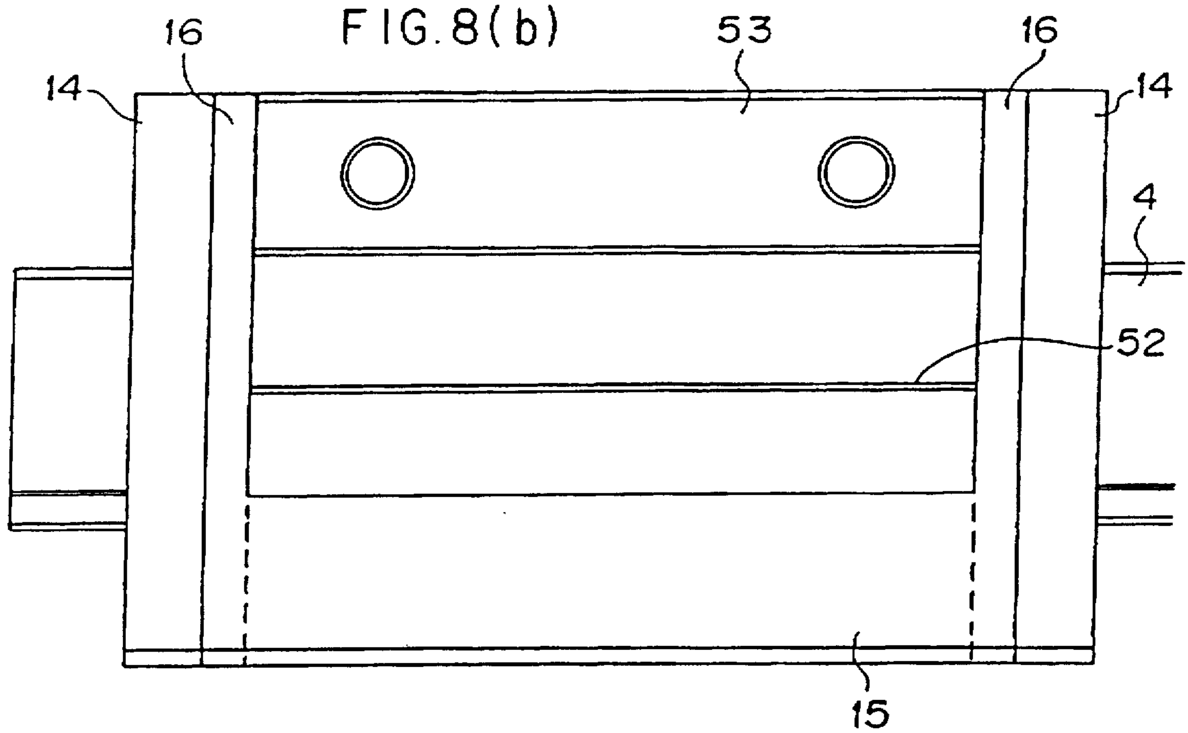


FIG. 8(b)



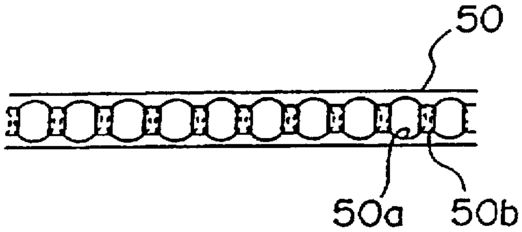
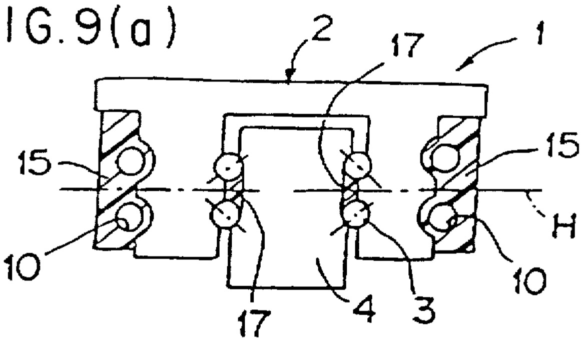


FIG. 8(c)

FIG.9(a)



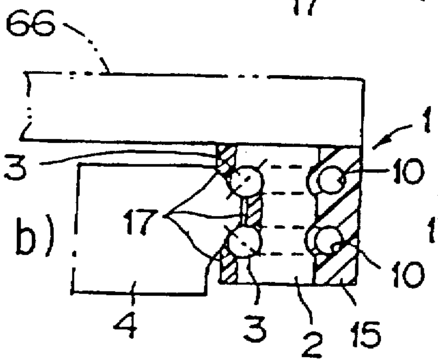


FIG.9(b)

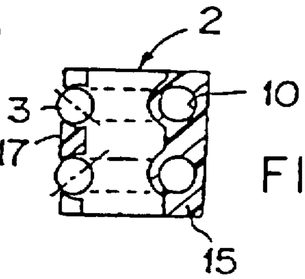


FIG.9(c)

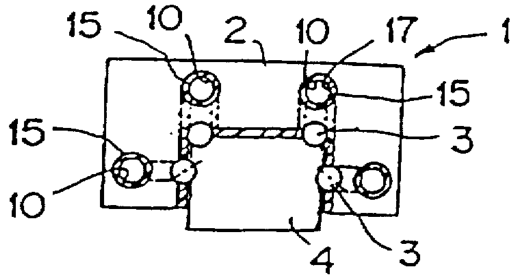


FIG.9(d)

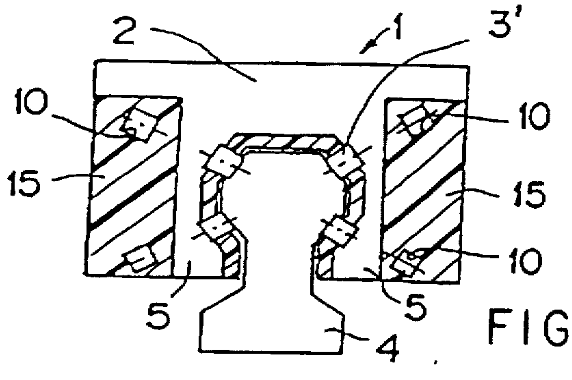


FIG.9(e)

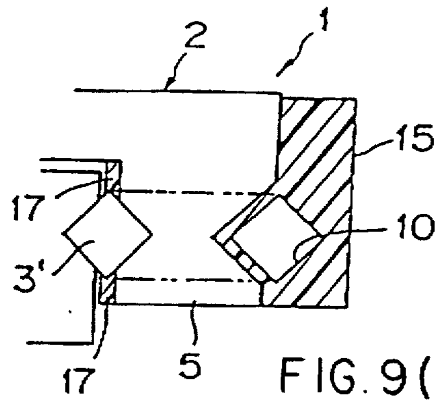


FIG.9(f)

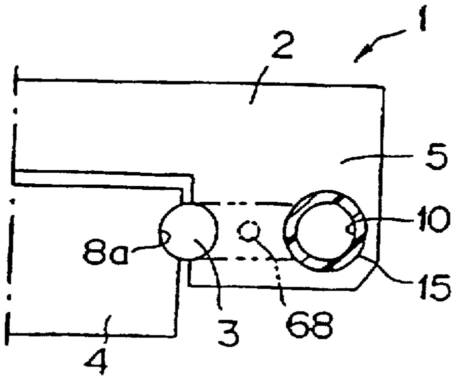


FIG.9(g)

ROLLING GUIDE APPARATUS AND METHOD OF MANUFACTURING MOVABLE BLOCK OF ROLLING GUIDE APPARATUS

This application is a continuation of application Ser. No. 08/569,125 filed Apr. 3, 1996, now abandoned; which is a 371 of PCT/JP95/00974 filed May 22, 1995.

TECHNICAL FIELD

The present invention relates to a rolling guide apparatus of contact-type for guiding a rolling member along a linear passage or the like, more particularly, to a structure of a rolling member circulation passage and also relates to a method of manufacturing a movable block of the rolling guide apparatus.

BACKGROUND ART

A conventional rolling guide apparatus of this type generally has a structure in which a movable block is supported to be movable along a guide rail through a number of rolling members, the movable block is provided with a circulation passage through which the rolling members are guided and circulated. The rolling member circulation passage is formed with a loaded rolling member rolling passage composed of loaded rolling member rolling grooves formed to opposing surfaces of the movable block and the guide rail, respectively, and is formed with a return passage formed to a non-loaded area and connected at their both end portions with the loaded rolling member rolling passage so that the rolling member circulates the loaded rolling member rolling passage and the return passage. The return passage is composed of a rolling member escape hole extending in parallel to the loaded rolling member rolling passage and a direction changing passage connecting both end portions of the rolling member escape hole to both ends of the loaded rolling member rolling passage to change the rolling direction of the rolling member.

In the conventional structure, however, the rolling member escape hole is formed through a drilling working to a block body so as to penetrate it vertically, which requires a troublesome working and involves a factor of cost increasing.

In order to obviate this defect, a conventional technology has provided a structure in which a rolling member escape hole in a non-loaded area is formed by cutting away a side surface of the block body and the cut-out portion is covered by a cover member formed of a resin material, for example. However, according to this conventional structure, it is difficult to assemble the rolling member circulation passage, and noise is generated due to an assembling error, thus providing a problem.

Furthermore, in the conventional rolling guide apparatus, it is attempted to construct the block body to have a sufficient rigidity so as not to be deformed even if a heavy load is applied to the guide apparatus. On the contrary, in a case where there causes a large misalignment between the guide rail and the movable block (for example, an error in degree of parallelism between a fixing surface of the guide rail and a fixing surface of a conveyer table fixed to the movable block), an unnatural force is applied to a contact surface between the rolling member and the rolling member rolling groove. This unnatural force obstructs smooth rolling of the rolling member and, hence, the rolling member and the rolling member rolling groove are easily worn, providing a problem.

In view of this point, in the case of the structure in which the rolling member escape hole is formed by cutting away the outside surface of the block body, the block body has a reduced thickness portion corresponding to the cut-away portion and hence the rigidity thereof is lowered correspondingly. However, in the type of this structure, the rolling member contacts the cutout portion of the block body and then is covered by the cover member. Therefore, the thickness of the block body is not reduced to a thickness more than that corresponding to a gap between the rolling member escape hole and the loaded rolling member rolling groove and the rigidity is also not reduced correspondingly. However, the gap between the rolling member escape hole and the rolling member rolling groove is not so much reduced because of the smooth rolling direction changing of the rolling member. Thus, there is a limit to reduce the thickness of the block body.

The rolling member circulates the circulation passage formed in the loaded and non-loaded areas, and as far as the positional relationship of the rolling member escape hole with respect to the loaded rolling member rolling groove is not accurately decided, the direction changing passage between the loaded rolling member passage and the rolling member escape hole is not also accurately positioned. Further, in a case where the loaded rolling member rolling passage is not smoothly and continuously connected with the direction changing passage, the rolling member is not smoothly rolled and circulated therein.

Furthermore, a retainer is also disposed to both sides of the loaded rolling member rolling passage for preventing the rolling member from falling off at a time when the movable block is disassembled from the guide rail. It is necessary to form a gap between the retainer and the rolling member rolling passage so that the rolling member does not interfere with the retainer at a time when the rolling member rolls in and along the rolling member rolling passage, and because of this reason, it is necessary to accurately position the retainer with respect to the loaded rolling member rolling passage and it is also required for the passage to have an accurate linearity.

Still furthermore, in the conventional structure, respective members or elements assembled with the movable block body made of steel are often fastened by insufficient fastening force, and because of this reason, these members or elements resonate and generate noises, thus also providing a problem at a time of the rolling circulation of the rolling member particularly in the non-loaded area at which the rolling member is rolled with no load.

The present invention was conceived to solve the above problems and aims to provide a rolling guide apparatus which does not require a drilling working for a rolling member escape hole by integrally molding a block body and at least the rolling member escape hole through a molding process, assembling process can be possibly reduced and generation of noise during the rolling of the rolling member is effectively reduced, and also provide a method of manufacturing the movable block.

In addition to the above object, it is aimed to change the rigidity of the block body without changing a gap between the rolling member escape hole and the loaded rolling member rolling groove.

Furthermore, in addition to the above objects, it is aimed to ensure smooth circulation of the rolling member by accurately positioning the rolling member circulation passage with respect to the rolling member rolling groove.

DISCLOSURE OF INVENTION

The present invention relates to a rolling guide apparatus in which a movable block is supported to be movable along a guide rail through a number of rolling members, a circulation passage for guiding circulation of the rolling members is formed to the movable block, the rolling member circulation passage being composed of a loaded rolling member rolling passage in a loaded area between loaded rolling member rolling grooves formed to opposing surfaces of the movable block and the guide rail and a non-loaded return passage for returning the rolling members in the loaded area from one end of the loaded rolling member rolling passage to another one end thereof, the return passage being composed of a rolling member escape hole extending in parallel to the loaded rolling member rolling passage and a direction changing passage having inner and outer peripheral portions connecting both ends of the rolling member escape hole to both ends of the loaded rolling member rolling passage, and the rolling guide apparatus being characterized in that at least one of the rolling member escape hole, the inner peripheral portion of the direction changing passage and a retainer extending along the loaded rolling member rolling passage is formed of a molded body and the molded body is integrally formed with a block body having high rigidity.

The molded body may be composed of only the rolling member escape hole, only the inner peripheral portion of the direction changing passage or only the retainer, or composed of integral combination thereof.

That is, the molded body may be provided with the rolling member escape hole and the inner peripheral portion of the direction changing passage integrally connected to the rolling member escape hole and joined with both end surfaces of the block body.

The molded body may be provided with the rolling member escape hole and the retainer extending along the loaded rolling member rolling passage.

The molded body may be provided with the inner peripheral portion of the direction changing passage joined with both end surfaces of the block body and the retainer extending along the loaded rolling member rolling passage and integrally connected at its both ends with the inner peripheral portion of the direction changing passage.

The molded body may be provided with the rolling member escape hole, the inner peripheral portion of the direction changing passage integrally connected to the rolling member escape hole and joined with both end surfaces of the block body and the retainer extending along the loaded rolling member rolling passage and integrally connected at its both ends with the inner peripheral portion of the direction changing passage, the molded body having a closed sectional shape surrounded by the rolling member escape hole, the direction changing passage and the retainer.

Furthermore, a recess-protrusion engaging portion is formed to joining surfaces of the molded body and the block body.

The molded body is formed of a resin material, and a portion between the loaded rolling member rolling groove and the rolling member escape hole of the movable block is formed as one portion of the resin molded body so as to define a reduced thickness in the block body having high rigidity to provide an elastic property.

It is effective that the rolling members rolling in the loaded rolling member rolling passage are scooped by a guide, each in two point contact state, extending in the loaded area of the direction changing passage from the loaded rolling member rolling groove to the direction changing passage in a manner of being separated gradually from each other.

It is further characterized that the movable block is provided with a pair of leg portions between which the guide rail is interposed and a connection portion connecting the leg portions, and the rolling member circulation passages are formed to the leg portions.

It is characterized that a covering portion is provided for covering at least one of upper and lower surfaces of the connection portion of the movable block and the covering portion is integrally formed with the inner peripheral portion of the direction changing passage joined with both the end surfaces of the block body.

The rolling member escape hole has a sectional shape having a rolling member passing section through which the rolling member passes and a lubrication agent storing section capable of storing a lubrication agent bled outward from the rolling member passing section.

In another aspect, the present invention relates to a method of manufacturing a movable block, which is supported to be movable with respect to a guide rail through a number of rolling members, of a rolling guide apparatus provided with loaded rolling member rolling grooves formed to opposing surfaces of the movable block and the guide rail, a rolling member escape hole extending in parallel to the loaded rolling member rolling grooves, and a direction changing passage having inner and outer peripheral portions connecting both ends of the rolling member escape hole with both ends of the loaded rolling member rolling passage, the manufacturing method being characterized in that the block body is placed in a mold, and at least one of the rolling member escape hole, the inner peripheral portion of the direction changing passage and a retainer extending along the loaded rolling member rolling passage is formed integrally with the block body through an insertion molding process.

The rolling member escape hole and the inner peripheral portion of the direction changing passage may be integrally formed together through the insertion molding process.

The rolling member escape hole and the retainer extending along the loaded rolling member rolling passage may be integrally formed together through the insertion molding process.

The inner peripheral portion of the direction changing passage and the retainer extending along the loaded rolling member rolling passage may be integrally formed together through the insertion molding process.

The rolling member escape hole, the inner peripheral portion of the direction changing passage, and the retainer extending along the loaded rolling member rolling passage may be integrally formed together through the insertion molding process.

The block body is positioned in the mold with reference to the rolling member rolling groove formed to the movable block.

According to the present invention, since the rolling member escape hole is integrally formed with the block body through the molding process, the drilling working can be eliminated to thereby easily form the structure.

Particularly, since the rolling member escape hole forming portion is integrally formed in the non-loaded area with the molded body, noise which will be caused by an insufficient fastening force can be prevented from generating.

The degree of integral formation can be increased by integrally forming the inner peripheral portion of the direction changing passage with the rolling member escape hole, making easy the assembling process.

Furthermore, by integrally forming the rolling member escape hole, the inner peripheral portion of the direction changing passage and the retainer, the tensile stress is applied, by the shrinkage of the molded portions, to the rolling member escape hole, so that the fastening force can be increased by the remaining tensile stress, thus remarkably reducing the generation of the noise.

Particularly, with respect to the retainer, the degree of straightness can be made high by the function of the remaining tensile stress, so that the retainer is made parallel and straight with respect to the loaded rolling member rolling passage, and as a result, when the loaded rolling member is rolled and moved, the retainer does not contact and interfere with the rolling member and the rolling member is hence rolled smoothly and the movable block is also smoothly moved along the guide rail.

Furthermore, since the retainer is firmly secured to the block body through the tensile stress, no resonance is caused by the rolling vibration of the rolling member, thus remarkably reducing the noise.

Further, the thickness of the block constituting material such as metal constituting the block body at its portion between the loaded rolling member rolling groove to the rolling member escape hole which affects on rigidity thereof can be made thin so as to provide an elastic property without changing the dimension between the rolling member rolling groove and the rolling member escape hole, in other words, with the dimension suitable for the smooth direction changing operation being maintained, by forming the rolling member escape hole by the molded resin body.

Accordingly, if an assembling error between the guide rail and the movable block (for example, misalignment such as assembling error due to an error in parallelism between the fixing surface of the guide rail and the fixing surface of a conveyer table to be fixed to the movable block) be caused, such error can be absorbed through the flexibility of the thin portions of the block body and the contact portion between the rolling member and the rolling member rolling groove is prevented from being applied with an excessive force.

The rolling member escape hole is formed so as to provide a sectional shape having a rolling member passing section along which the rolling members roll and a lubrication agent storing section capable of storing lubrication agent bled outward from the rolling member passing section, and according to such structure of the rolling member escape hole, since the lubrication agent can be retained without obstructing the circulating motion of the rolling member, the smooth circulating motion thereof can be surely maintained for the long time operation with no substantial maintenance. Furthermore, the escape hole having such complicated sectional shape can be easily formed through the molding process.

The positioning of the block body inserted into the mold is performed with reference to the rolling member rolling groove through the insertion molding process, and accordingly, since the position of the rolling member escape hole and the position of the retainer can be determined with reference to the rolling member rolling groove, the relative positional relationship among the loaded rolling member rolling passage, the direction changing passage and the escape hole constituting the rolling member circulation passage can be exactly determined. Accordingly, no staged portion is formed to the connection portion between the loaded rolling member rolling passage, the inner peripheral portion of the direction changing passage and the rolling member escape hole, thus smoothly circulating the rolling members.

Furthermore, when the position of the block body in the mold is determined, the contacting portion of the mold with the block body is minimally limited to the rolling member rolling groove by positioning it with reference to the rolling member rolling groove, and the other portions of the mold can be maintained with non-contact state, which requires no precise working, thus easily performing manufacturing process.

BRIEF DESCRIPTION OF DRAWINGS

FIGS. 1 through 5 shows a rolling guide apparatus according to one embodiment of the present invention, in which: FIG. 1(*a*) is a vertical sectional view and FIGS. 1(*b*) to 1(*d*) show structures of a ball circulation passage;

FIG. 2(*a*) is a perspective view of an outer appearance of the rolling guide apparatus of FIG. 1 and FIG. 2(*b*) is a disassembled perspective view of a movable block;

FIGS. 3A–3K show a disassembled perspective view of the block body and a molded body of the movable block of the rolling guide apparatus of FIG. 1;

FIGS. 4*a*–4*k* shows the movable block body of the rolling guide apparatus of FIG. 1, in which FIG. 4(*a*) is a front view, FIG. 4(*b*) is a side view, FIG. 4(*c*) is a sectional view taken along the line C—C of FIG. 4(*a*) and FIG. 4(*d*) is a sectional view taken along the line D—D of FIG. 4(*b*); and

FIG. 5 shows a side cover of the rolling guide apparatus of FIG. 1, in which FIG. 5(*a*) is a front view, FIG. 5(*b*) is a sectional view taken along the line B—B of FIG. 5(*a*), FIG. 5(*c*) is backside view, FIG. 5(*d*) is a sectional view taken along the line D—D of FIG. 5(*c*), FIG. 5(*e*) is a sectional view taken along the line E—E of FIG. 5(*c*) and FIG. 5(*f*) is a end view along the line F—F of FIG. 5(*b*).

FIGS. 6*a*–6*c* is a view showing a manufacturing process of the movable block of the rolling guide apparatus of the present invention.

FIG. 7 shows a rolling guide apparatus according to another embodiment of the present invention, in which FIG. 7(*a*) is a vertical sectional view, FIG. 7(*b*) is a view showing an endless type retainer and FIG. 7(*c*) is a plan view partially broken away.

FIG. 8 shows a structure of a further rolling guide apparatus utilizing the endless type retainer of FIG. 7, in which FIG. 8(*a*) is a vertical sectional view, FIG. 8(*b*) is a plan view and FIG. 8(*c*) is a view showing the retainer.

FIGS. 9(*a*) to (*g*) represent structures of various types of the rolling guide apparatus of the present invention.

BEST MODE FOR EMBODYING INVENTION

The present invention will be described hereunder by way of the embodiments shown in the accompanying drawings.

FIGS. 1 and 2 represent a rolling guide apparatus of one embodiment according to the present invention.

The rolling guide apparatus 1 has a structure in which a movable block 2 is supported, through a plurality of balls as rolling members, by a guide rail 4 to be movable therealong.

The movable block 2 has a]-shape in section and is provided with a pair of leg portions 5, 5 between which the guide rail 4 is interposed and a horizontal portion 6 to which the leg portions 5, 5 are rigidly connected.

Four ball circulation passages 7 for guiding a number of balls 3 are formed to the movable block 2. In the illustrated example, two pairs of upper and lower circulation passages 7 are formed to the bilateral leg portions 5, 5, respectively.

Each of the respective ball circulation passages 7 is composed of a loaded ball rolling passage 8 defined by loaded ball rolling grooves 8*a*, 8*b* respectively formed to the opposing surfaces of the movable block 2 and the guide rail 4 and a return passage 9, formed in a non-loaded area, for returning the balls 3 from one end of the loaded ball rolling passage 8 to the other one end thereof.

Contact lines showing directions of contact angles of the four rows of the loaded balls incline in directions to be closed with respect to horizontal line towards the center of the guide rail 4. In such structure, the contact line means a line connecting contact portions of the balls contacting to the ball rolling grooves of the movable block and the guide rail, and the term "contact line" used hereinafter means the same content.

The return passage 9 formed to the non-loaded area is composed of a ball escape hole 10 extending in parallel to the loaded ball rolling passage 8 and a ball rolling direction changing passage 11 connecting both ends of the ball escape hole 10 to both the ends of the loaded ball rolling passage 8. The direction changing passage 11 is composed of an end surface cover portion 16 integrally joined with the end surface of a high rigid movable block body 13, to which the loaded ball rolling passage is formed, and a side cover 14 as an outer periphery constituting member.

In the illustrated embodiment, an escape hole forming portion 15 to which the ball escape hole 10 of the ball circulation passage, the end surface cover portion 16 and a retainer 17 extending along the loaded ball rolling passage are formed with a resin molded body 12 integrally with the high rigid block body 13.

The escape hole forming portions 15 are joined integrally with cutouts 18, substantially rectangular in section, formed to the bilateral side surfaces of the metallic block body 13, and the two rows of the upper and lower ball escape holes 10 are independently formed with space. Each of the ball escape holes 10 is entirely peripherally surrounded by the escape hole forming portion 15. In the illustrated embodiment, an inside portion 10*a* of the ball escape hole 10 is formed in arc shape, and this inside portion 10*a* is integrally connected with the end surface cover portion 16 integrally joined to the end surface of the block body 13.

The most simple structure of the end surface cover portion 16 is shown in FIG. 1(*c*) and comprises only an inner peripheral portion 19 of each of the direction changing passages which is connected with the inside portion 10*a* of the ball escape hole 10, but in the present embodiment, a staged protruded portion 20 fitted to the side cover 14 is formed, and an inner periphery guide surface 11*a* of the direction changing passage is formed in shape of recess to the staged protruded portion 20. Further, a central staged protruded portion 21 is formed to the end surface of the horizontal portion 6 of the block body 13 so as to connect the bilateral staged protruded portions 20, 20.

Recess-protrusion engaging portions 23 are formed to surfaces to be joined of the bilateral staged protruded portions 20 and the end surface of the block body 13 for preventing the mold forming member and the block body from positionally shifting from each other through their recess-protrusion engagement. Each of these recess-protrusion engaging portions 23 is composed of a recess 23*a* formed to the end surface of the block body 13 and a protrusion 23*b* fitted to the recess 23*a*.

Screw tap holes 20*a* are formed to the end surfaces of the bilateral staged protruded portions 20 for fastening the side covers 14. These screw tap holes 20*a* are formed to the end surfaces of the molded body 12, and on the other hand, tap prepared holes each having a diameter smaller than that of the tap hole 20*a* are formed, through resin formation, to the end surfaces of the block body 13 to positions corresponding to the screw tap holes 20*a*, respectively, and screw tap holes 20*a* are also formed to these prepared holes. The side covers 14 are formed with bolt insertion holes 22*a* through which bolts 22 are inserted and screw engaged with the screw tap holes 20*a*, thereby fastening the side covers 14.

The staged protruded portions 20 and the central protruded portion 21 are both formed with positioning holes 25 at their end faces at portions near the ball rolling direction changing portions 11, and the side covers 14 are formed with positioning projections 24, at their end surfaces, at portions near the ball rolling direction changing portions 11 corresponding to the positioning holes 25. These positioning projections 24 and holes 25 are engaged with each other when these members are joined together, whereby the outer peripheral side of the ball rolling direction changing portion 11 on the side cover side and the inner peripheral side of the ball rolling direction changing portion 11 on the mold forming member side of the block body 13 can be surely positioned.

The inner periphery of the ball escape hole 10 may have a simple circular section having a diameter slightly larger than that of the rolling ball, but a guide projection 10*b* as shown in FIG. 3(*c*) will be provided for constituting three-point contact structure, or a spline shape guide projection 10*c* as shown in FIG. 3(*b*) may be provided. Since the position of the ball is determined by three point support structure, it is desired to provide the guide projections contacting the ball at more than three points and portions other than the projections 10*b* and 10*c* may be formed as escape. It is desired that the gap between the ball outer periphery and a virtual circle connecting the tip ends of the projections 10*b* and 10*c* is made small so as to be approximately equal to the diameter of the ball.

According to this structure, the balls 3 are guided by the tip ends of these projections, thus preventing meandering motion of the balls 3.

. Furthermore, a lubrication agent such as grease in the ball escape hole 10 stays in a portion between the guide projections 10*b* and 10*c*, and accordingly, resistance caused by the lubrication agent during the rolling motion of the balls 3 through the escape holes 10 can be made small, thus the balls 3 being smoothly rolled with less obstruction of the lubrication agent.

Still furthermore, as shown in FIG. 3(*d*), a structure in which parallel two rows of the ball escape holes 10, 10 are connected with each other to prevent the balls 3 from clogging due to the presence of the lubrication agent. In this arrangement, the connection groove 10*d* acts as lubrication agent stay position so that the lubrication agent staying in front of the balls does not obstruct the rolling of the balls 3.

The ball escape hole 10 is formed so as to provide other various shapes in its section such as shown in FIGS. 3(*h*), (*i*) and (*j*) showing triangular shape, square shape and grooved circular shape, respectively. That is, in other words, it will be said that it is desired for the ball escape hole to have a non-circular section provided with a virtual circular section 10A as a rolling member passing section for passing the ball 3 as rolling member and a lubrication agent staying section 10B capable of storing the lubrication agent bled out from the virtual circular section 10A.

In the conventional drilling technology, it is impossible to form the ball escape hole having such section as mentioned above and such drilling working can be realized by the integral molding method according to the present invention.

Further, in order to make large the rotation radius of the ball in the direction changing passage 11, the both end portions of the ball escape hole forming portion is cut away at the outer peripheral portion of the ball escape hole **10** by a predetermined length, and according to the ball escape hole forming portion **15** of the above structure provided for the side cover **14**, the cutout portion **27** is covered to thereby connect the end portion of the ball escape hole **10** with the end portion of the direction changing passage **11**. That is, since the balls **3** can be circulated more smoothly by making possibly large the rotation radius of the direction changing passage, it will be not desired to adopt the structure having a small curvature.

The escape hole outer periphery forming portion **26** of the side cover **14** is formed with positioning projections **28** and the end surfaces of the cutout portions **27** formed to both the ends of the escape hole forming portions **15** of the mold forming member **12** are formed with positioning holes **29**, which are engaged with the projections **28** with each other. According to this structure, the ball escape holes **10** and the ball direction changing passages **11** are surely positioned at their outer peripheral and inner peripheral sides, providing no staged portion at the joined portions. Since the connection portions between the ball escape holes **10** and the direction changing passages **11** are formed as continuous guide surfaces with no staged portion, the smooth circulation of the balls **3** can be ensured. Particularly, as shown in FIG. 3(*e*), it is desired for the ball escape hole **10** to have an annular tapered projection **10*e*** and desired for the direction changing passage **11** to have a taper received portion **11*e*** which is circumferentially entirely engaged with the tapered projection **10*e*** as a faucet joint engagement. The tapered projection **10*e*** and the taper receiving portion **11*e*** are formed at the connection portion of the ball escape hole **10** and the direction changing passage **11**. According to this structure, the ball escape hole **10** and the direction changing passage **11** can be substantially completely joined together.

The retainer **17** acts to hold the balls **3** to prevent the balls **3** from falling off from the movable block **2** when the guide rail **4** is drawn out from the movable block **2**, and in the assembling state of the guide rail **4** and the movable block **2**, the retainer **17** is designed in its dimension so that a gap is formed between the retainer **17** and the balls **3** so as not to obstruct the rolling motion of the balls rolling in the loaded ball passage **8**.

In the described embodiment, the retainer **17** is disposed between the upper and lower two rows of loaded balls **3** formed to the bilateral leg portions **5**, **5** and includes a first retainer section **30** for holding the lower edge portion of the ball **3** in the upper row of balls **3** and the upper edge portion of the ball **3** in the lower row of balls **3**, a second retainer section **31** for holding the upper edge portion of the ball **3** of the upper row of balls **3** and a third retainer section **32** for holding the lower edge portion of the ball **3** of the lower row of balls **3**. The upper ball row is held by the first and second retainer sections **30** and **31** and the lower ball row is held by the first and third retainer sections **30** and **32**. The portions of the balls **3** are exposed between these first to third retainer sections **30**, **31** and **32** and contact the ball rolling groove **8*b*** on the guide rail side to be capable of freely rolling.

These retainer sections **30**, **31** and **32** are integrally connected, at their both ends, with the end surface cover portion **16**, and in the illustrated embodiment, the third retainer section **32** is integrally connected with the ball escape hole forming portions **15** of the bilateral leg portions **5**, **5** of the block body **13** through the lower surface cover portion **33** covering the lower side surfaces of the leg portions **5**, **5**.

The connection between the ball direction changing passage **11** and the loaded ball passage **8** is done by the manner such that each of the balls **3** is scooped gradually at bilateral two points by a tongue piece **34** having a boat shape serving as a guide suitable for scooping the ball **3** by invading the loaded area, the tongue piece **34** being provided at the outer peripheral end portion of the direction changing passage of the side cover **14**, thereby smoothly transferring the balls **3** to the direction changing passage **11** from the loaded ball passage **8**. That is, as shown in FIG. 3(*f*), the tongue piece **34** is provided with a groove **34*a*** having a width gradually reduced towards both the end portions, and as shown in FIG. 3(*g*), the ball **3** is supported at two points and the loaded ball **3** then rolls apart from the ball rolling groove **8*b*** of the guide rail **4**.

Accordingly, the ball **3** circulates to the direction changing passage **11** from the non-loaded ball hole **10** through the tapered projection and receiving portions **10*e*** and **11*e***, then, to the loaded ball passage **8** in the loaded area through the boat shaped tongue piece **34**, to the direction changing passage **11** at the end portion of the tongue piece **34** and again to the ball escape hole **10** through the tapered projection and receiving portions **10*e*** and **11*e***, thus the balls **3** being circulated in a rolling state through this circulation route. Thus, the connection portions of these portions are not formed with no staged portion to thereby smoothly perform the circulation of the balls **3**.

According to this structure, in which, as shown in FIG. 3(*b*), the ball escape hole **10** has at least three point contact structure by providing the guide projections **10*b***, **10*c***, the balls **3** roll from the two point contact state in the scooping operation of the boat bottom shaped tongue piece **34** to the three point contact structure, and an ideal ball rolling route can be established throughout the entire ball circulation passage, so that the balls **3** can be smoothly rolled therealong, and hence, generation of noise caused by unbalanced rolling of the balls **3** can be also minimized. In addition, since the idle ball rolling is also reduced, the noise can be minimized.

The movable block **2** of the rolling guide apparatus according to the present invention of the structure described above will be manufactured in the following manner.

A loaded ball rolling groove **8*a*** is preliminarily formed to the block body **13**, and the block body **13** is inserted into the mold **40** to integrally form the rolling member escape hole **10** to the block body **13** through the insertion molding process.

FIG. **6** shows a structure of the mold, which is formed with a cavity **41** for forming ball escape hole forming portions **15** outside the leg portions **5**, **5**, a cavity **42** for forming the retainers **17** inside the leg portions **5**, **5** and a cavity **43** for forming the inner peripheral portions of the direction changing passages **19** at both longitudinal ends of the leg portions **5**, **5**. A stationary mold half **44** is provided with a protruded portion **45** to be fitted to the ball rolling groove **8*a*** to position the same and a movable mold half **46** is provided with a pin **47** for forming the ball escape hole **10**.

At the time of the insertion molding process, as shown in FIG. **6**(*c*), the positioning inside the mold **40** is made with reference to the ball rolling groove **8*a*** of the block body **13**. According to this manner, when the insertion molding process is performed with reference to the ball rolling groove **8*a***, since the positioning of the ball escape hole **10** and the retainer **17** can be done, relative positional relationship among the loaded ball rolling passage **8**, the direction changing passage **11** and the ball escape hole **10** can be accurately established.

In addition, at the time of the positioning in the mold **40** for the block body **13**, if the positioning is performed with reference to the ball rolling groove **8***a*, the contact point to the block body **13** is minimally made to the ball rolling groove **8***a* and the other portions of the mold **40** are allowed to take non-contact arrangement and an accurate working is hence not required to these portions of the mold **40**, resulting in easy manufacture thereof.

Furthermore, the inner peripheral portion **19** of the direction changing passage can be integrally formed with the block body **13** together with the ball escape hole **10** through the insertion molding process.

The retainer **17** can be also integrally formed with the block body **13** together with the ball escape hole formation portion **15** and the end surface covering portion **16** through the insertion molding process.

Thereafter, the direction changing passage **11** can be completed at both the end portions of the loaded ball rolling groove **8***a* by assembling the side covers **14**.

According to the rolling guide apparatus of the structure described above, the ball escape hole forming portion **15** is integrally formed with the block body **13** as the mold forming body **12** through the insertion molding process, so that the drilling working for the ball escape hole **10** can be eliminated, thus making simple the manufacturing process.

Furthermore, since the integral molding can be realized through the molding process, any assembling process can be eliminated, thus reducing the assembling working.

Still furthermore, according to the present embodiment, the ball escape hole forming portion **15**, the end surface covering portion **16** and the retainer **17** are integrally formed as the mold forming body **12**, thus making more simple the manufacturing process.

According to the structure for enclosing the outer periphery of the block body **13**, a tensile stress is applied, by the shrinkage of the mold forming body **12**, to the retainer **17**, the escape ball forming portion **15** and the end surface covering portion **16**, and hence, the ball escape hole forming portion **15** and the retainer **17** are formed with high degree of straightness. Particularly, the ball **3** and the respective retainer sections are not contacted by the application of the tensile stress to the thin retainer sections for the upper side loaded ball and the lower side loaded ball, thus realizing smooth circulation of the balls **3**.

However, in a case where the retainer **17** is formed of a resin material, there is a case of causing a shifting in position by temporary lowering of the tensile stress by a creeping phenomenon, and for such case, the joining surfaces of the first retainer section **30** of the retainer **17** and the block body **13** are formed with recesses and protrusions so as to be firmly joined together through the engagement of these recesses and protrusions. This engagement structure is composed of an engaging groove **35** formed to the joining surface of the block body **13** so as to extend entirely along the axial direction of the block body **13** and an engaging protrusion **36** fitted to the engaging groove **35**. This engaging protrusion **36** is formed by invading the forming material into the groove **35** at the molding time. It will be of course noted that substantially the same engagement is realized to the joining surfaces between the second and third retainer sections **31**, **32** and the block body **13**.

Furthermore, according to the present embodiment, the thickness of the block constituting material such as metal constituting the block body **13** at its portion between the loaded ball rolling groove **8***a* to the ball escape hole **10** which affects on rigidity thereof can be made thin so as to provide an elastic property without changing the dimension between the ball rolling groove **8a** and the ball escape hole **10**, in other words, with the dimension suitable for the smooth direction changing operation being maintained, by forming the ball escape hole **10** by the resin molded body **12**. The thin thickness of the block body will be performed by making large the thickness of the circular portion as shown with two-dot chain line a in FIG. **1**(*a*) or by performing a linear cutting as shown with two-dot chain line b in FIG. **1**(*a*).

Accordingly, if an assembling error between the guide rail **4** and the movable block **2** (for example, misalignment such as assembling error due to an error in parallelism between the fixing surface of the guide rail **4** and the fixing surface of a conveyer table to be fixed to the movable block **2**) will be caused, such error can be absorbed through the flexibility of the thin leg portions of the block body **13** and the contact portion between the ball **3** and the ball rolling groove **8***a* is prevented from being applied by an excessive force.

The ball escape hole may be formed to a structure in which half of the ball escape hole **10** is integrally formed as shown in FIG. **3**(*k*). In such case, an effect due to the thin thickness of the block body will be expected in comparison with the drilling working to the metal block though this effect may be small in comparison with the above embodiment.

FIG. **7** represents another embodiment according to the present invention, in which like reference characters are added to elements or portions corresponding to those of the first mentioned embodiment and explanations thereof are omitted hereunder.

In this embodiment, one ball row is formed to each of bilateral leg portions **5** of the movable block **2**, and the balls **3** are held by means of an endless retainer **50** as shown in FIG. **7**(*b*).

The endless retainer **50** is a flexible belt-shaped member formed of a resin or like material, and a number of ball retaining holes **50***a* are formed with predetermined space from each other. The ball **3** is held by the inner peripheral surface of the respective ball retaining holes **50***a* to be freely rollable and slidable to thereby guide the balls along the entire periphery of the ball circulation passage **7**. Spacers **50***b*, each having a recess of spherical crown shape corresponding to an outer spherical shape of the ball, are disposed between adjacent ball retaining holes **50***a* so as to squeeze the ball **3** from both axial sides of the retainer **50**.

Since the endless retainer **50** is vibrated during the rolling motion of the balls **3**, retainer support members **55** to **58** are disposed linearly along the loaded ball rolling passage **8** to suppress the vibration thereof, and a guide groove **60** is also formed to the ball escape hole **10** for guiding both side edges of the endless retainer **50**.

In this embodiment of FIG. **7**, the ball escape hole forming portion **15**, the end surface covering portion **16** and the retainer support members **55** to **58** are formed integrally as the molded body **12**. The contact line of the left side ball **3** is inclined downward towards the central portion of the guide rail **4** by a predetermined angle with respect to the horizontal line H, and the contact line of the right side ball **3** is inclined upward towards the central portion of the guide rail **4** by a predetermined angle with respect to the horizontal line H. Thus, these contact lines are substantially in parallel to each other. In an arrangement of a certain contact angle case, there may appear a case wherein each of the retainer support members has a portion having insufficient thickness, so that a reinforcing member **60** such as metal plate may be embedded to such portion as occasion demands. In the illustrated embodiment, the reinforcing members **60** such as metal plates are embedded in the right upper retainer support member 56 and the left lower retainer support member 57.

An upper surface covering portion 51 for covering the upper surface of the block body 13 and an inner peripheral surface covering portion 54 for covering the upper surface of the inner periphery of the central recessed portion 13a of the block body 13 are provided to the block body 13. These covering members 51 and 54 are formed integrally through the end surface covering portion 16 to thereby achieve the reinforcement of the block body 13 and the resin portion formed integrally with the block body 13. The inner peripheral surface covering portions 54 are formed integrally with the left upper retainer support member 55 and the right upper retainer support member 56. Lower surface covering portions 61 for covering the lower surfaces of the leg portions 5, 5 of the block body 13 are also integrally provided to the block body 13 and formed integrally with the left and right lower retainer support members 57 and 58.

The upper surface of the block body 13 has a low level surface portion 52 and a high level surface portion 53 having a surface level higher than that of the lower level surface portion 52, and the high level surface portion 53 is formed as a bearing surface formed with a bolt hole 54 through which a fixing bolt is inserted for clamping, whereby the upper surface covering portion 51 is covered over the lower level surface portion 52 to make equal the surface level to that of the high level surface portion 53, providing a flat surface of the block body 13. In this embodiment, two high level surface portions 53 are provided in correspondence to the left and right leg portions 5, 5 of the block body 13, and three low level surface portions 52 are provided at an intermediate portion between the two high level surface portions 53 and at bilateral both end portions of the block body 13.

FIG. 8 shows an example of a structure which utilizes the endless retainer 50 described above.

In this example, the levels in arrangements of the left and right balls 3 are made different in a manner such that one of the ball rows is arranged to the right side edge of the upper surface of the guide rail 4 and the other one of the ball rows is arranged to the intermediate portion of the left side surface of the guide rail 4. The block body 13 is formed to have substantially an L-shape in section having one leg portion 5, and one of the ball escape holes 10 is formed to the right side portion of the upper surface of the horizontal portion 6 of the block body 13 and the other one of the ball escape holes 10 is formed to the leg portion 5. That is, a cutout 62 is formed to the right edge portion of the upper surface of the horizontal portion 6 of the block body 13, and the ball escape hole forming portion 15 formed of the resin material is integrally joined with the cutout 62 and the other ball escape hole forming portion 15 is integrally joined with a cutout 63 formed to the lower surface of the leg portion 5 and the corner portion of the left side surface thereof.

The left side surface covering portion 64 of the leg portion 5 and the left upper retainer support member 55 disposed to the inner periphery of the leg portion 5 are formed integrally through the front and rear end surface covering portions 16 so as to surround the leg portion 5. The inner side edge portion of the lower surface covering portion 61 for covering the lower surface of the leg portion 5 is integrally joined with the retainer support member 57 at the left side ball lower side edge portion. The escape ball hole forming portion 15 formed to the horizontal portion 6 and the lower surface covering portion 65 of the horizontal portion 6 are integrally joined together through the front and rear end surface covering portions 16 so as to vertically surround the horizontal portion 6. The lower surface covering portion 65 and the ball escape hole forming portion 15 are integrally formed through the right side surface covering portion 65 of the block body 13, and the inner side edge portion of the lower surface covering portion 65 is joined with the retainer support member 58 for the right lower ball row.

As described above, with the structure of the block body 13, only the portions necessary for the positioning are exposed and portions not required to form with high precision are covered with resin materials, so that portions of the block body 13 requiring cut working or the like are reduced, thus reducing manufacturing cost.

FIG. 9 shows a further example of arrangement of the present invention, in which like reference numerals are added to elements or portions corresponding to those of the former examples and explanations thereof are omitted herein.

FIG. 9(a) shows a structural example of the linear motion guide apparatus provided with four rows of ball circulation passages 7 as like the above first embodiment, in which the ball escape hole 10, the inner peripheral portion of the direction changing passage and the retainer 17 are integrally formed. This example differs from the former one in that the contact angle lines to the bilateral upper and lower two ball rows are opened towards the guide rail 4 with respect to the horizontal line.

In the illustrated embodiment, one retainer 17 is disposed between each of bilateral upper and lower ball rows.

An example shown in FIG. 9(b) has a structure in which the left and right leg portions such as shown in the embodiment of FIG. 1 are independently separated and which is utilized for conveying and guiding a table 66 or the like by using a pair of linear motion guide apparatus. In this structure, the ball escape hole 10, the direction changing passage inner peripheral surface 19 and the retainer 17 are also integrally formed.

An example shown in FIG. 9(c) has a structure in which the left and right leg portions 5 of the linear motion guide apparatus such as shown in FIG. 9(b) are independently separated. In this structure, the ball escape hole 10, the direction changing passage inner peripheral portion 19 and the retainer 17 are also integrally formed.

An example shown in FIG. 9(d) represents a structure of a linear motion guide apparatus provided with four ball rows including two rows formed to the upper surface of the guide rail 4 and respective one row formed to left and right side surfaces thereof, and in this arrangement, the ball escape hole 10, the direction changing passage inner peripheral portion 19 and the retainer 17 are integrally formed together.

In this example, the ball escape hole forming portion 15 of the molded body 12 is fitted in a lower hole 67 formed through the block body 13.

In such arrangement, however, high precision is not basically required with respect to the lower hole 67 to be formed to the block body 13, thus easily forming the same.

FIG. 9(g) is an example employing the structure of the lower hole 67 to the left and right two ball rows, and particularly, in this example, no retainer is provided and an engaging portion 68 performing recess-protrusion engagement for preventing the positional shifting is formed to the end surface of the block body 13 at the direction changing passage inner peripheral portion.

FIGS. 9(e) and 9(f) show examples of arrangements of the linear motion guide apparatus in which rollers 3' are used instead of the balls 3, and FIG. 9(*e*) shows a linear motion guide apparatus provided with four roller rows and FIG. 9(*f*) shows a linear motion guide apparatus provided with two roller rows.

With respect to the above examples, it is to be noted that the present invention is described with reference to the linear motion guide apparatus, but it is of course applicable to a linear guide rail slidably assembled with a curved motion guide rail, and as the molded body, a die cast product, sintered metal or the like other than resin material may be utilized.

According to the present invention having the structures and functions mentioned hereinbefore, since the rolling member escape holes are integrally formed with the block body through the molding process, the drilling working can be eliminated to thereby easily form the structure.

In addition, since the integral structure can be provided through the molding process, the assembling process can be reduced.

The degree of integral formation can be increased by integrally forming the inner peripheral portion of the direction changing passage with the ball escape hole, making easy the assembling process.

By integrally forming the rolling member escape hole, the inner peripheral portion of the direction changing passage and the retainer to surround the periphery of the block body, the tensile stress is applied, by the shrinkage of the molded portions, to the rolling member escape hole, the inner peripheral portion of the direction changing passage and the retainer, so that the degree of straightness of the rolling member escape hole and the retainer can be made high, and the generation of resonance noise, at the time of rolling member circulation, to the respective parts of the guide apparatus by residual tensile stress can be prevented.

The low noise frequency due to the rolling member circulation can be prevented from causing by the increasing of vibration frequency including mass of the block body.

Furthermore, the thickness of the block constituting material such as metal constituting the block body at its portion between the loaded rolling member rolling groove to the rolling member escape hole which affects on rigidity thereof can be made thin so as to provide an elastic property without changing the dimension between the rolling member rolling groove and the rolling member escape hole, in other words, with the dimension suitable for the smooth direction changing operation being maintained, by forming the rolling member escape hole by the molded resin body. Accordingly, if an assembling error between the guide rail and the movable block (for example, misalignment such as assembling error due to an error in parallelism between the fixing surface of the guide rail and the fixing surface of a conveyer table to be fixed to the movable block) be caused, such error can be absorbed through the flexibility of the thin portions of the block body and the contact portion between the rolling member and the rolling member rolling groove is prevented from being applied with an excessive force.

The rolling member escape hole is formed so as to provide a sectional shape having a rolling member passing section along which the rolling members roll and a lubrication agent storing section capable of storing lubrication agent bled outward from the rolling member passing section, and according to such structure of the rolling member escape hole, since the lubrication agent can be retained without obstructing the circulating motion of the rolling member, the smooth circulating motion thereof can be surely maintained for the long time operation with no substantial maintenance. Furthermore, the escape hole having such complicated sectional shape can be easily formed through the molding process.

The positioning of the block body inserted into the mold is performed with reference to the rolling member rolling groove through the insertion molding process, and accordingly, since the position of the rolling member escape hole and the position of the retainer can be determined with reference to the rolling member rolling groove, the relative positional relationship among the loaded rolling member rolling passage, the direction changing passage and the escape hole constituting the rolling member circulation passage can be exactly determined. Accordingly, no staged portion is formed to the connection portion between the loaded rolling member rolling passage, the inner peripheral portion of the direction changing passage and the rolling member escape hole, thus smoothly circulating the rolling members.

Furthermore, when the position of the block body in the mold is determined, the contacting portion of the mold to the block body is minimally limited to the rolling member rolling groove by positioning it with reference to the rolling member rolling groove, and the other portions of the mold can be maintained with non-contact state, which requires no precise working, thus easily performing manufacturing process.

We claim:

1. A rolling guide apparatus in which a movable block is supported to be movable along a guide rail through a number of rolling members, a circulation passage for guiding circulation of the rolling members is formed to the movable block, said rolling member circulation passage being composed of a loaded rolling member rolling passage in a loaded area between loaded rolling member rolling grooves formed to opposing surfaces of the movable block and the guide rail and a non-loaded return passage for returning the rolling members in the loaded area from one end of the loaded rolling member rolling passage to another one end thereof, said return passage being composed of a rolling member escape hole extending in parallel to said loaded rolling member rolling passage and a direction changing passage having inner and outer peripheral portions connecting both ends of the rolling member escape hole to both ends of the loaded rolling member rolling passage,

said rolling guide apparatus being characterized in that at least one of said rolling member escape hole, said inner peripheral portion of the direction changing passage and a retainer extending along the loaded rolling member rolling passage is formed of a molded body and said molded body is integrally formed with a block body having high rigidity.

2. A rolling guide apparatus according to claim 1, wherein said molded body is provided with the rolling member escape hole and the inner peripheral portion of the direction changing passage integrally connected to the rolling member escape hole and joined with both end surfaces of the block body.

3. A rolling guide apparatus according to claim 1, wherein said molded body is provided with the rolling member escape hole and the retainer extending along the loaded rolling member rolling passage.

4. A rolling guide apparatus according to claim 1, wherein said molded body is provided with the inner peripheral portion of the direction changing passage joined with both end surfaces of the block body and the retainer extending along the loaded rolling member rolling passage and integrally connected at its both ends with the inner peripheral portion of the direction changing passage.

5. A rolling guide apparatus according to claim 1, wherein said molded body is provided with the rolling member escape hole, the inner peripheral portion of the direction changing passage integrally connected to the rolling member escape hole and joined with both end surfaces of the block body and the retainer extending along the loaded rolling member rolling passage and integrally connected at its both ends with the inner peripheral portion of the direction changing passage, said molded body having a closed sectional shape surrounded by said rolling member escape hole, said direction changing passage and said retainer.

6. A rolling guide apparatus according to any one of claims 1, 2, 3, 4 and 5, wherein recess-protrusion engaging portion is formed to joining surfaces of the molded body and the block body.

7. A rolling guide apparatus according to any one of claims 1, 2, 3, 4 and 5, wherein said molded body is formed of a resin material, and a portion between the loaded rolling member rolling groove and the rolling member escape hole of the movable block is formed as one portion of the resin molded body so as to define a reduced thickness in the high rigid block body to provide an elastic property.

8. A rolling guide apparatus according to any one of claims 1, 2, 3, 4 and 5, wherein the rolling members rolling in the loaded rolling member rolling passage are scooped by a guide, each in two point contact state, extending in the loaded area of the direction changing passage from the loaded rolling member rolling groove to the direction changing passage in a manner of being separated gradually apart from each other.

9. A rolling guide apparatus according to any one of claims 1, 2, 3, 4 and 5, wherein the movable block is provided with a pair of leg portions between which the guide rail is interposed and a connection portion connecting said leg portions, and the rolling member circulation passages are formed to said leg portions.

10. A rolling guide apparatus according to claim 9, wherein a covering portion is provided for covering at least one of upper and lower surfaces of the connection portion of the movable block and said covering portion is integrally formed with the inner peripheral portion of the direction changing passage joined with both the end surfaces of the block body.

11. A rolling guide apparatus according to any one of the preceding claims 1 to 5, wherein said rolling member escape hole has a sectional shape having a rolling member passing section through which the rolling member passes and a lubrication agent storing section capable of storing a lubrication agent bled outward from the rolling member passing section.

12. A method of manufacturing a movable block, which is supported to be movable with respect to a guide rail through a number of rolling members, of a rolling guide apparatus provided with loaded rolling member rolling grooves formed to opposing surfaces of the movable block and the guide rail, a rolling member escape hole extending in parallel to the loaded rolling member rolling grooves, and a direction changing passage having inner and outer peripheral portions connecting both ends of the rolling member escape hole to both ends of the loaded rolling member rolling passage,

said manufacturing method being characterized in that said block body is placed in a mold, and at least one of said rolling member escape hole, said inner peripheral portion of the direction changing passage and a retainer extending along the loaded rolling member rolling passage is formed integrally with the block body through an insertion molding process.

13. A movable block manufacturing method according to claim 12, wherein the rolling member escape hole and the inner peripheral portion of the direction changing passage are integrally formed together through the insertion molding process.

14. A movable block manufacturing method according to claim 12, wherein the rolling member escape hole and the retainer extending along the loaded rolling member rolling passage are integrally formed together through the insertion molding process.

15. A movable block manufacturing method according to claim 12, wherein the inner peripheral portion of the direction changing passage and the retainer extending along the loaded rolling member rolling passage are integrally formed together through the insertion molding process.

16. A movable block manufacturing method according to claim 12, wherein the rolling member escape hole, the inner peripheral portion of the direction changing passage, and the retainer extending along the loaded rolling member rolling passage are integrally formed together through the insertion molding process.

17. A movable block manufacturing method according to any one of claims 12 to 16, wherein said block body is positioned in the mold with reference to the rolling member rolling groove formed to the movable block.

* * * * *

US005716139A

United States Patent [19]

Okamoto et al.

[11] **Patent Number: 5,716,139**

[45] **Date of Patent: Feb. 10, 1998**

[54] **ROLLING GUIDE UNIT**

[75] Inventors: **Isao Okamoto**, Higashi-Murayama; **Takeki Shirai**, Ichikawa, both of Japan

[73] Assignees: **THK, Co., Ltd.**; **Railway Technical Research Institute**, both of Tokyo, Japan

[21] Appl. No.: **404,925**

[22] Filed: **Mar. 15, 1995**

[30] **Foreign Application Priority Data**

Mar. 18, 1994 [JP] Japan 6-072950

[51] **Int. Cl.**^{6} **F16C 31/06**

[52] **U.S. Cl.** **384/45**

[58] **Field of Search** 384/43, 44, 45, 384/48, 49

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,898,273	2/1933	Stevens	384/48
2,047,868	7/1936	Harley	384/49
4,582,369	4/1986	Itoh	384/45 X
4,616,886	10/1986	Teramachi	384/45
5,158,372	10/1992	Ueki	384/45
5,240,331	8/1993	Ninomiya et al.	384/45
5,249,867	10/1993	Iida	384/54 X
5,273,365	12/1993	Kondoh	384/45 X

FOREIGN PATENT DOCUMENTS

39 31 351	3/1991	Germany .	
41 32 320	4/1992	Germany .	
41 34 864	4/1992	Germany .	
42 09 824	3/1993	Germany .	
102714	4/1992	Japan	384/49
2 139 298	11/1984	United Kingdom .	

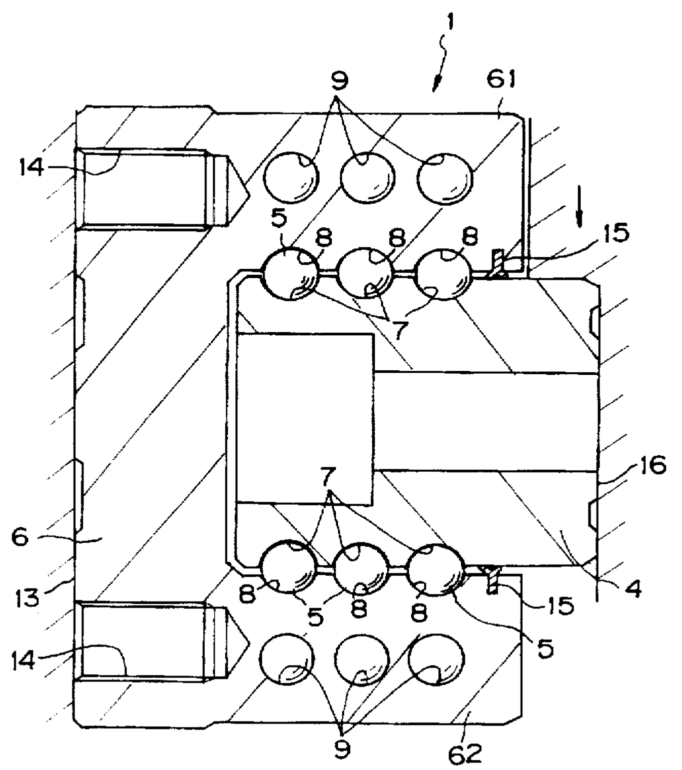
Primary Examiner—Thomas R. Hannon

Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

A rolling guide unit comprises a movable member provided with a pair of support portions extending from lateral end portions of a main body portion so as to provide a recessed portion between the main body portion and both the support portions, a guide rail disposed in the recessed portion of the movable member so that side surfaces of the guide rail face the inner surfaces of the support portions, respectively, and a number of rolling members disposed to be rollable between corresponding rolling member rolling grooves formed to the guide rail and the support portions of the movable member so that each of the rolling members contact the rolling member rolling grooves at two contact points and the the rolling members apply load to the rolling member rolling grooves, the movable member and the guide rail being relatively movable through the rolling of the rolling members. Each of the rolling member rolling grooves has an arcuate shape in section having radius of curvature larger than that of the rolling member and the contact points are displaceable along the arcuate shape of the rolling member rolling groove.

6 Claims, 17 Drawing Sheets



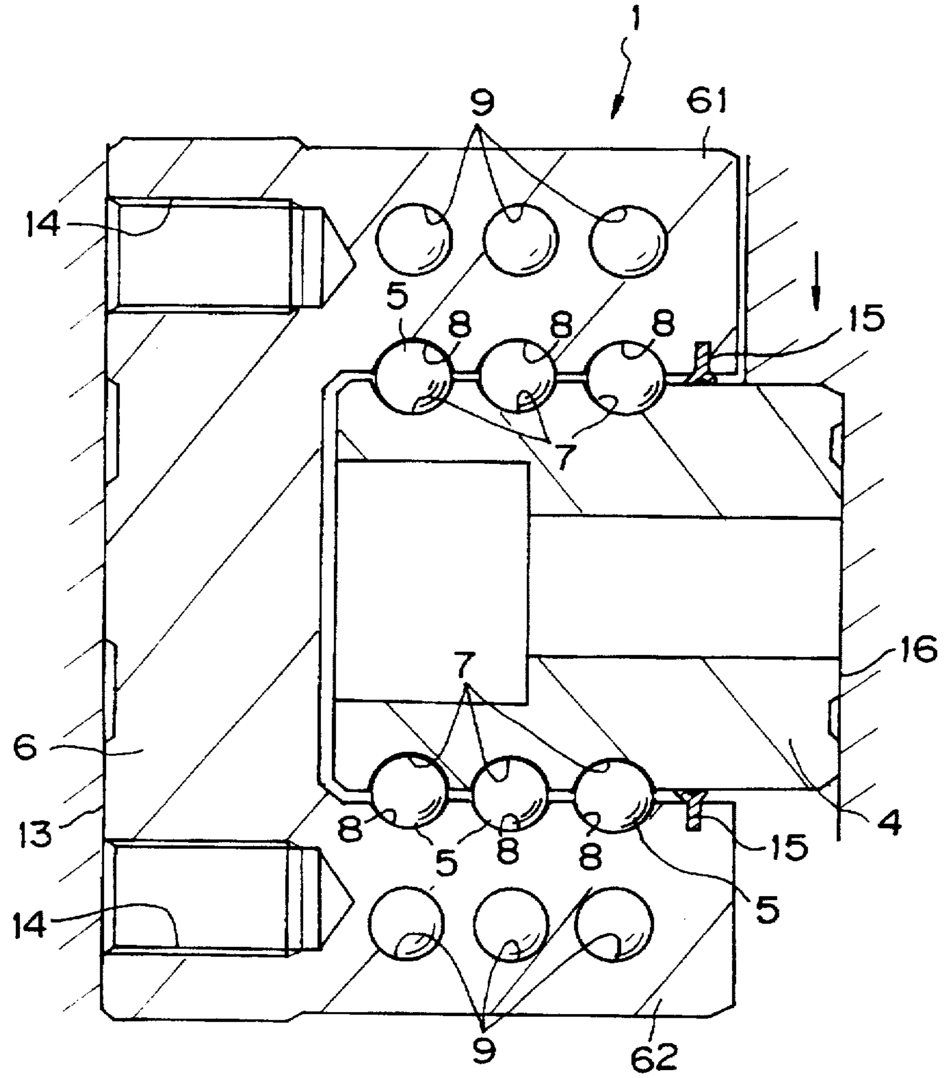


FIG. 1A

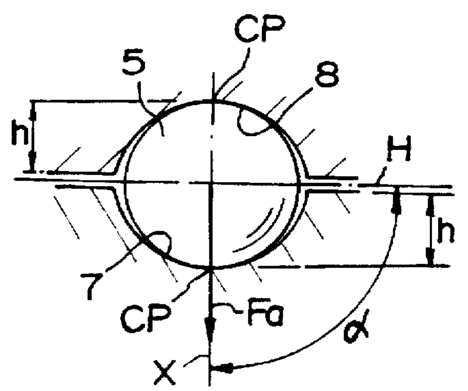


FIG. 1B

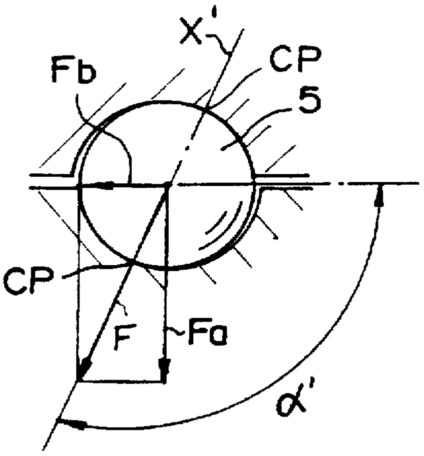


FIG. 1C

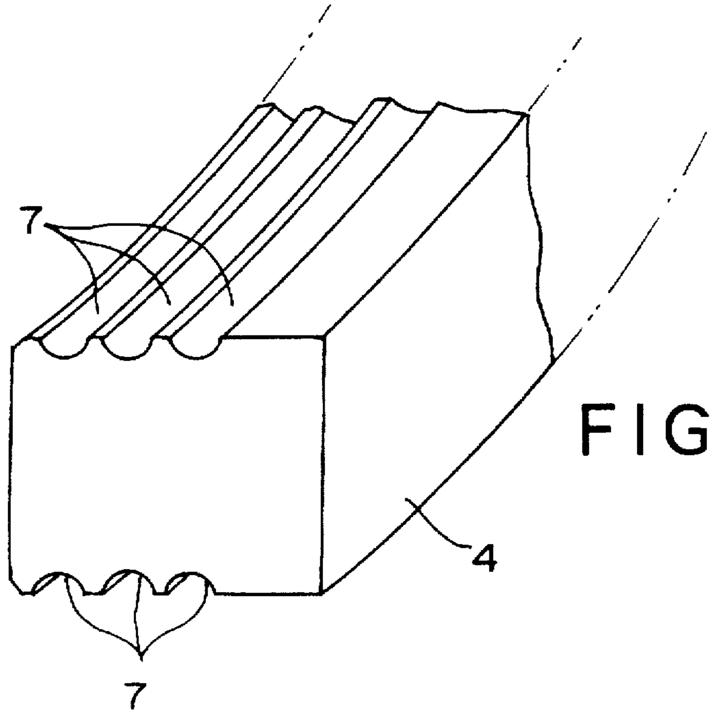


FIG. 2A

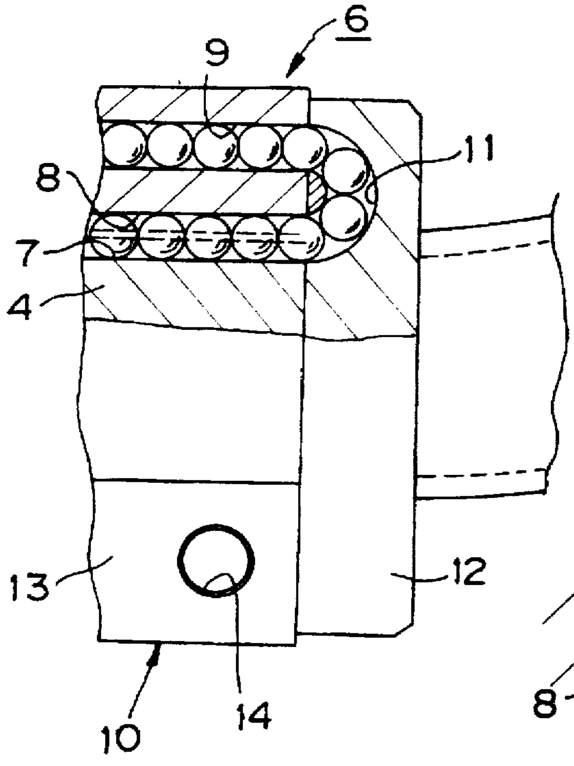


FIG. 2B

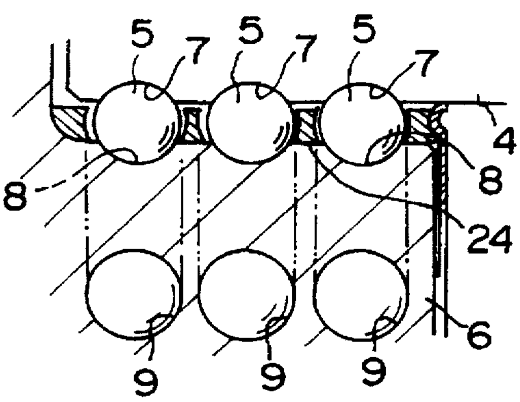


FIG. 2C

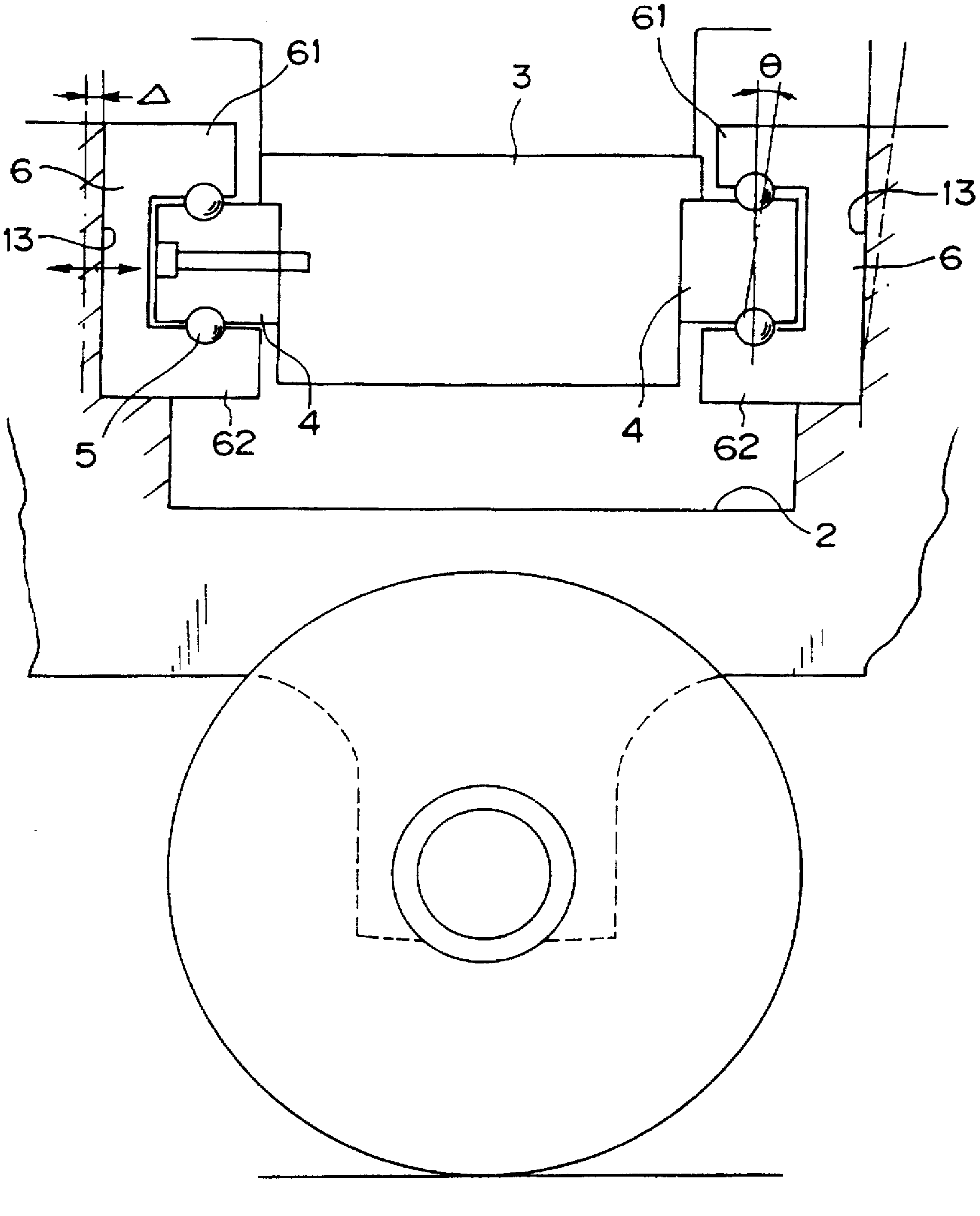


FIG. 3

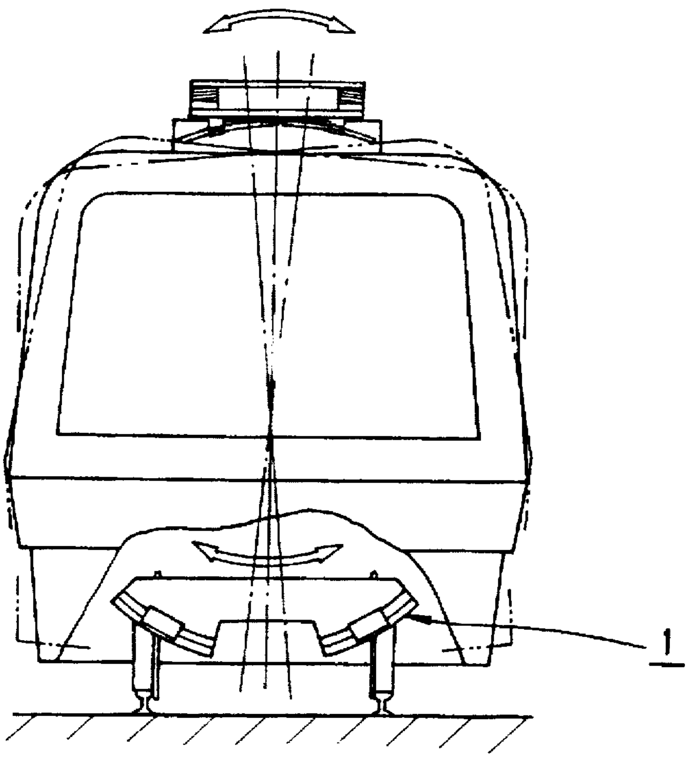


FIG. 4A

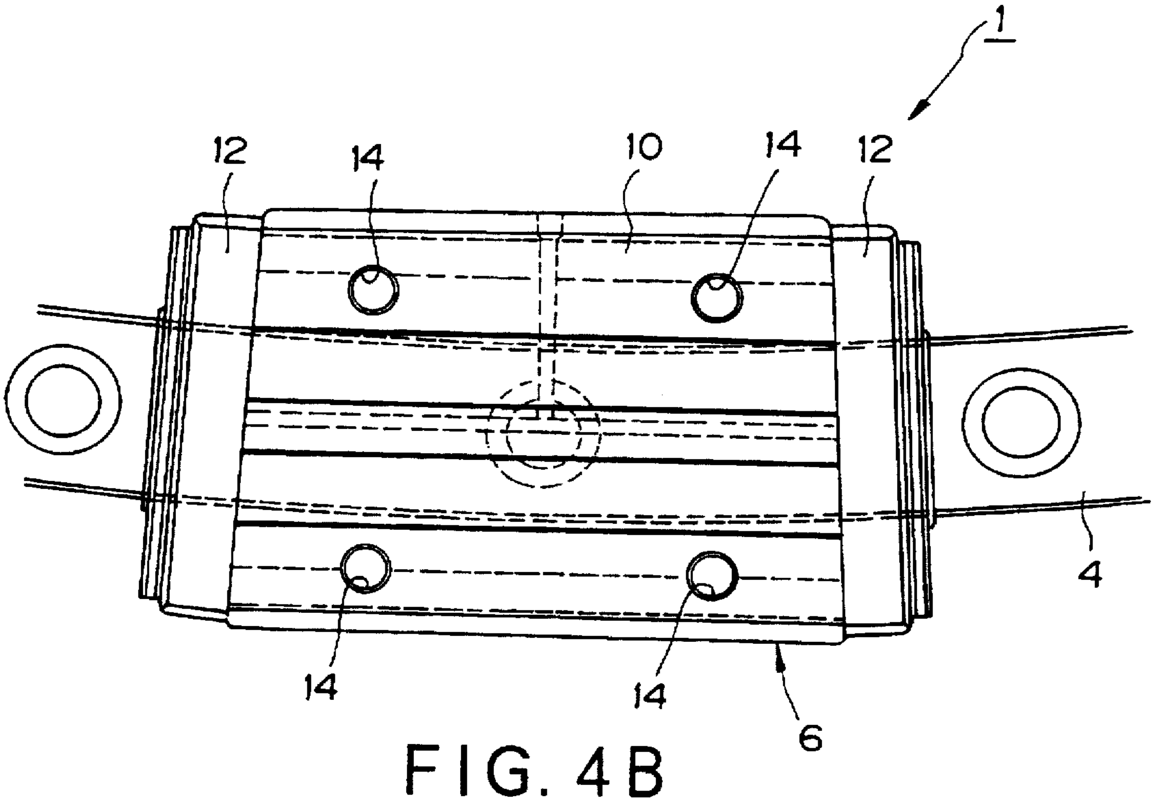


FIG. 4B

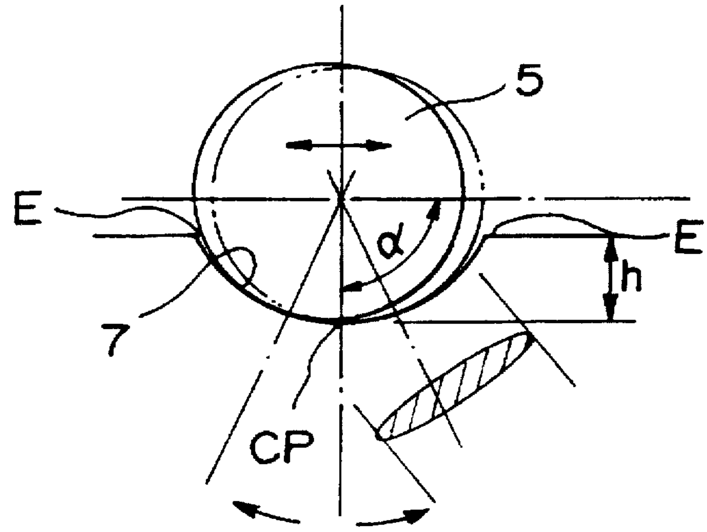


FIG. 5A

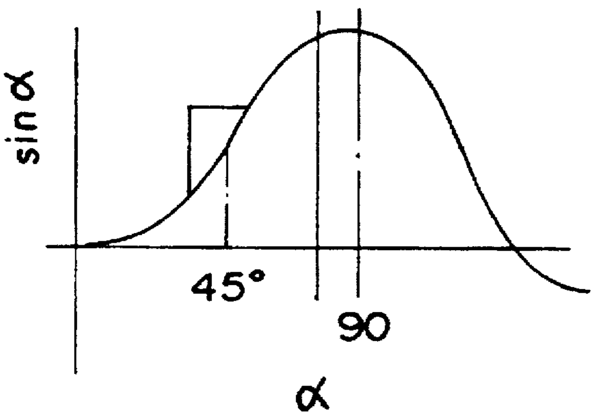


FIG. 5B

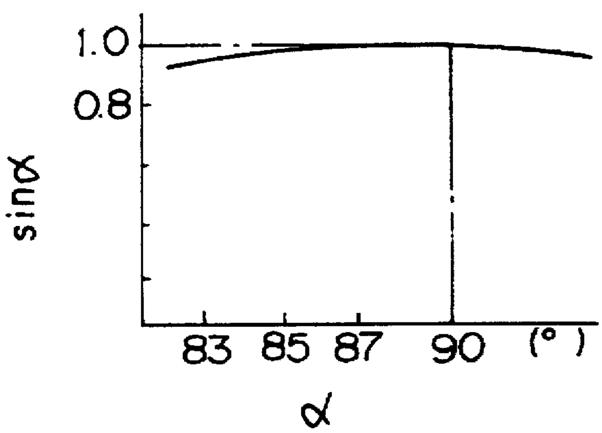


FIG. 5C

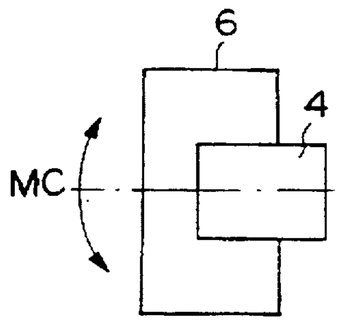


FIG. 6A

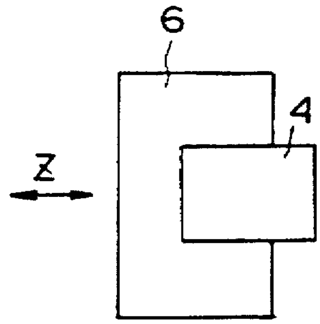


FIG. 6B

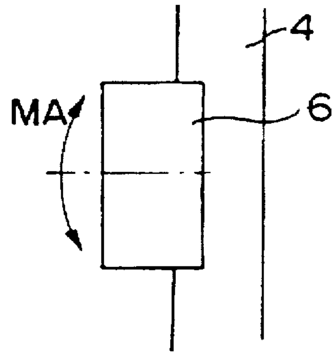


FIG. 6C

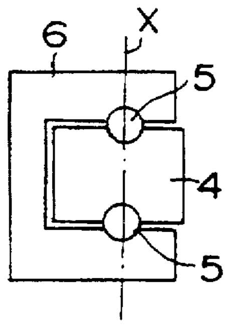


FIG. 6D

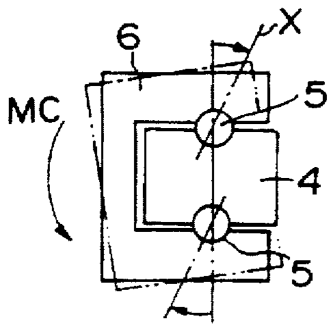


FIG. 6E

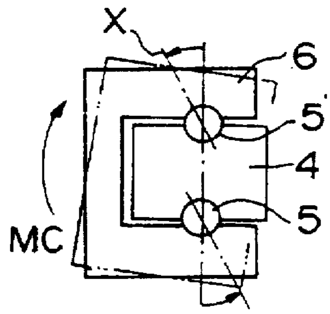


FIG. 6F

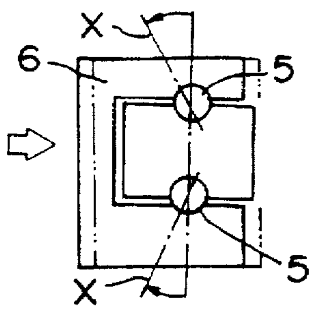


FIG. 6G

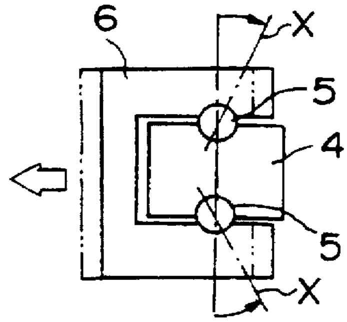


FIG. 6H

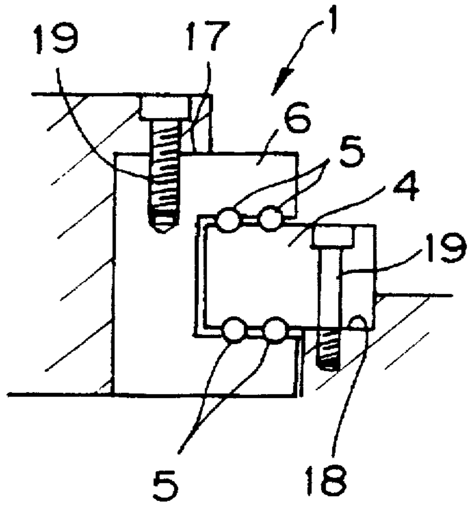


FIG. 7A

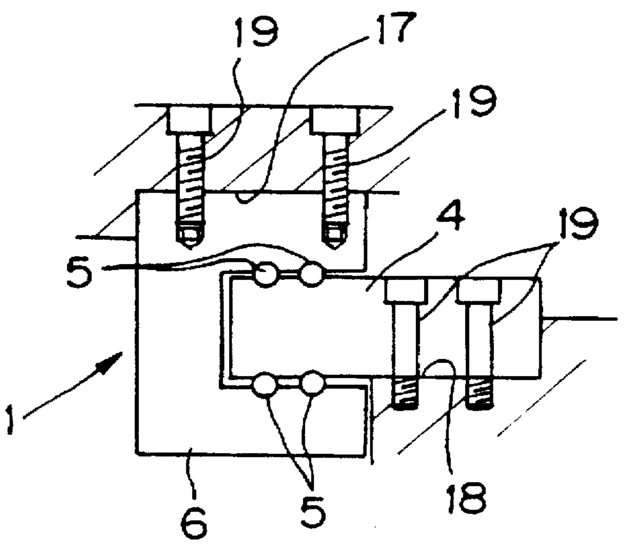


FIG. 7B

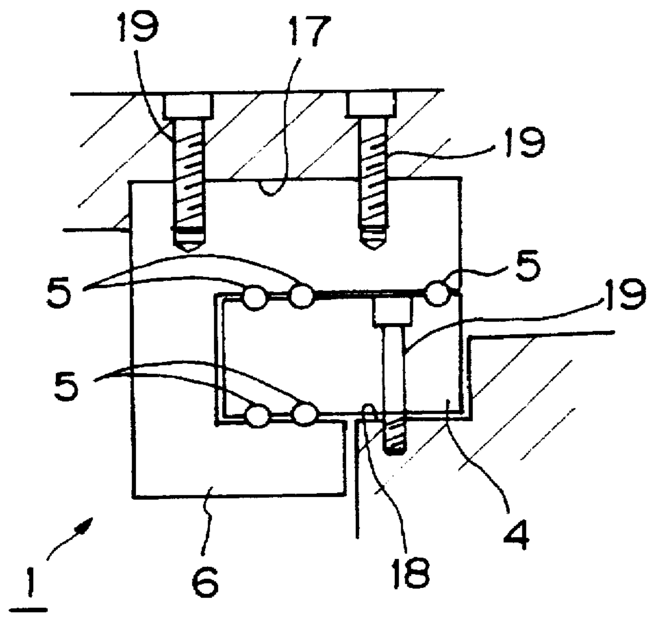


FIG. 7C

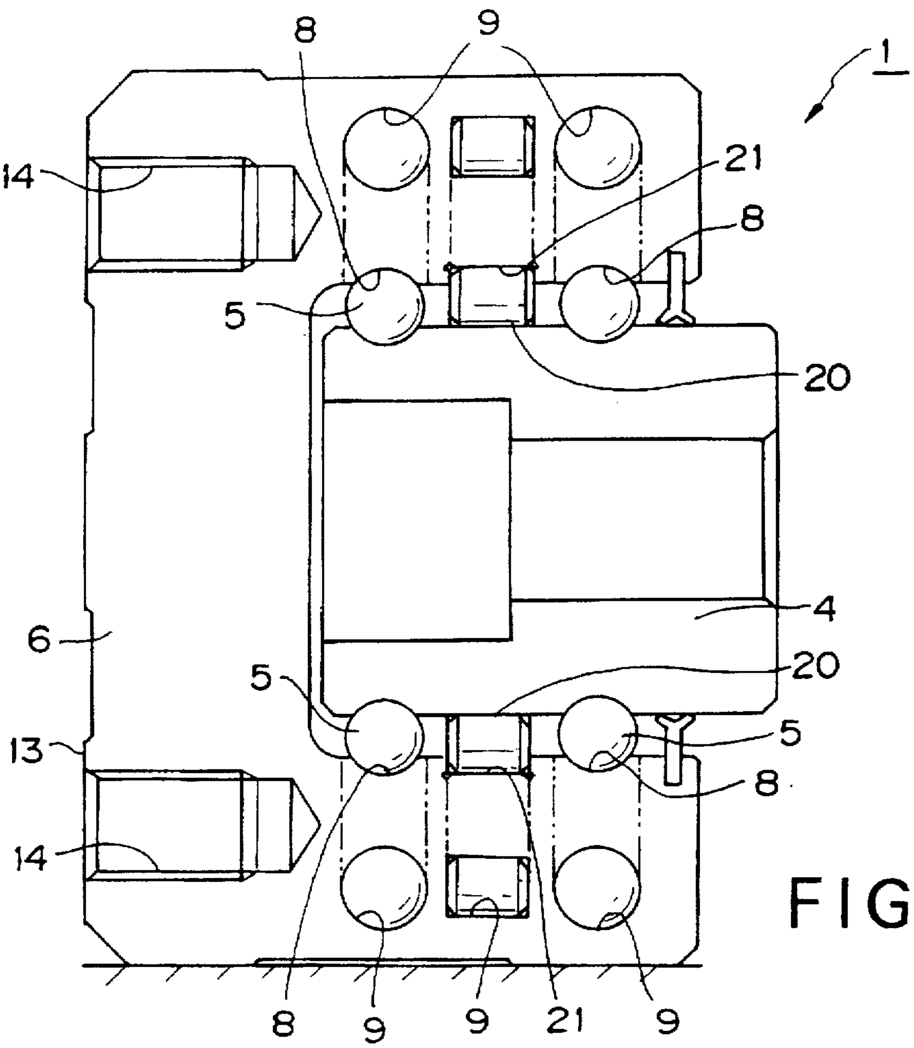


FIG. 8A

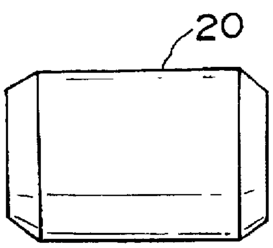


FIG. 8B

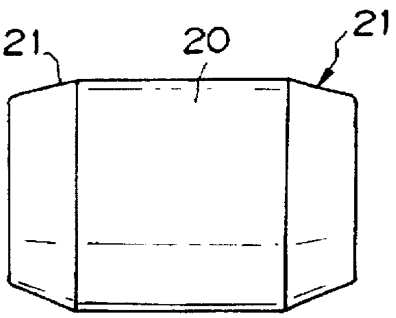


FIG. 8C

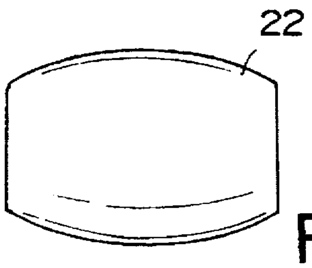


FIG. 8D

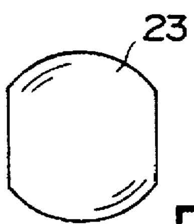


FIG. 8E

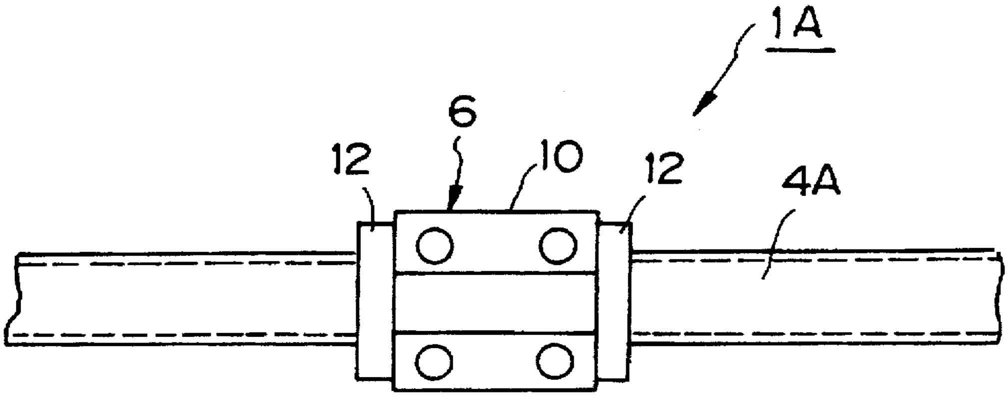


FIG. 9A

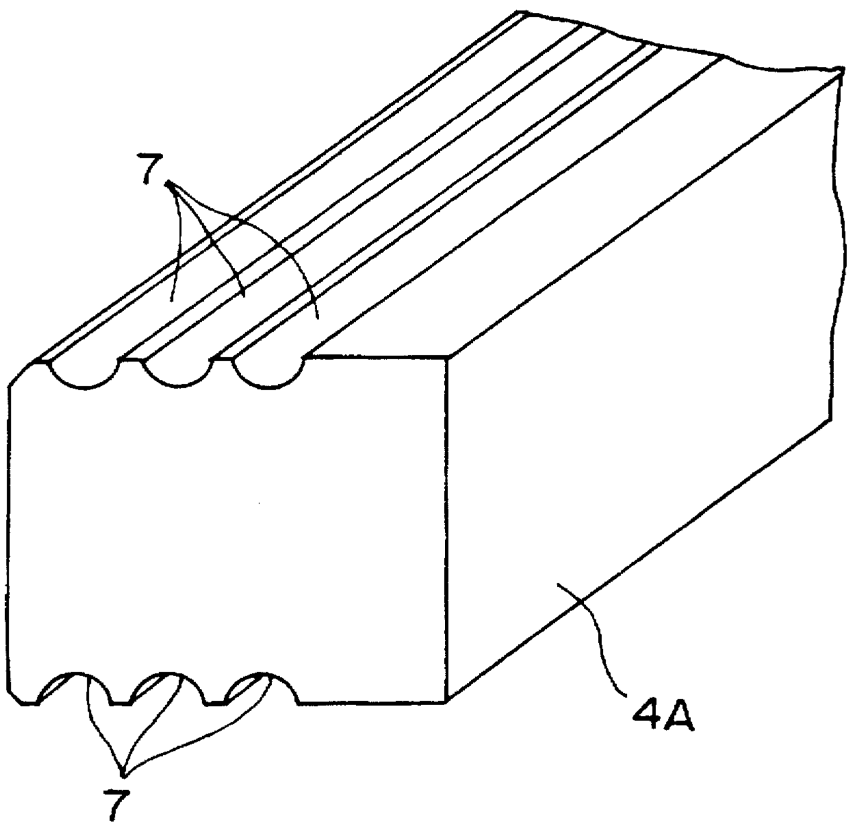


FIG. 9B

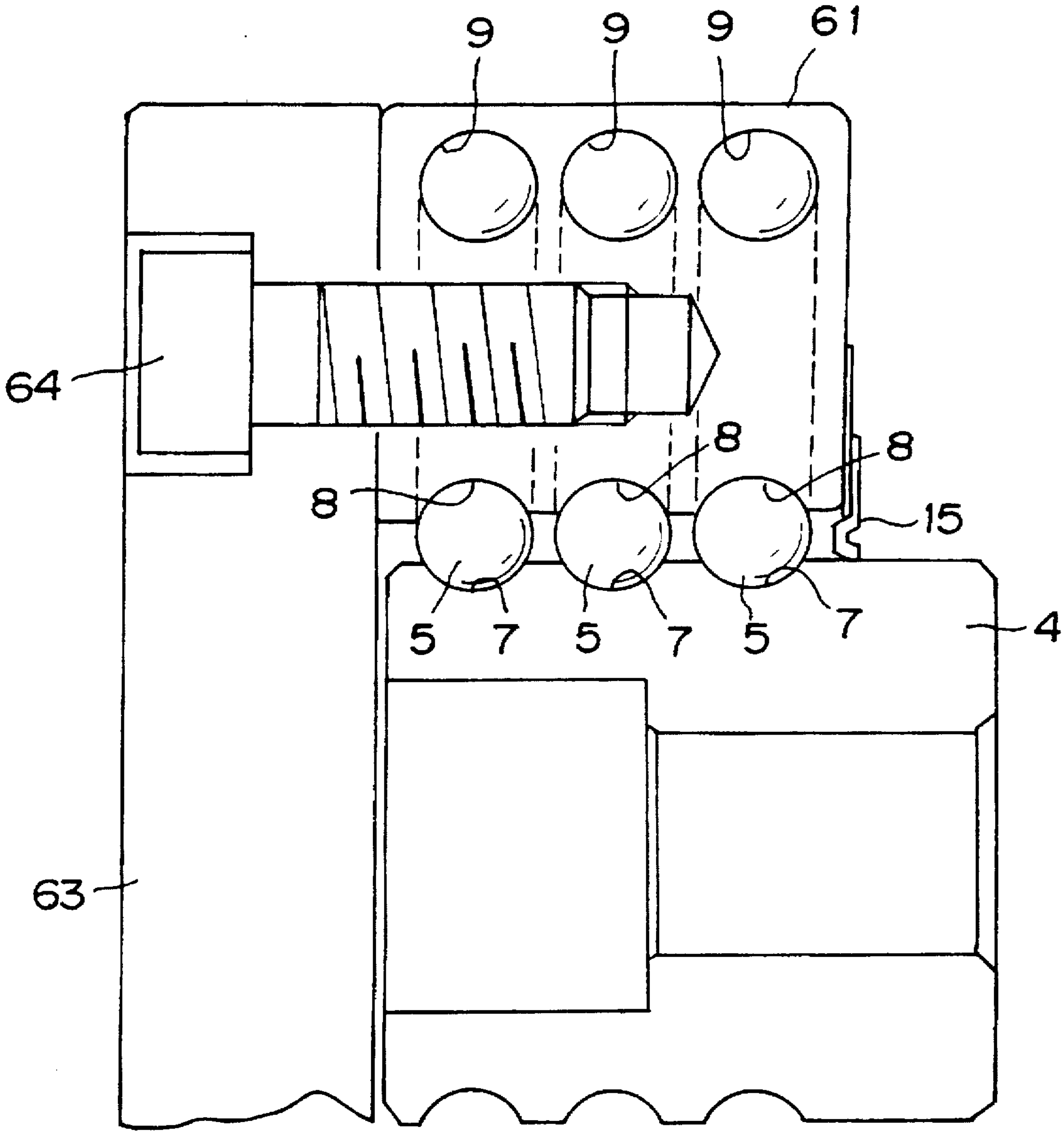


FIG. 10

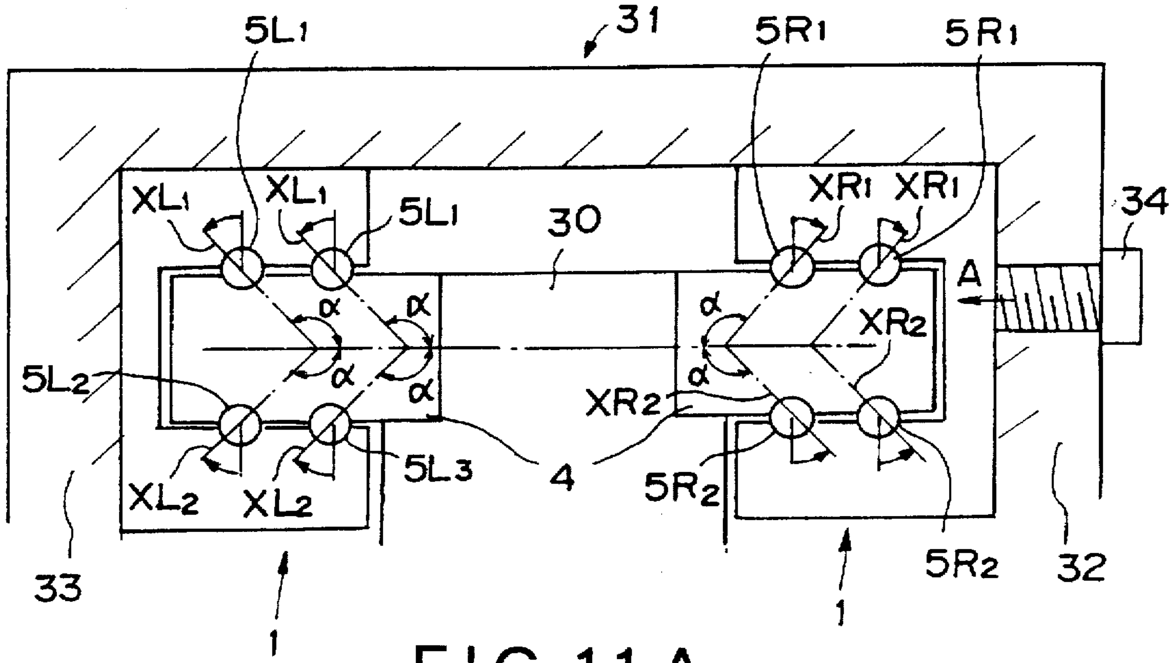


FIG. 11A

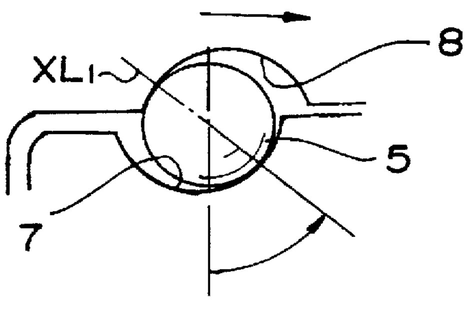


FIG. 11B

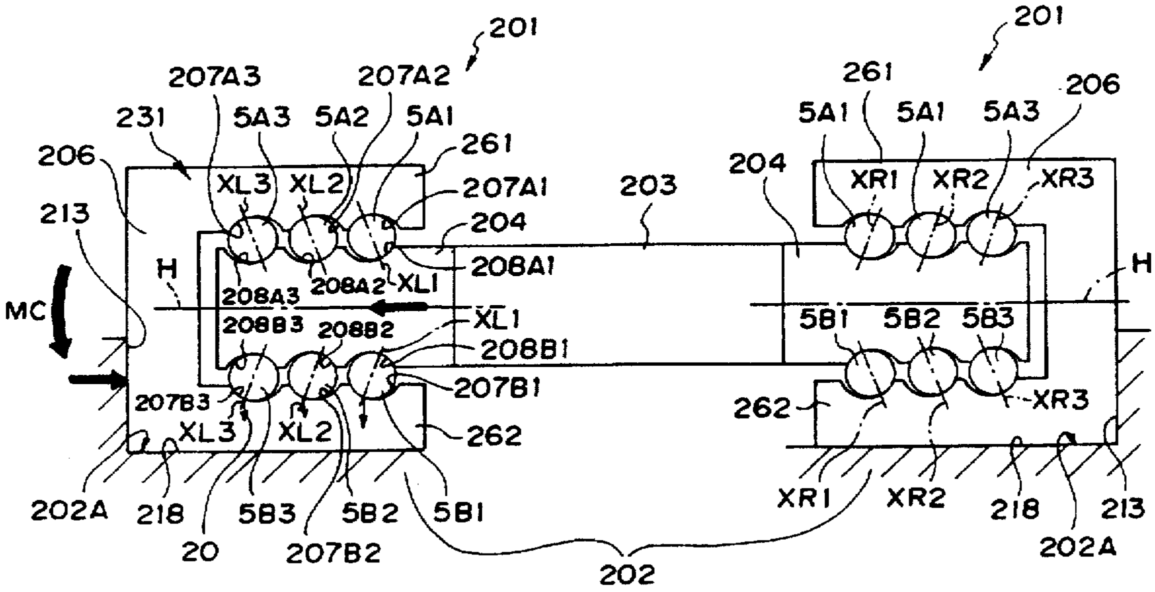

201
207A3
207A2
231
5A3
5A2
5A1
261
206
XL3
XL2
207A1
203
204
213
H
MC
208A3
208A2
XL1
208A1
208B3
208B2
208B1
207B3
207B1
262
202A
218
20
5B3
207B2
5B2
5B1
202
201
261
206
5A1
5A1
5A3
XR1
XR2
XR3
5B1
5B2
5B3
XR3
262
XR1
XR2
218
213
202A

FIG.12

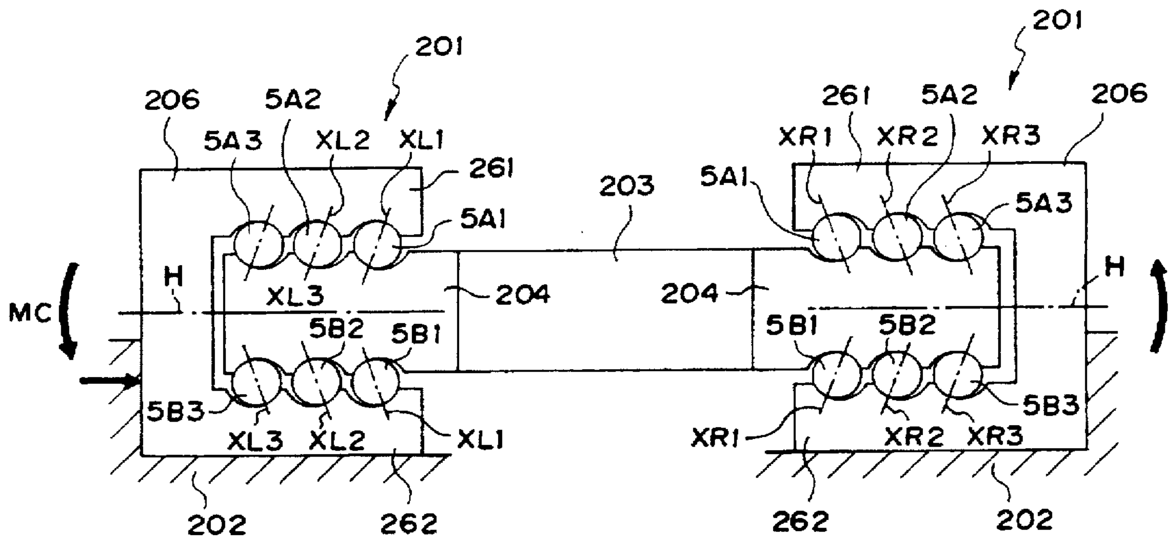

201
206
5A2
5A3
XL2
XL1
261
5A1
H
MC
XL3
204
5B2
5B1
5B3
XL3
XL2
XL1
202
262
203
201
261
5A2
206
XR1
XR2
XR3
5A1
5A3
204
H
5B1
5B2
5B3
XR1
XR2
XR3
262
202

FIG.13

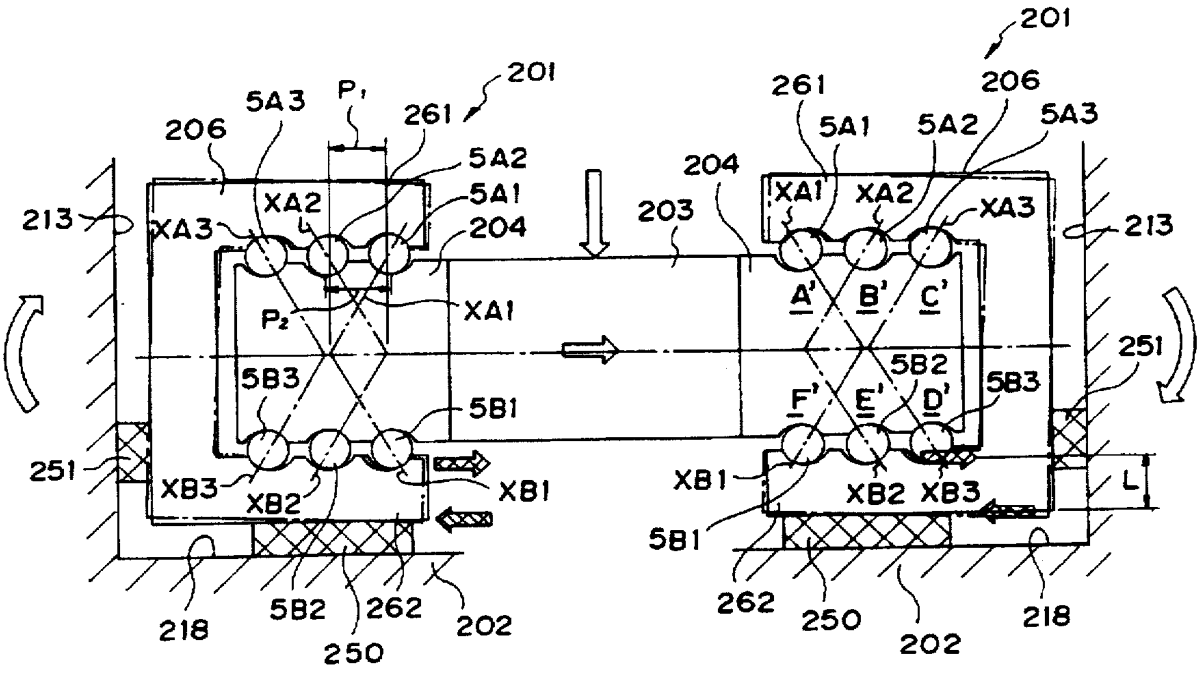

201
201
206
5A3
P1
261
5A2
5A1
204
213
XA3
XA2
XA1
P2
5B3
5B1
251
XB3
XB2
XB1
218
5B2
262
250
202
203
261
5A1
5A2
206
5A3
XA1
XA2
XA3
A'
B'
C'
F'
E'
D'
5B2
5B3
XB1
XB2
XB3
5B1
L
262
250
202
218

FIG. 14

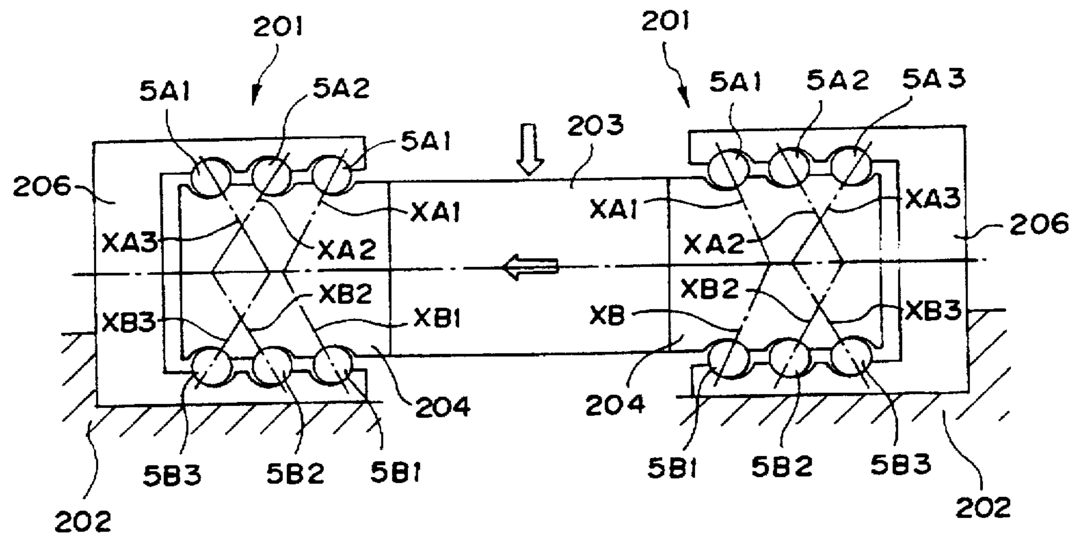

201
201
5A1
5A2
5A1
203
5A1
5A2
5A3
206
XA1
XA1
XA3
XA3
XA2
XA2
206
XB2
XB2
XB3
XB1
XB
XB3
204
204
5B3
5B2
5B1
5B1
5B2
5B3
202
202

FIG. 15

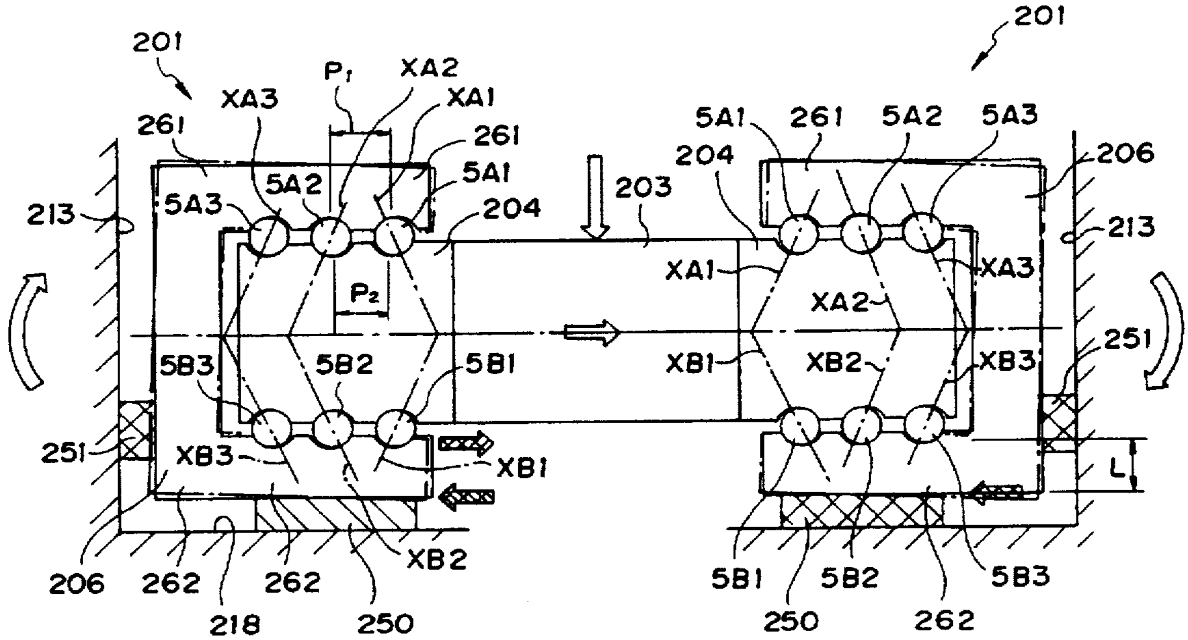

201
201
XA3
P1
XA2
XA1
261
261
5A2
5A1
5A3
204
203
213
P2
5B3
5B2
5B1
XB1
XB3
251
206
262
262
218
250
XB2
5A1
261
5A2
5A3
206
XA1
XA2
XA3
XB1
XB2
XB3
5B1
5B2
5B3
L

FIG. 16

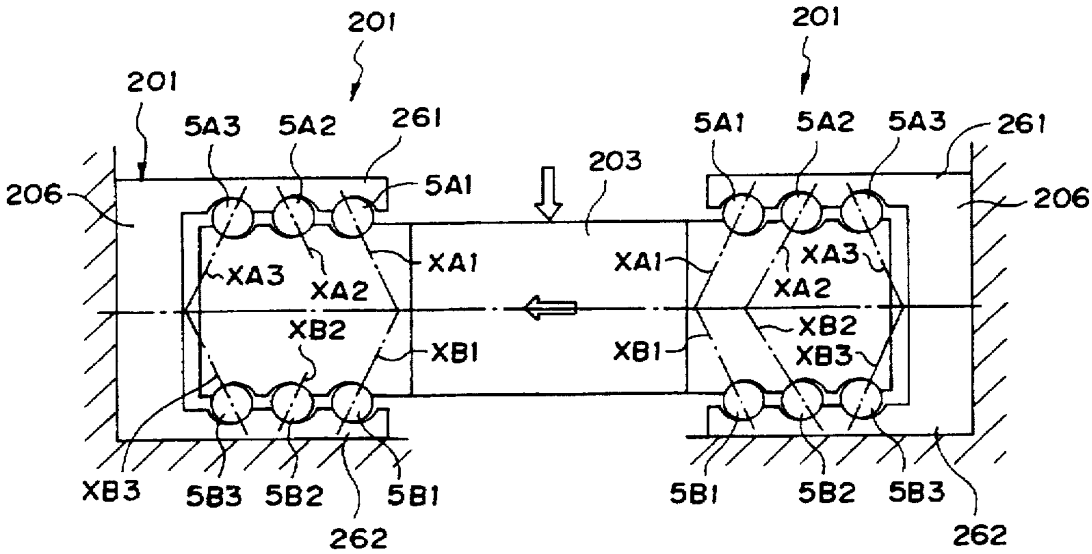

201
201
201
206
5A3
5A2
261
5A1
203
XA1
XA3
XA2
XB2
XB1
XB3
5B3
5B2
5B1
262
5A1
5A2
5A3
261
206
XA1
XA3
XA2
XB1
XB2
XB3
5B1
5B2
5B3
262

FIG. 17

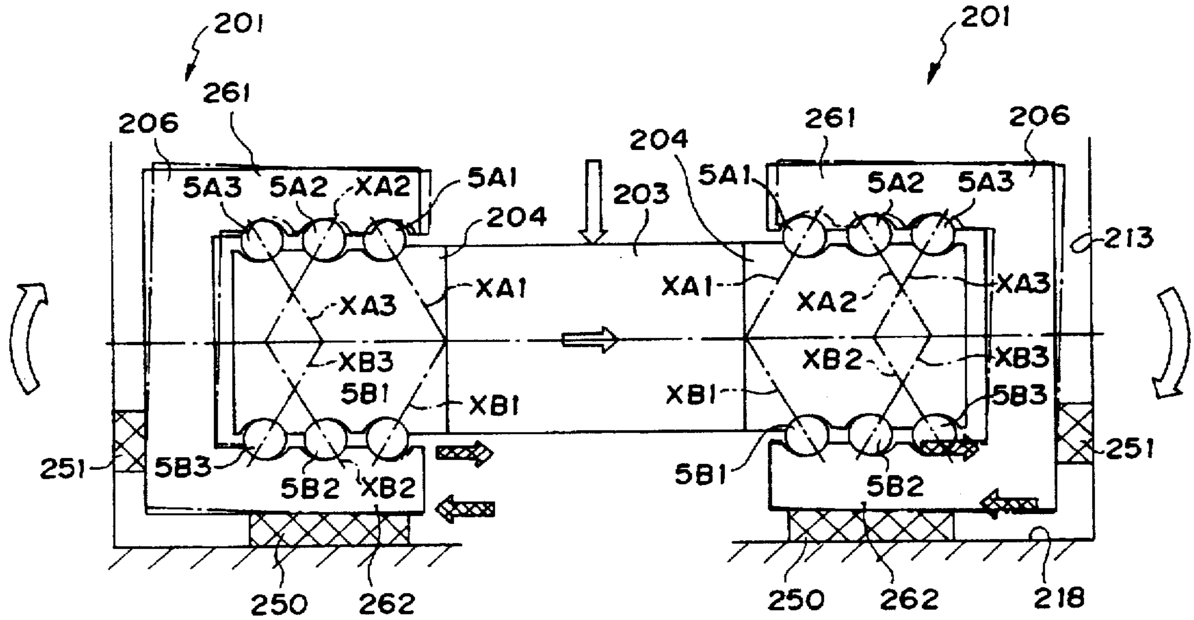

201
201
261
206
206
261
204
5A1
5A3
5A2
XA2
5A1
5A2
5A3
203
204
213
XA1
XA1
XA3
XA2
XA3
XB3
XB2
XB3
5B1
XB1
XB1
5B3
251
251
5B3
5B1
5B2
XB2
5B2
250
262
250
262
218

FIG. 18

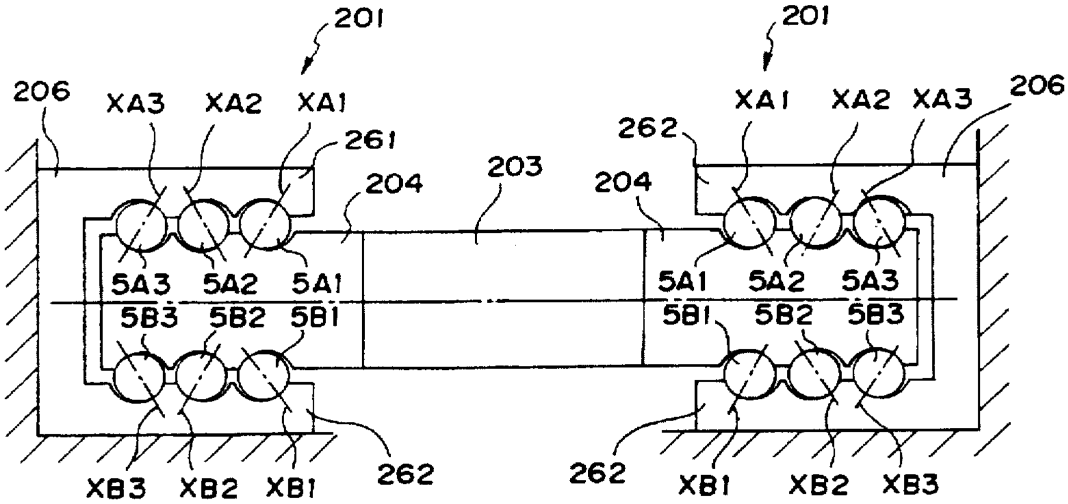

201
201
206
XA3
XA2
XA1
XA1
XA2
XA3
206
261
262
203
204
204
5A3
5A2
5A1
5A1
5A2
5A3
5B3
5B2
5B1
5B1
5B2
5B3
262
262
XB3
XB2
XB1
XB1
XB2
XB3

FIG. 19

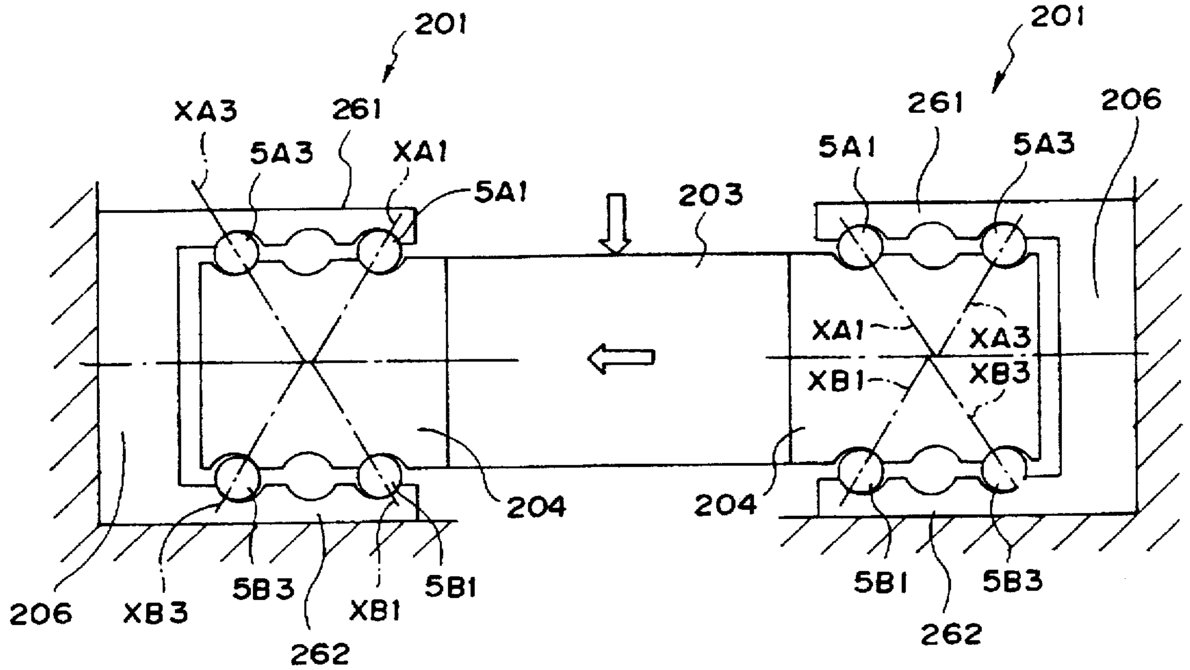

201
XA3
261
5A3
XA1
5A1
203
206
5A1
5A3
XA1
XA3
XB1
XB3
204
204
206
XB3
5B3
XB1
5B1
262
5B1
5B3
262

FIG. 20

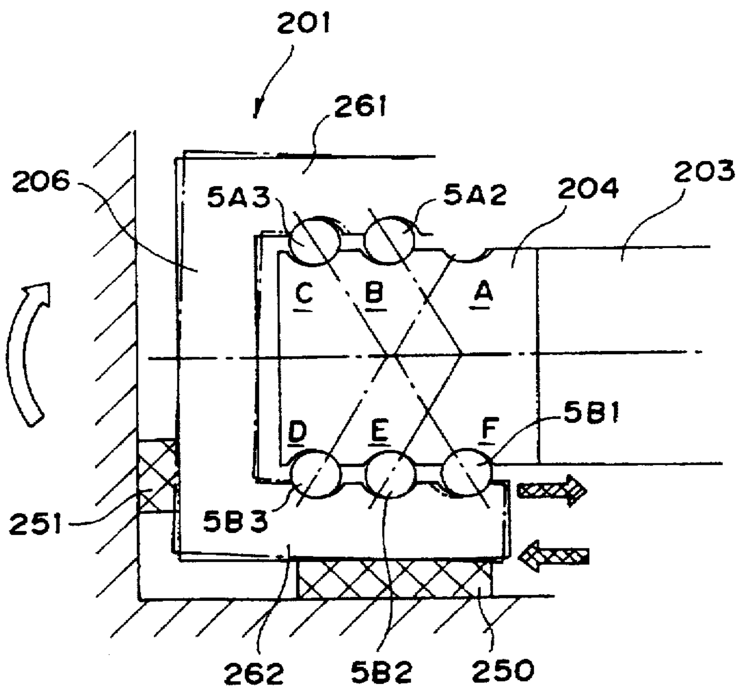

201
261
206
5A3
5A2
204
203
C
B
A
D
E
F
5B1
251
5B3
262
5B2
250

FIG. 21

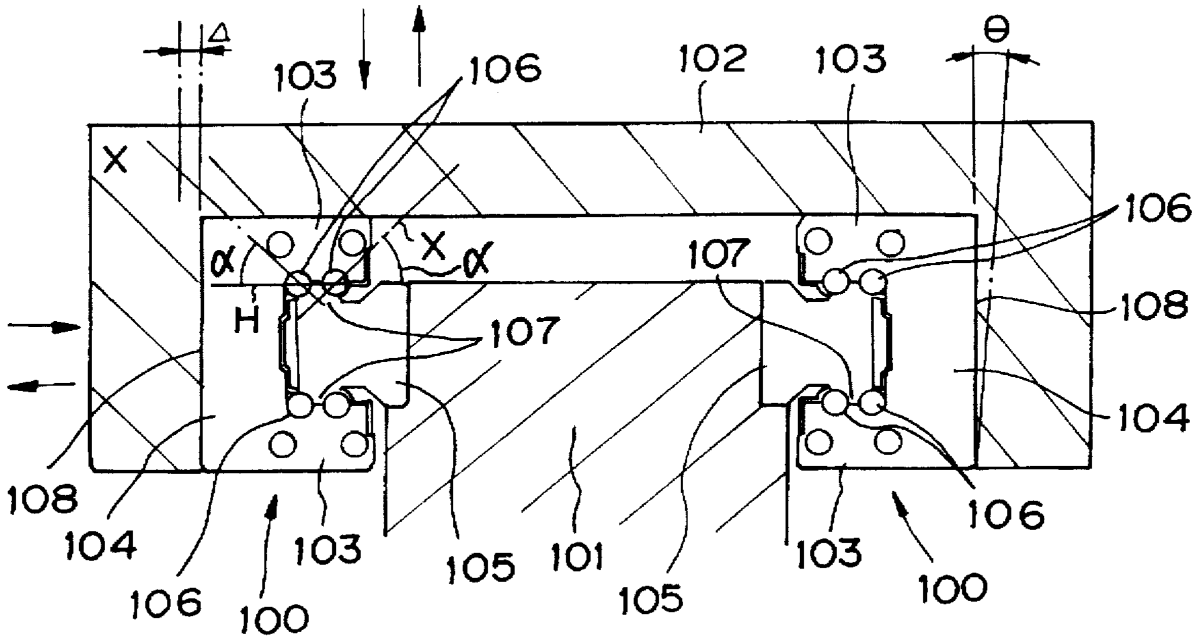


FIG. 22 PRIOR ART

ROLLING GUIDE UNIT

BACKGROUND OF THE INVENTION

The present invention relates to a rolling guide unit of rolling contact type linear or curved, such as circular, guide passage, particularly capable of being excellent in misalignment adjustment performance.

As a known example of such rolling guide unit, there is provided an example shown in FIG. 22 in which a rolling guide unit **100** is disposed so as to guide a table **102** with respect to a fixed base **101**.

The rolling guide unit **100** is assembled in a manner that a movable member **104** having a U-shape in cross section is provided with a pair of upper and lower support portions **103** extending in a lateral direction, i.e. longitudinal direction of the movable member, and upper and lower surfaces of a guide rail disposed in the U-shaped hollow portion of the movable member **104** are supported by the support portions through upper and lower two rows of balls **106**. In general, high rigidity is required for such rolling guide unit, and in the known art, the rigidity in every direction including vertical and horizontal directions is made high by applying a preload to the balls **106** and forming projecting ribs **107** to the upper and lower side surfaces of the guide rail **105** so as to project therefrom thereby to clamp the ribs **107** by the respective two rows of the balls **106** from the upper and lower directions thereof. Particularly, in the illustrated example, in order to equally support the load in every direction, a contact angle α of a line X connecting contacting points of the ball **106** to two ball rolling grooves with respect to a virtual horizontal line is set to 45°.

The known rolling guide unit of the type shown in FIG. 22, however, has high rigidity, and accordingly, when a working error, for example, an angular error θ and a dimensional error Δ in the horizontal direction, is caused to a mounting surface of the movable member **104**, a misalignment is caused between the guide rail **105** and the movable member **104** at the time of clamping and fixing the rolling guide unit between the table **102** and the fixed base **101**. Such misalignment constitutes a cause of an application of excessive force to the movable member **104**, resulting in the increasing of a sliding resistance and abrasion of the balls **106** and the ball rolling grooves, thus providing a problem.

Such misalignment will be avoided by increasing the working performance of the respective members of the rolling guide unit. However, the increasing of the working performance has a limit itself and involves cost increasing.

In the meantime, the misalignment will be somewhat reduced by making small the preload to be applied to the balls **106**, but the high rigidity of the rolling guide unit will be reduced by making small the preload to be applied. As mentioned above, the requirement of the high supporting rigidity is contrary to the reduction of the misalignment of the members, and hence, in the prior art construction, it is difficult to satisfy both the requirements for the realization of the high rigidity and the less misalignment.

SUMMARY OF THE INVENTION

An object of the present invention is to substantially eliminate defects or drawbacks encountered in the prior art described above and to provide a rolling guide unit capable of absorbing misalingment in a horizontal direction while maintaining vertical rigidity of the unit and also maintaining an allowable load bearing ability.

This and other objects can be achieved according to the present invention by providing a rolling guide unit comprising:

- a movable member provided with a main body portion and a pair of support portions extending from lateral end portions of the main body portion so as to provide a recessed portion between the central portion and both the support portions, the support portions having inner surfaces to which rolling member rolling grooves are formed;
- a guide rail disposed in the recessed portion of the movable member so that side surfaces of the guide rail face the inner surfaces of the support portions, respectively, the side surfaces of the guide rail being formed with rolling member rolling grooves at portions corresponding to the rolling member rolling grooves of the support portions, respectively; and
- a number of rolling members disposed to be rollable between the corresponding rolling member rolling grooves of the guide rail and the support portions of the movable member so that each of the rolling members contact the rolling member rolling grooves at two contact points and the the rolling members apply load to the rolling member rolling grooves, the movable member and the guide rail being relatively movable through the rolling of the rolling members,
- wherein each of the rolling member rolling grooves has an arcuate shape in section having radius of curvature larger than that of the rolling member and the contact points are displaceable along the arcuate shape of the rolling member rolling groove.

In preferred embodiments, the rolling member is a ball and each of the rolling member rolling grooves has a depth of approximately ¼ to ½ of a diameter of the ball.

A plurality of rolling member rolling grooves are formed at least one of the side surfaces of the guide rail and at least corresponding one inner surface of the support portion of the movable member.

An initial contact angle constituted by a line connecting the two contact points of the rolling members to the rolling member rolling grooves and a horizontal line passing a center of the rolling member is set substantially 90°.

A plurality of rolling member rolling grooves are formed at least one of the side surfaces of the guide rail and at least corresponding one inner surface of the support portion of the movable member, and an initial contact angle constituted by a line connecting the two contact points of the rolling members in at least one of the plurality of rolling member rolling grooves to this rolling member rolling groove and a horizontal line passing a center of the rolling member is set so as to have an inclination by a predetermined angle with respect to the angle of substantially 90°. All the rolling members disposed in the plurality of rolling member rolling grooves have contact angles inclined in the same direction or in directions reverse to each other.

A plurality of rolling member rolling grooves are formed at least one of the side surfaces of the guide rail and at least corresponding one inner surface of the support portion of the movable member, and the rolling members disposed in at least one of the plurality of rolling member rolling grooves are formed as tubular members and the rolling member rolling groove in which the tubular members are rolled is formed so as to provide a flat groove bottom. The rolling member rolling grooves for the tubular members are formed to the inner surfaces of the support portions so as to provide a groove bottom shape corresponding to an outer shape of the tubular member and the side surfaces of the guide rail for the tubular members are formed to be flat. Three rows of the rolling member grooves are formed and a central one is formed for the tubular members.

The guide rail has substantially rectangular cross section and is bent in a curved shape or has substantially linear shape.

Retainer means are disposed between the facing inner surfaces of the support portions of the movable member and the side surfaces of the rail guide.

The support portions are integrally formed with the main body portion of the movable member. The support portions may be independently formed with the main body portion of the movable member and the support portions are fixed to the main body portion of the movable member by means of bolts. The support portions have extending lengths different from each other and the numbers of rows of the rolling members of the respective support portions are different from each other.

According to the structures and characters of the rolling guide unit according to the present invention described above, the vertical load is born by the rolling members disposed between the upper and lower, as viewed in the illustrations of the drawings, support portions of the movable member and the guide rail. Particularly, in an arrangement in which the initial contact angle of the rolling member is set to approximately 90°, a vertical large load can be effectively born. When a horizontal load is applied, the contact points of the rolling member to the rolling member rolling groove are displaced to change the contact angle by the load balance between the vertical load and the horizontal, i.e. lateral, load, thereby to effectively bear both the loads.

With respect to the misalignment in the horizontal direction, the contact points of the rolling members are displaced along the arcuate shape of the rolling member rolling groove thereby to absorb the misalignment.

Since the rolling member rolling groove has an arcuate shape in section, the allowable load is represented by a sine function with a contact angle being variable. According to the present invention, the contact angle is set to a value near 90° about which the sine function shows a curve having a gentle variation, so that the allowable load varies small in amount even if the contact angle varies.

Since the depth of the rolling member rolling groove is set to a value approximately ¼ to ½ of the diameter of the rolling member such as ball, the ball does not contact the edge portions of the groove even if the contact points are displaced, and hence, the edge load is eliminated.

Furthermore, according to the present invention, the guide rail can be prevented from forming with a complicated cross section such as provided with projection ribs as in a conventional structure and the rolling member rolling grooves can be worked through a horizontal grinding working. Particularly, when the guide rail having a curved shape is formed, it can be formed so as to provide a simple rectangular shape, thus being uniformly bent.

In the case of contact angle of 90°, the contact points are displaced by the application of the horizontal load, and the variation of the contact points can be absorbed immediately by changing the initial contact angle in accordance with the load to be applied. The contact angle can be changed to an optional value by applying a horizontal load of predetermined amount, and for example, the horizontal load can be born by setting the contact angle to, for example, 30° or 45° in accordance with the load to be applied. In such case, since the contact points of the rolling member to the rolling member rolling groove can be displaceable, the misalignment can be effectively absorbed.

The nature and further characters of the present invention will be made more clear through the following descriptions made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 represents one embodiment of a rolling guide unit according to the present invention, in which FIG. 1A is a cross-sectional view of the guide unit, FIG. 1B is a view showing a contacting condition of a ball to a ball rolling groove of FIG. 1A in an enlarged scale, and FIG. 1C is a view similar to FIG. 1B at a time when loads are applied to the ball in both horizontal and vertical directions as viewed;

FIG. 2 includes FIGS. 2A, 2B and 2C, in which FIG. 2A is a perspective view of a portion of a guide rail of the guide unit in FIG. 1A, FIG. 2B is a side view, partially broken away, of FIG. 2A, and FIG. 2C is a partial sectional view showing an assembled arrangement of a retainer;

FIG. 3 is an illustration of a support portion for a railway rolling stock to which the rolling guide unit of the present invention is applicable;

FIG. 4 includes FIGS. 4A and 4B, in which FIG. 4A is an illustration of an entire railway rolling stock to which the rolling guide unit of the present invention is applicable and FIG. 4B is an enlarged view of the rolling guide unit of FIG. 4A;

FIG. 5 includes FIGS. 5A, 5B and 5C, in which FIG. 5A is a view showing a condition of movement of a contacting point of the ball to the ball rolling groove, FIG. 5B is a sine function graph with the contact angle of the ball being variable, and FIG. 5C is a view in an enlarged scale at a point near the contact angle of 90° in FIG. 5B;

FIG. 6 includes FIGS. 6A to 6H for the explanatory of steps for absorption of misalignment by means of the rolling guide unit according to the present invention in this order;

FIG. 7 includes FIGS. 7A to 7C representing structures of other embodiments of the rolling guide unit according to the present invention;

FIG. 8 represents a further embodiment of the rolling guide unit according to the present invention, in which FIG. 8A is a side view thereof and FIGS. 8B to 8E show various types of rolling members;

FIG. 9 represents an embodiment of a rolling guide unit of linear guide type according to the present invention, in which FIG. 9A is a side view of the linear guide type rolling guide unit and FIG. 9B is a perspective view of a guide rail to which the guide unit of FIG. 9A is mountable;

FIG. 10 is a sectional view of a partial portion of another embodiment of the rolling guide unit in which a support structure is constructed as a separate member;

FIGS. 11A and 11B are schematic views showing the support structure of a movable member capable of increasing supporting rigidity both in the horizontal and vertical directions by utilizing the rolling guide unit according to the present invention;

FIG. 12 is a schematic view of the rolling guide unit representing one example of a tandem contact structure;

FIG. 13 is a schematic view, similar to that of FIG. 12, representing another example of the tandem contact structure;

FIG. 14 is a schematic view of the rolling guide unit representing one example of a DF type compound contact structure;

FIG. 15 is a schematic view representing another example of the DF type compound contact structure;

FIG. 16 is a schematic view of the rolling guide unit representing one example of a DB type compound contact structure;

FIG. 17 is a schematic view representing another example of the DB type compound contact structure;

FIG. 18 is a schematic view of the rolling guide unit representing one example of a compound contact structure of both the DF type and DB type;

FIG. 19 is a schematic view representing another example of the compound contact structure of both the DF type and DB type;

FIG. 20 is a schematic view showing a further example of the contact structure;

FIG. 21 is a schematic view showing a still further example of the contact structure; and

FIG. 22 is a cross sectional view of a table moving apparatus utilizing a rolling guide unit of conventional structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

It is first to be noted that the terms "upper" and "lower" used herein for the following respective embodiments or examples are made with reference to the corresponding illustrations of the accompanying drawings.

FIGS. 1 and 2 represent one embodiment of the present invention, and this embodiment will be preferably described hereunder with reference to an example of a rolling guide unit for guiding on a curved line a pendulum type vehicle such as railway rolling stock such as shown in FIGS. 3 and 4.

As shown in FIGS. 3 and 4, the rolling guide unit **1** is one usable for the curve guide for a vehicle body such as railway rolling stock, and a pair of such rolling guide units **1**, **1** are oppositely arranged for supporting the vehicle body **3** swingably on a bogie **2**. Each of the rolling guide unit **1** comprises as shown in FIGS. 1 and 2, a guide rail **4** and a movable member **6** assembled with the guide rail **4** so that the movable member **6** is movable along the guide rail **4** through rolling members **5** having a spherical outer shape such as balls.

The guide rail **4** has, as shown in FIG. 2A, rectangular section and is bent in an arcuate shape so as to provide a predetermined radius of curvature. The guide rail **4** has upper and lower (as viewed) side surfaces to which ball rolling grooves **7** are formed entirely therealong. The ball rolling grooves **7** are formed in three rows in the illustrated example on the upper and lower sides as shown in FIG. 2A. One row, two rows or more than three rows of the ball rolling grooves may be formed. The invention is not limited to the illustrated three-row arrangement.

Each of the ball rolling grooves **7** has an arcuate cross section having a radius of curvature larger than that of the ball **5** and has a depth of about ¼ to ½ of the diameter of the ball **5**.

The movable member **6** is formed of a block member provided with a pair of supporting portions **61** and **62** which extend sideway substantially perpendicularly from a central portion thereof so as to entirely provide a]-shaped cross section, and as shown in FIG. 2A, the movable member **6** is assembled with the guide rail **4** so that the supporting portions **61** and **62** are positioned on both the upper and lower sides of the guide rail **4** to be movable therealong. Each of the supporting portions **61** and **62** are formed with ball rolling grooves **8** corresponding to the ball rolling grooves **7** formed to the guide rail **4** in their positions and numbers. Each of the ball rolling grooves **8** also has an arcuate cross section having a radius of curvature larger than that of the ball **5** and has a depth of about ¼ to ½ of the diameter of the ball **5**.

When assembled, the balls **5** are disposed between these ball rolling grooves **7** and **8** each so as to contact at two points CP, in FIG. 1B or 1C, near groove bottoms thereof, and an angle α constituted by a line connecting these two contact points CP and a virtual horizontal line is set to approximately 90°. Accordingly, the contact points CP of the ball **5** is bilaterally displaceable with the position of contact angle α of 90° being the center of this displacement.

As shown in FIG. 2B, the movable member **6** comprises a main body **10** of the movable member **6**, having the supporting portions **61** and **62**, and side covers **12** mounted to front and rear end portions of the main body **10**. The movable member main body **10** is provided with return passages **9** in an unloaded region for circulating the balls **5** in addition to the ball rolling grooves **8**, **8**, and each of the side covers **12** is formed with a ball turning passage **11** for changing the ball rolling direction.

The left side, as viewed in FIG. 1A, surface of the movable member **6** is formed as a mounting surface **13** to which tap holes **14** for fixing bolts **13** are formed. The right side, as viewed in FIG. 1A, surface of the guide rail **4** is formed as a mounting surface **16** which is fixed by means of bolts, not shown. Seal members **15** are disposed to the gaps between the inside surfaces of the upper and lower supporting portions **61** and **62** of the movable member **6** and the upper and lower side surfaces of the guide rail **4**, and retainers **24** for holding the balls **5** are also disposed between these gaps as shown in FIG. 2C.

Preload is applied to the balls **5** by a suitable means.

In the rolling guide unit of the structure described above, load Fa applied in a vertical direction, as viewed in FIG. 1C, is born by three row of balls **5** having the initial contact angle of 90°. On the other hand, when a load Fb from the horizontal direction is born by the balls **5** having the displaced contact angle of α' at which the line X' connecting the contact points CP of the balls **5** to the ball rolling grooves **7** and **8** substantially accords with a direction of composite vector F of the vertical load Fa and the horizontal load Fb. In the thus manner, the vertical and horizontal loads are applied to the balls **5** at the displaced contact angle α'.

In this embodiment, since the ball rolling grooves **7** and **8** are formed so as to provide the arcuate cross sections and the ball contact angle α is set to approximately 90°, variation of allowable load is small even if the contact angle α be changed.

That is, the allowable load will be expressed as follows.

$$Co=f(Da \cdot z \cdot i \cdot \sin \alpha)$$

Da: diameter of ball

z: number of balls

i: number of ball rows

α: contact angle (90° in the perpendicular case)

As shown in FIG. 5B, the allowable load is expressed as sine function. A sine curve varies gently, as shown in FIG. 5C, at a portion near 90°, and the sine function value is 1 at the contact angle α of 90°; 0.998 of 87°; 0.996 of 85°; and 0.992 even of 83°. This means that even if the contact angle varies in the range of 90°±7°, the reduction ratio of the allowable load is less than 1%, being very small, and of course, the displacement of the allowable contact angle can be properly selected.

In addition, since the depth h of the ball rolling grooves 7 and 8 are made deep as mentioned hereinbefore, the ball 5 does not contact the edge E of the ball rolling groove 7 as shown in FIG. 5A even if the contact points CP are displaced, thus preventing the edge load from occurring. The depth h of the groove is determined in consideration of the edge load, but it is preferred to set the depth h to approximately ¼ to ½ of the diameter of the ball 5.

The misalignment absorbed according to the present invention basically corresponds to displacement of the guide rail and the movable member in the horizontal direction, and it is possible to absorb the following misalignments as shown in FIG. 6: (1) a misalignment in the rotating direction about the central axis of the guide rail 4 (MC direction in FIG. 6A); a misalignment in the rotating direction reversely changing the front and rear end portions of the movable member 6 (MA direction in FIG. 6C); and a misalignment in the direction displacing the movable member 6 in the horizontal direction (Z direction in FIG. B) .

The above misalignements are caused by, for example, a working error of the mounting surface of the movable member 6 as shown in FIG. 3 and an error caused by an angular error θ or dimensional error Δ in the horizontal direction. In addition, an error in degree of parallelism of the bilateral guide rails 4, 4 and an excessive clamping of the fastening bolt may also cause the misalignments.

FIGS. 6D to 6H represent the change of the contact angles in the absorption of the misalignments. FIG. 6D represents a position at which the initial contact angle α of 90° being the reference value preliminarily set, FIGS. 6E and 6F represent a position at which the misalignment in the MC direction is absorbed and the contact angle is displaced in a direction reverse to the rotating direction, and FIGS. 6G and 6H represent a position at which the misalignment in the Z direction is absorbed and the contact angle is displaced in a direction reverse to the first displaced direction.

In the meantime, when the misalignment in the MC direction is absorbed, the front and rear end portions of the movable member 6 are displaced in the horizontal direction reverse to each other, and the contact angle of the ball 5 positioned at the front and rear end portions of the movable member 6 are displaced in directions reverse to each other as shown in FIGS. 6G and 6H.

As discussed above, since the contact angle is initially set to approximately 90°, it is not necessary as in the conventional technology for the guide rail to be formed with complicated structure having a projection, and since the ball rolling groove 7 can be ground by a horizontal grinding technique, the guide rail can be easily manufactured. In the case where a plurality of ball rolling grooves 7 are formed, they can be formed with high performance of a pitch between adjacent ones. Furthermore, since the grinding allowance is constant along the entire length of the guide rail 4 and hence is easily measured, the ball rolling grooves 7 can be worked so as to provide a smooth finishing surface with high performance.

Particularly, when the guide rail 4 is formed to provide a curved line shape, since it is not necessary to form the guide rail with the projected rib 107, and the guide rail is formed so as to provide a simple rectangular shape, a plastical deformation in a bending working can uniformly progress with substantially no camber, thus being easily manufactured, and accordingly, the grinding allowance in the finishing working can be minimally suppressed, thus being effective in production.

FIG. 7 represents other embodiments of the present invention.

FIG. 7A shows an embodiment, in which the upper end surface 17 of the movable member 6 and the lower end surface 18 of the guide rail 4 are formed as mounting surfaces of the movable member 6 and the guide rail 4, respectively, and these members are fastened each by means of single fixing bolt 19 in the vertical direction as viewed. In the structure of FIG. 7B, two fixing bolts 19 are utilized respectively for the movable member 6 and the guide rail 4, respectively. In the embodiment of FIG. 7C, two fixing bolts 19 are utilized for the movable member 6 and single fixing bolt 19 is utilized for the guide rail 4. The numbers of rows of the balls 5 are different between the upper side surface and the lower side surface of the guide rail, and in the illustrated embodiment, three ball rows are formed on the upper side surface of the guide rail 4 and two ball rows are formed on the lower side surface thereof.

FIG. 8 represents a further embodiment of the present invention, which has a basic structure essentially identical to that of the embodiment shown in FIG. 1 and only has a different point that the balls rolling along the central ball rolling groove 7 in FIG. 1 are substituted with cylindrical rollers 20 rolling along a rolling groove 21.

In accordance with this structural difference, the roller rolling groove 21 for the rollers 20 formed to the inside surfaces of the supporting portions 61 and 62 of the movable member 6 is formed so as to provide a rectangular cross section so as to accord with the shape or the cylindrical roller 20. The bottom of the groove 21 is made flat accordingly. On the other hand, any roller rolling groove for the rollers 20 is not formed to the upper and lower side surfaces of the guide rail 4 and the upper and lower surfaces thereof are directly utilized for the roller rolling surface as they are.

According to this structure of the embodiment of FIG. 8, the rollers 20 can move in the horizontal direction along the upper and lower side surfaces of the guide rail 4, and hence, the misalignment in the horizontal direction can be absorbed by the embodiment of FIG. 1. In addition, according to this embodiment of FIG. 8, a larger load in the vertical direction can be born in comparison with the structure of the embodiment of FIG. 1, thus being more advantageous.

Furthermore, the misalignments in the horizontal (Z) direction and the MA direction of the kind shown in FIGS. 6B and 6C can be absorbed in the same manner as described with reference to the embodiment of FIG. 1, and the misalignment in the MC direction shown in FIG. 6A does not constitutes a problem since the rollers 20 are positioned at the central portion of the guide rail side surface and the displacement of the roller 20 is hence small in comparison with the bilateral side ones.

However, since there may be a slight fear of causing the edge load at the end portion of the roller 20, a crowning treatment will be effected to the edge portion 21 as shown in FIG. 8C, or barrel shaped roller having a central portion swelled in section such as shown in FIG. 8D may be utilized, as occasion demands. In the case where the barrel shaped rollers 20 are utilized, it is necessary to form the roller rolling groove so as to provide an arcuate cross section having a radius of curvature larger than that of the barrel roller 20.

In a modification, the barrel shaped rollers 20 or spherical, partially cut away, rollers 23 shown in FIG. 8E may be utilized in substitution for the ball rollers 5.

In the forgoing description, the embodiments of the curved line guiding structure were provided, the present invention is not limited to such curved line guiding structure and it can be applied as it is to the rolling guide units 1A for the linear guiding structure as shown in FIG. 9. That is, in comparison with the curved line guiding structure, the curved guide rail 4 is constructed to a linear guide rail 4A and the respective ball rolling grooves are formed linearly so as to accord with the linear guide rail 4A, and the other structure is the same as that of the former embodiment.

Furthermore, in the first described embodiment, the supporting portions 61 and 62 are formed integrally to the central portion of the movable member 6, but these portions may be independently formed as shown in FIG. 10, for example. That is, the supporting portion 61 is fixed to the main body 63 (FIG. 10) of the movable member 6 by a fastening means 64 such as bolt. Both these portions or either one of these portions may be independently formed from the main body 63 of the movable member 6.

In the present invention, the horizontal gap is formed between the ball and the ball rolling grooves for absorbing the misalignment of the ball. However, this gap may be eliminated by applying a horizontal preload, and in such arrangement, the horizontal supporting rigidity will be increased.

FIG. 11 shows an example increasing the horizontal supporting rigidity.

Referring to the example of FIG. 11, a movable table 31 is movably supported by a fixed table 30 through a pair of opposing rolling guide units 1, 1, and the movable table 31 is formed with skirt portions 32 and 33, as supporting portions, extending downward, as viewed, from both the bilateral ends thereof. The paired rolling guide units 1, 1 are mounted between the inner surfaces of the skirt portions 32 and 33 and the outer side surfaces of the fixed table 30.

In order to apply a preload to the structure shown in FIG. 11A, in one example, a preload adjusting bolt 34 may be screwed to one of the skirt portion 32, for example, thereby to push the side surface of one of the rolling guide unit 1 against the guide rail 4 fixed to the fixed table 30, whereby the horizontal gap between the balls 5 and the ball rolling grooves 7 and 8 is eliminated, thus applying the horizontal preload in a state shown in FIG. 11B. In a modification, a tapered wedge member, for example, not shown, may be inserted forcibly into the gap between the facing surfaces of the skirt portion 32 and the movable member 6 of the rolling guide unit 1, thus also applying the horizontal preload.

That is, when one of the movable members 6 of the rolling guide unit 1 is pressed through one 32 of the skirt portions of the movable table 31 by, for example, the preload adjusting bolt 34, a reaction force of the pressing force is transferred to the other one 33 of the skirt portions through the movable table 31, and then, the other movable member 6 of the other rolling guiding unit 1 is pressed against the guide rail 4, fixed to the fixed table 30 through the other skirt portion 33. Through this preload applying process, in the illustration of FIG. 11A, the contact angles a of the upper and lower balls in the right rolling guide unit 1 are displaced such that the upper ball 5R1 is rotated clockwisely from the initial contact angle 90° position and the lower ball 5R2 is rotated counterclockwisely therefrom. On the other hand, the contact angles α of the upper and lower balls in the left rolling guide unit 1 are also displaced such that the upper ball 5L1 is rotated counterclockwisely from the initial contact angle 90° position and the lower ball 5L2 is rotated clockwisely therefrom. In the thus manner, the horizontal gap between the respective balls 5 can be eliminated.

In the assumption that lines connecting the contact points of the respective balls 5R1, 5R2 5L1 and 5L2 and the ball rolling grooves 7 and 8 into which theses balls disposed constitute contact angle lines XR1, XR2, XL1 and XL2, upper and lower these contact angle lines in the right and left

rolling guide units 1, 1 are inclined outward of the guide units as shown in FIG. 11A.

According to the arrangement of the ball contact angles, the supporting rigidity in the vertical direction can be improved as well as that in the horizontal direction.

Therefore, according to the rolling guide unit of the present invention, the supporting structure having improved load bearing performance in the vertical and horizontal directions, i.e. every direction, can be realized as well as achieving the misalignment absorbing performance.

FIGS. 12 to 21 represent various examples each having such a contact angle structure as mentioned above of a plurality of ball rows, typically through examples of the upper and lower three ball rows.

FIG. 12 shows an example of tandem type, which has the respective upper and lower three rows, total six rows, of balls and the contact angles in the same directions as in the example of FIG. 11.

That is, as like in FIG. 3, a vehicle body 203 is movably supported by a bogie 202 through a pair of rolling guide units 201, 201. The paired rolling guide units 201, 201 have guide rails 204, 204 opposing to each other on the inner side, vehicle body side, thereof and movable members 206, 206 opposing to each other on the outer side thereof such that the inner side surfaces of the guide rails 204, 204 are fixed to the mounting surface of the vehicle body 203 and the outer side surfaces and the lower surfaces of the movable members 206, 206 are fixed to stepped mounting portions 202A, 202A formed to the bogie 202.

Each of the stepped portions 202A, 202A has an L-shaped cross section having a horizontal mounting surface 218 to which the lower side surface of the movable member 206 is fixed and a perpendicular mounting surface 213 to which the outer side surface of the movable member 206 is fixed.

Each of the movable members 206, 206 has substantially a]-shaped cross section having a pair of upper and lower supporting portions 261 and 262 extending in a horizontal direction as viewed in FIG. 12, and each of the guide rails 204, 204 having substantially rectangular cross section is fitted into a]-shaped recessed portion of the corresponding movable member 206 from the horizontal direction.

The balls as rolling members in respectively three rows are rollably disposed between the facing surfaces of the upper and lower supporting portions 261 and 262 and the guide rails 204, 204. Supposing that the upper and lower respectively three rows of balls are referred to as upper first, second and third balls 5A1, 5A2 and 5A3 and lower first, second and third balls 5B1, 5B2 and 5B3 from the inner side to the outer side as in the illustration of FIG. 12, these upper and lower balls have the same diameters and are arranged linearly symmetrically respectively with respect to a horizontal axis H passing the center of the guide rails 204, 204.

The upper first, second and third balls 5A1, 5A2 and 5A3 and the lower first, second and third balls 5B1, 5B2 and 5B3 are rollablY disposed between upper first, second and third ball rolling grooves 207A1, 208A1; 207A2, 208A2; 207A3, 208A3, and the lower first, second and third ball rolling grooves 207B1, 208B1; 207B2, 208B2; 207B3, 208B3 of the upper and lower supporting portions 261, 262 of the movable member 206 and the corresponding upper and lower side surfaces of the guide rails 204.

In such example of tandem type structure, the upper first, second and third ball rolling grooves 207A1, 208A1; 207A2, 208A2; 207A3, 208A3 formed to the upper supporting portion 261 and the upper side surface of the guide rail 204 are formed so as to provide the same phases and pitches as those of the lower first, second and third ball rolling grooves

207B1, 208B1; 207B2, 208B2; 207B3, 208B3 formed to the lower supporting portion 262 and the lower side surface of the guide rail 204. In a free arrangement of the balls, the initial contact angles of the upper first, second and third balls 5A1, 5A2 and 5A3 and lower first, second and third balls 5B1, 5B2 and 5B3 are made to substantially 90°.

In the illustrated example, the outer side surface of the movable member 206 of one of the rolling guide units 201 is pressed against the guide rail 204 mounted to the vehicle body side by means of a preload adjusting bolt such as shown in FIG. 6 or by using a tapered wedge member thereby to eliminate the horizontal gap between the balls 5A1 . . . , 5B1 . . . and the ball rolling grooves 207A1, 208A1; 207B1, 208B1 . . . , whereby a horizontal preload is applied, thereby inclining the balls by a predetermined angle with respect to the initial contact angle 90° to the ball rolling grooves.

That is, the ball contact angles α of the upper first, second and third balls 5A1, 5A2 and 5A3 of the right side rolling guide unit 201 are displaced clockwisely in the illustration from the initial contact angle 90°, and the ball contact angles α of the lower first, second and third balls 5B1, 5B2 and 5B3 of the right side rolling guide unit 201 are displaced counterclockwiselY in the illustration from the initial contact angle 90°. On the contrary, with respect to the upper and lower balls 5 of the left side rolling guide unit 201, the contact angles have linear symmetric arrangement with respect to the central perpendicular line between the right and left side rolling guide units 201, 201, and the contact angles of the upper first, second and third balls 5A1, 5A2 and 5A3 are displaced in the counterclockwisely in the illustration and the contact angles of the lower first, second and third balls 5B1, 5B2 and 5B3 are displaced clockwisely. In thus manner, the horizontal gaps of the respective balls can be eliminated, and the contact angle lines XR1, XR2, XR3 and XL1, XL2, XL3 of the upper and lower balls of the right and and left side rolling guide units 201 are inclined to be opened outward.

As described above, the example of FIG. 12 represents the tandem type structure which has the respectively upper and lower three rows, total six rows, of balls having the contact angles in the same direction. In a modified example, as shown in FIG. 13, the inclination of the contact angle lines may be set in directions reverse to those of FIG. 12.

That is, referring to FIG. 13, the contact angle lines XR1, XR2, XR3 and XL1, XL2, XL3 of the upper and lower balls of the right and and left side rolling guide units 201 are inclined to be opened inward. A structure having such contact angle arrangement will be easily realized by applying a force in the direction to outwardly draw out the movable member from the guide rail 204.

The basic structure of such tandem type example is identical to that shown in FIG. 6 in which the single row of balls are disposed at each of upper and lower sides, and accordingly, a moment load caused by the mounting error and eccentric load are not born, so that any inner load is not caused by such moment, thus being advantageous. That is, when the moment load MC acts, the movable member is moved in an inclined state in the direction of an arrow in FIG. 13.

Furthermore, according to this example, even in a case where the degree of parallelism between two axes of the respective guide rails are out of order, only the ball contact point varies and no forcible force acts on the balls, thus absorbing a geometric distortion of the parallelism between the axes of the guide rails.

Loads in the vertical and horizontal directions may be easily uniformly born.

According to the arrangement of the ball contact angles described above, the supporting rigidity in the horizontal direction can be improved as well as in the vertical direction. Accordingly, the rolling guide unit of these examples, the misalignment of the balls can be absorbed as well as realizing the support structure having high load bearing ability in the horizontal and vertical, i.e. every, directions in its use.

FIGS. 14 to 19 represent other examples of compound contact type structure in which the ball contact structure of respectively upper and lower three rows of balls is adapted such that at least one pair of balls of the upper or lower side rows have contact angles inclined reversely to each other. In such a compound contact type structure, the moment load caused by the mounting error or eccentric load can be born by one movable member.

As the basic structures of these examples are substantially identical to that of FIG. 12, the same reference numerals are added to members or portions corresponding to those of FIG. 12 and the descriptions thereof are omitted herein, and only the direction of the contact angle is referred to hereunder.

Elastic members 250 and 251 made of such as rubber material are interposed between the horizontal mounting surface 218 of the mounting stepped portion of the bogie and the lower side surface of the movable member 206, that is, between the perpendicular mounting surface 213 and the outer side surface of the movable member 206 for the purpose of absorbing the mounting error or the like. Of course, these mounting surfaces may be directly secured without interposing such elastic members 250 and 251.

In the example of FIG. 14, the contact angle lines are symmetrically inclined by predetermined angles with respect to the initial angle 90° so that the contact angle lines XA1 and XA2 of the upper first and second balls 5A1 and 5A2 are opened upward in the illustration and the contact angle lines XB1 and XB2 of the lower first and second balls 5B1 and 5B2 are opened downward. The contact angle line XA3 of the upper third ball 5A3 and the contact line XB3 of the lower third ball 5B3 are set in parallel to the contact angle lines XA2 and XB2 of the upper and lower second balls 5A2 and 5B2, respectively.

Such ball contact structure will be realized, for example, by setting a pitch P1 between the upper and lower first ball rolling grooves 207A1 and 207B1 and the upper and lower second ball rolling grooves, 207A2 and 207B2 of the upper and lower supporting portions 261 and 262 to be smaller than a pitch P2 between the upper and lower first ball rolling grooves 208A1 and 208B1 and the upper and lower second ball rolling grooves 208A2 and 208B2 of the guide rails 204, and also setting a pitch between the upper and lower second ball rolling grooves 207A2 and 207B2 and the upper and lower third ball rolling grooves 207A3 and 207B3 of the upper and lower supporting portions 261 and 262 to be equal to a pitch between the upper and lower second ball rolling grooves 207A2 and 207B2 and the upper and lower third ball rolling grooves 207A3 and 207B3 of the guide rails 204.

As described above, by adopting the ball contact structure of a pair of angular contact arrangement, the gap can be adjusted and the initial contact angle is made stable at the time of assembling the guide rail 204 and the movable member 206.

FIG. 15 shows an example in which an angle between the upper and lower contact angle lines are opened outward, in which an angle of the contact angle lines XA2 and XA3 of the upper second and third balls 5A2 and 5A3 and an angle of the contact angle lines XB2 and XB3 of the lower second and third balls 5B2 and 5B3 are opened outward.

In the example of FIG. 16, the contact angle lines are symmetrically inclined by predetermined angles with respect to the contact angle of 90° so that an angle between the contact angle line XA1 and XA2 of the upper first and second balls **5A1** and **5A2** is opened inward toward the inner guide rail **204**, and an angle between the contact angle line XB1 and XB2 of the lower first and second balls **5B1** and **5B2** is opened inward toward the inner guide rail **204**. On the other hand, the contact angle lines XA3 and XB3 of the upper and lower third balls **5A3** and **5B3** are set to be substantially parallel to the contact angle lines XA2 and XB2 of the upper and lower second balls **5A2** and **5B2**, respectively.

Such ball contact structure will be realized, for example, by setting a pitch P1 between the upper and lower ball rolling grooves **207A1** and **207B1** and the lower second ball rolling grooves **207A2** and **207B2** of the upper and lower supporting portions **261** and **262** to be larger than a pitch P2 between the upper and lower first ball rolling grooves **208A1** and **208B1** and the upper and lower second ball rolling grooves **208A2** and **208B2** of the guide rails **204**, and also setting a pitch between the upper and lower second ball rolling grooves **207A2** and **207B2** and the upper and lower third ball rolling grooves **207A3** and **207B3** of the upper and lower supporting portions **261** and **262** to be equal to a pitch between the upper and lower second ball rolling grooves **207A2** and **207B2** and the upper and lower third ball rolling grooves **207A3** and **207B3** of the guide rails **204**.

FIG. 17 shows an example in which an angle between the upper and lower contact angle lines are opened inward, in which an angle of the contact angle lines XA2 and XA3 of the upper second and third balls **5A2** and **5A3** and an angle of the contact angle lines XB2 and XB3 of the lower second and third balls **5B2** and **5B3** are opened inward.

Examples of FIGS. 18 and 19 shows an arrangement in which angles between respectively adjacent contact angle lines XA1, XA2, XA3, XB1, XB2 and XB3 are opened alternately outward and inward.

That is, FIG. 18 shows an example in which angles between the contact angle lines XA1 and XA2 of the upper first and second balls **5A1** and **5A2** and between the contact angle lines XB1 and XB2 of the lower first and second balls **5B1** and **5B2** are opened inward, and angles between the contact angle lines XA2 and XA3 of the upper second and third balls **5A2** and **5A3** and between the contact angle lines XB2 and XB3 of the lower second and third balls **5B2** and **5B3** are opened outward.

FIG. 19 shows an example in which angles between the contact angle lines XA1 and XA2 of the upper first and second balls **5A1** and **5A2** and between the contact angle lines XB1 and XB2 of the lower first and second balls **5B1** and **5B2** are opened outward, and angles between the contact angle lines XA2 and XA3 of the upper second and third balls **5A2** and **5A3** and between the contact angle lines XB2 and XB3 of the lower second and third balls **5B2** and **5B3** are opened inward.

In these examples, the numbers of ball rows, the numbers of the balls in each ball row, and the ball diameter are optionally selected in accordance with a load to be applied. For example, regarding the numbers of the ball rows, as shown in FIG. 20, two ball rolling grooves corresponding to the upper and lower first and third balls **5A1**, **5A3** and **5B1**, **5B3**.

Furthermore, the contact structure of the respective balls of the upper and lower supporting portions **261** and **262** are made linearly symmetrical with respect to the horizontal axis, it is not always necessary to adapt the linear symmetric structure, and as shown in FIG. 21, in accordance with the load to be applied, an arrangement different in ball rows may be adapted such that two rows of the second and third balls **5A2** and **5A3** are formed on the upper side and three rows of the first, second and third balls **5B1**, **5B2** and **5B3** are formed on the lower side.

Further, it is to be noted that, in the above respective embodiments or examples, the rolling guide units are referred to for the guide support mechanism of a railway rolling stock, but the present invention is not limited to such specific utilization and many other applications may be adapted for guide mechanisms of, for example, various industrial robots or the like.

What is claimed is:

1. A rolling guide unit comprising:

a movable member provided with a main body portion and a pair of upper and lower support portions extending from lateral end portions of the main body portion so as to provide a recessed portion between the main body portion and both the support portions, said support portions having inner surfaces to which rolling member rolling grooves are formed;

a guide rail disposed in the recessed portion of the movable member so that upper and lower side surfaces of the guide rail face the inner surfaces of the support portions, respectively, the upper and lower side surfaces of said guide rail being formed with rolling member rolling grooves at portions corresponding to the rolling member rolling grooves of the upper and lower support portions, respectively, and

a number of rolling members disposed to be rollable between the corresponding rolling member rolling grooves of said guide rail and said upper and lower portions of the movable member so that each of the rolling members contact the rolling member rolling grooves at two contact points and the rolling members apply load to the rolling member rolling grooves, said movable member and the guide rail being relatively movable through the rolling of the rolling members,

wherein each of said rolling member rolling grooves has an arcuate shape cross section having radius of curvature larger than that of the rolling member and the contact points are displaceable along the arcuate shape of the rolling member rolling groove; and

wherein a plurality of rolling member rolling grooves are formed in at least one of the upper and lower side surfaces of the guide rail and at least one corresponding inner surface of the support portions of the movable member, and at least one pair of said plurality of rolling members have contact angles inclined in directions reverse to each other with respect to an initial contact angle of 90°.

2. A rolling guide unit assembly which comprises a first member and a second member disposed in an opposing arrangement to the first member to be relatively movable along the first member through a pair of rolling guide units arranged to bilateral side surfaces of said first member,

said pair of rolling guide units comprising:

guide rails respectively secured to both side surfaces of said first member;

a movable member secured to said second member disposed so as to oppose bilateral side surfaces of said guide rails and having a pair of upper and lower support portions extending along lateral side portions thereof by which the guide rails are clamped at upper and lower side surfaces thereof; and a number of rolling members disposed rollably in rolling member rolling grooves formed in the upper and lower side surfaces of the guide rails and opposing surfaces of the upper and lower support portions of the movable member in a manner facing correspondingly,

wherein each of said rolling member rolling grooves has a circular section having a curvature larger than a radius of each of the rolling members so that the rolling members are movable along the circular shape of the rolling member rolling grooves, a plurality of rolling member rolling grooves are formed at least one of the upper and lower side surfaces of the guide rail, and the contact angles of a plurality of rolling members disposed on the upper side surface or the lower side surface are bilaterally symmetrical and have at least a pair of inclinations reversely inclined to each other with respect to the rolling guide units, respectively.

3. A rolling guide unit comprising:

a movable member provided with a main body portion and a pair of upper and lower support portions extending from lateral end portions of the main body portion so as to provide a recessed portion between the main body portion and both the support portions, said support portions having inner surfaces to which rolling member rolling grooves are formed;

a guide rail disposed in the recessed portion of the movable member so that upper and lower side surfaces of the guide rail face the inner surfaces of the support portions, respectively, the upper and lower side surfaces of said guide rail being formed with rolling member rolling grooves at portions corresponding to the rolling member rolling grooves of the upper and lower support portions, respectively; and

a number of rolling members disposed to be rollable between the corresponding rolling member rolling grooves in said guide rail and said upper and lower support portions of the movable member so that each of the rolling members contact the rolling member rolling grooves at two contact points and the rolling members apply load to the rolling member rolling grooves, said movable member and the guide rail being relatively movable through the rolling of the rolling members,

wherein each of said rolling member rolling grooves has an arcuate shape cross section having a radius of curvature larger than that of the rolling member and the contact points are displaceable along the arcuate shape of the rolling member rolling groove;

wherein an initial contact angle formed between a line connecting the two contact points on the rolling members to the rolling member rolling grooves and a horizontal line passing through a center of the rolling member is set to substantially 90°;

wherein a plurality of rolling member rolling grooves are formed at least on one of the upper and lower side surfaces of the guide rail and at least one corresponding inner surface of the support portions of the movable member, and the rolling members disposed in at least one of the plurality of rolling member rolling grooves are formed as cylindrical members and the rolling member rolling groove in which the cylindrical members are rolled is formed so as to provide a flat groove bottom; and

wherein three rows of the rolling member grooves are formed and a central one is formed for the cylindrical members.

4. A rolling guide unit assembly which comprises a first member and a second member disposed in an opposing arrangement to the first member to be relatively movable along the first member through a pair of rolling guide units arranged to bilateral side surfaces of said first member,

said pair of rolling guide units comprising:

guide rails respectively secured to both side surfaces of said first member;

a movable member secured to said second member disposed so as to oppose to bilateral side surfaces of said guide rails and having a pair of upper and lower support portions extending along lateral side portions thereof by which the guide rails are clamped at upper and lower side surfaces thereof; and

a number of rolling members disposed rollably in rolling member rolling grooves formed in the upper and lower side surfaces of the guide rails and opposing surfaces of the upper and lower support portions of the movable member in a manner facing correspondingly,

wherein each of said rolling member rolling grooves has a circular section having a curvature larger than a radius of each of the rolling members so that the rolling members are movable along the circular shape of the rolling member rolling grooves, and

wherein each of the guide rails of the paired rolling guide units has a cross section substantially rectangular and bent to provide an arcuate portion and said guide rails support the first member relatively swingable with respect to the second member.

5. A rolling guide unit assembly which comprises a first member and a second member disposed in an opposing arrangement to the first member to be relatively movable along the first member through a pair of rolling guide units arranged to bilateral side surfaces of said first member,

said pair of rolling guide units comprising:

guide rails respectively secured to both side surfaces of said first member;

a movable member secured to said second member disposed so as to oppose to bilateral side surfaces of said guide rails and having a pair of upper and lower support portions extending along lateral side portions thereof by which the guide rails are clamped at upper and lower side surfaces thereof; and

a number of rolling members disposed rollably in rolling member rolling grooves formed in the upper and lower side surfaces of the guide rails and opposing surfaces of the upper and lower support portions of the movable member in a manner facing correspondingly,

wherein each of said rolling member rolling grooves has a circular section having a curvature larger than a radius of each of the rolling members so that the rolling members are movable along the circular shape of the rolling member rolling grooves,

wherein each of the guide rails of the paired rolling guide units has a cross section substantially rectangular and bent to provide an arcuate portion and said guide rails support the first member relatively swingable with respect to the second member, and

wherein said first member is a pendulum type vehicle and said second member is a railway rolling stock which is swingably supported by the vehicle.

6. A rolling guide unit assembly which comprises a first member and a second member disposed in an opposing arrangement to the first member to be relatively movable along the first member through a pair of rolling guide units arranged to bilateral side surfaces of said first member,

said pair of rolling guide units comprising:

guide rails respectively secured to both side surfaces of said first member;

a movable member secured to said second member disposed so as to oppose to bilateral side surfaces of said guide rails and having a pair of upper and lower support portions extending along lateral side portions thereof by which the guide rails are clamped at upper and lower side surfaces thereof; and

a number of rolling members disposed rollably in rolling member rolling grooves formed in the upper and lower side surfaces of the guide rails and opposing surfaces of the upper and lower support portions of the movable member in a manner facing correspondingly,

wherein each of said rolling member rolling grooves has a circular section having a curvature larger than a radius of each of the rolling members so that the rolling members are movable along the circular shape of the rolling member rolling grooves,

wherein each of the guide rails of the paired rolling guide units has a cross section substantially rectangular and bent to provide an arcuate portion and said guide rails support the first member relatively swingable with respect to the second member; and

wherein said first member is fixed to a pendulum type vehicle and said second member is fixed to a pantograph.

* * * * *

US005487609A

United States Patent [19]

Asada

[11] Patent Number: 5,487,609

[45] Date of Patent: Jan. 30, 1996

[54] SLIDE UNIT FOR LINEAR MOTION

[75] Inventor: **Makoto Asada**, Kurokawa, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **339,280**

[22] Filed: **Nov. 8, 1994**

Related U.S. Application Data

[63] Continuation of Ser. No. 961,721, filed as PCT/JP92/00610, May 13, 1992, abandoned.

[30] **Foreign Application Priority Data**

May 13, 1991 [JP] Japan .... 3-042344 U

[51] **Int. Cl.**^{6} **F16C 29/06**

[52] **U.S. Cl.** **384/18**; 384/45

[58] **Field of Search** 384/45, 44, 43, 384/18; 464/168

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,527,842 7/1985 Teramachi 384/45

FOREIGN PATENT DOCUMENTS

58-95481 12/1984 Japan .
61-48009 10/1986 Japan .
62-42126 10/1987 Japan .

Primary Examiner—Lenard A. Footland
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

In a linear motion slide unit, it is usable under a heavy load with high precision, or in a light load, an over-stroke amount can be made large. The linear motion slide unit comprises an elongated inner rail having high rigidity, a pair of outer rails attached to be reciprocally movable in an axial direction of the inner rail, and linear motion guides of endless track type structure disposed to be slidable with respect to the inner rail and fixed to the outer rails. A bearing body of the linear motion guide has also high rigidity, and accordingly, the balls mounted inside the endless track is applied with a large preload.

10 Claims, 5 Drawing Sheets

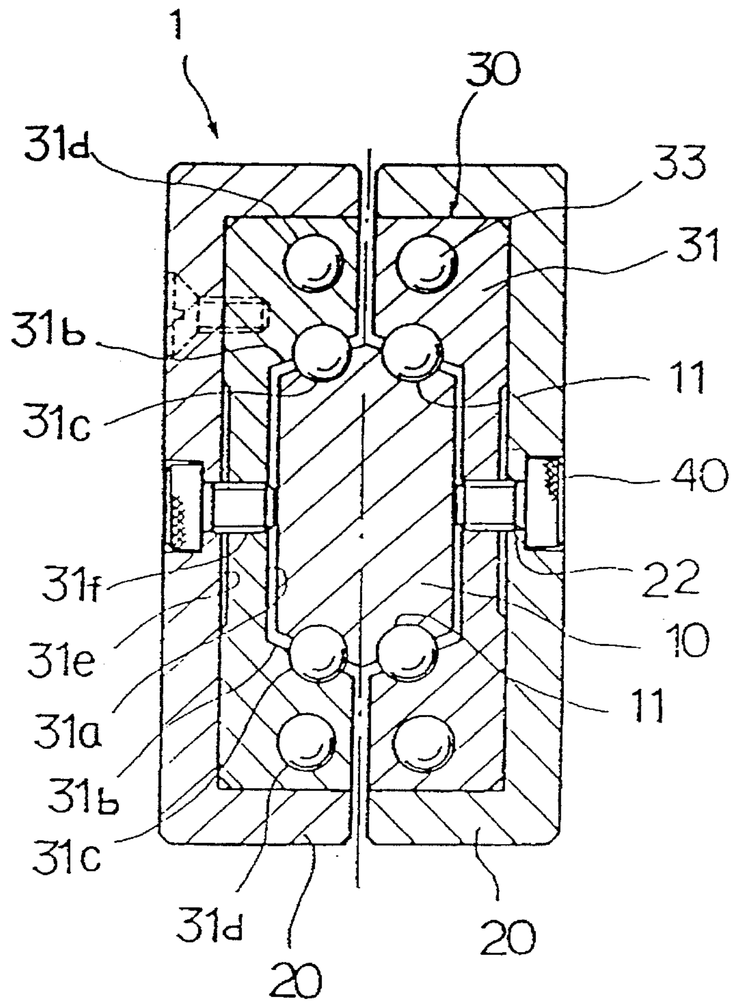


FIG. 1

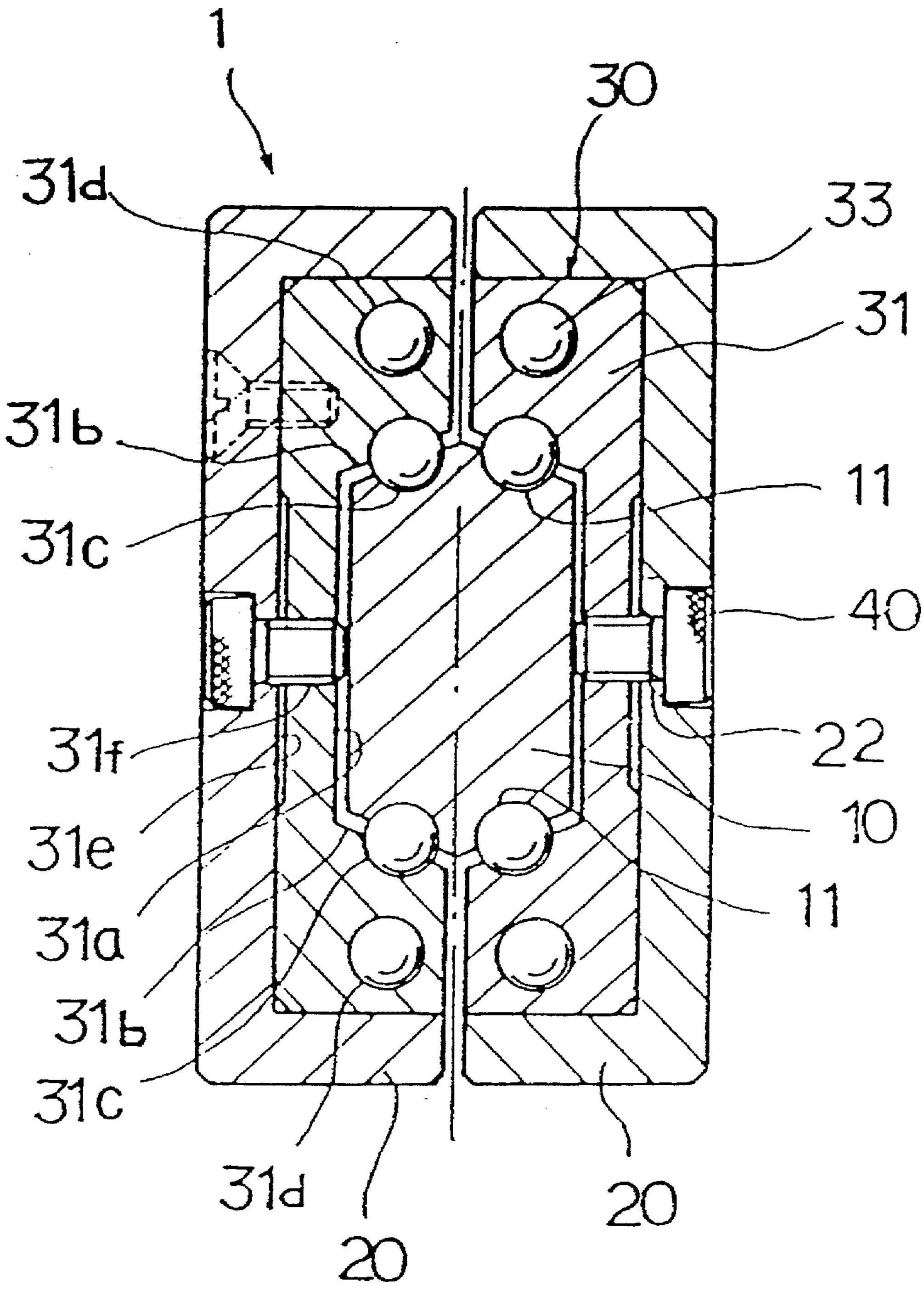

1
30
31d
33
31
31b
11
31c
40
31f
22
31e
10
31a
11
31b
31c
31d
20
20
20

FIG. 2

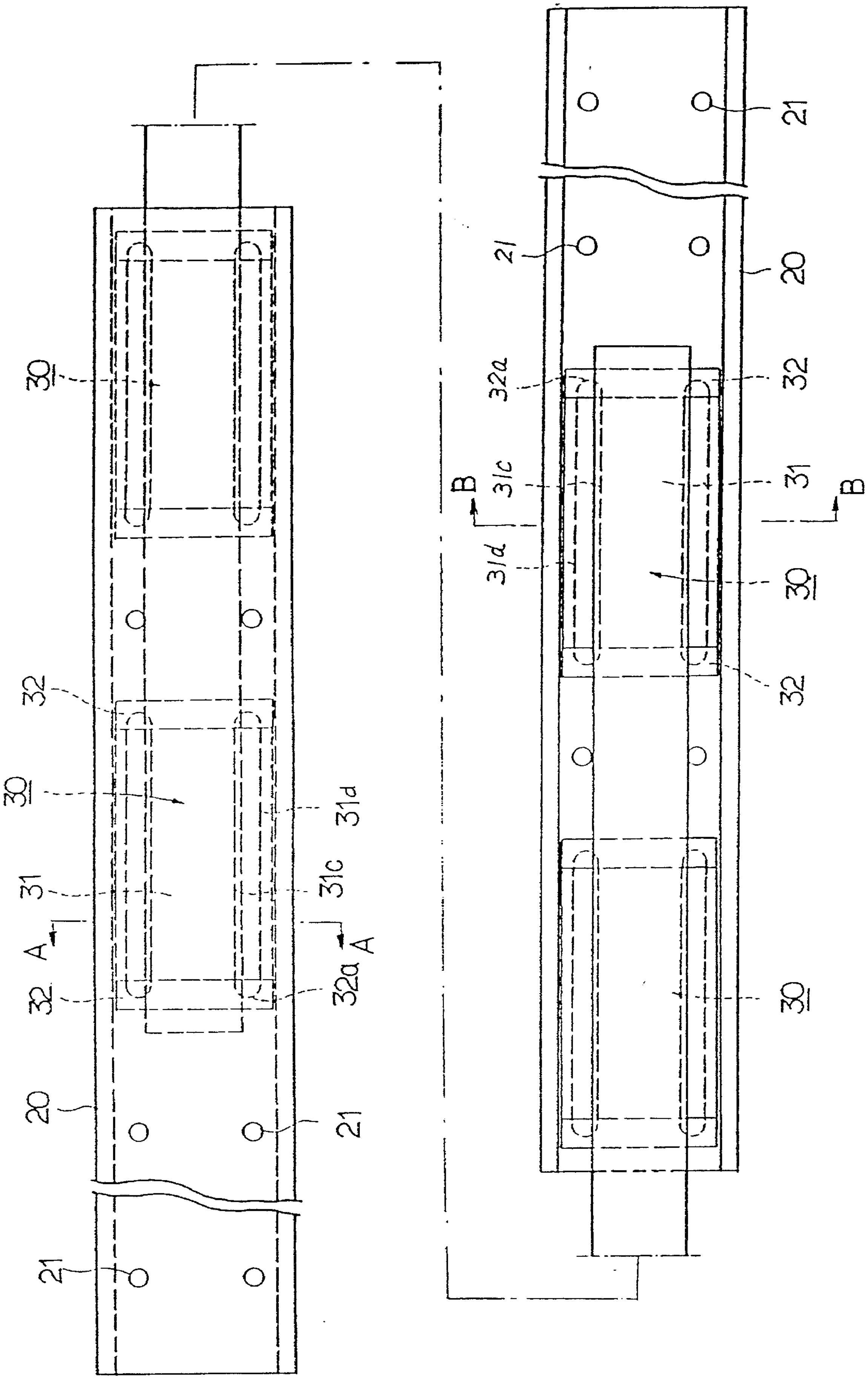


FIG. 3

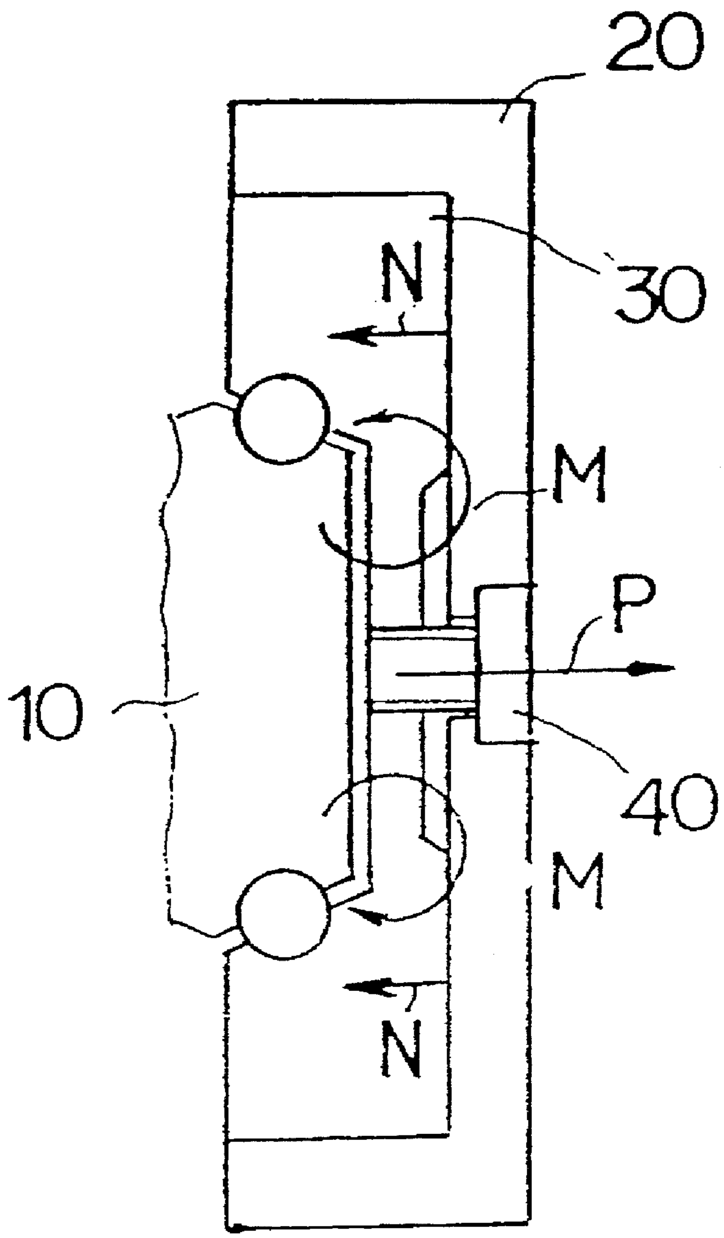


FIG. 4

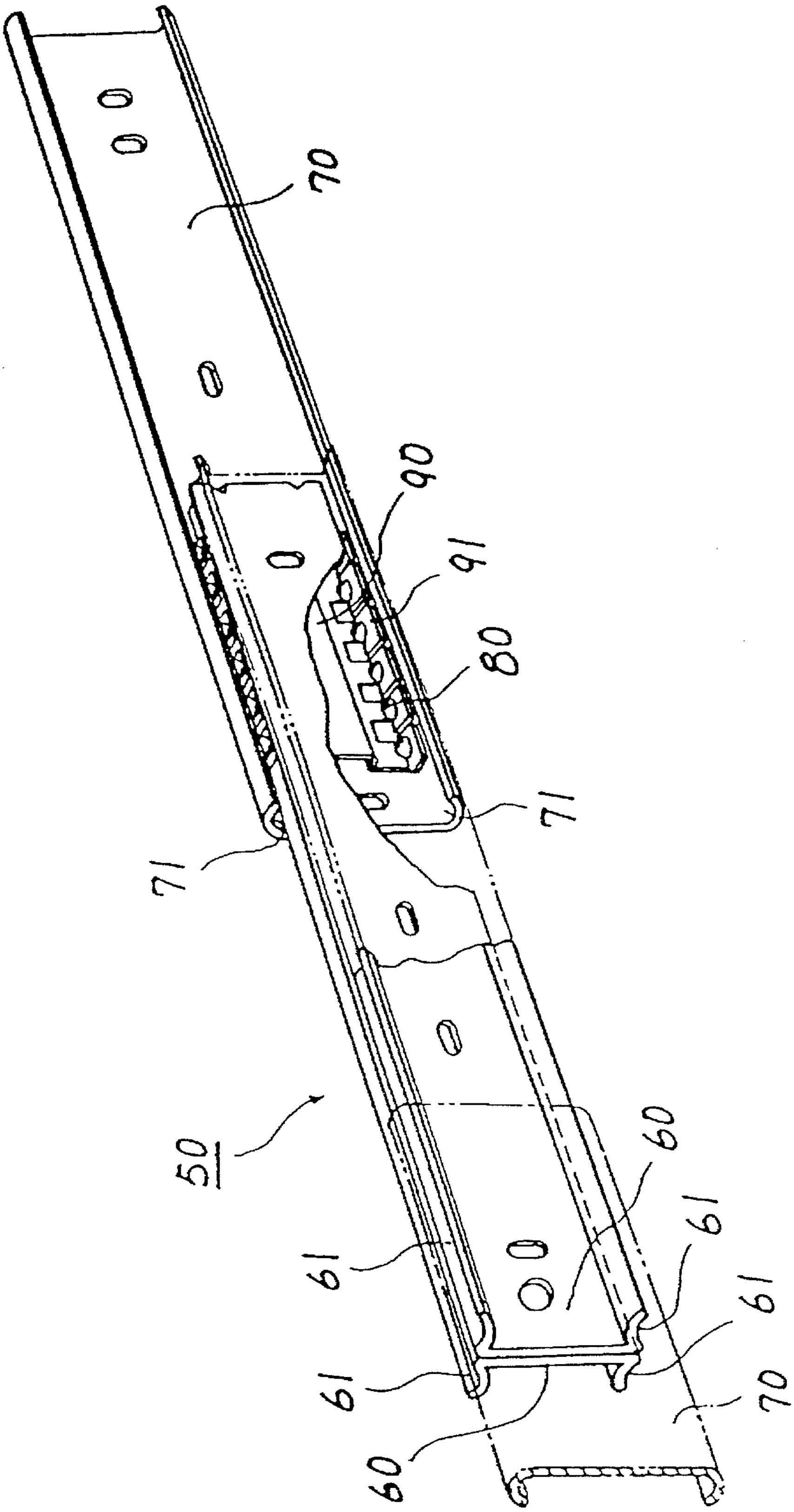


FIG. 5(a)

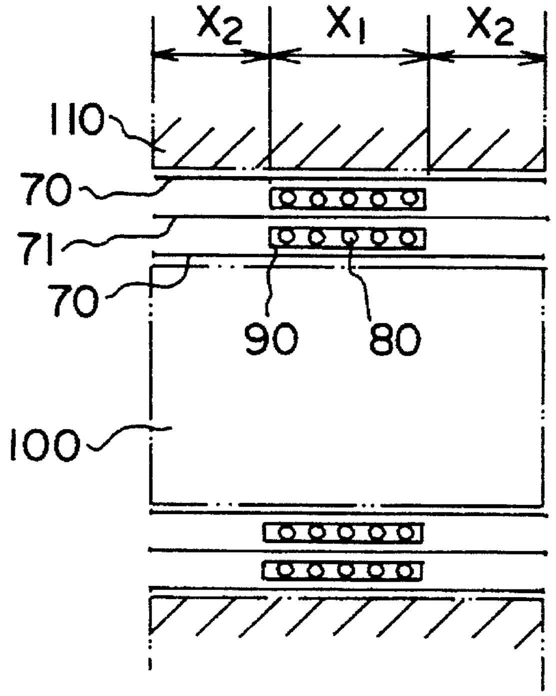
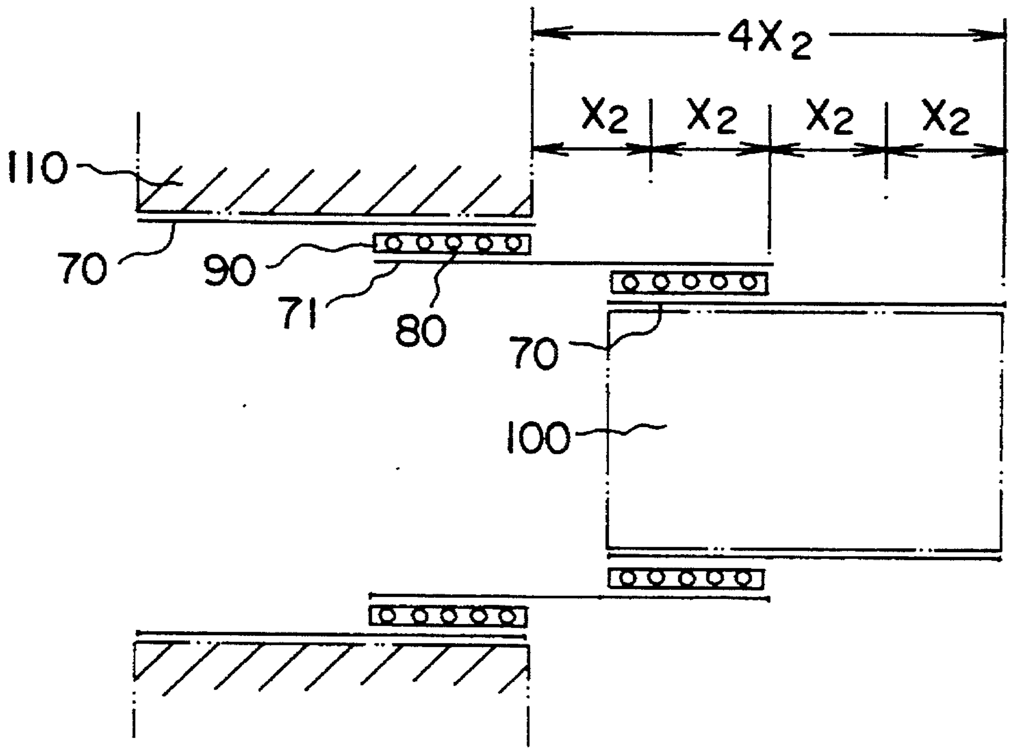


FIG. 5(b)



SLIDE UNIT FOR LINEAR MOTION

This application is a continuation of application Ser. No. 07/961,721 filed as PCT/JP92/00610, May 13, 1992, now abandoned.

TECHNICAL FIELD

This invention relates to a slide unit for a linear motion to be used for a slide portion such as a drawer, and more particularly to a linear motion slide unit with high performance for a heavy load.

BACKGROUND TECHNOLOGY

In office tables, peripheral devices for computers, copying machines, measuring instruments, telecommunication equipments, medical instruments, various office equipments, and the like, slide portions are utilized by over-stroking them over entire lengths of rails.

A slide unit for linear motion is utilized as a mechanical element for smoothly and precisely performing such sliding operation of the slide portion.

FIG. 4 represents a typical one example of a slide unit **50** for the linear motion of a conventional structure.

The linear motion slide unit **50** is generally composed of a pair of inner rails **60**, **60** secured back to back to each other, a pair of outer rails **70**, **70** attached to the inner rails **60**, **60** respectively to be axially reciprocal, a number of balls **80** interposed between corresponding inner and outer rails **60** and **70** in rolling contact to the rails, and a retainer **90** for holding the balls **80** in a predetermined positional relationship.

The inner and outer rails **60** and **70** are formed of steel plates subjected to a precise roll-forming process, and these rails **60** and **70** are formed with ball rolling grooves **61**, **61** and **71**, **71** on upper and lower surfaces thereof so as to oppose to each other.

The retainer **90** is formed with a number of holes **91** corresponding in numbers to the balls **80** and, hence, since the balls **80** are arranged with equal spaces with each other always, respectively, the balls **80** are free from the mutual friction, thus obtaining a smooth sliding mechanism.

Then, a case where such linear motion slide unit **50** is applied to a slide portion of a drawer of, for example, an office table will be described hereunder.

One of the paired outer rails **70** is fastened to a body **110** of the office table by means of bolt or the like and the other one of the rails **70** is fastened to a side surface of the drawer **100** of the office table by means of bolt or the like. A possible extending length of the drawer **100** is determined to be equal to an over-stroke amount of the other one of the outer rails **70** with respect to one of the outer rails **70**. As shown in FIG. **5**(*a*), it is assumed that the linear motion slide unit **50** be composed of a portion X_1 in which a number of balls **80** are disposed and both side slidable portions X_2. As shown in FIG. **5**(*b*), when the drawer is fully drawn out, the front end of the other one of the outer rails **70** can be drawn out from the front end of one of the outer rails **70** by an amount four times of the length of the portion X_2. Accordingly, the over-stroke amount of the linear motion slide unit **50** is made long as the length of the portion X_2 is possibly extended, and in other words, as the length of the portion X_1, is possibly made short.

In the slide unit **50** for the linear motion, since the balls **80** are held always with equal space between adjacent ones by the retainer **90** formed by a precise pressing operation, the balls are free from the mutual friction and can be rolled smoothly.

However, in recent years, there has been required to utilize such kind of linear motion slide unit for a sliding portion on which a heavy load is applied. The described linear motion slide unit **50** is not suitable for the heavy load, and therefore, development of a linear motion slide unit capable of withstanding the heavy-load has been required.

In the case of requiring an increased over-stroke amount, as described above, the length of the portion X_1, will be shorten. However, in the conventional linear motion slide unit, less number of balls **80** are utilized or less amount of a preload is applied in the present technology in this art, so that there is a limit for making short the length of the portion X_1.

DISCLOSURE OF THE INVENTION

This invention aims to solve the problems of the prior art described above and to provide a slide unit for linear motion capable of withstanding a heavy load with high precision.

This invention is characterized by comprising an elongated inner rail, a pair of outer rails attached to be reciprocally movable in an axial direction of the inner rail and linear motion guides supported slidable with respect to the inner rail through a number of rolling members and secured to the paired outer rails, the linear motion guides being formed with endless tracks in which the rolling members are endlessly circulated.

The linear motion guides comprise a bearing body provided with rolling member rolling grooves opposing to rolling member rolling grooves formed to the inner rail and return passages for non-loaded rolling members and a pair of side covers secured to both end surfaces of the bearing body and provided with rolling member returning grooves connecting the opposing rolling member rolling grooves of the bearing body and the return passages for the non-loaded rolling members to thereby constitute endless tracks.

It is preferred that the bearing body is a block member having a U-shaped cross section having a central recessed portion into which the inner rail is inserted, and rolling member rolling grooves are formed to the bilateral inner side surfaces of the central recessed portion so as to oppose to those formed to the opposing surfaces of the inner rail.

In addition, it is preferred that the inner rail and the bearing body are formed of a material having high rigidity and a preload is applied to the rolling members.

Furthermore, it is preferred that each of the linear motion guides is provided with a preload adjustment mechanism for adjusting the preload to be applied to the rolling members.

Still furthermore, each of the preload adjusting mechanisms provided for the linear motion guide is characterized by comprising a recessed portion for adjustment formed to the central portion of a surface to which the outer rail of the bearing body is fixed and an adjustment bolt screwed in a screw hole bored to the bottom surface of the preload adjustment recessed portion through a through hole formed to the outer rail, and in that the adjustment recessed portion is pulled towards the outer rails by fastening the adjustment bolt, a moment is caused to the bearing body by this pulling force in a direction narrowing a gap between bilateral inner side surfaces of the central recessed portion to thereby apply the preload to the rolling members, and an amount of the preload of the rolling members is made adjustable in accordance with the fastening force of the adjustment bolt.

Since the endless track is formed, it is possible to increase in number the rolling members withstanding the load, thus withstanding the heavy load. Furthermore, the rigidity of the linear motion guide can be improved by applying the preload to the rolling members mounted in the endless track, and accordingly, the rigidity of the slide unit for the linear motion can be improved.

Since the linear motion guide having such endless track is utilized, the load withstanding ability to the heavy load can be increased, and in the case of the over-stroke under the heavy load, the slide unit can be utilized without causing a gap between the respective members, and that is, in the case of the heavy load, precise and smooth sliding motion can be achieved.

Furthermore, in the case of the light load, the effective length of the linear motion guide can be shortened, and accordingly, the amount of the over-stroke can be made large.

Particularly, by applying the preload to the rolling members, the load withstanding ability against the heavy load can be improved, so that a more large preload can be applied by constituting the inner rail and the bearing body by a member having high rigidity.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1** and **2** represent a linear motion slide unit according to one embodiment of this invention, in which righthand half of the linear motion slide unit of FIG. **1** is a view taken along the line A—A of FIG. **2** and a lefthand half thereof is a view taken along the line B—B in FIG. 2, and FIG. **2** is a front view, partially eliminated, of the linear motion slide unit.

FIG. **3** is an illustration for the explanatory of the preload adjustment.

FIG. **4** is a perspective view of a conventional linear motion slide unit, partially omitted.

FIG. **5** is a view for the explanatory of an over-stroke amount of the linear motion slide unit.

BEST MODE FOR EMBODYING THE INVENTION

The details of the linear motion slide unit according to this invention will be described hereunder with reference to the accompanying drawings.

With reference to FIGS. **1** and **2**, one embodiment of the linear motion slide unit of this invention is shown.

As shown in these figures, a linear motion slide unit **1** of this invention generally comprises an elongaged inner rail **10** having high rigidity, a pair of outer rails **20** attached to be reciprocally movable in an axial direction of the inner rail **10**, and linear motion guides **30** secured fixedly to the outer rails **20** and slidably to the inner rail **10**.

The inner rail **10** is manufactured by cold-drawing a steel material. The inner rail **10** is formed with two rows of ball rolling grooves **11** on its upper and lower surfaces. The ball rolling grooves **11** are subjected to hardening treatment to apply sufficient hardness.

Each of the outer rails **20** has substantially a U-shaped cross section and has a longitudinal length slightly larger than that of the inner rail **10**. Each of the outer rails **10** is formed with a plurality of holes **21** for attachment and the outer rail **20** is secured to an office table body or a side surface of a drawer, for example, by means of bolts. The central portion of the outer rail **20** is formed with a through hole **22** provided with a back facing through which an adjustment bolt **40** for adjusting the preload amount to the balls, as described hereinlater.

Linear motion guides **30** disposed between the inner rail **10** and the respective outer rails **20** are of endless track type structure having high rigidity. In the illustrated embodiment, two linear motion guides **30** are mounted with respect to one outer rail **20** as shown in FIG. **2**.

The linear motion guide **30** is itself known in this art field and comprises a bearing body **31** made of iron steel, a pair of side covers **32**, **32** mounted in abutment to both end surfaces of the bearing body **31** and a number of balls **33** as rolling members.

The bearing body **31** is manufactured by cold-drawing a steel material. A recessed portion **31*a*** for receiving the inner rail **10** is formed to a central inside portion of the bearing body **31**. Ball rolling grooves **31*c*** opposing to the ball rolling grooves **11** of the inner rail **10** are formed to an inclining surface **31*b*** adjacent to the recessed portion **31*a***. These ball rolling grooves **31*c*** are also subjected to the hardening treatment to thereby apply sufficient hardness thereto.

Furthermore, return holes **31*d*** for the non-loaded balls are formed to the bearing body **31** so as to penetrate it in its axial direction.

In the illustrated preferred embodiment, a central outside portion of the bearing body **31** is formed as a shallow recessed portion **31*e*** for adjustment and a female screw hole **31*f***, which is screw engaged with a male screw of the adjustment bolt **40**, is bored at the central portion of the recessed portion **31*e***. Each of the preload adjustment mechanisms is composed of this recessed portion **31e** for adjustment and the adjustment bolt **40**.

The side covers **32** may be cheaply formed of a dicast alloy or synthetic resin because large load is not applied to these side covers **32**. The side covers **32** connect the corresponding ball rolling grooves **31*c*** and the non-loaded ball return holes **31*d***, thus being provided with ball returning grooves **32*a*** as endless tracks, respectively.

A number of balls **33** mounted in the respective endless tracks can apply a large preload for the reason that the inner rail **10** and the bearing body **31** transferring the load are made themselves of a material having high rigidity and the ball rolling grooves **11** and **31*c*** holding the loaded balls are hardened. Accordingly, in the over-stroke use under the heavy load any gap is not substantially caused between the respective members. In the light load use, the effective length of the linear motion guide **30**, corresponding to the portion X_1, in FIG. **5**, can be shortened, thus making large the over-stroke amount, corresponding to the four portions X_2 in FIG. **5**.

The adjustment bolts **40** are screw engaged with the female screw holes **31*f*** of the bearing body **31** through the through holes **22** of the outer rails **20**. As described before, since the shallow recessed portions **31*e*** are formed between the outer rails **20** and the bearing body **31** to provide spaces therebetween, the inclining surfaces **31*b***, i.e. the ball rolling grooves **31*c***, are minutely moved by fastening the adjustment bolts **40** so as to approach the inner rail **10**, thus adjusting the preload amount to the balls **33**.

FIG. **3** is an illustration showing this preload adjusting condition. That is, when the recessed portions **31*e*** of the bearing body **31** for adjustment are pulled by the fastening of the adjustment bolts **40** towards the outer rails **20** with fastening forces P, the pulling forces P and resisting forces N acting on the fixed surfaces constitute couple of forces, which causes to the bearing body **31**, moments M for narrowing the bilateral inner side surfaces of the central recessed portions **31***a*. According to the moments

the preload is applied to the balls **33** and the amount of the preload to be applied to the balls can be adjusted in accordance with the fastening amount of the adjustment bolts **40**.

A method of using the linear motion slide unit of this invention is identical to that of the conventional technology, so that the details thereof are omitted herein.

POSSIBILITY OF INDUSTRIAL USAGE

As described hereinabove, in the linear motion slide unit according to this invention, it is usable for the sliding portions of office tables, computer peripheral devices copying machines, measuring instruments, telecommunication equipments, medical instruments, various kinds of office equipments, and the like, and particularly, it is preferable for the use in which a heavy load can be supported by drawing out the sliding portion so as to extend over the entire length of the rail, that is, in the over-stroke condition.

I claim:

1. A linear motion slide unit comprising:

an elongated inner rail;

said elongated inner rail having at least one first side rolling member groove extending along the length of said inner guide rail on a first side of a width of said inner guide rail;

said elongated inner guide rail having at least one second side rolling member groove extending along the length of said inner guide rail on a second side, opposite to said first side, of the width of said inner guide rail;

a first outer rail attached to said first side of said elongated inner rail and reciprocally movable in an axial direction of said inner rail along said first side thereof;

a second outer rail attached to said second side of said elongated inner rail and reciprocally movable in the axial direction of said inner rail along said second side thereof;

at least one first side linear motion guide fixedly secured to said first outer rail and supported slidable with respect to the inner rail through a number of rolling members, said first side linear motion guide being formed with endless tracks in which the rolling members are endlessly circulated, said rolling members being supported along said first side rolling member groove;

at least one second side linear motion guide fixedly secured to said second outer rail and supported slidable with respect to the inner rail through a number of rolling members, said second side linear motion guide being formed with endless tracks in which the rolling members are endlessly circulated, said rolling members being supported along said second side rolling member groove; and

whereby said first side linear motion guide and said second side linear motion guide each are located on opposite sides of said inner guide rail from one another.

2. A linear motion slide unit according to claim **1**, wherein said linear motion guides each include a bearing body provided with rolling member rolling grooves opposing to the rolling member rolling grooves formed in the inner rail and return passages for non-loaded rolling members, and a pair of side covers secured to both end surfaces of the bearing body and provided with rolling member returning grooves connecting the opposing rolling member rolling grooves of the bearing body and the return passages for the non-loaded rolling members to thereby constitute endless tracks.

3. A linear motion slide unit according to claim **2**, wherein said bearing body is composed of a block member having substantially a U-shaped cross section having a central recessed portion into which the inner rail is inserted and rolling member rolling grooves are formed to the bilateral inner side surfaces of the central recessed portions so as to oppose to those formed to the opposing surfaces of the inner rail.

4. A linear motion slide unit according to claim **3**, wherein said inner rail and said bearing body are formed of a material having high rigidity and a preload is applied to the rolling members.

5. A linear motion slide unit according to claim **4**, wherein said linear motion guides are provided with preload adjustment mechanisms for adjusting the preload to be applied to the rolling members.

6. A linear motion slide unit according to claim **3**, wherein each of said preload adjustment mechanisms provided for said linear motion guides is characterized by comprising a recessed portion for adjustment formed to the central portion of a surface to which the outer rail of the bearing body is fixed and an adjustment bolt screwed in a screw hole bored to a bottom surface of the preload adjustment recessed portion through a through hole formed to the outer rail, and in that the adjustment recessed portion is pulled towards the outer rails by fastening the adjustment bolt, a moment is caused to the bearing body by this pulling force in a direction narrowing a gap between bilateral inner side surfaces of the central recessed portion to thereby apply the preload to the rolling members, and an amount of the preload to the rolling members is made adjustable in accordance with the fastening force of the adjustment bolt.

7. A linear motion slide unit, comprising:

an elongated inner rail, said inner rail having a pair of first side rolling grooves extending along a length of the elongated inner rail on a first side of a width thereof and having a pair of second rolling grooves extending along the length of the elongated inner rail on a second side of a width thereof;

a pair of first and second bearing bodies which are arranged on opposite sides of the elongated inner rail and which are reciprocally movable along the elongated inner rail, said first bearing body having a pair of first side rolling grooves opposing to the first side of the elongated inner rail and being reciprocally movable in an axial direction of the elongated inner rail along the first side thereof, said second bearing body having a pair of second side rolling grooves opposing to the second side of the elongated inner rail and being reciprocally movable in an axial direction of said elongated inner rail along the second side thereof, said first bearing body having a pair of endless tracks in which first side rolling members are endlessly circulated and the second bearing body having a pair of endless tracks in which second side rolling members are endlessly circulated; and

a pair of first and second outer rails, said first outer rail being fixedly secured to the first bearing body opposing to the elongated inner rail and including means for applying a preload to the first side rolling members cooperating with the first bearing body, and the second outer rail being fixedly secured to the second bearing body opposing to the inner rail and including means for applying a preload to the second side rolling members cooperating with the second bearing body;

whereby said elongated inner rail and the bearing bodies to which the outer rail are secured being relatively movable to each other.

8. A linear motion slide unit according to claim **7**, further comprising a pair of first and second preload adjustment members, said first preload adjustment member being arranged in said first bearing body and the first outer rail for adjusting an amount of preload to be applied to the first side rolling members and said second preload adjustment member being arranged in said second bearing body and the second outer rail for adjusting an amount of preload to be applied to the second side rolling members.

9. A linear motion slide unit according to claim **7**, wherein said inner rail is relatively movable by a movable stroke thereof in a single longitudinal direction with respect to said first outer rail through said first bearing body and said second outer rail is relatively movable by a movable stroke thereof in the same said single longitudinal direction with respect to said inner rail through said second bearing body.

10. A linear motion slide unit comprising:

a first outer rail;

an elongated inner rail attached to said first outer rail and reciprocally movable in an axial direction of the first outer rail, said elongated inner rail having at least one first side rolling member groove extending along the length of the inner rail on a first side of a width of the inner rail, said elongated inner rail having at least one

second side rolling member groove extending along the length of the inner rail on a second side opposite to said first side, of the width of said inner rail;

a second outer rail attached to said second side of the elongated inner rail and reciprocally movable in the axial direction of the inner rail along said second side thereof, wherein said outer rail is movable with respect to said first outer rail by a distance corresponding to a movable stroke of the inner rail with respect to the first outer rail and a movable stroke of the second outer rail with respect to the inner rail;

at least one first side linear motion guide fixedly secured to the first outer rail and supported slidable with respect to the inner rail through a number of rolling members, said first side linear motion guide being formed with endless tracks in which the rolling members are endlessly circulated, said rolling members being supported along said first side rolling member groove;

at least one second side linear motion guide fixedly secured to said second outer rail and supported slidable with respect to the second outer rail through a number of rolling members, said second side linear motion guide being formed with endless tracks in which the rolling members are endlessly circulated, said rolling members being supported along said second side rolling member groove.

* * * * *

US005380099A

United States Patent [19]

Teramachi

[11] **Patent Number: 5,380,099**

[45] **Date of Patent: Jan. 10, 1995**

[54] **LINEAR BEARING AND ITS PRODUCTION METHOD**

[75] Inventor: **Hiroshi Teramachi**, Tokyo, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **50,374**

[22] PCT Filed: **Sep. 17, 1992**

[86] PCT No.: **PCT/JP92/01186**

§ 371 Date: **Jul. 16, 1993**

§ 102(e) Date: **Jul. 16, 1993**

[87] PCT Pub. No.: **WO93/06377**

PCT Pub. Date: **Apr. 1, 1993**

[30] **Foreign Application Priority Data**

Sep. 19, 1991 [JP] Japan 3-266962

[51] **Int. Cl.**[6] **F16C 29/06**

[52] **U.S. Cl.** **384/45**

[58] **Field of Search** 384/45, 43, 44; 464/168

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,076,713 12/1991 Morita 384/45
5,176,453 1/1993 Jacob 384/43

FOREIGN PATENT DOCUMENTS

61-79021 9/1984 Japan .
61-180016 2/1985 Japan .
2-261924 3/1989 Japan .

OTHER PUBLICATIONS

Japanese Laid-Open Utility Model Publication No. 2-14824, filed Jan. 30, 1990; with English abstract.
Japanese Laid-Open Utility Model Publication No. 2-43521, filed Mar. 26, 1990; with English abstract.
Japanese Laid-Open Utility Model Publication No. 3-48417, filed Oct. 16, 1991; with English abstract.

Primary Examiner—Lenard A. Footland
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

It is an object of the present invention to provide a linear bearing which is easy to manufacture and has sufficient mechanical strength, and its production method. A slider **1** guides a table or other movable bodies along a rail **2** and includes a thin ball plate **6** in which load ball channels **61** are formed to move balls **5** therein, and a thin mounting plate **7** adapted to secure the movable body. A molding material **8** such as resin or die cast alloy is molded to insert the ball plate **6** and the mounting plate **7** thereinto. The rail **2** is made of a metallic material **2** whose surface is hardened to a predetermined level when subjected to plastic deformation. During plastic deformation, the ball channels **23** are hardened to a predetermined level.

4 Claims, 11 Drawing Sheets

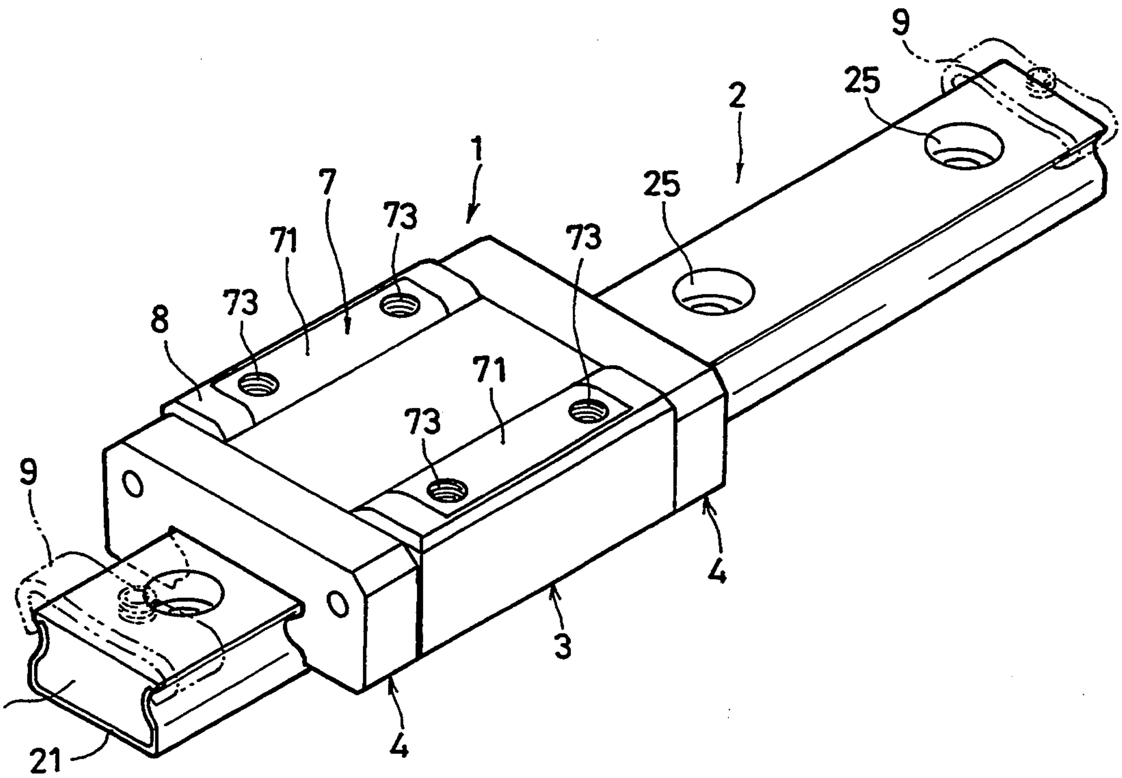


FIG. 1

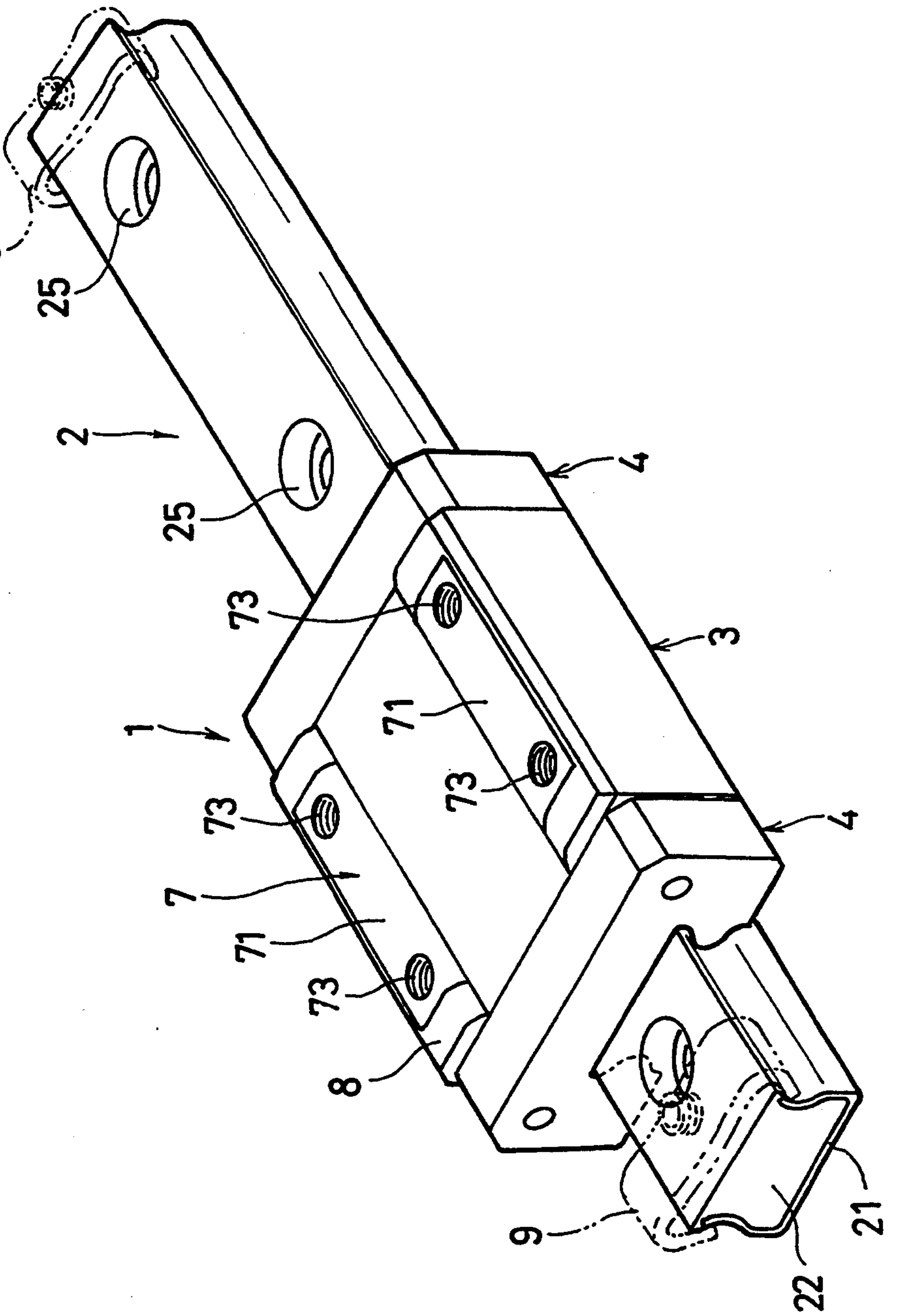


FIG. 2

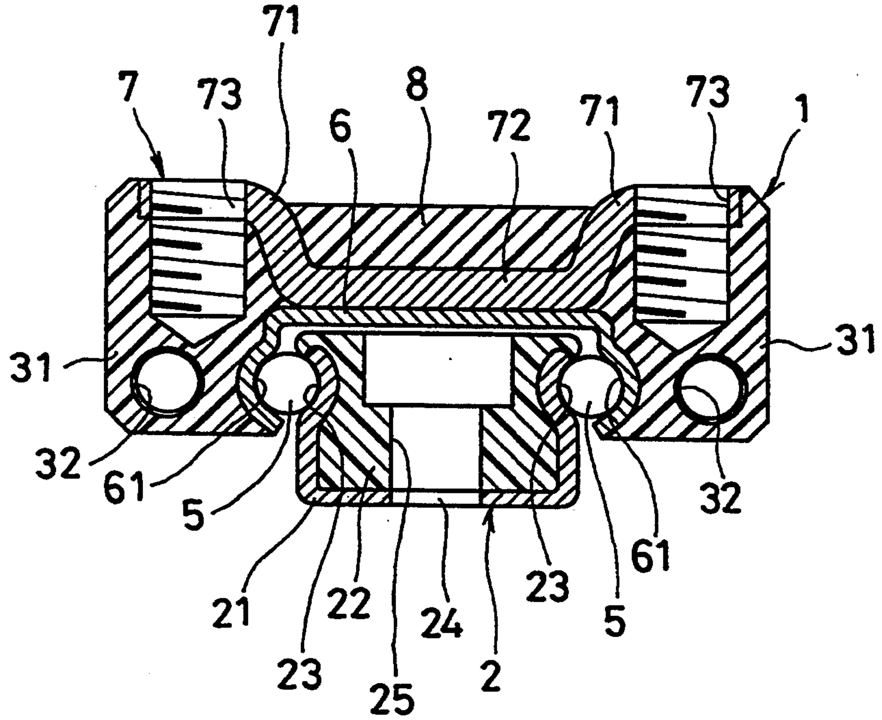


FIG. 3

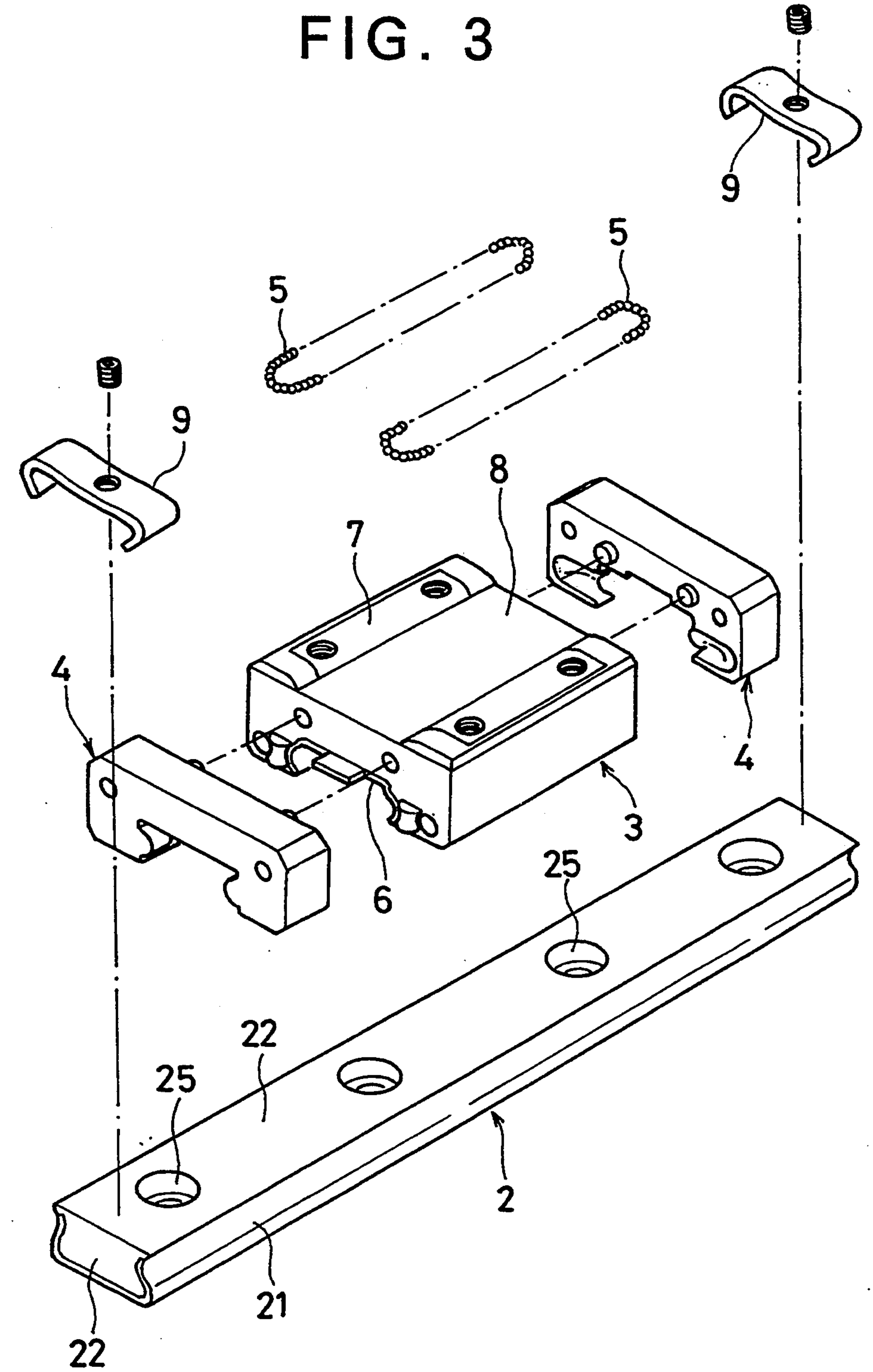


FIG. 4

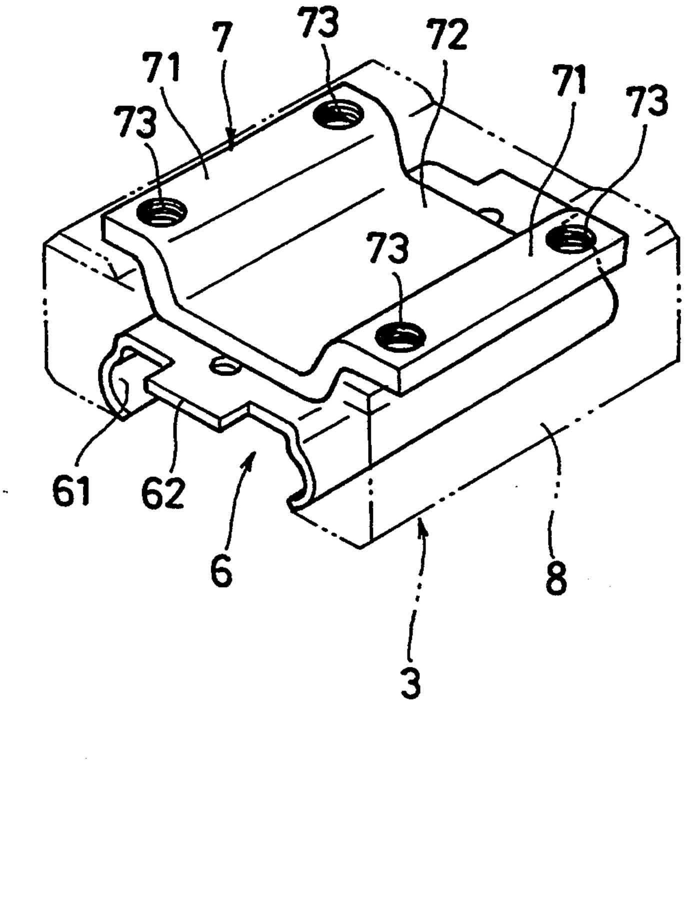


FIG. 5

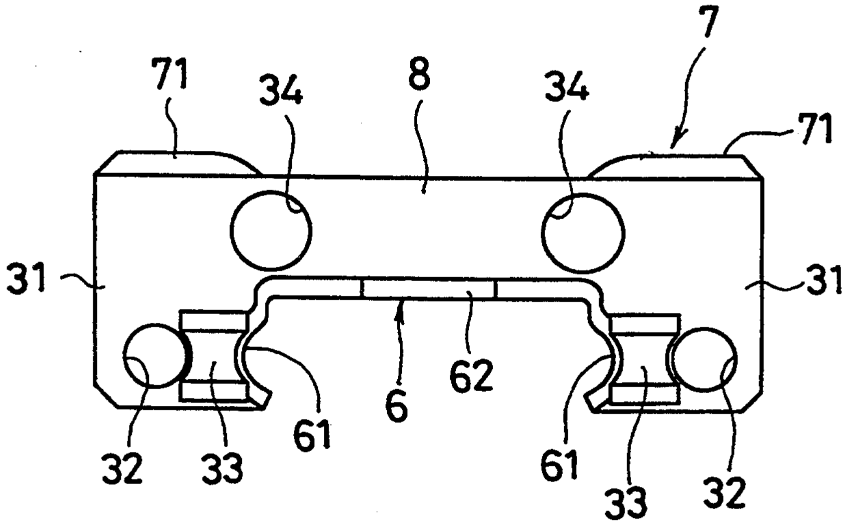

71
34
8
34
7
71
31
31
32
33
61
6
62
61
33
32

FIG. 6

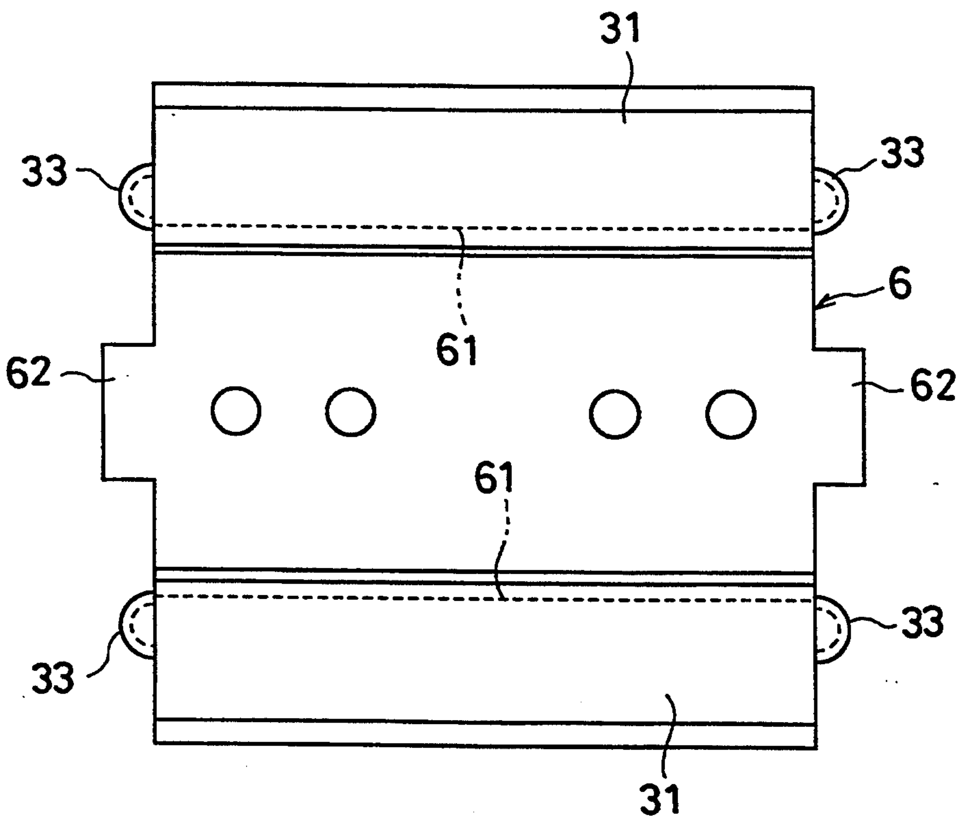

31
33
33
6
61
62
62
61
33
33
31

FIG. 7

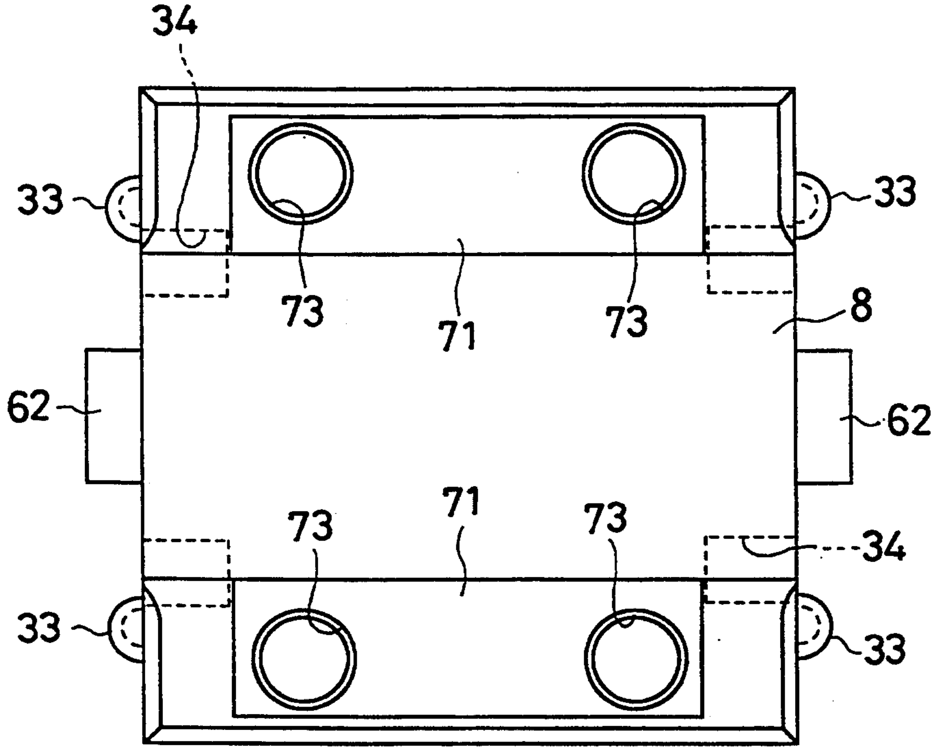


FIG. 8

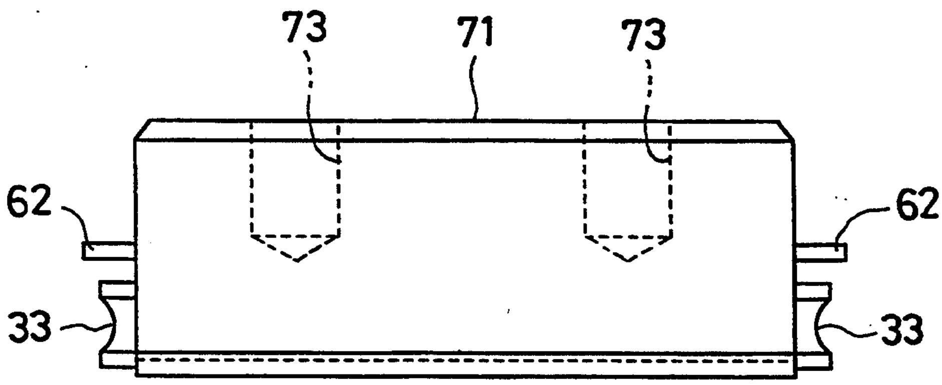


FIG. 9

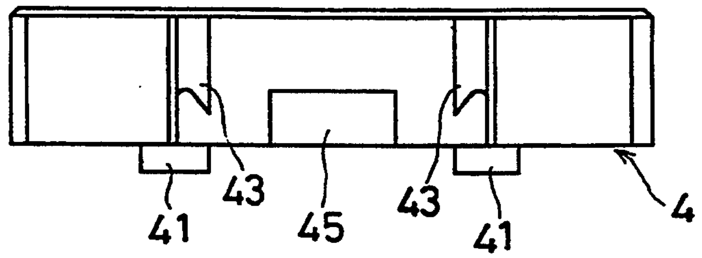


FIG. 10

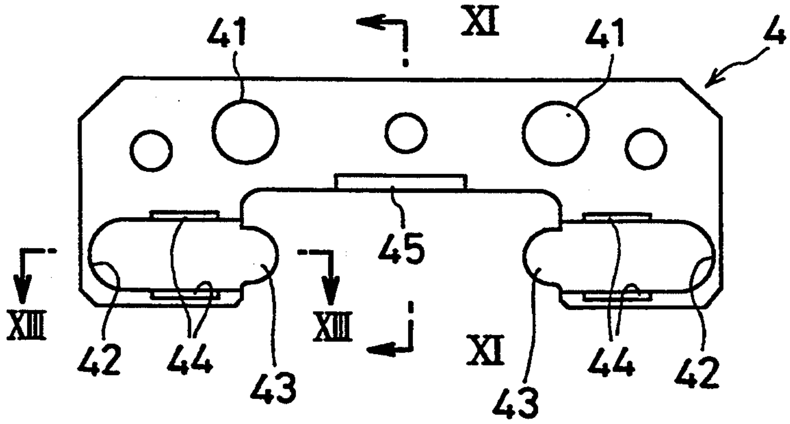


FIG. 11

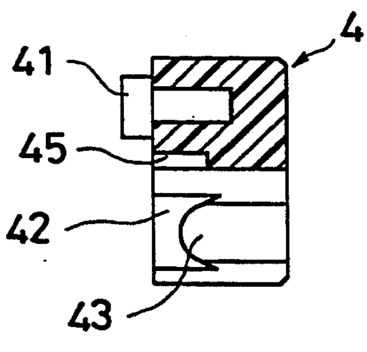


FIG. 12

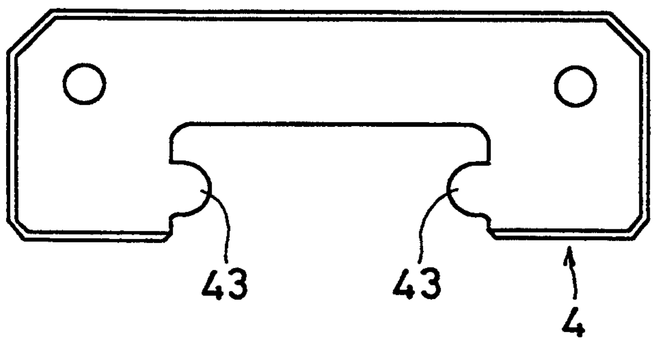


FIG. 13

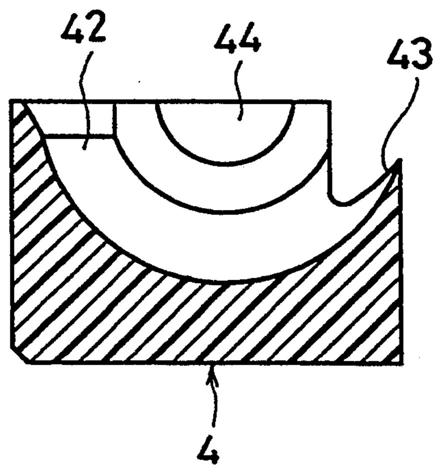


FIG. 14

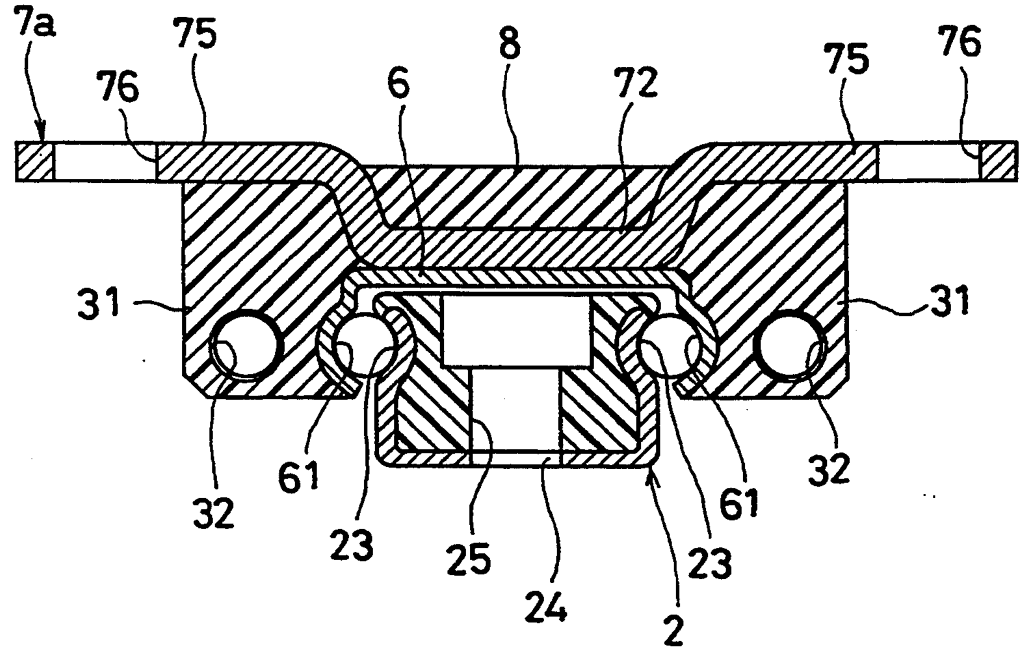


FIG. 15

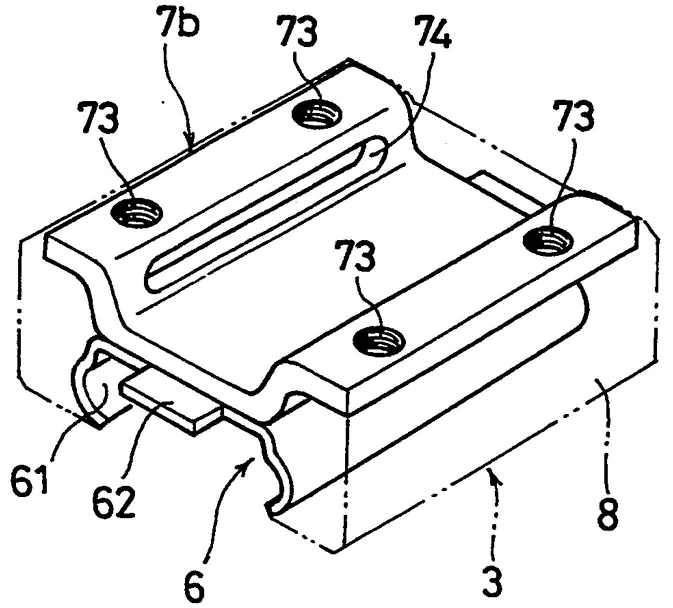

7b
73
74
73
73
73
61
62
6
3
8

FIG. 16

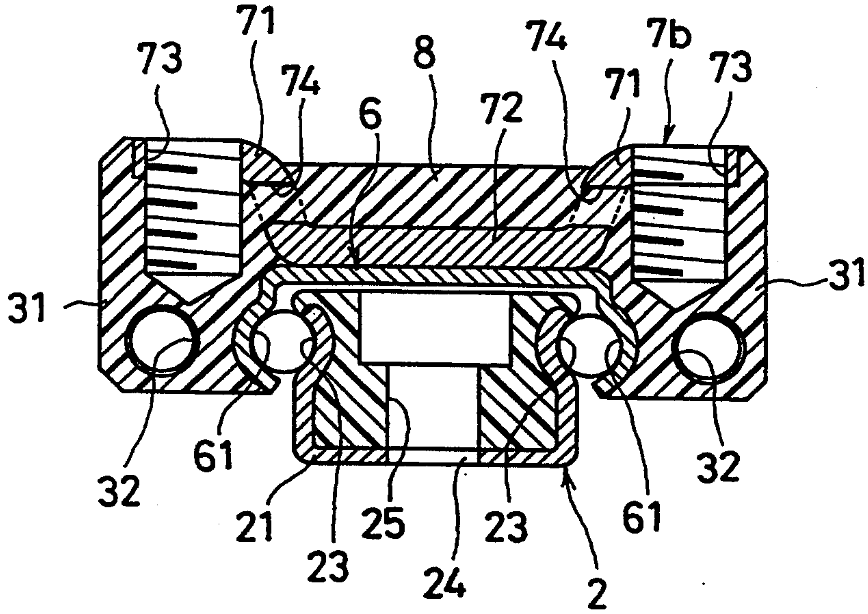
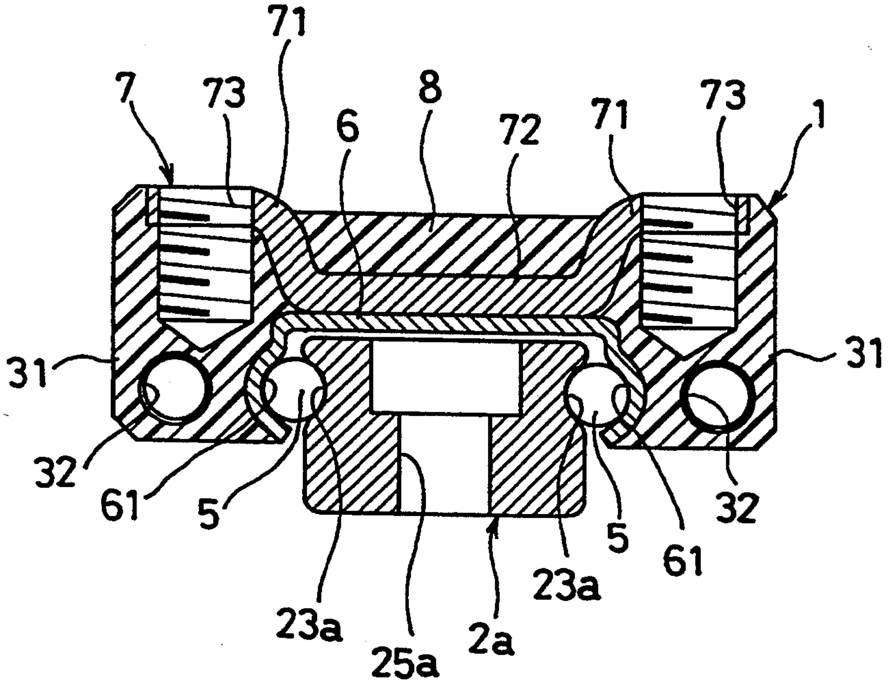

73
71
74
8
6
72
74
71
7b
73
31
31
32
61
21
23
25
24
23
2
61
32

FIG. 17



LINEAR BEARING AND ITS PRODUCTION METHOD

TECHNICAL FIELD

The present invention relates to a linear bearing for guiding movable bodies such as tables for use in various machine tools or industrial robots along a straight bed or stationary element.

BACKGROUND ART

This kind of linear bearing comprises a rail having ball channels in which balls are moved and secured to a bed or stationary element, and a slider having load ball channels cooperating with the ball channels to sandwich a multiplicity of balls and adapted to guide a table or movable body along the rail.

The slider has a function such that the load of the movable body is applied directly thereto. Under the circumstances, if the slider is deformed, the movable body is displaced relative to the base to which the rail is mounted. This presents a problem that the movable body can not be guided accurately on a straight line. The slider body to which the movable body is secured must have high rigidity.

To this end, the slider conventionally has a slider body formed from a metal block made, for example, of bearing steel. The slider body is made by first cutting a rectangular metal block to a predetermined shape, then, forming nonload ball bores and tapping bolt holes for securement of a movable body, and finally, carburizing a portion of the slider body and cutting and lapping that portion of the slider body to form load ball channels.

However, where a slider body is made from a metal block made, for example, of bearing steel, such a metal block must be machined in various ways. This production method is thus cumbersome.

It is necessary to accurately and smoothly cut the slider body at a predetermined angle to form load ball channels. However, it is difficult to accurately contact a grinder or other cutting tools when the slider body has a complicated shape. This deteriorates the accuracy of load ball channels.

There is proposed a slider body made from materials other than metal block. A thin metal plate has load ball channels and is molded, at its outer periphery, of epoxy concrete or synthetic resin (see Japanese utility model publication No. 48417/91)

According to this proposal, load ball channels can be readily and accurately formed by pressing or ball burnishing the thin metal plate. Also, the slider body can readily be machined to a complicated shape. This slider body can be more economically made than those formed by machining metal blocks.

However, the proposed slider body is less in rigidity than those made from metal blocks since it is like a metal plate with load ball channels attached to a block made of synthetic resin. The slider body is thus susceptible to deformation or breakage when substantial load is exerted from a movable body.

A slider must have a mounting portion for securement of a movable body. Movable bodies have various shapes and are, therefore, secured to the slider in various ways. The mounting portion may be in the form, for example, of a flange as an extension of the slider. Under the circumstances, linear bearing manufacturers are required to provide sliders with various mounting portions to meet a user's need. Its manufacture is, however, rather cumbersome. Thus, there is a need for sliders which allow for ready securement of movable bodies in various ways and which are economical to manufacture.

Conventionally, a rail is formed by drawing a metal block to have a predetermined cross section, carburizing a portion of the metal block, and cutting or lapping that portion to form ball channels. This production method is as cumbersome as that of the slider. Another problem is that the surface of the rail where balls are moved is susceptible to cracking.

There has recently been proposed a rail which includes a thin metal plate in which ball channels are formed by press, and synthetic resin inserted within the metal plate (see Japanese laid-open utility model publication No. 43521/90). However, to give ball channels predetermined hardness, it is necessary to treat the metal plate with TUFFTRIDE or thermally treat the metal plate such as quenching to harden the surfaces of the ball channels on which balls are moved. This treatment is also cumbersome and does not improve the fragility of the surfaces on which balls are moved.

DISCLOSURE OF THE INVENTION

In view of these problems, it is an object of the present invention to provide a linear bearing which is easy to manufacture and has high mechanical strength, and its production method.

In order to achieve the object, the present invention provides a slider for a linear bearing which comprises a thin ball plate having load ball channels, and a thin mounting plate having mounting portions to which a movable body is secured, characterized in that the ball plate and the mounting plate are integrated together by molding a molding material such as resin or die cast alloy.

According to such technical means, the slider can be formed by injection or extrusion molding synthetic resin within which the ball plate and mounting plate are inserted, or by die casting an alluminum or zink alloy. This allows for ready production of the slider having various shapes such as an inclined C-shape or L-shape. The shape of the ball plate may thus be altered in response to the shapes of a slider. Also, the number and angle of load ball channels formed in the ball plate may be changed as necessary.

The mounting plate may take any shape so far as it has mounting portions to secure a table or other movable bodies. However, it is necessary for the mounting plate to have high rigidity according to its shape and material since the load of a movable body is applied locally to the mounting plate.

Further, nonload ball channels can be any means applicable to the existing linear bearings so far as it can bring balls up at ends of the load ball channels. In the present invention, for example, the slider includes nonload ball bores extending in parallel to the load ball channels. End caps may be attached to front and rear ends of the slider to provide a communication between the load ball channels and the nonload ball bores. Alternatively, ball tubes may be inserted in the slider to provide a communication between opposite ends of the load ball channels.

The present invention has for its purpose to reduce the number of production steps and the production cost. It is therefore preferable to form part of the nonload all channels during insert molding process.

The mounting plate is integrated in the slider by insert molding, but the molding material such as resin surrounds the mounting plate, only. The mounting may be separated from the slider when substantial load is exerted on the mounting plate. To more firmly integrate the mounting plate in the slider, an adhesive agent may be applied to the mounting plate prior to insert molding. Alternatively, the ball plate and the mounting plate may be projection welded or riveted together. However, the use of these means results in an increase in the number of production steps and is not preferable as the purpose of the present invention is to reduce the production cost.

Therefore, the mounting plate preferably has a fixed portion which is embedded in the molding material during insert molding. This results in a decrease in the number of production steps simply by changing the shape of the mounting plate. The fixed portion may be in the form of pawls provided at opposite ends of the mounting plate. Alernatively, recesses may be formed centrally in the mounting plate.

Where the mounting plate has a fixed portion, the fixed portion preferably has an axial length less than that of the ball plate or has through openings. This prevents separation of the molding material covering the fixed portion from the molding material surrounding the ball plate and thus ensures firm integration of the mounting plate with the ball plate.

The present invention also provides a rail for use in a linear bearing to achieve the foregoing object.

A first rail is made of a metallic material which has such a characteristic that its surface hardness is increased when subjected to plastic deformation. The ball channels have predetermined surface hardness when the rail is plastically deformed to a predetermined shape.

With these technical means, the rail is pressed or rolled to a predetermined shape where the rail is made from a thin metal plate. At that time, the surface of the ball channels is hardened to a predetermined level. The rail is drawn to a predetermined shape where the rail is made from a metal block. During drawing process, the surface of the ball channel is hardened to a predetermined level.

The surface hardness required for the ball channels may vary depending on the material of balls and the load to be exerted on the slider, but is normally at least H_RC35. With this production method, the greater the deformation during plastic deformation, the greater the hardness of the ball channel surface on which balls are moved. Thus, where the rail is made, for example, by drawing process, the surface hardness of the ball channels can be adjusted by changing the volume as drawn by a die.

The same production method is applicable to the ball plate of the slider. The surface of the load ball channels can be hardened to a predetermined level simply by pressing or rolling a thin metal plate to a predetermined shape.

To achieve the foregoing object, a second rail is made from a metal rod and includes ball channels which is subjected to quenching and subzero (or deep freezing) treatment.

With these technical means, the fragile metallic system is improved during quenching process to effectively prevent crack which may occur in the ball channels upon repeated application of loads.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a linear bearing according to a first embodiment.

FIG. **2** is a sectional view of the linear bearing according to the first embodiment.

FIG. **3** is an exploded view, in perspective, of the linear bearing according to the first embodiment.

FIG. **4** is a perspective view of the linear bearing according to the first embodiment, part of which is taken away to show the structure of a slider body.

FIG. **5** is a front view of the slider body of the linear bearing according to the first embodiment.

FIG. **6** is a bottom plan view of the slider body of the linear bearing according to the first embodiment.

FIG. **7** is a top plan view of the slider body of the linear bearing according to the first embodiment.

FIG. **8** is a side view of the slider body of the linear bearing according to the first embodiment.

FIG. **9** is a bottom plan view of an end cap of the linear bearing according to the first embodiment.

FIG. **10** is a rear view of the end cap of the linear bearing according to the first embodiment.

FIG. **11** is a sectional view taken along the line XI—XI of FIG. **10**. FIG.

12 is a front view of the end cap of the linear bearing according to the first embodiment.

FIG. **13** is a sectional view taken along the line XIII—XIII of FIG. **10**.

FIG. **14** is a sectional view showing a modified form of the slider of the linear bearing according to the first embodiment.

FIG. **15** is a perspective view of a linear bearing according to a second embodiment, part of which is taken away to show the structure of a slider.

FIG. **16** is a sectional view of the linear bearing according to the second embodiment.

FIG. **17** is a sectional view of the linear bearing according to the first embodiment, showing a modified form of a rail.

BEST MODE FOR CARRYING OUT THE INVENTION

A linear bearing and its production method of the present invention will now be described with reference to the accompanying drawings.

FIGS. **1** and **2** show a linear bearing according to a first embodiment of the present invention. The linear bearing generally includes a rail **2**, and a slider **1** movable along the rail **2**. FIG. **3** is a disassembled view of the slider **1** which includes a slider body **3** having a substantially inclined C-shape and extending over the rail **2**, and a pair of end caps **4** coupled to front and rear ends of the slider body **3**. The slider **1** is mounted on the rail through balls **5** which endlessly circulate in the slider **1**.

As shown in FIG. **4**, the slider body **3** includes a channel-like ball plate **6**, and a mounting plate **7** having mounting portions **71** for mounting a movable body (not shown). The ball plate **6** and the mounting plate **7** are integrally formed together by a synthetic resin **8** (for example, TORAYCA).

The ball plate **6** is made of stainless steel or other metal (for exmple, SUS430) and shaped by a press. Opposite inner surfaces of the ball plate **6** form load ball channels **61** which cooperate with ball channels **23** of the rail **2** to sandwich the balls **5**. Positioning projections **62** extend axially from opposite ends of the ball plate 6 to position the end caps. The load ball channels **61** are quenched and then, subzero treated. This treatment hardens the load ball channels **61** to increase its resistance to wear and stabilizes the metallic system of the load ball channels **61** to improve its fragility.

Alternatively, a metal sheet whose surface hardness can be increased when subjected to plastic deformation may be pressed or rolled to a predetermined shape. It is then plastically deformed to harden the surface of the load ball channels **61** to a predetermined level. Such a metal sheet which can be used in this process is, for example, austenite SUS304. The surface hardness of the load ball channels **61** is less than H_RC10 prior to pressing and increased to H_RC35 to 40 after it has been pressed. This method eliminates a need for heat treatment and results in lower production cost.

The mounting plate **7** is formed also by pressing a sheet metal made, for example, of stainless steel and having a thickness slightly greater than that used for the ball plate **6**. The mounting plate **7** includes a recess or fixed portion **72** embedded in the synthetic resin **8** and located between a pair of mounting portions **71**. The mounting portions **71** are tapped to form bolt holes **73** for threading engagement with bolts (not shown) of a movable body. The axial length of the mounting plate **7** is shorter than that of the ball plate.

The slider body **3** is formed by insert molding the ball plate **6** and the mounting plate **7**. FIGS. **5** to **8** show the slider body **3** after it is insert molded.

As is clear from these figures, the ball plate **6** is wrapped by synthetic resin and is not separated from the slider body **3** in any direction. The mounting portions **71** of the mounting plate **7** extend outwardly from the surface of the slider body **3**. The fixed portion **72** of the mounting plate **7** is embedded in the synthetic resin **8**. The mounting plate **7** is thus not separated from the slider body **3** in any direction. During insert molding, part of nonload ball bores is defined in the slider body **3** to provide a connection between ends of the load ball channels to circulate the balls **2** therethrough. Specifically, the slider body **3** has legs **31** in which ball bores **32** through which nonload balls are moved are defined in parallel relationship to the load ball channels **61**. Semicircular return guides **33** are formed in front and rear end surfaces of the slider body **3** to direct the balls **5** from the load ball channels **61** and the ball bores **32** and vice versa. Positioning holes **34** are defined during insert molding to receive projections **41** of the end caps **4**.

The slider body **3** is formed substantially during the insert molding process. Finally, the mounting portions **71** of the mounting plate **7** which extend outwardly from the surface of the slider body **3** is abraded to provide a reference surface.

The end caps **4** coupled to front and rear ends of the slider body **3** are injection molded of synthetic resin. Semi-circular ball return channels **42** are formed in the inner sides of the end caps **4** and form part of the nonload ball channels. As shown in FIGS. **9** to **13**, the ball return channels **42** provide a connection between the load ball channels **61** of the slider body **3** and the ball bores **32**. Tongues **43** extend from ends of the end caps **4** to bring the balls **5** up from the load ball channels **61**. Also, seats **44** are provided centrally in the ball return channels **42** to receive return guides **33** of the slider body **3** when the end caps **4** are coupled to the slider body **3**. This facilitates guidance of the balls **5** through the ball return channels **42**.

The end caps **42** are adhesively attached to the slider body **3**. To ensure accurate attachment of the end caps **4** to the slider body **3**, the end caps **4** have recesses **4** to receive projections **62** of the ball plate **6**, and projections **41** to fit into the positioning holes **43** of the slider body **3**.

As shown in FIGS. **2** and **3**, the rail **2** includes a channel-like rail plate **21** made by pressing, and a synthetic resin **22** inserted in the rail plate **21** during molding process. A pair of ball channels **23** are formed in opposide outer sides of the rail plate **21** during pressing process. Also, through holes **24** are formed in the base along the length of the rail plate **21**. Bolt holes **25** are formed during insert molding process and correspond to the through holes **24**. In this embodiment, the slider **1** has no ball retainer. To avoid accidental removal of the slider **1** from the rail **2** and disengagement of the balls **5** from the load ball channels **61**, stoppers **9** are attached to opposite ends of the rail **2**.

The surface of the ball channels **23** are hardened to a predetermined level completely in the same manner as the load ball channels **61** of the ball plate **6**. After the rail has been pressed, the ball channels **23** are quenched and then, subzero treated. Alternatively, a metal sheet made of austenite SUS304 may be pressed or rolled to a predetermined shape to thereby increase the surface hardness of the ball channels **23** to a predetermined level.

When the slider **1** is in use, the balls **5** are placed in the nonload ball channels composed of the ball return channels **42** of the end caps **4** and the ball bores **32** of the slider body **3**. The balls **5** are also placed between the ball channels **23** of the rail **2** and the load ball channels **61** of the slider body **3**. A movable body is then secured to the mounting portions **71** which extend outwardly from the upper surface of the slider **1**.

A substantial part of the slider **1** is formed of synthetic resin **8**. However, part of the mounting plate **7** which has high regidity is embedded in the synthetic resin **8** to be integral with the slider body **3**. This mounting plate **7** serves as a reinforcing element for the slider body **3** to increase the rigidity of the slider body **3**. Thus, the slider body **3** is free from deformation or breakage if substantial load is exerted.

The mounting plate **7** and the slider body **3** are integrally formed during insert molding of the slider **3**. A change in shape of the mounting plate **7** results in a corresponding change in shape of the slider.

FIG. **14** shows a modification of the slider body **3** as insert molded. The slider body includes a mounting plate **7a** which has wider mounting portions than those of the mounting plate **7**, and bolt holes **76**.

According to this embodiment, while the ball plate **6** and other elements are commonly used, a variety of mounting plates **7** can be employed to provide a variety of sliders. Thus, various types of sliders can economically and readily be fabricated according to user's need.

In the foregoing embodiment, the axial length of the mounting plate **7** is less than that of the ball plate **6** so that the synthetic resin **8** which covers the fixed portion **72** of the mounting plate **7** are safely joined to the synthetic resin **8** which surrounds the ball plate **6**. As an alternative, the axial length of the mounting plate **6** may be identical to that of the slider body **3**. In such a case, slots or through openings **74** may be formed in the fixed portion **72** as shown in FIG. **15**.

FIG. **16** is a sectional view showing a second embodiment of the slider **1** wherein a mounting plate **7b** has the through openings **74**. As is clear from FIG. **16**, the synthetic resin **8** which covers the fixed portion **72** of the mounting plate **7** through the through openings **74** is safely joined to the synthetic resin **8** which surrounds the ball plate **6**. This embodiment also allows for firm integration of the mounting plate *7b* with the slider body **3**.

In this embodiment, the ball plate **6** is pressed, but the load ball channels **61** are not abraded. However, the load ball channels **61** may need be abraded when the plate **6** per se is made of a material which does not provide a smooth surface.

The rail **2** in which the slider **1** of this embodiment is assembled may be made by pressing a metal sheet. As shown in FIG. **17**, a metal block may be drawn to form a rail *2a* of a predetermined shape. In such a case, ball channels *23a* of the rail *2a* are quenched and then, subzero treated after it has been drawn so as to increase resistance to wear and improve the fragility of the ball channels *23a*.

To reduce the cost of manufacturing the rail *2a*, a block made of austenite SUS304 may be drawn to a predetermined shape. The rail *2a* is plastically deformed to thereby increase the surface hardness of the ball channels *23a* to a preetermined level.

INDUSTRIAL APPLICABILITY

As described above, according to a linear bearing and its production method of the present invention, a slider is formed by integrating a high rigid mounting plate with a ball plate by the use of molding material such as resin or die cast alloy. The slider thus made is highly rigid even if molding material is relatively flexible. It is therefore possible to provide a linear bearing which has high mechanical strength.

Also, according to a linear bearing and its production method of the present invention, a rail is plastically deformed to a predetermined shape to thereby harden a ball channels. This eliminates a need for heat treatment of the ball channels. It is therefore possible to provide a linear bearing which has high mechanical strength and is economical to manufacture.

Further, according to a linear bearing and its production method of the present invention, when a rail is quenched to harden ball channels, subzero treatment is subsequently effected to alter metallic system to improve the fragility of the rail. The ball channels are thus free from crack. It is therefore possible to provide a linear bearing which has high mechanical strength.

What is claimed is:

1. A linear bearing, comprising:

a rail having ball channels; and

a slider having load ball channels cooperating with said ball channels of said rail to sandwich a plurality of balls therebetween, in order to guide a movable body secured to said slider along a path of said rail, said slider including,

(a) a ball plate in which said load ball channels are formed,

(b) a mounting plate having mounting portions for supporting the movable body and a fixed portion connected to said mounting portions, and

(c) a resin molding material at least partially surrounding said ball plate and said mounting plate, wherein said fixed portion of said mounting plate is embedded in said resin molding material.

2. A linear bearing according to claim **1**, wherein said mounting plate has an axial length less than that of said ball plate.

3. A linear bearing according to claim **1**, wherein said ball plate is made from a metal plate whose surface hardness is increased when subjected to plastic deformation, and said load ball channels are hardened to a predetermined level when said ball plate is plastically deformed to a predetermined shape.

4. A slider for a linear bearing, wherein the linear bearing includes a rail having ball channels, and a slider having load ball channels cooperating with the ball channels of the rail and to sandwich a plurality of balls therebetween, in order to guide a movable body secured to said slider along a path of the rail, said slider comprising:

(a) a ball plate in which said load ball channels are formed,

(b) a mounting plate having mounting portions for supporting the movable body and a fixed portion connected to said mounting portions, and

(c) a resin molding material at least partially surrounding said ball plate and said mounting plate, wherein said fixed portion of said mounting plate is embedded in said resin molding material.

* * * * *

US005275492A

United States Patent [19]

Shirai

[11] Patent Number: 5,275,492
[45] Date of Patent: Jan. 4, 1994

[54] **LINEAR MOTION SLIDE UNIT**

[75] Inventor: **Takeki Shirai**, Ichikawa, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **966,068**

[22] PCT Filed: **May 15, 1992**

[86] PCT No.: **PCT/JP92/00628**

§ 371 Date: **Jan. 15, 1993**

§ 102(e) Date: **Jan. 15, 1993**

[87] PCT Pub. No.: **WO92/20933**

PCT Pub. Date: **Nov. 26, 1992**

[30] **Foreign Application Priority Data**

May 16, 1991 [JP] Japan 3-141479

[51] **Int. Cl.**[5] **F16C 29/06**; F16C 33/72
[52] **U.S. Cl.** **384/15**; 384/45
[58] **Field of Search** 384/15, 43, 44, 45

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,253,709	3/1981	Teramachi	384/45
4,918,846	4/1990	Tsukada	384/15
5,087,130	2/1992	Tsukada	384/15
5,092,685	3/1992	Tonogai	384/15
5,102,235	4/1992	Mugglestone	384/45

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Kenyon & Kenyon

[57] **ABSTRACT**

A linear motion slide unit comprises a slider axially movably mounted on a guide rail by a number of rolling members. A sealing device comprises a pair of end plates mounted at both ends of the slider and a connection plate, connecting the pair of end plates, with the connection plate disposed between the slider and the guide rail in the axial direction. First sealing members are disposed on the end plates where the end plates face the guide rail. Second sealing members extend along the axial direction of the connection plate.

5 Claims, 4 Drawing Sheets

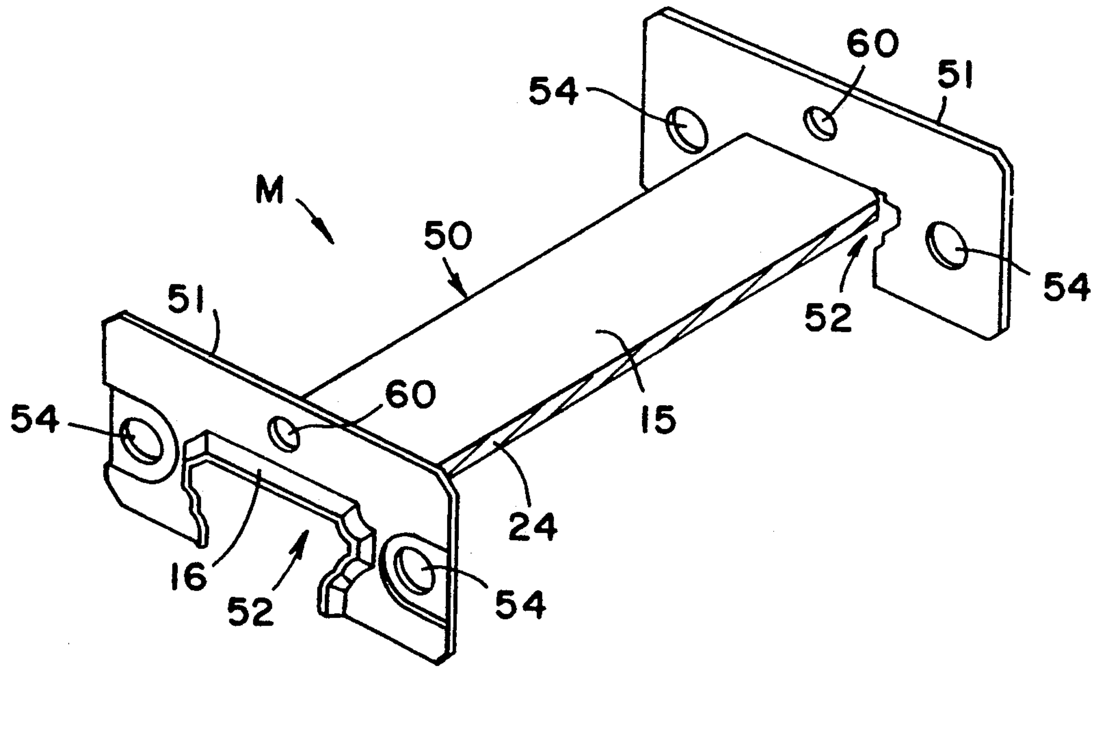


FIG. 1(A)

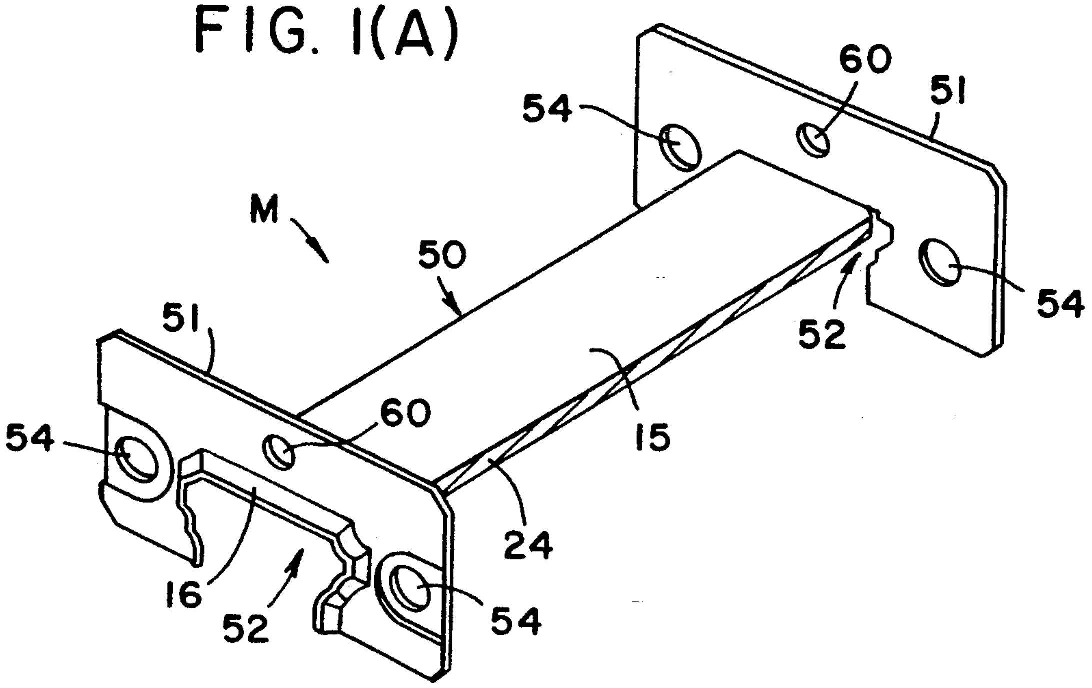

54
60
51
M
50
54
52
51
60
15
54
24
16
54
52

FIG. 1(B)

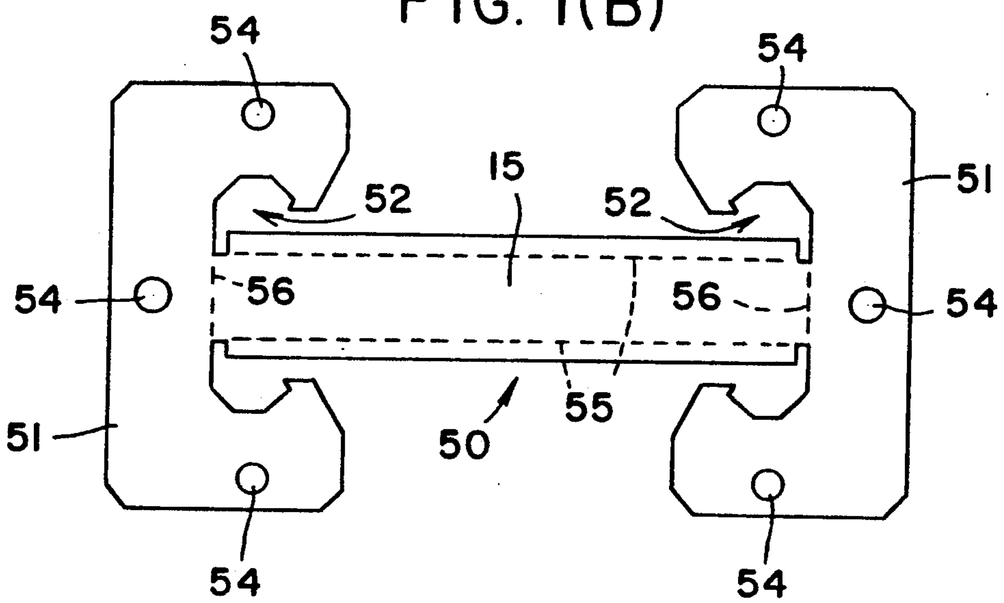

54
54
15
51
52
52
54
56
56
54
55
51
50
54
54

FIG. 2(A)

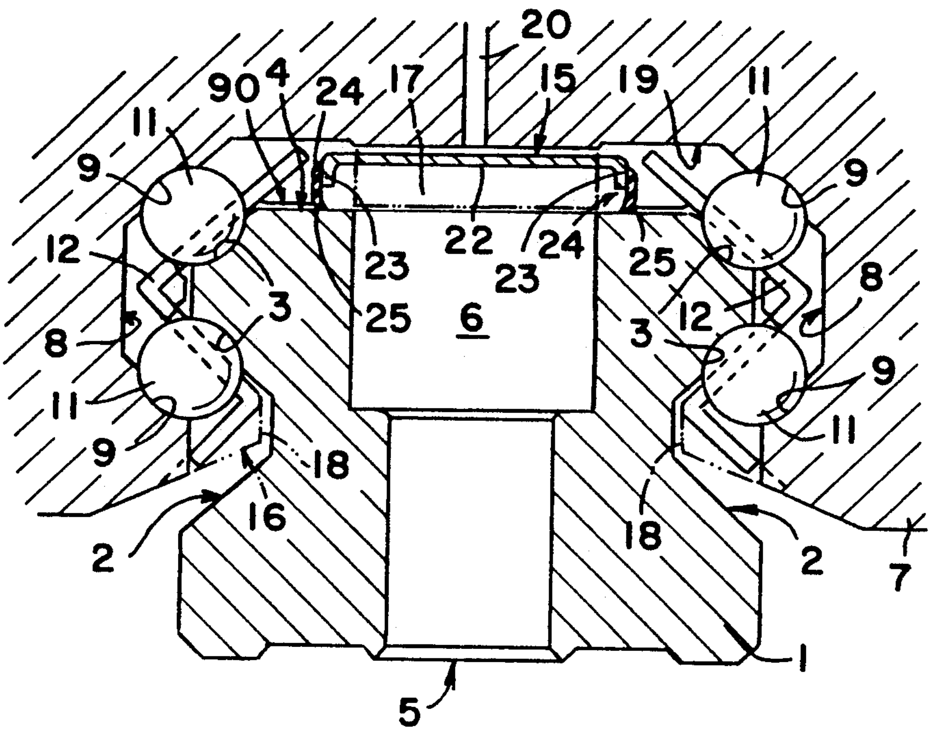

20
90
4
24
17
15
19
11
9
11
9
12
22
23
24
23
25
23
25
6
3
12
8
8
3
3
11
9
11
9
18
16
18
2
2
7
1
5

FIG. 2(B)

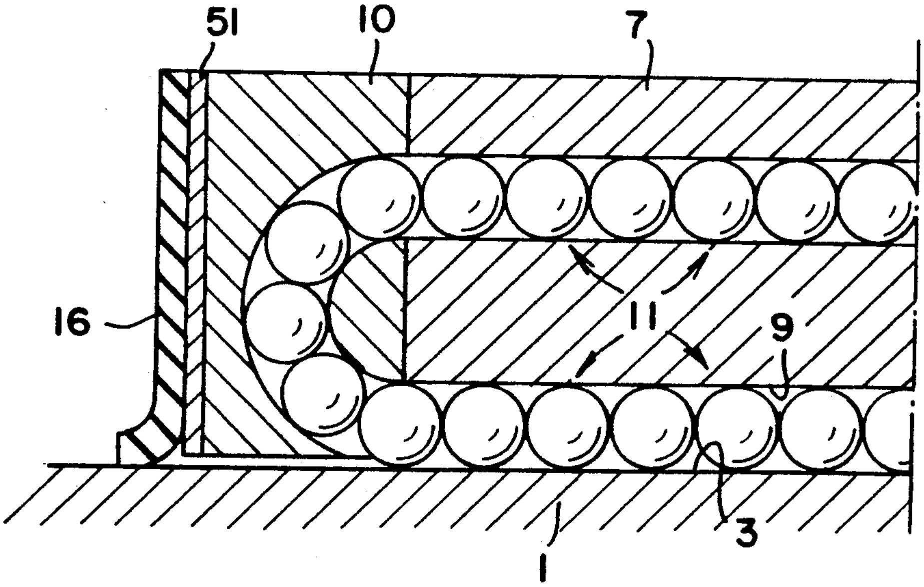
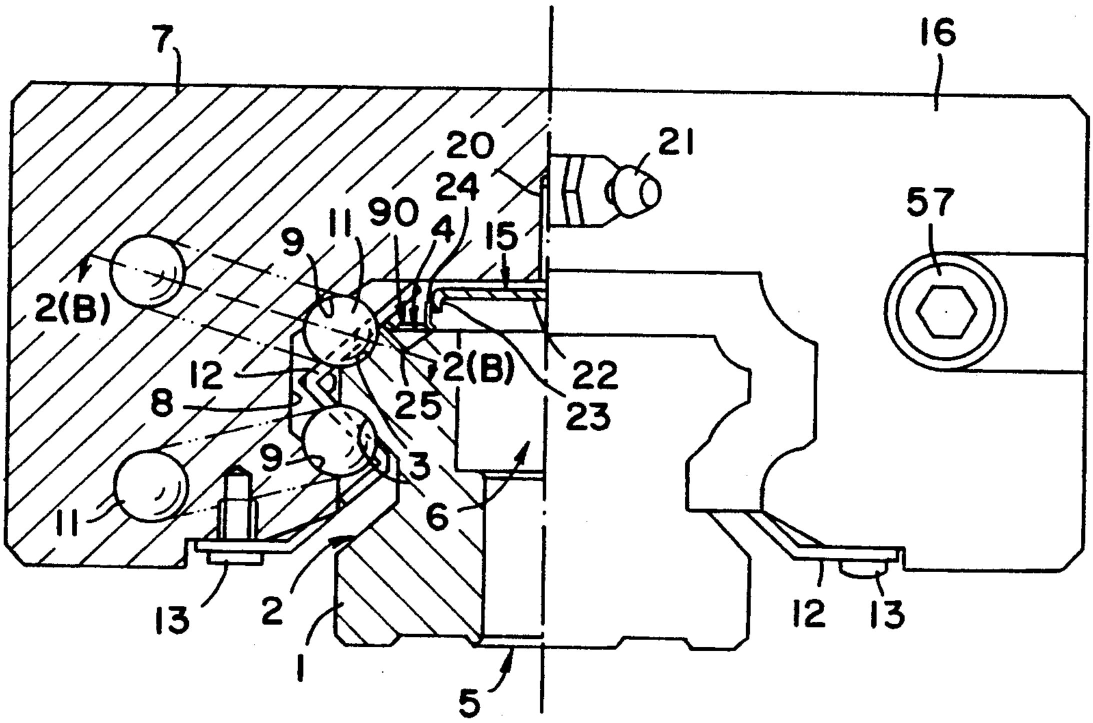

51
10
7
16
11
9
3
1

FIG. 3



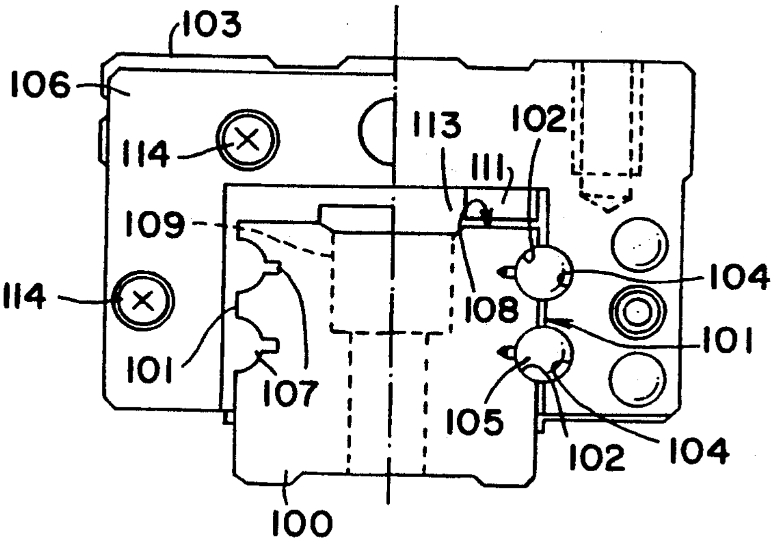


FIG. 4(A)
PRIOR ART

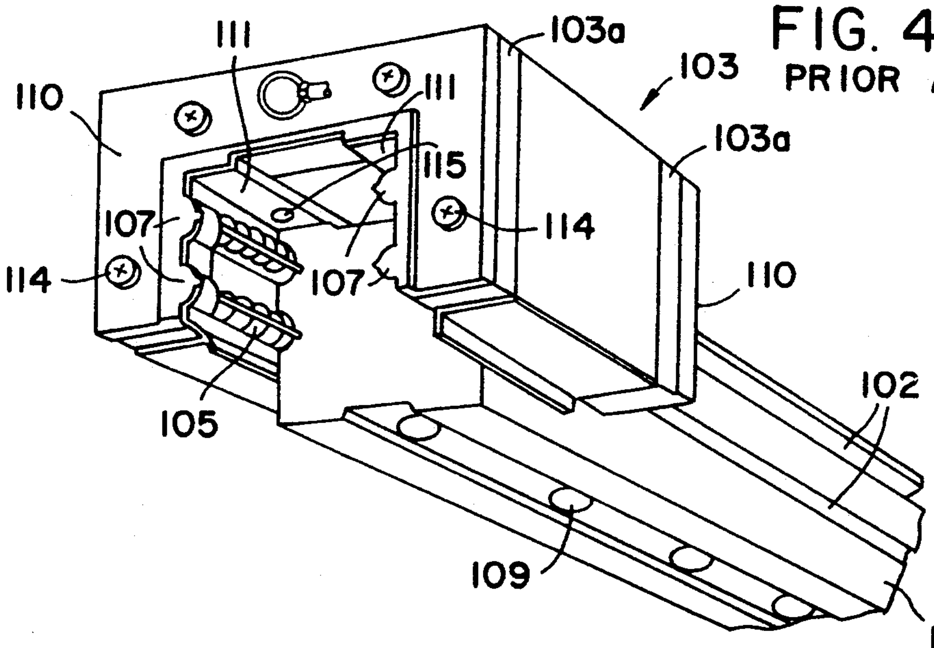


FIG. 4(B)
PRIOR ART

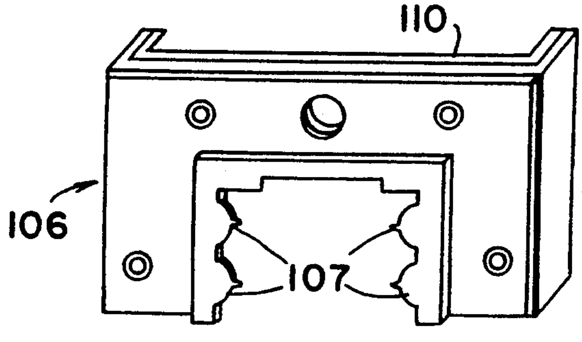


FIG. 4(C)
PRIOR ART

LINEAR MOTION SLIDE UNIT

TECHNICAL FIELD

This invention relates to a sealing device of a linealy movable mechanism and a method of manufacturing the sealing device.

BACKGROUND ART

FIG. **4** shows a conventional linearly movable mechanism, in which first rolling member rolling grooves **102** are provided to both side surfaces **101** of a guide rail **100** and second rolling member rolling grooves **104** facing the first rolling grooves **101** are formed to a slider **103**. The slider **103** is slidable on the guide rail **100** in the axial direction thereof through rolling members **105** disposed between the first and second rolling grooves **102** and **104**.

A pair of end plates **103***a* are attached to both the axial ends of the slider **103**, and end seals (first seal members) **106** are secured to end plates **110** disposed at the end faces of the end plates **103***a*. The end plates **103***a* and the end plates **110** are fastened fixedly to the slider **103** by means of screws **114**. The end seals **106** are provided with sealing projections **107** slidably contacting the first rolling grooves **102**. Upper seals (second sealing members) **111** extending axially are fixedly fastened to the slider **103** by means of screws **115** at portions corresponding to the upper surface **108** of the guide rail **100**, and the upper seals **111** are constructed as members independent from the end seals **106**.

In the conventional linearly movable mechanism of the structure described above, the rolling members **105** are rolled to thereby axially move the slider **103** on and along the guide rail **100**. The sealing projections **107** prevent external cut chips or spatters from invading into the first and second rolling grooves **102** and **104**. In addition, the upper seals **111** prevent foreign materials from invading into the first and second rolling grooves **102** and **104** through the upper surface **108** of the guide rail **100**. However, in the conventional technology, the end seals **106** and the upper seals **111** are attached to the slider **103** independently with each other, thus performing less workability and reducing productionability.

DISCLOSURE OF INVENTION

The present invention is directed to a linear motion slide unit comprising:

a guide rail in which a first rolling member rolling groove extending in an axial direction is formed;

a slider in which a second rolling member rolling groove facing the first rolling member rolling groove is formed;

a number of rolling members disposed between the first and second rolling member rolling grooves to thereby axially movably support the slider on the guide rail; and

a sealing device comprising a pair of end plates axially disposed at both ends of the slider, a connection plate disposed between the slider and the guide rail in the axial direction thereof and integrally connected to the paired end plates, first sealing members disposed at positions at which the end plates face the guide rail and second sealing members extending along the axial direction of the connection plate.

The slider has preferably substantially a]-shape in cross section and the end plates each secured to the end portion of the slider has also a]-shape in cross section. The respective recessed portions of the end plates can be integrally connected with each other through the connection plate.

The first seal members are formed in a shape conforming with the outer peripheral shape of the guide rail.

Furthermore, the connection plate comprises a base portion and bent portions formed by bending both side edges of the base portion, and the second seal members are secured to the outer side surfaces of the bent portions.

Still furthermore, in a preferred embodiment, the second seal members are composed of lip portions inclining towards the centeral side of the guide rail.

The present invention further provides a method of manufacturing a sealing device of a linearly movable mechanism comprising the steps of forming a pair of end plates integrally with a plate-like body having a connection plate connected in an axial direction to the paired end plates, joining first seal members to the paired end plates, joining second seal members to the connection plate, and thereafter bending connected portions between the end plates and the connection plate in a widthwise direction, wherein the end plates and the connection plate is integrally formed, so that the first and second seal members are secured to the slider together in one assembling process.

Further, the sealing device can be constructed by the steps of forming a pair of end plates integrally with a plate-like body having a connection plate to which the paired end plates are axially connected, joining first seal members to the paired end plates and second seal members to the connection plate along the axial direction, and thereafter bending connected portions between the end plates and the connection plate in a widthwise direction.

As described above, according to the present invention, the first and second seal members are secured to the slider together by one assembling process, thus improving the assembling workability, and hence, improving the production efficiency of the linearly movable mechanisms.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**(A) is a perspective view of a sealing device of the present invention before the attachment to a slider; FIG. **1**(B) is a plan view of a punched plate according to the present invention; FIG. **2**(A) is a front sectional view showing the sealing device of the present invention; FIG. **2**(B) shows a second rolling member rolling groove according to the present invention and is a sectional view taken along the line 2(B)—2(B) in FIG. **3**; FIG. **3** is a front view, partially cut away, of the sealing device of a linearly movable mechanism according to the present invention; FIG. **4**(A) is a front view, partially cut away, of a sealing device of a linearly movable mechanism of a conventional structure; FIG. **4**(B) is a perspective view of FIG. **4**(A); and FIG. **4**(C) is a perspective view of an end seal secured to an end plate of a conventional structure.

BEST MODES FOR EMBODYING THE INVENTION

The present invention will be described hereunder with reference to the accompanying drawings. FIGS. **2**(A), **2**(B), and **3** show a guide mechanism of a linear motion to which the present invention is applied. In these figures, reference numeral **1** denotes a guide rail having a predetermined axial length, and the guide rail **1**, and two rows of first rolling member rolling grooves **3** are formed to both side surfaces **2** of the guide rail **1** in a vertically aligned attitude in the illustration, each of the first rolling grooves **3** having an arcuate cross section and extending in the axial direction of the guide rail **1**. A plurality of attachment holes **6** are formed to the central portion in the widthwise direction of the guide rail **1** with predetermined spaces therebetween in the axial direction thereof for inserting bolts, not shown, from the upper surface side **4** to the lower surface side **5**. The upper surface **4** of the guide rail **1** is formed to be flat.

A slider **7** having substantially a]-shaped cross section is mounted on the guide rail **1**. The inner side surfaces **8** of the]-shaped slider **7** face the side surfaces of the guide rail **1** and two rows of second rolling member rolling grooves **9** are formed to both the inner surfaces **8** of the sides of the slider **7** so as to extend in the axial direction thereof. End plates **10** each having a sectional shape substantially similar to that of the slider **7** are attached to both the axial end surfaces of the slider **7**.

Each of the second rolling grooves **9** is formed circularly through the insides of the slider **7** and the end plate **10**, and a number of balls **11** (such as steel balls) as the rolling members are disposed between the second rolling grooves **9** and the first rolling grooves **3**. According to the structure described above, the slider **7** is movable on the guide rail **1** along the axial direction thereof.

A sealing device M shown in FIG. **1**(A) is attached to the slider **7**, the sealing device M being described hereunder. Reference numeral **50** is a plate body made of a metal material, for example, which is composed of a pair of end plates **51** to be attached perpendicularly to both the ends of the end plate **10**, each of the end plates **51** having a]-shaped section and a horizontal connection plate **15** connecting]-shaped recesses **52** of both the end plates **51** at its both axial ends. End seals as first sealing members **16** made of a rubber-like elastic material (nitrile rubber, styrene rubber, butyl rubber, or the like) are bonded to the surfaces of the paired end plates **51** such as sintering manner. The end seals **16** serve to seal a space between the slider **7** and the upper surface **4** of the guide rail **1** and the inner peripheral surface of each of the end seals **16** has a shape similar to the outer peripheral surface of the guide rail **1**. The end seals **16** are formed on the entire surfaces of the end plates **51**, but they may be applied locally only on the surfaces of the recesses **52**. Screw insertion holes **54** and insertion holes **60** for grease nipples **21** are formed to the end plates **51** at portions opposing to each other, respectively.

The connection plate **15** has a cross sectional shape as shown in FIG. **2**(A) and is composed of a base portion **22** having a width of a size more than an opening diameter of the attachment hole **6** and bent portions **23** formed by bending downward both edge portions of the base portion **22**. A pair of inner seals **24** as second sealing members are bonded such as in sintering manner to the outside surfaces of the bent portions **23**. The inner seals **24** are formed of a rubber-like elastic material (nitlie rubber, styrene rubber, butyl rubber, or the like), and are provided with lip portions **25** at the lower end portions, as viewed, thereof so as to face each other, that is, to incline towards the attachment hole **6**. The lip portions **25** contact the upper surface **4** of the guide rail **1** in the axial direction thereof with a predetermined contacting pressure with respect to the space between the attachment hole **6** and the first rolling grooves **3**, thus forming a sealing surface.

The sealing device M will be manufactured in a manner described hereunder with reference to FIG. **1**(B).

The plate body **50** is first formed from a plate member by means of a pressing machine, not shown, so as to have a pair of end plates **51** and the connection plate **15** integrally formed to the end plates **51** so that the end plates **51** are positioned at both the axial ends of the connection plate **15**. The thus formed plate body **50** is placed in a cavity of a mold, not shown, and a rubber formation material is then fed into the cavity. The end seals **16** are sintered or baked on portions near the recesses **52** of the end plates **51** and the inner seals **24** are also sintered or baked to the bent portions **23** of the connection plate **15** along the axial direction thereof. Thereafter, the plate body **50** is separated from the mold and the plate body **50** is bent along folding lines **55** and **56**, thus completing the sealing device.

Furthermore, a passage **20** for supplying a lubricant is formed to the slider **7** so as to communicate with a space between the inner lower surface **19** of the slider **7** and the upper surface **4** of the guide rail **1**, and the passage **20** is also communicated with the grease nipples **21** connected to the end surface sides of the end seals **16**.

A plate **12** for holding the balls **11** is provided for the inside surface **8** of the slider **7** and the plate **12** is fastened to the lower surface of the slider **7** by means of bolts **13**.

The slider of the structure described above is assembled with the sealing device M in the following manner.

The end plates **10** are closely contacted to the corresponding surfaces of the end plates **51** and then placed on the connection plate **15**, and thereafter, the plate body **50** is assembled with the slider **7** from the lower side thereof and screws **57** are inserted into the insertion holes **54** and fastened thereto, thus completing the assembling working. In this assembling, the formation of femail threads on both the end surfaces of the slider **7** is a matter of natural. According to the present invention, the end seals **16** and the inner seals **24** are together secured to the slider at one assembling working, thus improving the workability and enhancing the productivity of the linearly movable mechanisms.

The sealing device M operates as follows.

The slider **7** can be freely slidable in a linearly reciprocal manner on the guide rail **1** along the axial direction thereof through the rolling motion of the balls **11** disposed between the first and second rolling grooves. Then, the end seals **16** slidably contact the upper surface **4** of the guide rail **1** and the both the side surfaces **2** thereof to construct the first sealing surface, and the inner seals **24** slidably contact the upper surface **4** of the guide rail **1** to form the second sealing surface between them and the end seals **16**. Accordingly, the invasion of the cut chips or foreign materials such as spatters into the space between the upper surface **4** of the guide rail **1** and the inner lower surface **19** of the slider **7** and the space between the side surfaces **2** of the guide rail **1** and the inner side surfaces **8** of the slider **7**, that is, the invasion into the first and second rolling grooves **3** and **9**, can be prevented. Furthermore, even if such chips or foreign materials be invaded thereinto through the space between the upper surface **4** of the guide rail **1** and the inner lower surface **19** of the slider, the chips or foreign materials can be prevented from invading into the first and second rolling grooves **3** and **9** by the presence of the second sealing surface formed between the inner seals **24** and the upper surface **4** of the guide rail **1**. Accordingly, the preferred ball rolling condition can be achieved, thus performing the stable linear motion of the slider **7**. Furthermore, since the inner seals **24** are slidably contacted to the upper surface **4** of the guide rail **1** in the axial direction, the sliding resistance with respect to the upper surface **4** of the guide rail **1** can be made small, thus being difficult to cause wearing thereof.

During the operation described above, the lubrication oil, i.e. grease, fed from the grease nipple **21** is fed into a portion **90** between the slider **7** and the guide rail **1** through the supply passage **20** as arrowed in FIG. 2A. In this operation, since the inner seals **24** contact to the upper surface **4** of the guide rail **1**, the displacement of the grease to the central portion of the upper surface **4** can be limited. Accordingly, the grease fed into the portion **90** can be effectively fed towards the first and second ball rolling grooves **3** and **9** from the outside of the upper surface **4** of the guide rail **1**, thus the sliding surface being well lubricated. Furthermore, the lip portions **25** of the inner seals **24** are inclined towards the central side of the upper surface **4**, so that the used and degraded grease lifts up the lip portions **25** and is removed to the central side of the upper surface **4**. However, when a pressure is applied to the lip portions **25** from the central side of the upper surface **4** of the guide rail **1**, the surface contacting pressure further increases, thus improving the sealing effect.

In the described embodiment, the balls are referred to as the rolling members, but other rolling members such as rollers may be utilized.

Field of Industrial Usage

As described above, the sealing device of the present invention can be utilized for linearly movable mechanisms for machine tools, measuring devices, medical equipments and the like.

Particularly, since the first and second sealing members are together fixed to the slider through one assembling working only by attaching the plate body to the slider, the present invention is applicable particularly for the assembling working to the linearly movable guide mechanisms.

I claim:

1. A linear motion slide unit comprising:

a guide rail in which a first rolling member rolling groove extending in an axial direction is formed;

a slider in which a second rolling member rolling groove facing the first rolling member rolling groove is formed;

a number of rolling members disposed between the first and second rolling member rolling grooves to thereby axially movably support the slider on the guide rail; and

a sealing device comprising a pair of end plates axially disposed at both ends of the slider, a connection plate disposed between the slider and the guide rail in the axial direction thereof and integrally connected to the paired end plates, first sealing members disposed at positions at which the end plates face the guide rail and second sealing members extending along the axial direction of the connection plate.

2. A linear motion slide unit according to claim **1**, wherein said slider has substantially a]-shaped cross section and said end plates have substantially]-shaped cross sections, respectively, to provide recessed portions, said recessed portions of said end plates being connected integrally through the connection plate.

3. A linear motion slide unit according to claim **1**, wherein said first sealing members each has a shape similar to an outer peripheral shape of the guide rail.

4. A linear motion slide unit according to claim **1**, wherein said connection plate comprises a base portion and bent portions formed by bending both edge portions of the base portion and said second sealing members are fixed to outer side surfaces of the bend portions.

5. A linear motion slide unit according to claim **1**, wherein said second sealing members are formed by lip portions inclined towards a central side of the guide rail.

* * * * *

US005265963A

United States Patent [19]

Kawaguchi

[11] **Patent Number: 5,265,963**

[45] **Date of Patent: Nov. 30, 1993**

[54] **SIDE COVER FIXING STRUCTURE FOR LINEAR MOTION BEARING**

[75] Inventor: **Takahiro Kawaguchi**, Tokyo, Japan

[73] Assignee: **Thk Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **961,708**

[22] PCT Filed: **May 12, 1992**

[86] PCT No.: **PCT/JP92/00602**

§ 371 Date: **Mar. 11, 1993**

§ 102(e) Date: **Mar. 11, 1993**

[87] PCT Pub. No.: **WO92/20930**

PCT Pub. Date: **Nov. 26, 1992**

[30] **Foreign Application Priority Data**

May 13, 1991 [JP] Japan .... 3-42343[U]

[51] **Int. Cl.**[5] **F16C 29/04**

[52] **U.S. Cl.** **384/43**; 384/45

[58] **Field of Search** 384/43, 44, 45, 49

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,637,739 1/1987 Hattori 384/45
4,674,893 6/1987 Teramachi 384/45
5,087,130 2/1992 Tsukada .... 384/45 X
5,102,235 4/1992 Mugglestone 384/45

FOREIGN PATENT DOCUMENTS

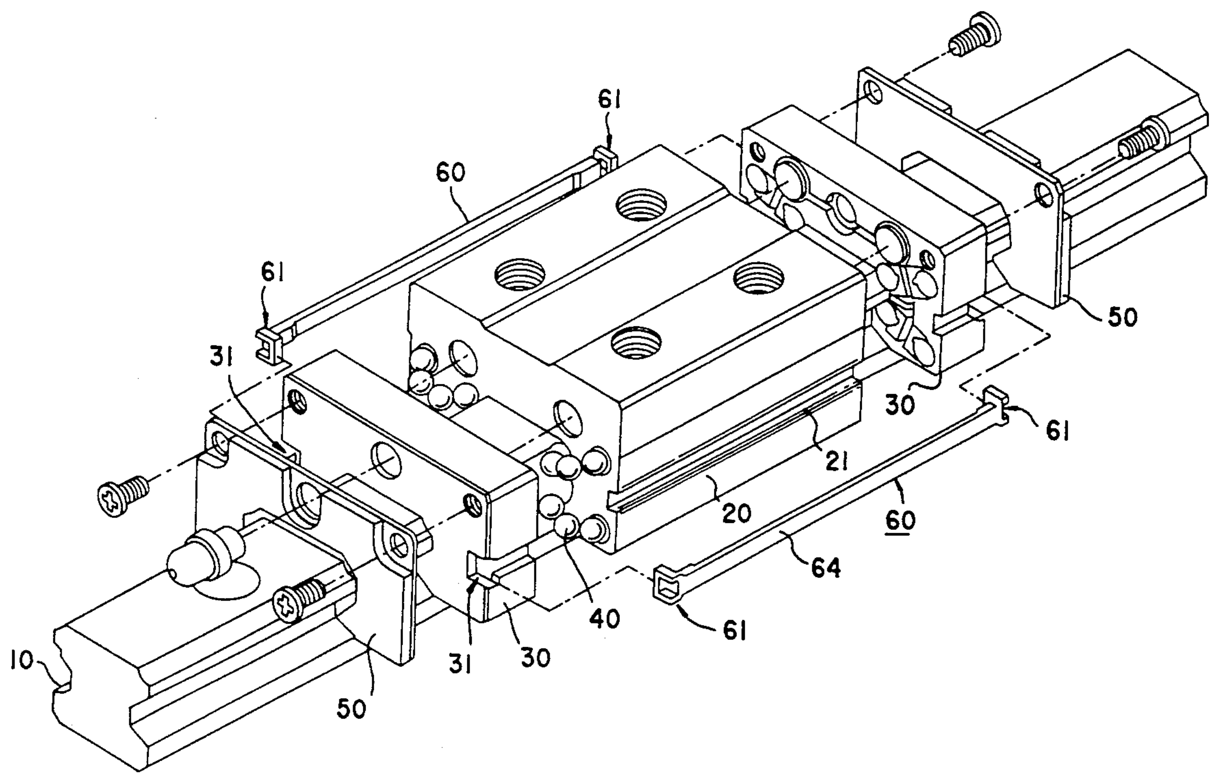
51-131542 4/1950 Japan .
55-72912 6/1980 Japan .
58-48778 10/1983 Japan .
58-153717 10/1983 Japan .

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

A structure is provided for a linear motion bearing to be widely used as an industrial machine element and especially for a small-sized linear motion bearing, to fix side covers simply and inexpensively on the bearing body. Each of paired side covers **30** and **30** to be fixed in abutment on the two end faces of the bearing body **20** is formed with at least two retaining portions **31** and **31**, and at least two connecting plates **60** and **60** to be bridged over the paired side covers **30** and **30** across the bearing body **10** are formed with hook portions **61** to be retained by the retaining portions **31** of the side covers **30**, whereby the bearing body **20** and the paired side covers **30** and **30** are integrally fixed by retaining the hook portions **61** of the two ends of the connecting plates **60** in the corresponding retaining portions **31** of the individual side covers **30**.

4 Claims, 5 Drawing Sheets



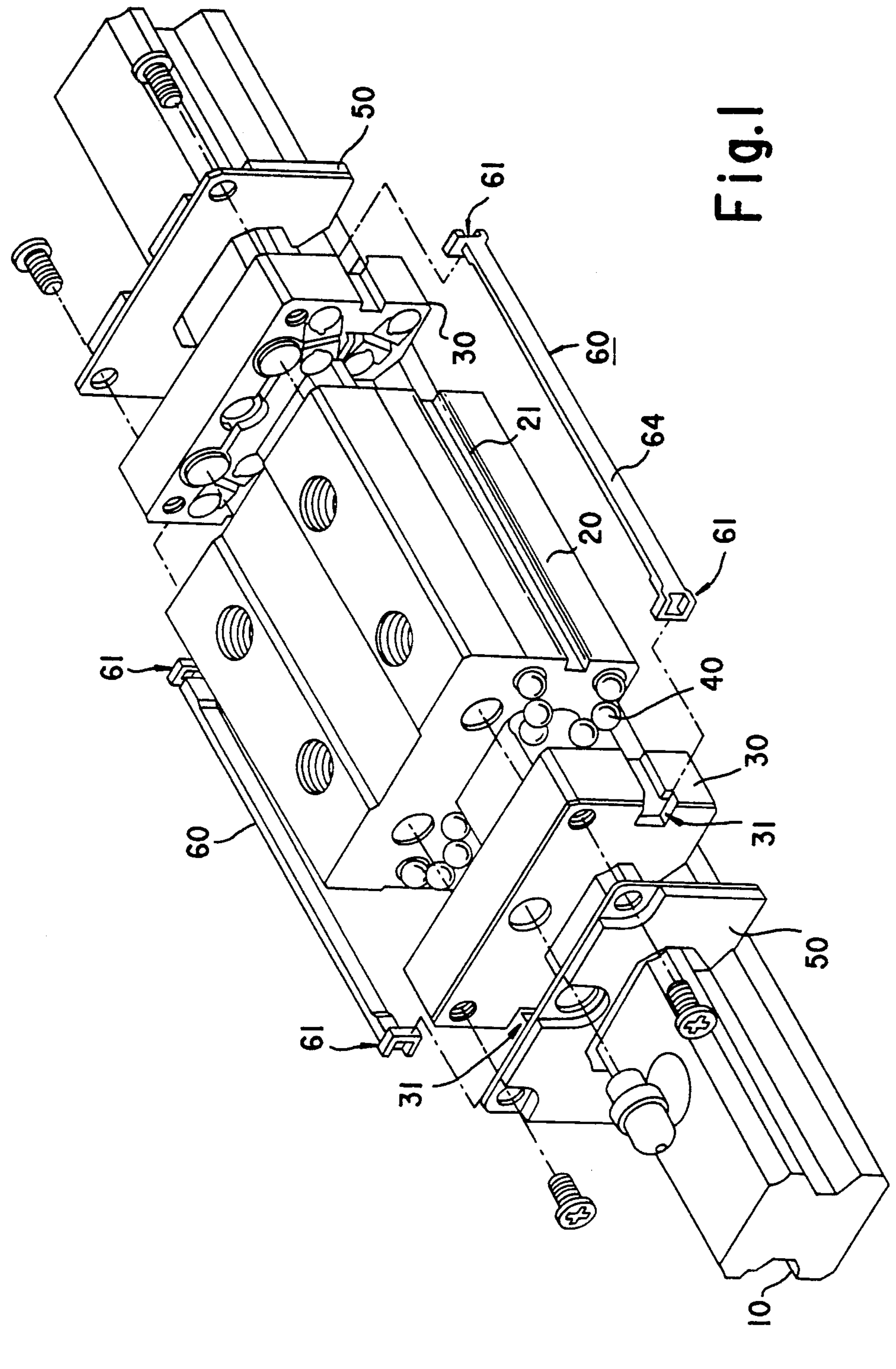


Fig. 1

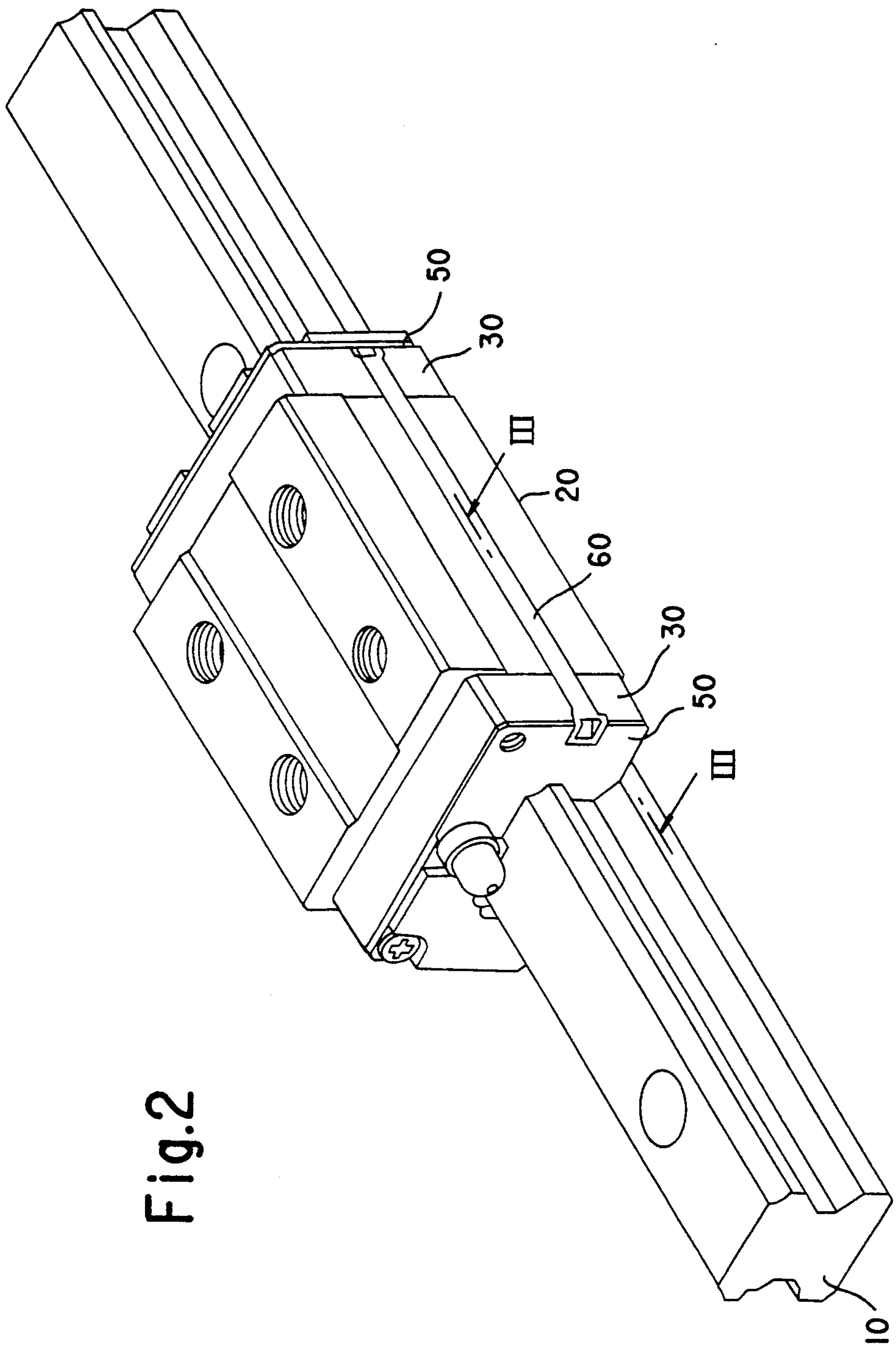


Fig.2

Fig.3

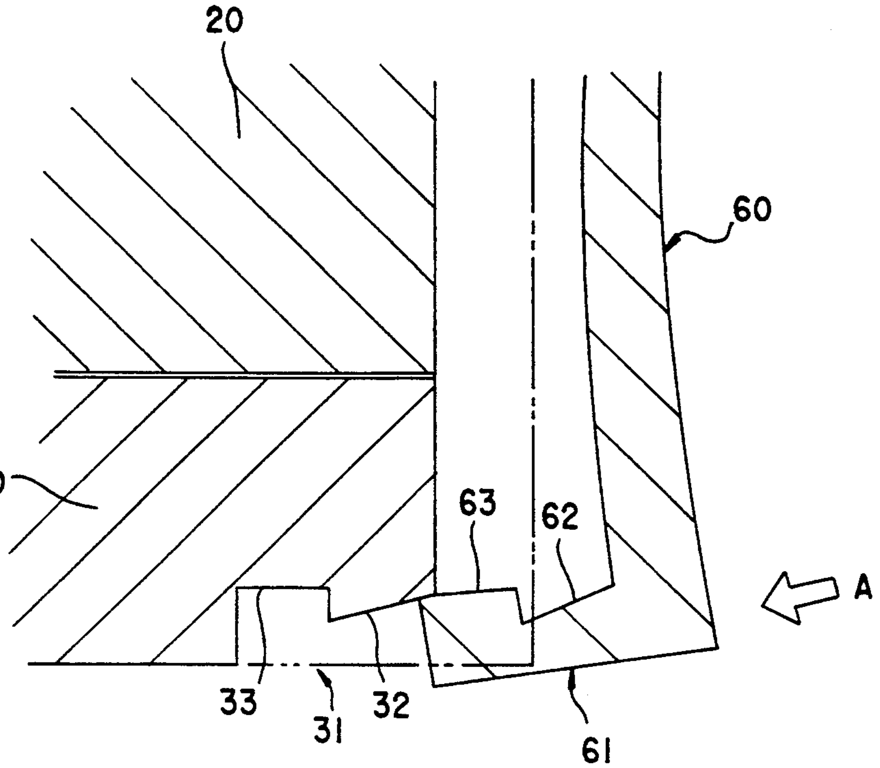


Fig.4

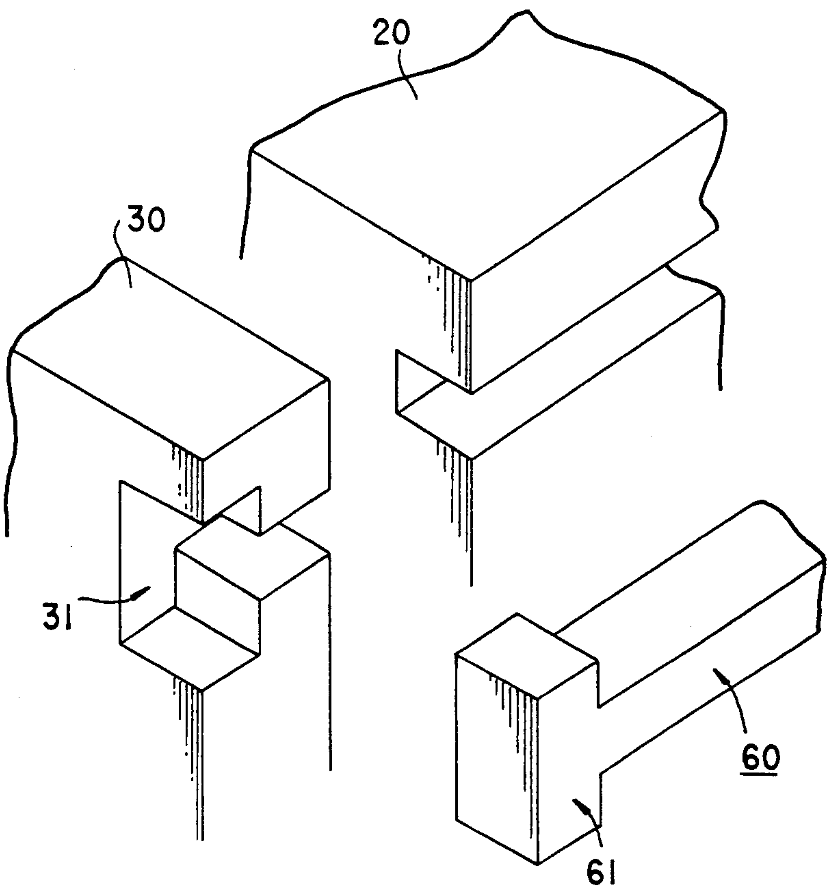
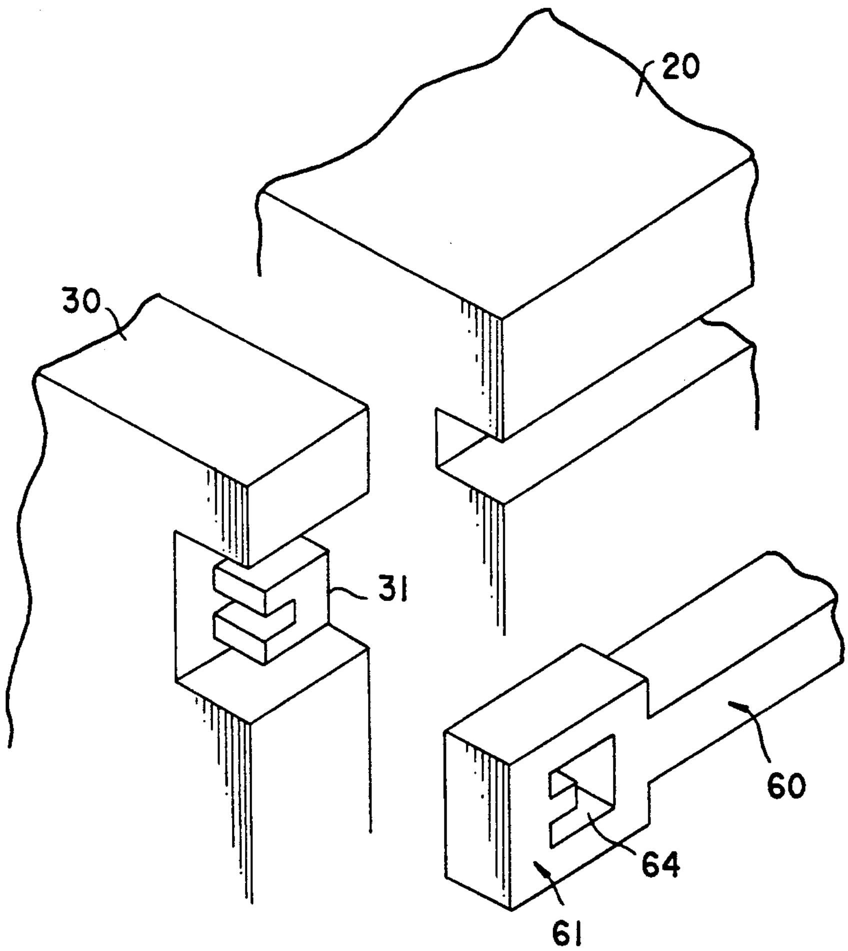


Fig.5



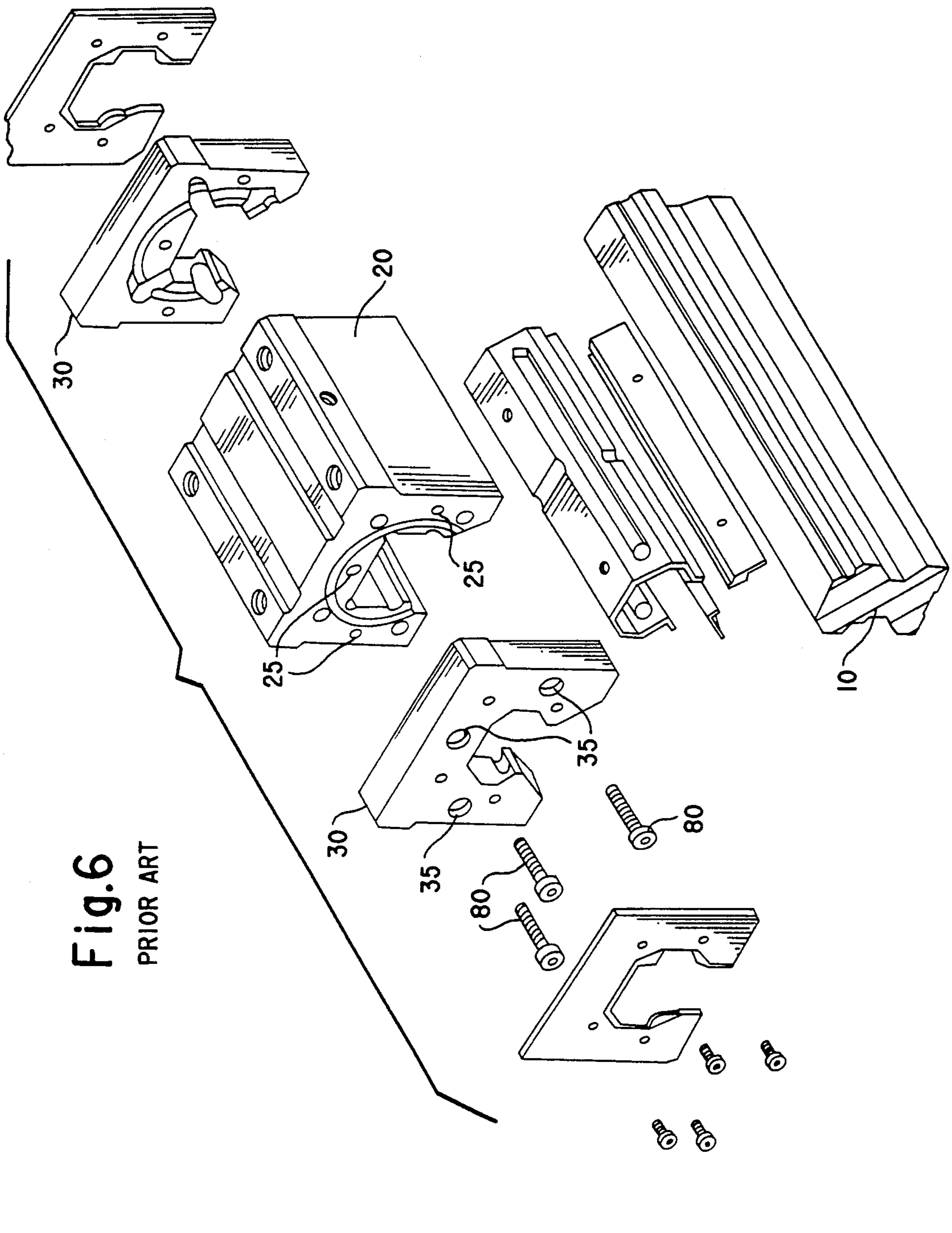


Fig.6
PRIOR ART

SIDE COVER FIXING STRUCTURE FOR LINEAR MOTION BEARING

TECHNICAL FIELD

The present invention relates to a side cover fixing structure in a linear motion bearing for fixing side covers on the bearing body.

BACKGROUND ART

The linear motion bearing is widely used as industrial machine elements such as a table saddle for a machine tool, a slide face of a machining center or a carriage of a conveyor.

The linear motion bearing of the prior art is constructed, as shown in FIG. **6**, to include: a track bed **10**; a bearing body **20** of a metal placed on the track bed **10**; a pair of side covers **30** and **30** of a synthetic resin fixed in abutment on the two end faces of the bearing body **20**; a number of balls **40** interposed between the bearing body **20** and the track bed **10**; and a not-shown retainer for preventing the balls **40** from coming out when the bearing body **20** is removed from the track bed **10**.

In the linear motion bearing thus constructed, the side covers **30** are fixed by using screws **80** on the two end faces of the bearing body **20**. Specifically, the side covers **30** of synthetic resin are formed with through holes **35** in their predetermined positions. Moreover, the metallic bearing body **20** is formed with tapped holes **25** in its corresponding positions. The screws are extended through the through holes **35** of the side covers **30** and fastened in the tapped holes **25** of the bearing body **20**.

In recent years, the linear motion bearing described above is used in OA equipment or electric appliances, too. In these examples of use, the linear motion bearing is generally small-sized and compact.

The tapping operations of the holes **25** in the bearing body **20** becomes the more difficult together with the screw fastening operations as the linear motion bearing has the smaller size.

An object of the present invention is to solve the aforementioned problems of the prior art and to provide a side cover fixing structure capable of fixing the side covers simply and inexpensively on the body of a small-sized linear motion bearing.

DISCLOSURE OF THE INVENTION

According to the present invention, there is provided a side cover fixing structure for a linear motion bearing, which structure comprises: a bearing body; a pair of side covers to be fixed in abutment on the two end faces of said bearing body and each having at least two retaining portions; and at least two connecting plates of an elastic member each having at its two ends hook portions to be retained by the retaining portions of said side covers, whereby said connecting plates fix said bearing body and said paired side covers integrally by having their two end hook portions retained by the corresponding retaining portions of said side covers.

In this technical means, the paired side covers are arranged in abutment against the two end faces of the bearing body. Each side cover is equipped with retaining portions in at least two portions, e.g., at the two side portions. Moreover, the connecting plates made of an elastic member have their two end hook portions so fitted on the retaining portions of the paired side covers as to cross the bearing body. As a result, the paired side covers are fixed on the two end faces of the bearing body by using at least two connecting plates.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded perspective view showing one embodiment of a linear motion bearing having a side cover fixing structure according to the present invention;

FIG. **2** is a perspective view showing the side cover fixing structure of FIG. **1** when the same is assembled;

FIG. **3** is a section showing a portion of the side cover fixing structure of FIG. **1** and taken along line III—III;

FIG. **4** is an exploded perspective view showing an essential portion of another embodiment of the side cover fixing structure according to the present invention;

FIG. **5** is an exploded perspective view showing an essential portion of still another embodiment of the side cover fixing structure according to the present invention; and

FIG. **6** is a perspective view showing the side cover fixing structure of the linear motion bearing of the prior art.

DESIGNATIONS OF REFERENCE NUMERALS

10 . . . Track Bed; **20** . . . Bearing Body; **30** . . . Side Covers; **31** . . . Retaining Portions; **32** . . . Slopes; **33** . . . Recesses; **40** . . . Balls; **60** . . . Connecting Plates; **61** . . . Hook Portions; **62** . . . Recesses; and **63** . . . Flat Faces.

BEST MODE FOR CARRYING OUT THE INVENTION

A side cover fixing structure of a linear motion bearing according to the present invention will be described in detail in the following with reference to the accompanying drawings.

With reference to FIGS. **1** and **2**, there is shown one embodiment of the side cover fixing structure of the linear motion bearing according to the present invention.

The linear motion bearing, as shown, is basically constructed of components similar to those of the linear motion bearing of the prior art shown in FIG. **6**. Specifically, the linear motion bearing is constructed to include: a track bed **10**; a bearing body **20** of a metal placed on the track bed; a pair of side covers **30** of die cast metal or synthetic resin fixed in abutment on the two end faces of the bearing body **20**; a multiplicity of balls **40** interposed between the bearing body **20** and the track bed **10**; and sealed retainer holders **50** for preventing any invasion of foreign substances. These are components well known in the art, and their detailed description will be omitted. p

The present invention is characterized in that the paired side covers **30** and **30** are fixed in abutment on the two end faces of the bearing body **20**.

In the embodiment of FIGS. **1** and **2**, each side cover **30** is formed at its two end portions with retaining portions **31**. Each of these retaining portions **31** is formed of a slope **32** and a deeper recess **33**, as shown in FIG. **3**.

The side cover fixing structure according to the present invention further includes two connecting plates **60** and **60** made of an elastic member such as synthetic resin. Each of these connecting plates **60** is formed at its two ends with a hook portion **61** to be retained by the retaining portion **31** of the side cover **30**. As shown in FIG. **3**, the hook portion **61** is formed of a recess **62** and a flat face 63, which mate with the slope 32 and the recess 33 of the retaining portion 31, respectively. The recess 62 may preferably have its bottom face inclined at such an angle that it contacts in a face-to-face relation with the slope 32 of the retaining portion 31. As a result, the side covers 30 and 30 are firmly fixed on the two end faces of the bearing body 20.

Since the side cover 30 is formed with the slopes 32, as described above, the hook portions 61 of the connecting plates 60 are opened, as shown, if pushed from the side faces of the linear motion bearing, until they fitted on the retaining portions 31 formed on the two side portions of the side covers 30. As a result, the hook portions 61 of the connecting plates 60 can be prevented from coming out of the retaining portions 31 of the side covers 30.

Incidentally, the metallic bearing body 20 may preferably be formed, as in the shown embodiment, with grooves 21 for accommodating the step portions 64 of the connecting plates. Generally speaking, the bearing body 20 is manufactured by the cold drawing process so that the formation of the grooves 21 extending in the axial direction of the bearing body 20 will not lead to a rise in the production cost. Since the connecting plates 60 are fitted as a whole in the side faces of the bearing body 20, there are obtained advantages that the connecting plates 60 can be prevented from coming out even with the possible contacts with foreign substances and that the bearing body 20 can have its side faces retaining their roles as reference faces.

FIG. 4 shows another embodiment of the side cover fixing structure according to the present invention. In this embodiment, each connecting plate 60 has a T-shaped hook portions 61 whereas the side cover 30 has its retaining portions 31 recessed to fit the hook portions 61.

According to the present embodiment, the T-shaped hook portions 61 formed at the connecting plate 60 are fixedly fitted in the recesses of the side covers 30 so that the connecting plates 60 can be prevented from coming out.

FIG. 5 shows still another embodiment of the side cover fixing structure according to the present invention. In this embodiment, each connecting plate 60 is formed in its hook portions 61 with C-shaped recesses whereas the side cover 30 has its retaining portions 31 formed into projections which are fitted in the recess of the connecting plate 60.

In the present embodiment, the retaining portions 31 and the hook portions 61 are caused to engage in more portions than those of FIG. 4 so that the connecting plates 60 can be firmly fixed in the side covers 30.

The retaining portions 31 of the side covers 30 and the hook portions 61 of the connecting plates 60 should not be limited to those of the foregoing embodiments but could adopt various constructions. Moreover, the numbers and positions of the retaining portions 31 formed at the side covers 30 and the connecting plates 60 can be suitably selected, if necessary.

Next, the method of assembling the side cover fixing structure according to the present invention will be described in the following.

First of all, the paired side covers 30 and 30 are applied to and arranged on the two end faces of the bearing body 20. Next, one hook portion 61 of the first connecting plate 60 is retained by the retaining portion of one side cover 30. After this, the other hook portion 61 of the connecting plate 60 is retained by the retaining portion 31 of the other side cover 30. These operations are accomplished by pushing the other hook portion 61 of the connecting plate 60 strongly in the direction of arrow A, as shown in FIG. 3. Similar operations are carried out for the second connecting plate 60, thus fixing the paired side covers 30 and 30 on the two end faces of the bearing body 20.

INDUSTRIAL APPLICABILITY

As has been described hereinbefore, according to the side cover fixing structure of the present invention, the paired side covers are fixed on the two end faces of the bearing body by using the paired connecting plates so that the linear motion bearing can be advantageously practiced simply and inexpensively even it is small-sized. As a result, it is possible to automate the assembly of the small-sized linear motion bearing and to manufacture a more compact linear motion bearing than that of the prior art.

I claim:

1. A side cover fixing structure for a linear motion bearing, comprising:
   - a bearing body;
   - a pair of side covers to be fixed in abutment on the two end faces of said bearing body and each having at least two retaining portions; and
   - at least two connecting plates of an elastic member each having at its two ends hook portions to be retained by the retaining portions of said side covers, whereby said connecting plates fix said bearing body and said paired side covers integrally by having their two end hook portions retained by the corresponding retaining portions of said side covers.

2. A side cover fixing structure for a linear motion bearing according to claim (1), wherein each of the retaining portions of said side covers is formed of a slope and a deeper recess whereas said connecting plates have their hook portions shaped to mate the retaining portions of said side covers.

3. A side cover fixing structure for a linear motion bearing according to claim (1), wherein said connecting plates have their hook portions formed to have a shape of letter "T" whereas said side covers have their retaining portions are formed with recess for retaining the hook portions of said connecting plates.

4. A side cover fixing structure for a linear motion bearing according to claim (1), wherein said connecting plates have their hook portions formed to have C-shaped recesses whereas said side covers have their retaining portions formed into protrusions to be fitted in the recesses of said connecting plates. j

* * * * *

US005248202A

United States Patent [19]

Kawasugi et al.

[11] Patent Number: 5,248,202

[45] Date of Patent: Sep. 28, 1993

[54] **BEARING AND A TABLE FOR LINEAR SLIDING MOTION**

[75] Inventors: **Masashi Kawasugi**, Onoda; **Mitsuhiro Nobukuni**, Shimonoseki, both of Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **828,958**

[22] PCT Filed: **May 30, 1991**

[86] PCT No.: **PCT/JP91/00729**

§ 371 Date: **Mar. 20, 1992**

§ 102(e) Date: **Mar. 20, 1992**

[87] PCT Pub. No.: **WO92/00462**

PCT Pub. Date: **Jan. 9, 1992**

[30] **Foreign Application Priority Data**

Jun. 22, 1990 [JP] Japan 2-162570

[51] **Int. Cl.^{5}** **F10C 29/06**

[52] **U.S. Cl.** **384/45**

[58] **Field of Search** 384/43–45; 464/168

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,443,042	4/1984	Walter et al.	384/43
4,799,803	1/1989	Tanaka	384/43

FOREIGN PATENT DOCUMENTS

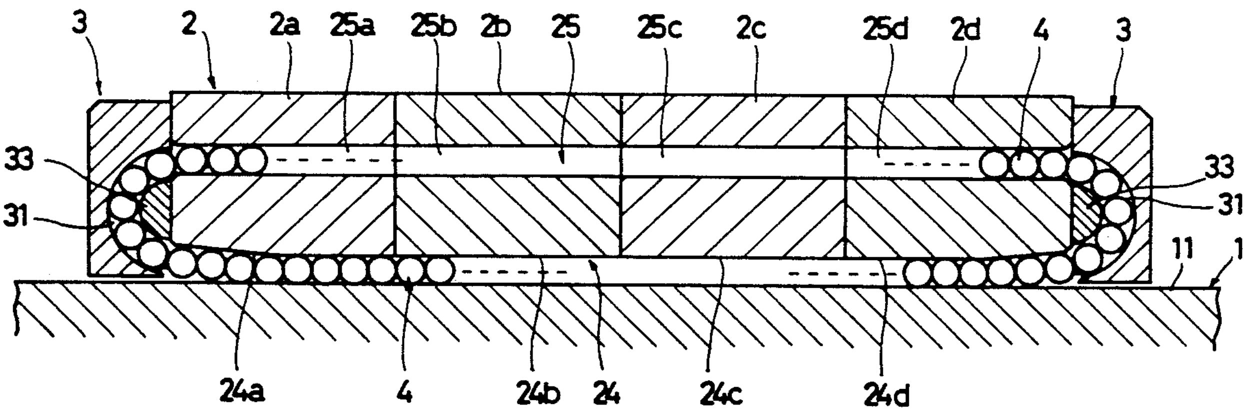
59-28773	7/1984	Japan .
61-266823	11/1986	Japan .
2-57718	2/1990	Japan .

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

According to a bearing and a table for linear sliding motion according to the invention, a sliding table is formed of a plurality of divided blocks which are aligned in one row and have load rolling surfaces on which rolling members rolls. By arbitrarily choosing a number of the divided blocks, a number of the load rolling members can be facilely increased depending on a size of the table to be linearly guided. Therefore, waving of the slide members can be minimized, and linearity of the movement thereof can be improved.

3 Claims, 12 Drawing Sheets



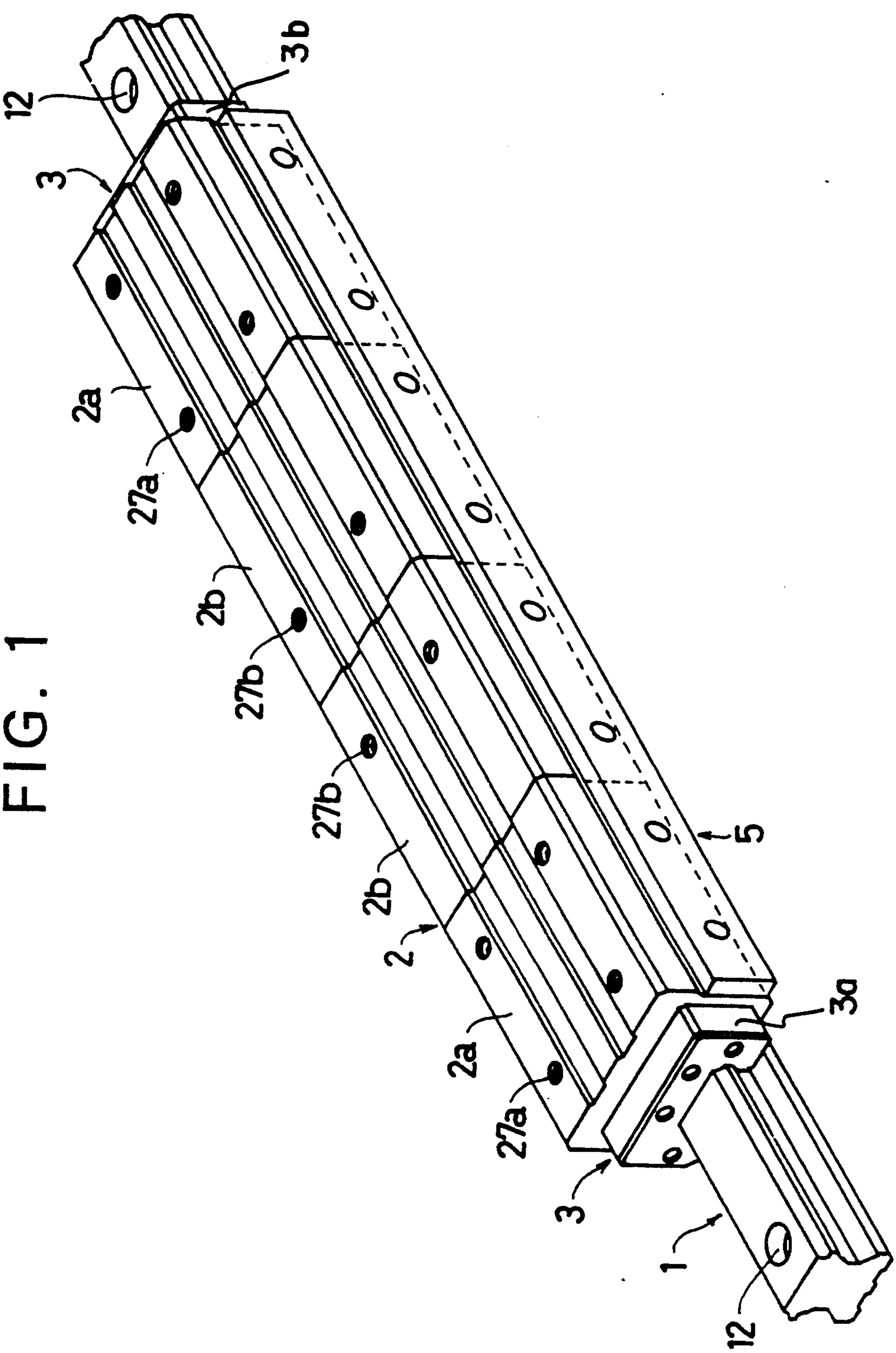


FIG. 1

FIG. 2

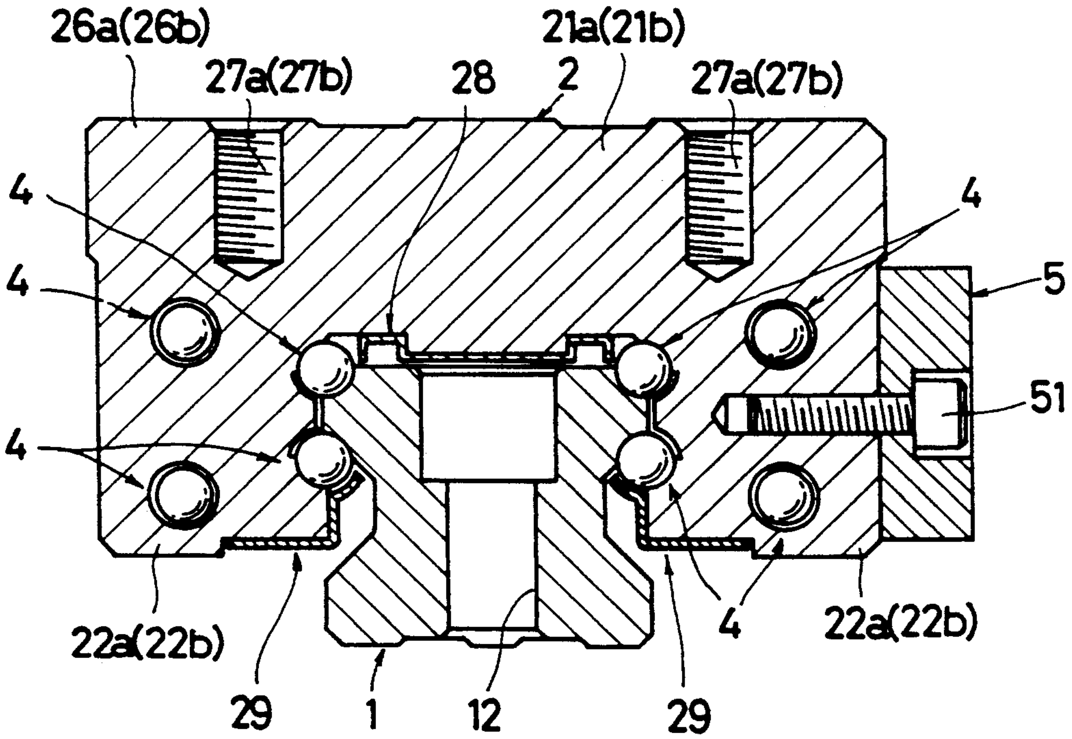

26a(26b)
27a(27b)
28
2
21a(21b)
27a(27b)
4
4
4
4
5
51
4
4
22a(22b)
22a(22b)
29
1
12
29

FIG. 3

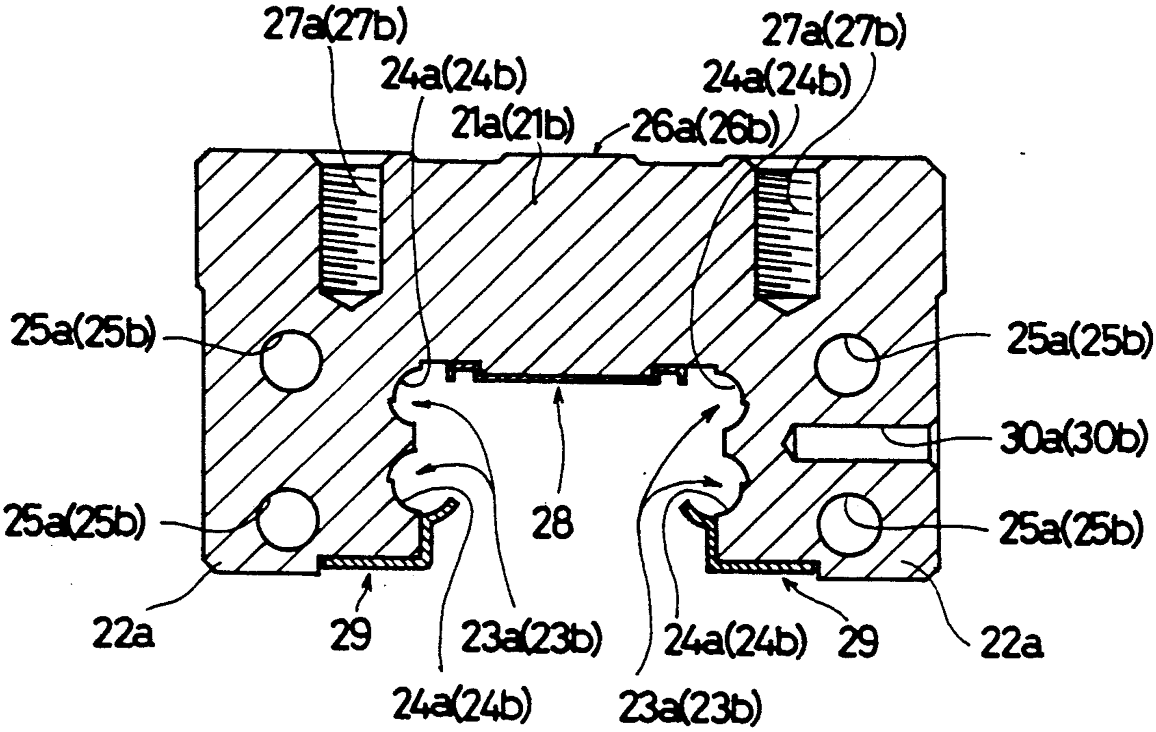

27a(27b)
24a(24b)
21a(21b)
26a(26b)
27a(27b)
24a(24b)
25a(25b)
25a(25b)
30a(30b)
25a(25b)
28
25a(25b)
22a
29
23a(23b)
24a(24b)
29
22a
24a(24b)
23a(23b)

FIG. 4

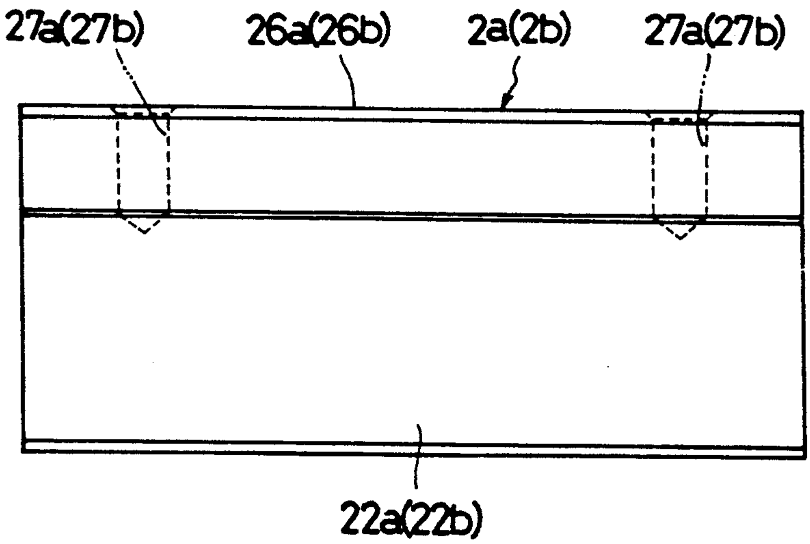

27a(27b)
26a(26b)
2a(2b)
27a(27b)
22a(22b)

FIG. 5

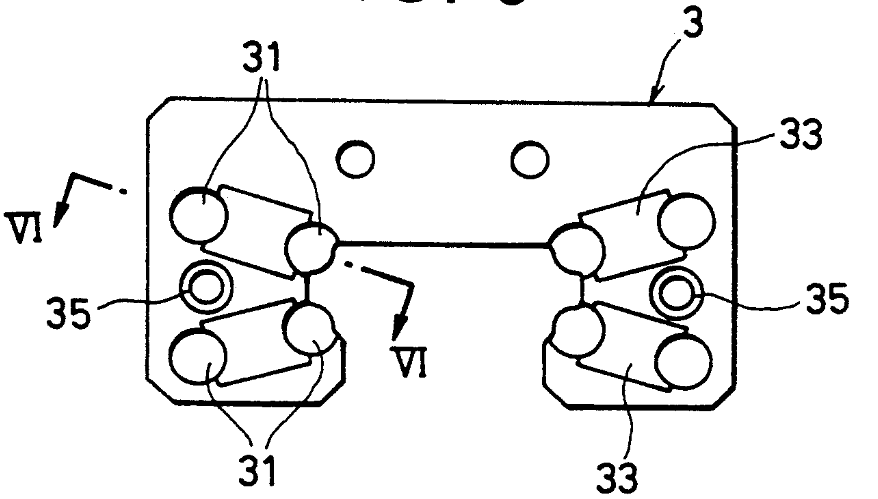


FIG. 6

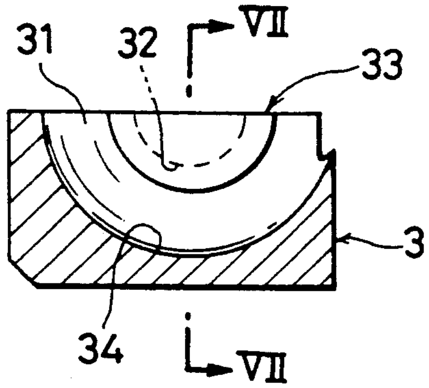


FIG. 7

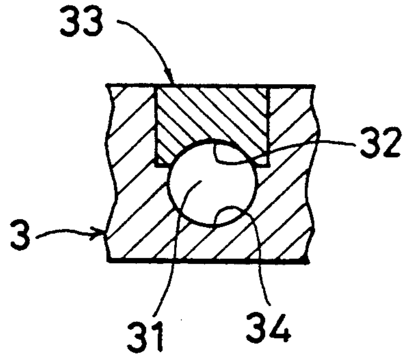


FIG. 8

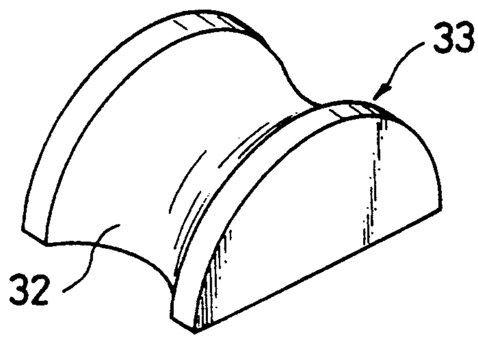


FIG. 9

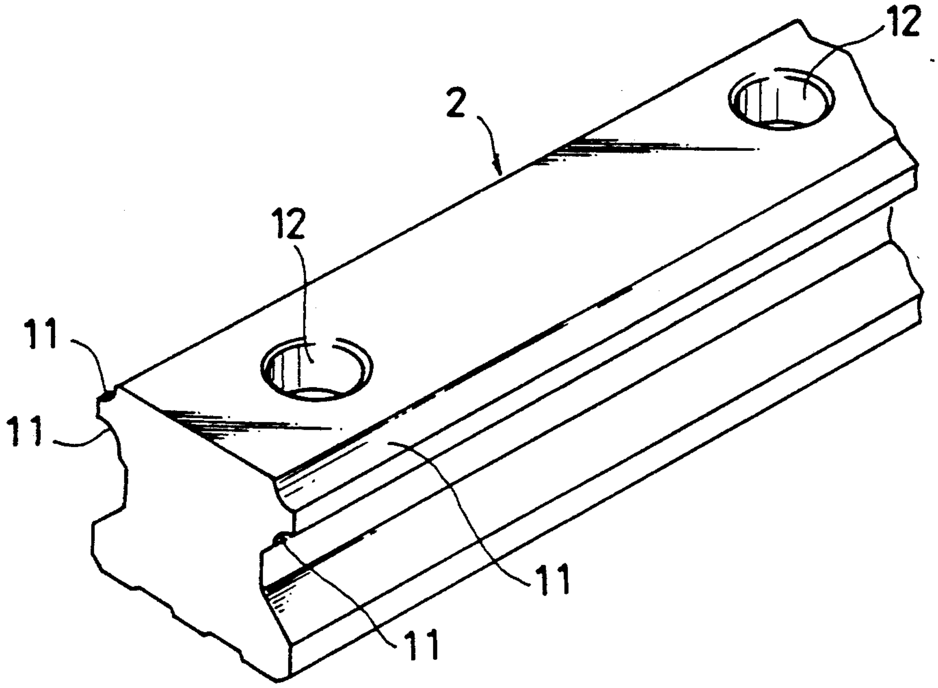
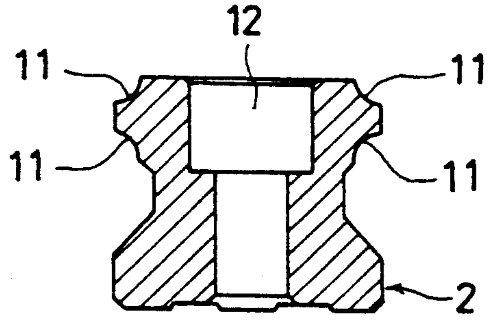


FIG. 10



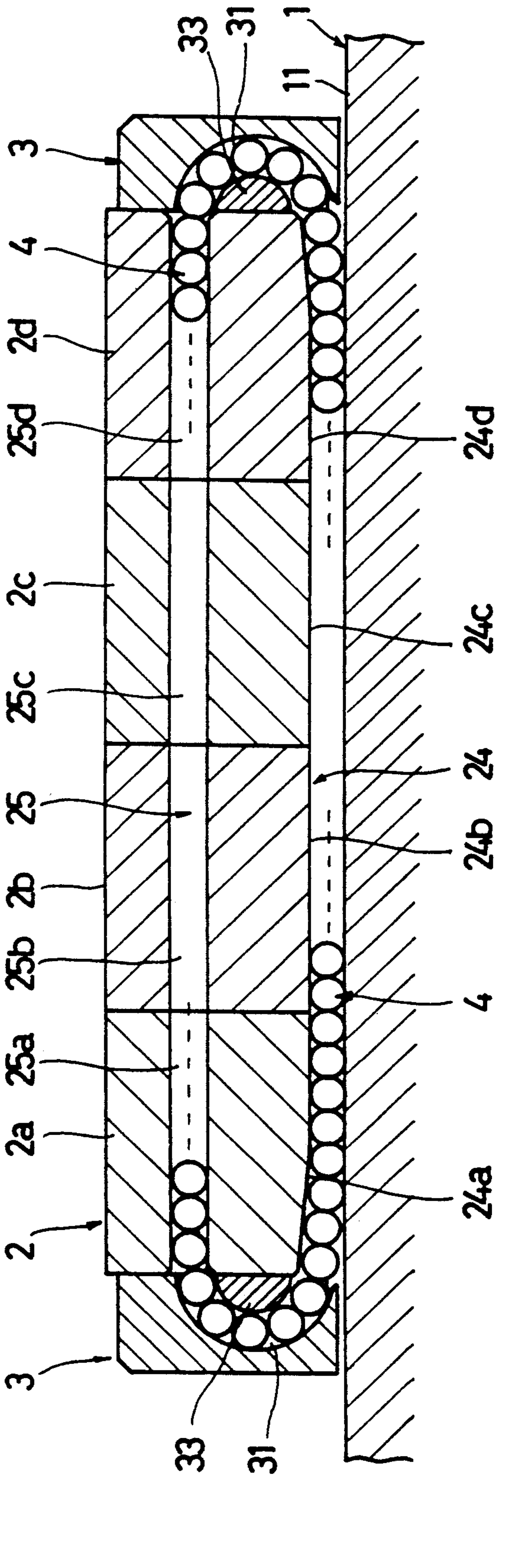

3
4
2d
25d
2c
25c
25
2b
25b
25a
2a
2
3
33
31
1
11
24d
24c
24
24b
4
24a
33
31

FIG. 11

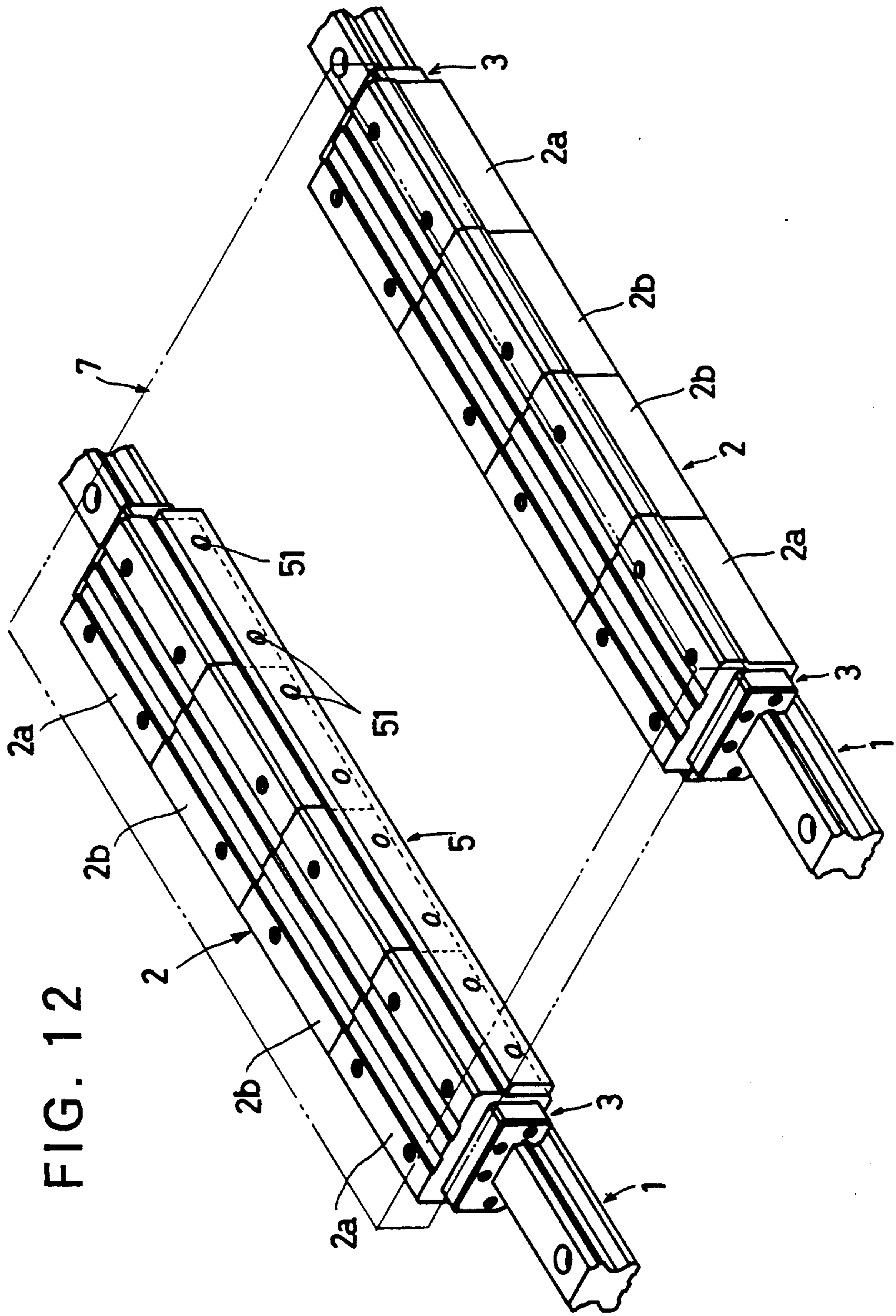


FIG. 12

FIG. 13

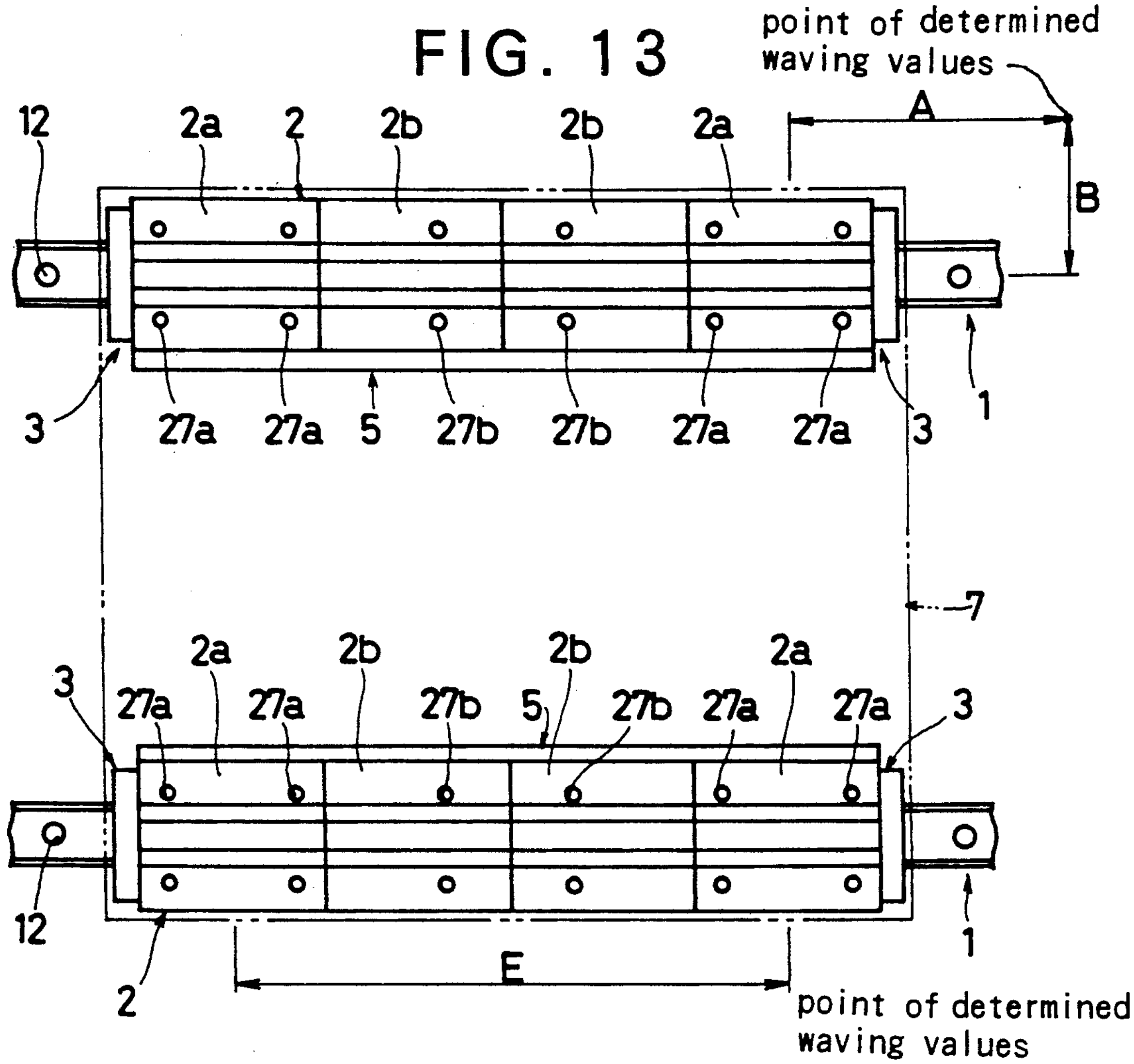

point of determined
waving values
A
B
12
2a
2
2b
2b
2a
3
27a
27a
5
27b
27b
27a
27a
3
1
7
2a
2b
2b
2a
3
27a
27a
27b
5
27b
27a
27a
3
12
2
E
1
point of determined
waving values

FIG. 14

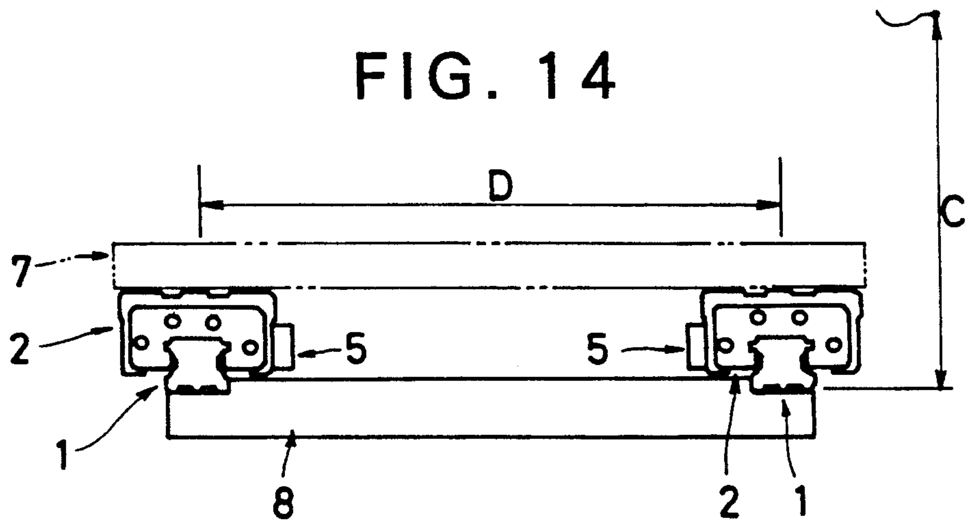
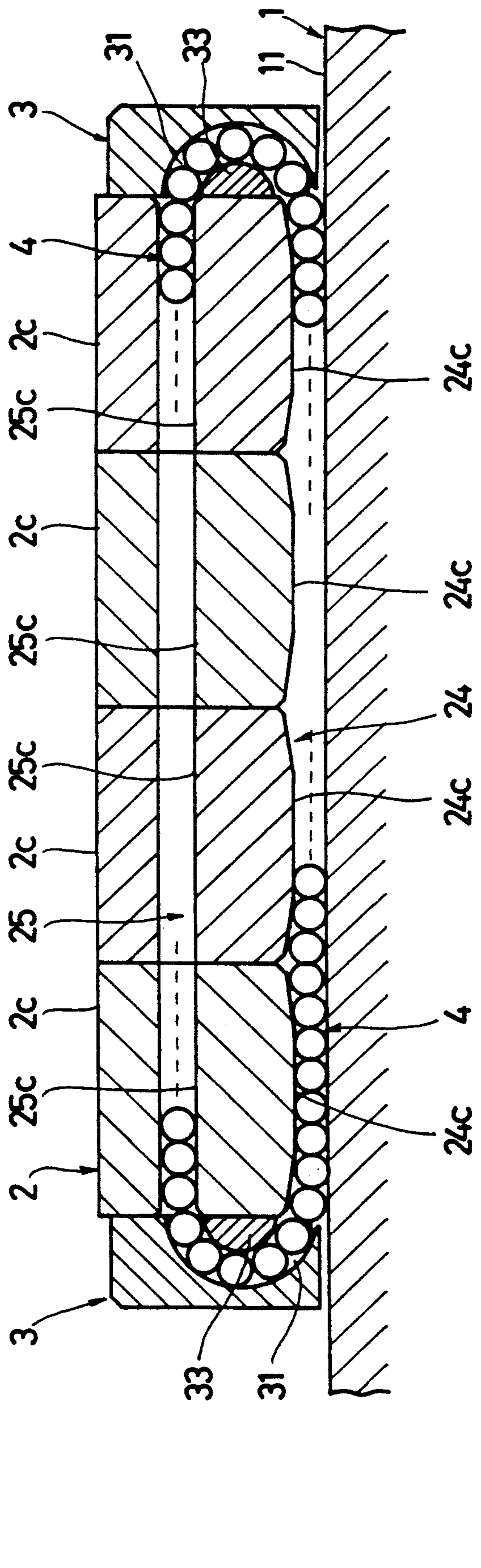
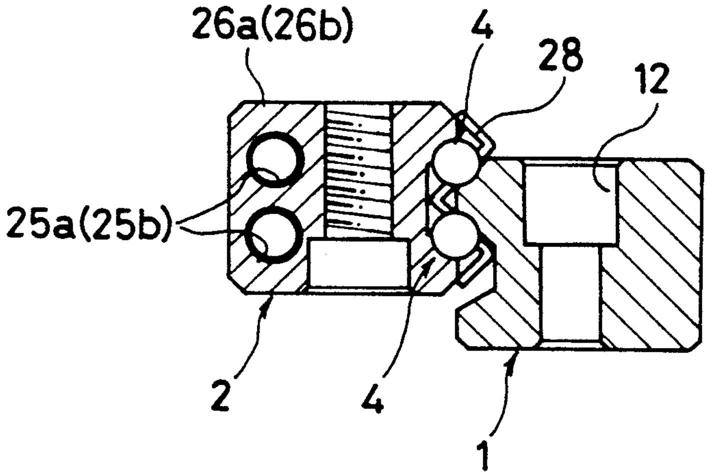

D
C
7
2
5
5
1
8
2
1

FIG. 15



3
31
33
11
1
4
2c
25c
24c
2c
25c
24c
24
25c
24c
2c
25
2c
4
25c
24c
2
3
33
31

FIG. 16



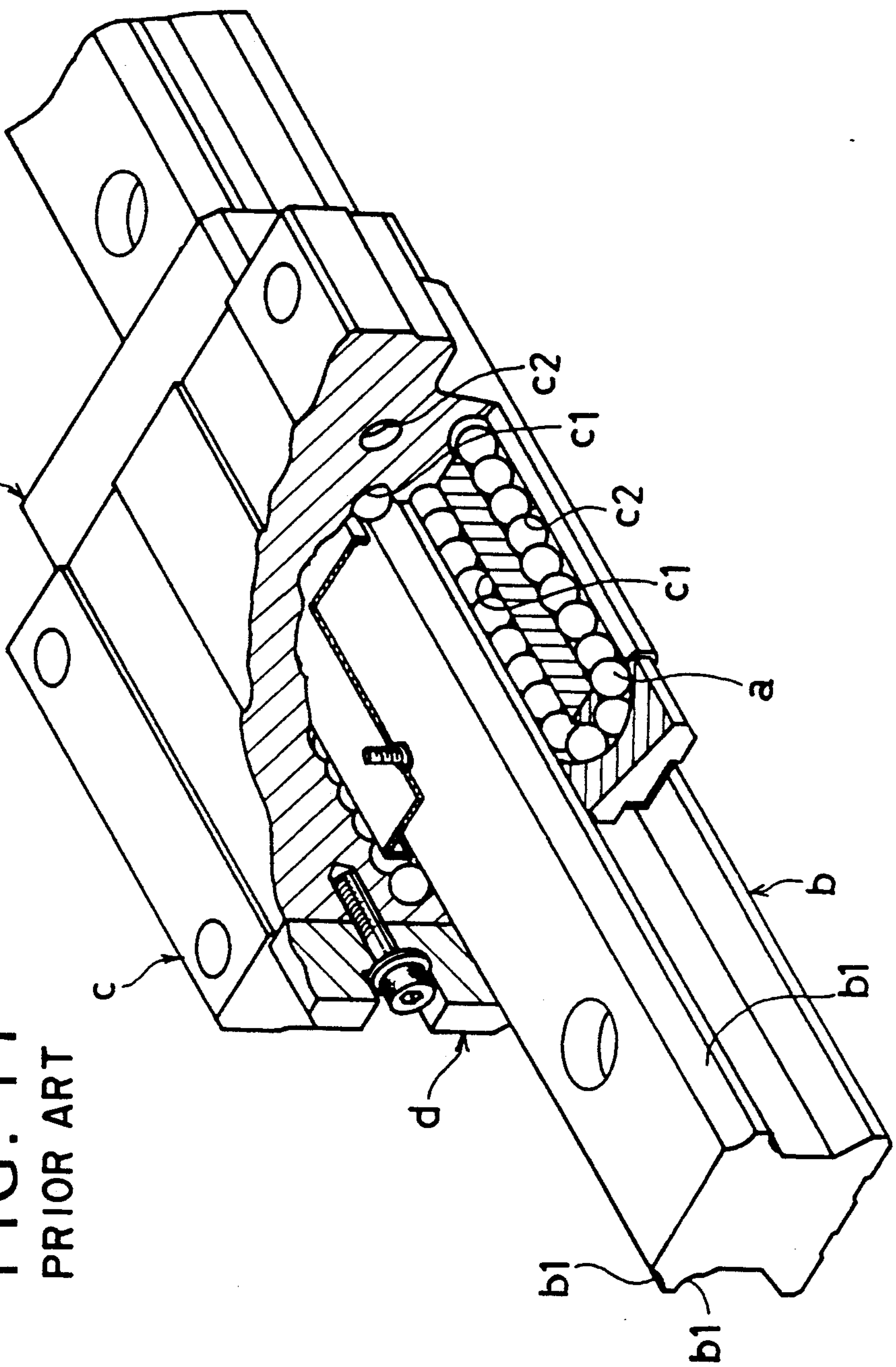


FIG. 17
PRIOR ART

FIG. 18
PRIOR ART

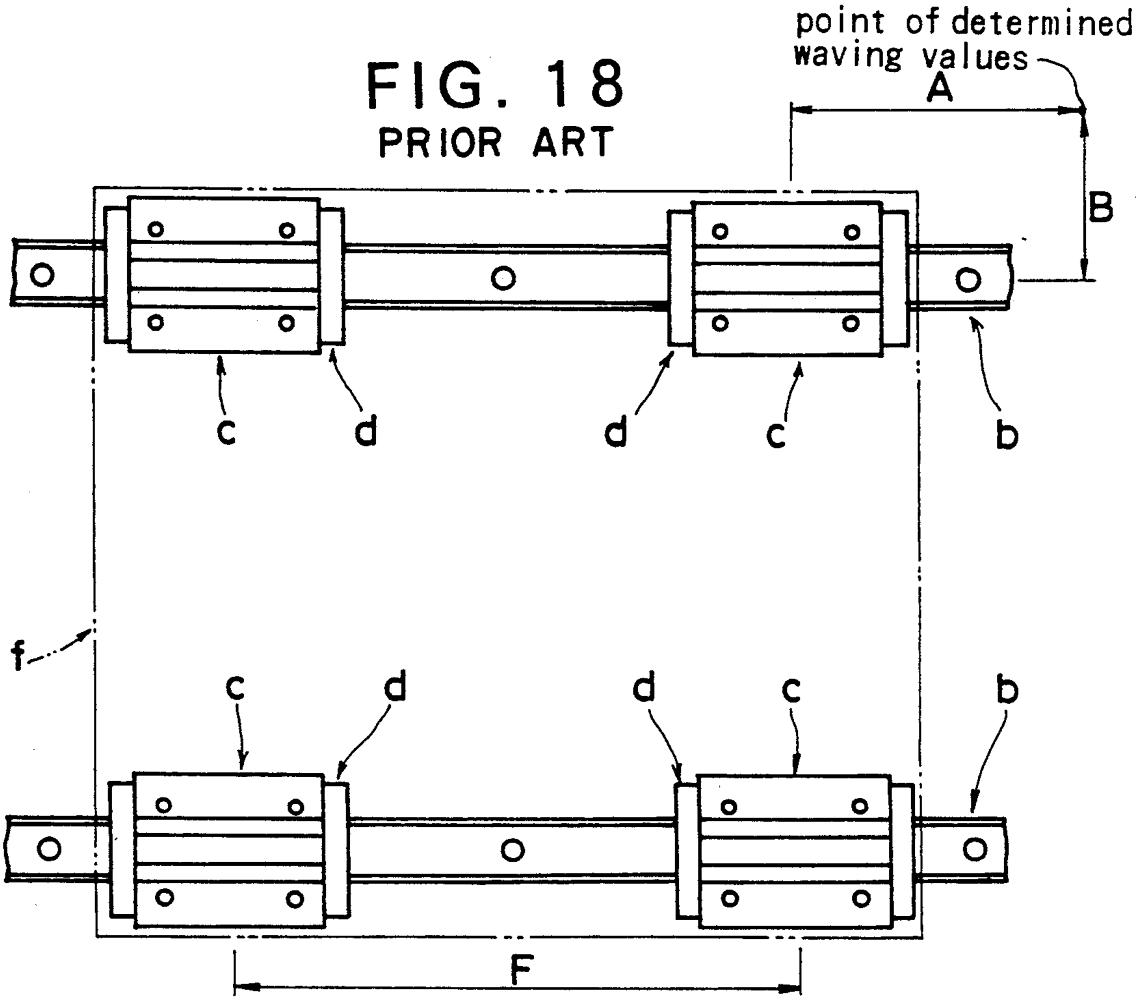
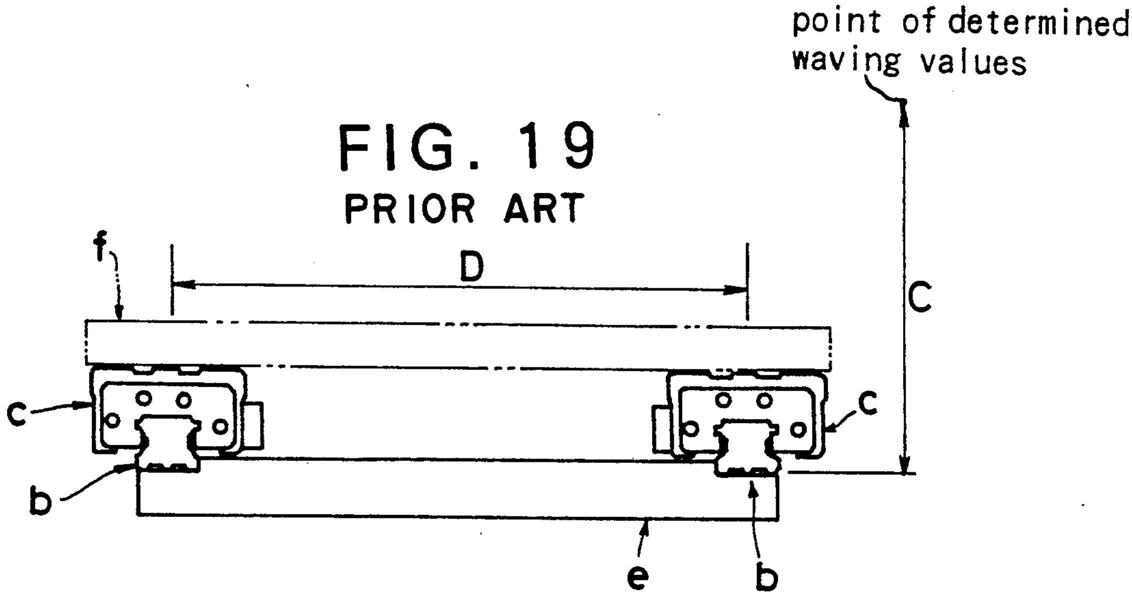


FIG. 19
PRIOR ART



BEARING AND A TABLE FOR LINEAR SLIDING MOTION

TECHNICAL FIELD

The present invention relates a bearing and a table for linear sliding motion for linearly guiding a movable object to be slid, for example, in a slide component for machine tools such N.C. machines or industrial robots.

BACKGROUND ART

A conventional bearing for linear sliding motion of a type described above generally has a construction shown in FIG. 17. Specifically, it is formed of a track bed (or track member) (b) having rolling surfaces (b1) on which rolling members (a) such as balls roll in an axial direction; a slide bed (or slide member) (c) having load rolling surfaces (c1), which cooperate with the rolling surfaces (b1) to hold the rolling members (a) therebetween, and no-load rolling apertures (c2) corresponding to the load rolling surfaces (c1); and covers (d) for coupling and connecting the load rolling surfaces (c1) and the no-load rolling apertures (c2) to form endless paths for the rolling members (a). In this construction, the rolling member (a) rolls through load regions between the rolling surfaces b1 of the track member (b) and the load rolling surfaces (c1) of the slide member (c), whereby the slide bed (c) can linearly move along the track member (b) with a remarkably small frictional resistance.

A table for linear sliding motion, which supports a machine tool or a work for guiding them, generally has a construction shown in FIGS. 18 and 19, in which a plurality of track members (b) (two in the Figure) used for the bearings for the linear sliding motion are disposed on a fixing portion (e), and a plurality of sliding members (c) (two in the Figure) for carrying a table (f) are assembled to each track bed with a space between one another.

However, such bearings for the linear sliding motion have following disadvantages with respect to the motion of the slide members due to its construction.

First, minute vibration called as "waving" is generated in the slide members. In the bearing for the linear sliding motion including the rolling members which circulate and perform an endless movement for the slide member, the rolling members are generally in preloaded conditions when they roll through a load region in order to increase rigidity of the slide member with respect to the track member and prevent rattling thereof. Therefore, when the rolling members are forcedly entered into the load region or released from the load region, the slide member minutely deviates in vertical or lateral directions, which causes the minute vibration, i.e., waving during the movement of the slide member.

A second disadvantage relates to a linearity of a motion of the slide member. It is ideal for the slide bed to move linearly with respect to the fixing portion on which the track member is disposed. However, the motion thereof is inevitably affected by a mounting accuracy of the track member to the fixing portion and a machining accuracy of the rolling surfaces, and thus it is very difficult in practice to obtain a high linearity of the movement. If it is attempted to obtain the desired linearity of the movement by increasing the mounting accuracy of the track member and the machining accuracy of the rolling surfaces, disadvantages such as high costs and low productive efficiency will be caused. Therefore, in view of the above, the linearity of the movement can be improved only to a restricted extent.

The disadvantages of the motion of the slide member described above form an important factor which cannot be overlooked in machine tools or the like which are guided by the bearings for the linear motion during machining operations, because the waving of the slide members or the insufficient linearity of the movement causes deviation of the tools of the machine tools, and thus directly affects the machining accuracy of the products.

However, in the recent industrial application, demands for higher accuracies in various products, and thus demands for higher machining accuracies have been increased in the machines and apparatuses such as machine tools for machining these products.

Accordingly, the bearings for the linear sliding motion for performing linear guiding in various machines and apparatuses have been required to prevent the waving during movement or travelling of the slide beds and to improve the linearity of the movement.

On the other hand, with respect to the tables for the linear sliding motion, reduction of costs has been attempted by minimizing thicknesses of tables which are mounted on the slide members in the recent years. However, this adversely affects the rigidity, and specifically, this may cause deflection or the like in the tables which may reduce the machining accuracies of machine tools mounted thereon.

In view of the above demands and problems, it is an object of the invention to provide a bearing for linear sliding motion, which can minimize the waving of the slide member and improve the linearity of the movement.

Another object of the invention is to provide a table for linear sliding motion which allows machining with a high accuracy by a machine or apparatus such as a machine tool mounted thereon.

DISCLOSURE OF THE INVENTION

The inventor of the invention and others have earnestly studied to achieve the objects described above, and found that, as a number of rolling members which roll through a load region increases, a waving value of a slide bed decreases and also a linearity of a movement is improved. Based on this, with respect to a table for linearly sliding motion, a slide member having a length which is increased to a maximum allowable extent and corresponds to a size of a table for linear sliding motion may be manufactured and attached to a lower surface of the table, whereby the table for the linear sliding motion can have the waving value and linearity for the movement which are improved as compared with the prior art.

However, since tables have various sizes depending on machines and apparatus mounted thereon, it is not preferable, in view of productive efficiency, to manufacture slide members of various sizes in accordance with user's orders.

In view of this, the inventors and others have further studied and devised the present invention.

A bearing for linear sliding motion of the invention comprises a track bed provided with rolling surfaces for rolling members such as balls or rollers extending in a lengthwise direction; a slide member formed of a plurality of divided blocks which are provided with load rolling surfaces cooperating with the rolling surfaces to hold the rolling members therebetween, said divided blocks being joined together to continuously connect the load rolling surfaces; and rolling member circulating means which connects opposite ends of the continuously connected load rolling surfaces to form an endless circulation path for the rolling members.

A table for linear sliding motion of the invention comprises a track member provided with rolling surfaces for rolling members such as balls or rollers extending in a lengthwise direction; a slide member formed of a plurality of divided blocks which are provided with load rolling surfaces cooperating with the rolling surfaces to hold the rolling members therebetween, said divided blocks being joined together to continuously connect the load rolling surfaces; rolling member circulating means which connects opposite ends of the continuously connected load rolling surfaces to form an endless circulation path for the rolling members; and table for mounting a movable member to be guided linearly, said table being fixed to the slide member for movement in a lengthwise direction of the track member.

According to the subject of the invention, in which the slide is formed of divided blocks having the load rolling surfaces and jointed together, a number of the divided blocks may be appropriately varied, and for example, may be determined in accordance with sizes of the table to be linearly guided.

Further, the divided blocks may be varied with respect to a configuration, a number of the load rolling surfaces and a contact angle of the rolling members and others depending on a practical application of the bearing, and slide member of a bearing for linear sliding motion may be utilized.

Although the load rolling surfaces of the divided blocks may be formed by individually applying grinding or the like to the respective blocks, it is preferable to simultaneously form the load rolling surfaces on the divided blocks, which are fixed to a jig for handling it as one component, in order to improve continuity of the load rolling surfaces of the slide member i.e., an assembly of the blocks.

Various variations such as use of ball tubes may be applied to a specific construction of the rolling member circulating means, which serves to scoop and return balls from one end of the continuously connected load rolling surfaces to the other end and cooperates with the load region to form an endless circulation path for the rolling members.

Further, the rolling members may be appropriately selected from cylindrical rollers, barrel rollers, balls and others.

Generally, so-called crowning may be applied to the load rolling surfaces of the slide member in order to achieve smooth circulation of the rolling members, and specifically, opposite side regions of the load rolling surfaces may be ground to a relatively large extent as compared with a middle region to form sections of the load rolling surfaces of the side regions into substantially convexly curved shapes. However, in the present invention, the construction requires to apply the crowning only to the load rolling surfaces of the divided blocks (hereinafter referred to "end blocks") located at opposite ends of the slide member. Therefore, a pair of end blocks to which the crowning is applied may be assembled together with an intended number of divided blocks (hereinafter referred to as "middle blocks") to which the crowning is not applied. This facilitates manufacturing of the slide member having a length corresponding to the number of the middle blocks.

According to the subject of the invention described above, by appropriately selecting the number of the divided blocks, the slide member can be facilely manufactured to have a long length corresponding to a movable member such as a table to be linearly guided, and the number of the load rolling members which rolls through the load region can be increased in accordance with the increase of the length of the slide member.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1** and **2** are a perspective view and a cross section illustrating a first embodiment of a bearing for linear sliding motion of the invention, respectively;

FIGS. **3** and **4** are a cross section and a side view illustrating an end block (middle block) according to a first embodiment, respectively;

FIG. **5** is a rear view of a cover;

FIG. **6** is a cross section taken along line VI—VI in FIG. **5**;

FIG. **7** is a cross section taken along line VII—VII in FIG. **6**;

FIG. **8** is a perspective view illustrating a guide piece;

FIGS. **9** and **10** are a perspective view and a cross section illustrating a track members, respectively;

FIG. **11** is a cross section illustrating an endless ball circulation path in the slide member;

FIGS. **12**, **13** and **14** are a perspective view, a top view and a front view illustrating a first embodiment of a table for linear sliding motion of the invention, respectively;

FIG. **15** is a cross section illustrating an endless ball circulation path for bearings for the linear sliding motion used in experiments;

FIG. **16** is a cross section illustrating another embodiment of a bearing for the linear sliding motion of the invention;

FIG. **17** is a perspective view illustrating a bearing for the linear sliding motion in the prior art; and

FIGS. **18** and **19** are a top view and a front view illustrating a table for the linear sliding motion in the prior art for comparison, respectively.

DESCRIPTION OF THE REFERENCE NUMERAL

1: track bed, **2**: slide bed, **2***a*: end block (divided block), **2***b*: middle block (divided block), **3**: cover (rolling member circulating means), **4**: ball (rolling member), **11**: rolling surface, **24**: load rolling surface

DETAILED DESCRIPTION OF THE INVENTION

A bearing and a table for linear sliding motion of the invention will be described with reference to the accompanying drawings.

FIGS. **1** and **2** illustrate a first embodiment of the bearing for the linear sliding motion of the invention. The bearing is formed of a track member **1** mounted on a stationary or fixing portion, a slide bed **2** disposed over the track member **1**, a pair of covers **3***a* and **3***b* (rolling member circulating means) attached to opposite ends of the slide member **2**, and a large number of balls (rolling members) which bear a load between the track member **1** and the slide member **2**.

As shown in FIG. **1**, the slide member is formed of end blocks **2***a* located at opposite ends thereof and two middle blocks **2***b* disposed therebetween. These blocks are connected by connecting bolts **51** through connecting plates **5**. As shown in FIGS. **3** and **4**, each of the blocks **2***a* and **2***b* has a base **21***a* (**21***b*) and a pair of wings **22***a* (**22***b*) extending downward therefrom to form an inverted C-shaped section, and is provided at an inner surface of each wing **22***a* (**22***b*) with vertically spaced two grooves **23***a* (**23***b*) extending in an axial direction. In each groove, there is formed a load rolling surface **24***a* (**24***b*) having a curved section of a radius of curvature larger than a radius of a ball **4** which rolls thereon. Both the sleeves **22** are provided with no-load rolling apertures **25***a* (**25***b*) which form parts of rolling member circulating means and respectively correspond to the load rolling surfaces **24***a* (**24***b*). Upper surfaces of the base **21***a* (**21***b*) form mounting surfaces **26***a* (**26***b*) on which a movable member such as a table is mounted, and are provided with tapped bolt holes **27***a* (**27***b*) engaging mounting bolts (not shown). In FIG. **3**, numerals **28** and **29** indicate ball retainers, which are fixed to the bases **21***a* (**21***b*) and the wings **22***a* (**22***b*) by screws (not shown), respectively, and serve to prevent the balls **4** from dropping from the grooves **23***a* (**23***b*) on the blocks **2** when the slide bed **2** is removed from the track member **1**. Numerals **30***a* (**30***b*) indicate bolt holes engaging the coupling bolts **51**.

In this embodiment, continuity of the load rolling surfaces **24***a* and **24***b* of the blocks **2***a* and **2***b* coupled together is improved by simultaneously grinding the four blocks **2***a* and **2***b* to form the load rolling surface **24**. That is; the four blocks **2***a* and **2***b* are coupled together when fixed to a machine tool, and are handled as one integral slide bed when the grinding is applied thereto.

Crowning is applied to the load rolling surfaces **24***a* of the end blocks **2***a* after the grinding so that the balls **4** may be smoothly forced into the load region and released therefrom. On the other hand, the covers **3** are made from synthetic resin and are provided, as shown in FIGS. **5**–**7**, at their inner sides with ball return paths **31** which connect the load rolling surfaces **24***a* formed on the end blocks **2***a* and the corresponding no-load rolling apertures **25***a*. These ball return paths **31** are formed by semicircular guide pieces **33** which have guide surfaces **32** continuing to the load rolling surfaces **24***a* and are fitted over ball guide grooves **34** formed in the covers **33**. Numerals **35** indicate through holes through which fixing bolts (not shown) screwed into the end blocks **2** are inserted.

The track member **1** has a rectangular cross-sectional shape as shown in FIGS. **9** and **10** which has opposite sides recessed into trapezoids and also has recessed right and left shoulders. On inclined surfaces which are faced obliquely downward and formed by the above trapezoidal as well as inclined surfaces which are faced obliquely upward and formed by the recessed shoulders, there are provided rolling surfaces **11** which correspond to the load rolling surfaces **24***a* and **24***b* of the end blocks **2***a* and the middle blocks **2***b*, respectively. Numerals **12** indicate attaching holes through which fixing bolts (not shown) are inserted for engaging the fixing portion.

According to the bearing for the linear sliding motion of the invention thus constructed, as shown in FIG. **11**, a pair of end blocks **2***a* and the two middle blocks **2***b* are coupled together to form the long load rolling surface **24** by the continuous load rolling surfaces **24***a* and **24***b* of the blocks **2***a* and **2***b*, and also the slide member **2** provided with the no-load rolling apertures **25** corresponding to the load rolling surfaces **24** are obtained therefrom. Further, by attaching the covers **3** to the end blocks **2***a*, the endless ball circulation paths which connect the load rolling surfaces **24** and the no-load rolling apertures **25** of the slide member **2** are formed, whereby the slide bed **2** shown in FIG. **1** is completed.

FIG. **12** shows a first embodiment of a table for the linear sliding motion including two sets of the bearing for the linear sliding motion of the embodiment described above. The track member **1** are disposed on the fixing portion with a predetermined space between one another, and a table **7** is fixed to the slide members **2**.

With respect to the manufacturing of the table for the linear sliding motion shown in FIG. **12**, since the number of the middle blocks **2***b* can be appropriately determined in the bearing for the linear sliding motion of the embodiment, the slide members **2** having lengths depending on the sizes of the area in which the slide members **2** are disposed can be facilely manufactured.

Accordingly, it is possible to increase the number of the load balls **4** rolling between the load rolling surfaces **24** of the slide members **2** and the rolling surfaces **11** of the track beds **1** in accordance with the sizes of the table **7**, so that waving in the vertical and/or lateral directions, which may be caused by circulation of the balls **4**, can be minimized, and the linearity of the movement can be increased.

Since the lengths of the slide members **2** are increased depending on the sizes of the table **7**, a contact area between the slide members **2** and the table **7** can be increased, so that the rigidity of the table can be increased, as compared with the conventional bearing for the linear sliding motion shown in FIG. **20**.

In order to confirm the effectiveness of the invention, the inventors of the application and others have actually determined waving values of the table for the linear sliding motion shown in FIG. **12**. The measured results are as follows. For comparison, similar measurement has been made with respect to the table for the linear sliding motion employing the conventional bearing for the linear sliding motion shown in FIGS. **18** and **19** (this table will be called as a "comparison example"), and the result of this measurement also will be described below.

The slide bed **2** used in the experiment is slightly different from that of the first embodiment in that the slide member **2** is formed of four conventional bearing blocks **2***c* coupled together. Therefore, as shown in FIG. **15**, the crowning has been applied to the load rolling surface **24***c* of each block **2**. However, other structures such as the load rolling apertures **25***c* are similar to those of the bearing of the first embodiment.

With respect to the table for the linear sliding motion of the invention, variation of the waving values which may be caused by the various coupling states between the blocks **2***a* and **2***b* and the table **7** were determined by measuring the waving values in a case (experiment (1)) in which only the attaching bolts for the bolt holes **27***a* in the end blocks **2***a* were fastened and in a case (experiment (2)) in which all the attaching bolts for the bolt holes **27***a* and **27***b* in the end blocks **2***a* and the middle blocks **2***b* were fastened (see FIG. **13**).

The waving values were determined at points of distances and heights of A=97 mm, B=107 mm in FIGS. **13**, **14**, **18** and **19**, and C=360 mm. Spaces between the track beds in the embodiment and the comparison example are equal to each other, i.e., D=315 mm. The slide bed of the embodiment has a length of

E=341 mm, and the space between the slide members in the comparison example is 341 mm (F=341 mm).

The waving values obtained from the experiments are as follows.

Experiment (1)
vertical direction: 0.11 μm
lateral direction: 0.09 μm

Experiment (2)
vertical direction: 0.095 μm
lateral direction: 0.073 μm

Comparison Example
vertical direction: 0.2∼0.25 μm
lateral direction: 0.2∼0.25 μm

As can be seen from the results described above, in the table for the linear sliding motion using the bearing for the linear sliding motion according to the invention has the waving values which are substantially half or less than those of the comparison example, and thus the effectiveness of the invention can be confirmed. Further, it has been found that the waving values are improved in the bearing for the linear sliding motion according to the invention, if all the blocks c are fixed to the table.

The bearing for the linear sliding motion of the invention is not restricted to the first embodiment described-above, and, for example, it may have a sectional configuration as shown in FIG. **16**. Structures in FIG. **16** are similar to those described above, except for the sectional configuration of the block *2a* (*2b*), and thus the same reference numerals are allotted thereto without detailed description thereof.

INDUSTRIAL APPLICABILITY

According to the bearing for the linear sliding motion of the invention, as described hereinabove, the slide member can be constructed by coupling the divided blocks and thus the number of the load rolling members can be facilely increased in accordance with the sizes of the table to be linearly guided, so that the waving of the slide member can be minimized and the linearity of the movement can be increased.

According to the table for the linear sliding motion of the invention which employs these bearings, the movable member such as a machine tool mounted thereon can be smoothly and linearly guided with a high linearity, and thus works can be machined with a high accuracy.

Further, since the table can be supported by the slide members having the lengths corresponding to the sizes of the table, the table for the linear sliding motion can have a high rigidity, whereby the thickness can be reduced for achieving low cost.

What is claimed is:

1. A bearing for linear sliding motion, comprising:

a track member provided with rolling surfaces for rolling members such as balls or rollers extending in a lengthwise direction;

a slide member formed of a plurality of divided blocks which are provided with load rolling surfaces which in cooperation with said rolling surfaces and said rolling members supported therebetween, serve to transfer a load between said slide member and said track member, said divided blocks being jointed together to continuously connect said load rolling surfaces; and

rolling member circulating means for connecting opposing ends of said continuously connected load rolling surfaces to form an endless circulation path for said rolling members.

2. A bearing as claimed in claim **1** wherein said slide member is formed of a pair of end blocks having load rolling surfaces to which crowning is applied, and at least one middle block disposed between said end blocks.

3. A table for linear sliding motion, comprising: a track member provided with rolling surfaces for rolling members such as balls or rollers extending in a lengthwise direction;

a slide member formed of a plurality of divided blocks which are provided with load rolling surfaces which, in cooperation with said rolling surfaces and said rolling members supported therebetween, serve to transfer a load between said slide member and said track member, said divided blocks being jointed together to continuously connect said load rolling surfaces;

rolling member circulating means for connecting opposing ends of said continuously connected load rolling surfaces to form an endless circulation path for said rolling members; and

a table for supporting a movable member to be guided linearly, said table being fixed to said slide member for movement in a lengthwise direction of said track member.

* * * * *

US005186545A

United States Patent [19]

Shirai

[11] Patent Number: 5,186,545

[45] Date of Patent: Feb. 16, 1993

[54] RECIPROCATING DEVICE

[75] Inventor: Takeki Shirai, Ichikawa, Japan

[73] Assignee: THK Co., Ltd., Tokyo, Japan

[21] Appl. No.: 748,945

[22] Filed: Aug. 23, 1991

[30] **Foreign Application Priority Data**

Aug. 27, 1990 [JP] Japan 2-222629

[51] Int. Cl.^{5} F16C 29/06; F16H 27/02

[52] U.S. Cl. 384/43; 74/89.2

[58] Field of Search 384/43–45; 74/89.15, 89.2, 424.8

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,095,854 6/1978 Teramachi 384/45
4,778,284 10/1988 Teramachi 384/45
4,934,202 6/1990 Hikita et al. .... 74/89.2 X
4,934,835 6/1990 Albert 384/43

FOREIGN PATENT DOCUMENTS

0367196 5/1990 European Pat. Off. .
200016 9/1987 Japan 384/43
1-320317 12/1989 Japan .
1216064 12/1970 United Kingdom 384/43

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Armstrong, Westerman, Hattori, McLeland & Naughton

[57] **ABSTRACT**

A reciprocating device has a construction, in which a slider is formed by fixing a table member to a bearing casing which is movable inside a track bed having a C-shaped section in a longitudinal direction thereof, and a continuous drive is disposed along the track bed for reciprocating the slider. A weight and sizes of the device can be reduced, and reciprocating motion without a pitching motion can be achieved. Accordingly, the invention can prevent generation of uncomfortable noises during a movement of the slider, and also can prevent reduction of durability of the device which may be caused by irregular wear of a bearing for guiding the slider.

9 Claims, 6 Drawing Sheets

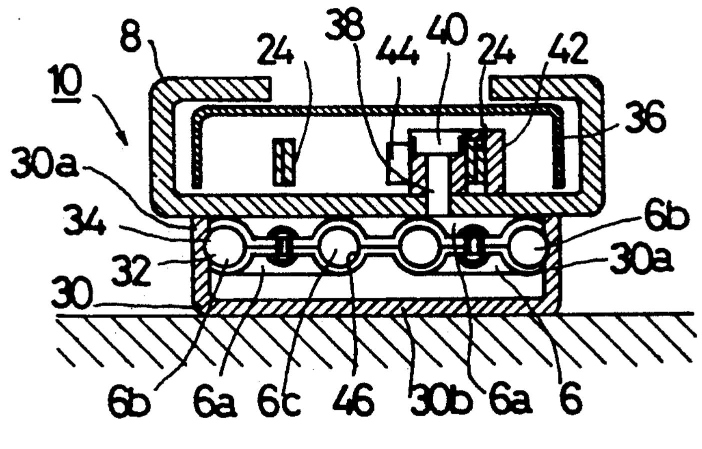


FIG. 1

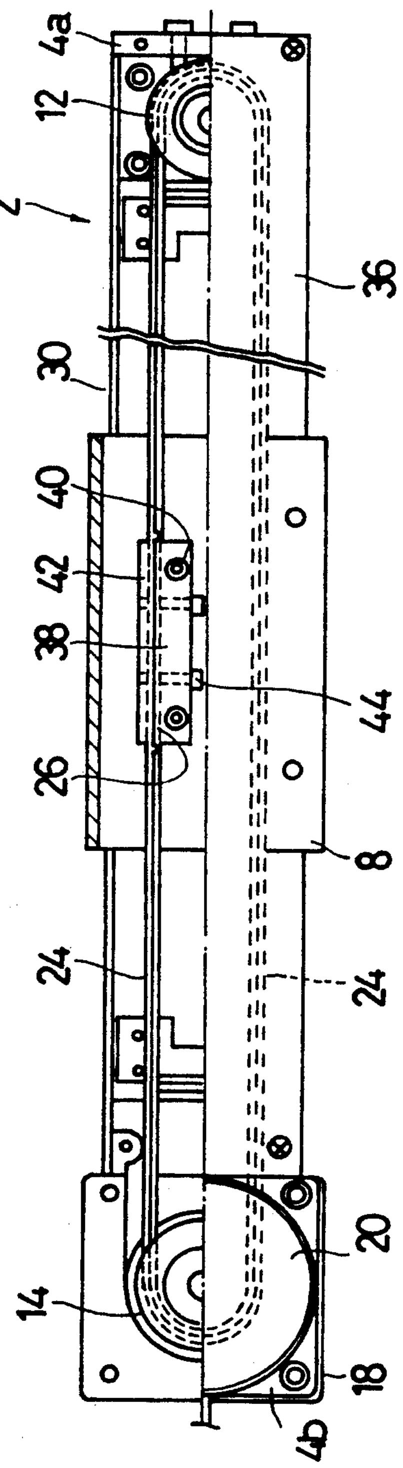


FIG. 2

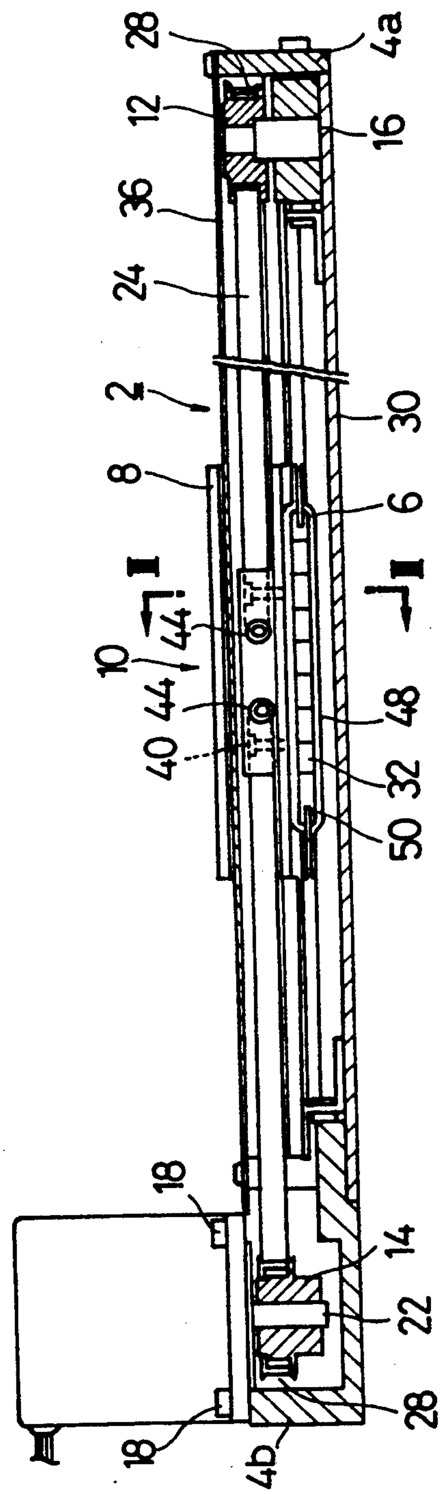


FIG. 3

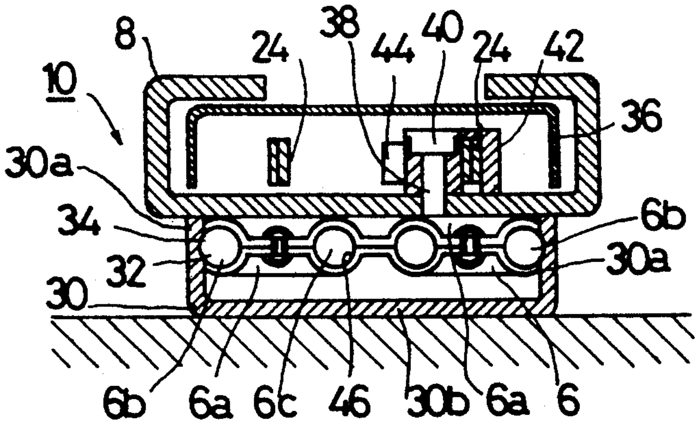


FIG. 4

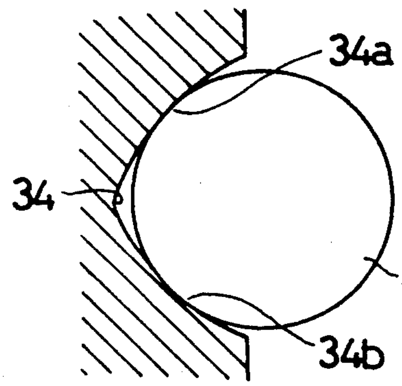


FIG. 5

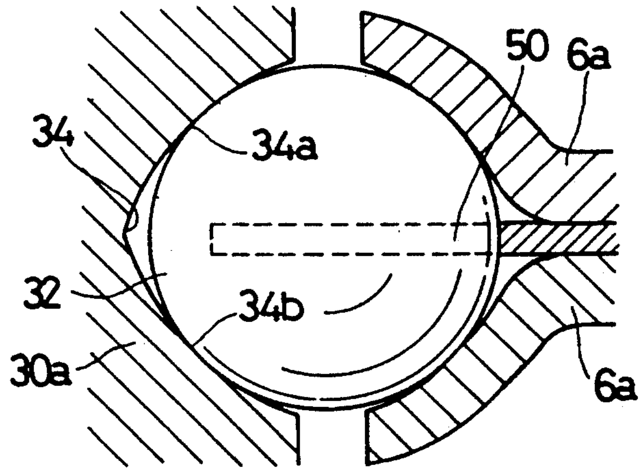


FIG.6

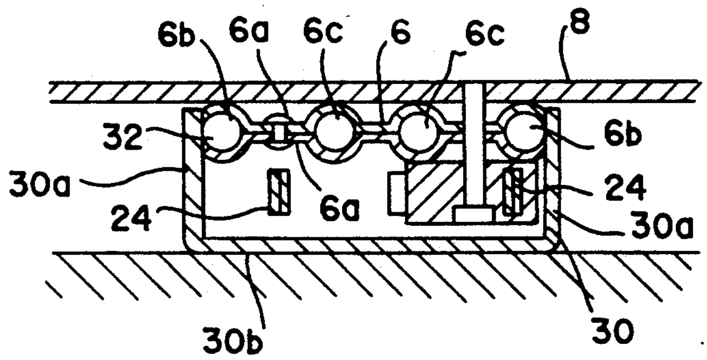


FIG.7

PRIOR ART

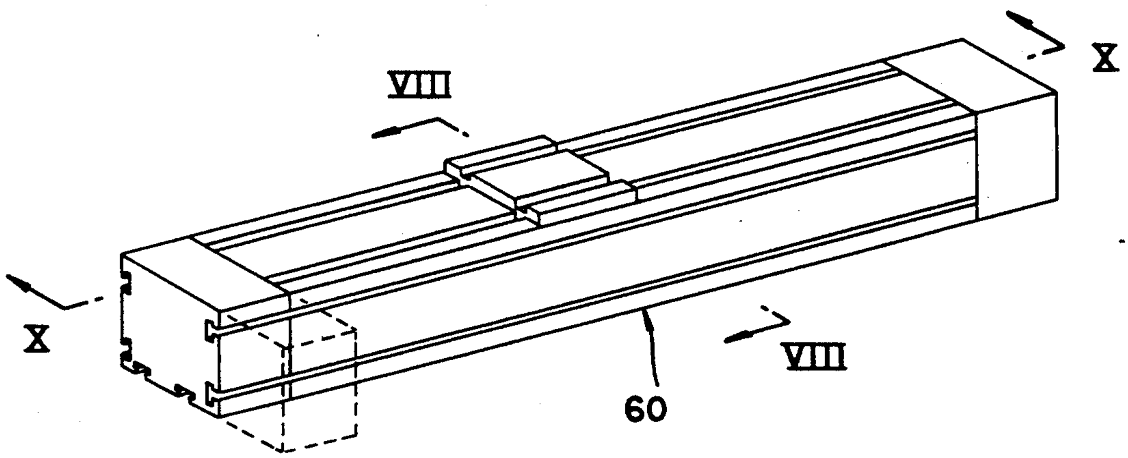
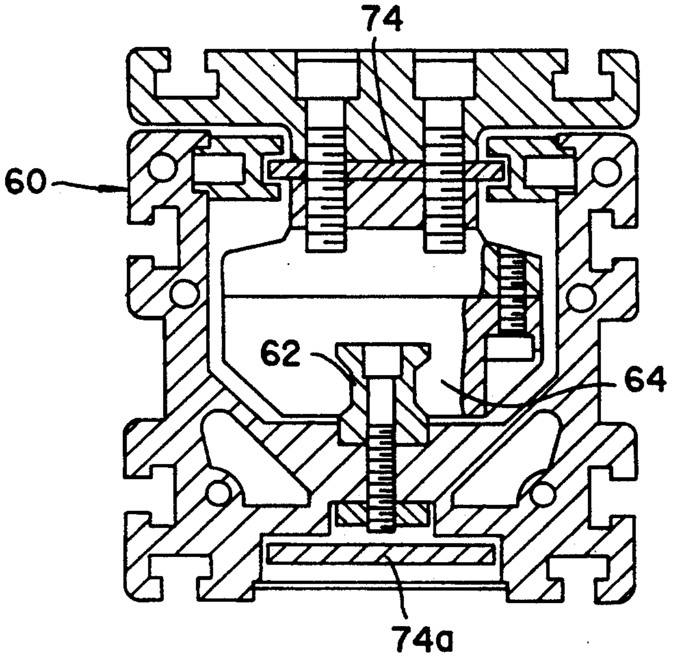


FIG.8
PRIOR ART



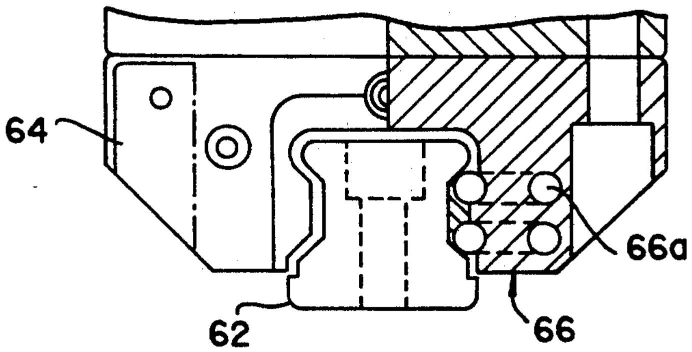
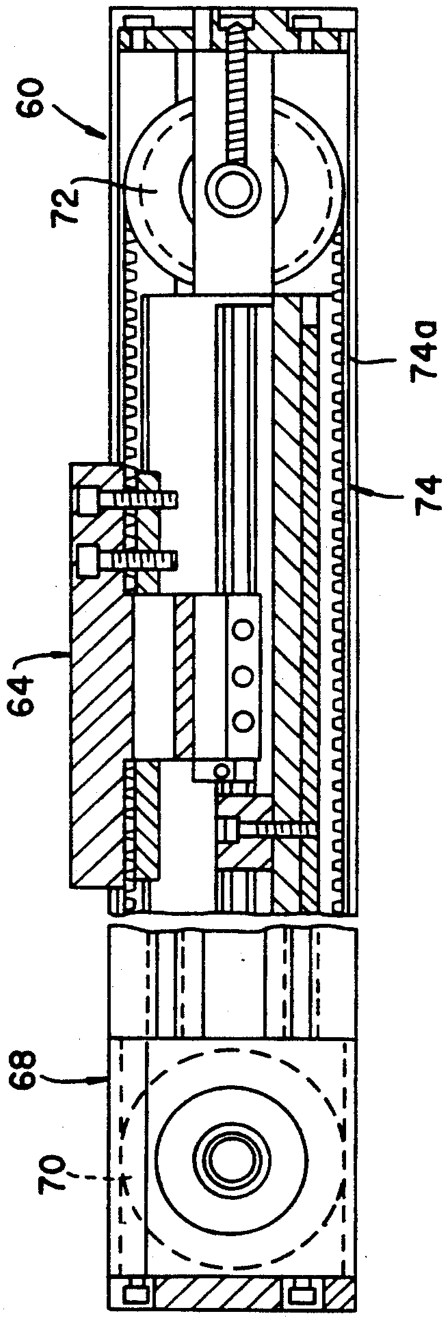


FIG.9
PRIOR ART

FIG.10
PRIOR ART



RECIPROCATING DEVICE

FIELD OF THE INVENTION AND RELATED ART STATEMENT

The present invention relates to a reciprocating device particularly for smoothly and linearly reciprocating a predetermined member or object to which a load is applied.

Such reciprocating devices are well known that a large number of balls are rotatably disposed in endless paths and these balls rotate and circulate through the endless paths. An example of such reciprocating devices is disclosed in the Japanese Laid-Open Patent publication No. 1-320317 (320317/1989).

The reciprocating device disclosed in this publication is basically formed of, as shown in FIGS. 7–10, an elongated guide casing **60**, a guide rail **62** disposed in the guide casing **60** and extending along a longitudinal axis thereof, a traveler **64** which is slidable along the guide rail **62**, linear bearing mechanisms each having a large number of balls **66a** which individually rotate in a pair of vertically spaced endless paths, the linear bearing mechanisms being disposed between the guide rail **62** and the traveler **64**, and a linear drive device **68** for moving the traveler **64** with respect to the guide rail **62**.

This linear drive device **68** is formed of, as best shown in FIG. **10**, a flexible tension member, i.e., a toothed belt **74** which extends from the traveler **64**, is deflected at opposite end areas of the guide casing **60** toward the traveler **64** by deflection guide rolls **70** and **72** and is fixed thereto. This toothed belt **74** runs in a plane perpendicular to the endless paths of the linear bearings **66**, and has a middle region **74a** which runs along a bottom surface of the guide casing **60** in order to achieve a compact construction of the whole device. Therefore, the connecting points of the traveler **64** and the toothed belt **74** are spaced by a relatively long distance from a position at which the balls **66a** of the linear bearing mechanisms **66** are supported by the ball supporting paths of the guide rail **62**, because the deflection guide rolls **70** and **72** have large diameters.

This distance is also increased by a fact that the employed linear bearing mechanisms **66** have pairs of vertically spaced endless paths.

As described above, in the prior art reciprocating device, a point of application of the force for driving the device is spaced by a considerably long distance from a position at which the balls are supported by the ball supporting path grooves of the guide rail **62**, so that a large angular moment is applied to a driven member. Therefore, a wavy motion or pitching motion is caused in the driven member during reciprocating, which prevents smooth transportation. This also causes noise and an irregular wear of bearing surfaces, resulting in reduction of durability.

OBJECT AND SUMMARY OF THE INVENTION

It is an object of the invention to overcome the problems of the prior art described above, to prevent a wavy motion which may be caused when a reciprocating device is driven and to reduce noise generated when the device is driven.

A reciprocating device according to the invention comprises: a track bed having a base and a pair of flanges, which are perpendicularly projected from the base with a predetermined space between each other and each are provided at the inner surface with one ball rolling groove extending in a reciprocating direction; a bearing casing formed of a pair of upper and lower plates provided with annular grooves and coupled together, said coupled plates forming a pair of endless ball tracks each of which is formed of a linear load ball region, a no-load ball region and turning regions connecting them; a large number of balls which circulate along the endless ball tracks in the bearing casing, said load ball regions being provided with recesses through which the balls partially project and are rotatably fitted in the ball rolling grooves in the track bed for slidably supporting the bearing casing with respect to the track bed; a table member fixed to an upper portion of the bearing casing for cooperating with the bearing casing to form a slider; and drive means which runs in a plane parallel to the endless ball tracks and having a portion fixed to the slider for reciprocatively driving the slider with respect to the track bed.

According to the features of the invention described above, the drive means such as a chain, wire or belt which runs in the plane parallel to the endless tracks is reciprocated by an appropriate drive source, e.g., a motor. Thereby, the bearing casing and the table member are smoothly reciprocated with respect to the track bed by means of the balls which partially project through the recesses provided in the no-load ball regions in the endless ball tracks and are fitted in the ball rolling grooves. Since the belt or the like runs in the plane parallel to the endless ball tracks, a distance from a point of application of a driving force by the motor to the belt or the like to supporting points in which the balls are supported by the rolling grooves is reduced. Further, the bearing casing is formed of the paired upper and lower plates provided with the concave grooves and these plates are coupled to form a pair of the endless ball tracks including the linear load ball regions, no-load ball regions and turning regions connecting them. Therefore, the bearing casing has a reduced vertical thickness, and thus the whole device has a small height. Thereby, the table member with an object mounted thereon has a small inertia force when it starts or stops.

According to the reciprocating device of the invention, since there is a short distance between the point at which the driving force is applied by the drive means such as a motor to the driven means and the supporting points at which the balls are supported by the ball rolling grooves, a moment applied to the slider formed of the bearing casing and the table member is reduced, and thus wavy motion of an assembly which may be caused by the moment is suppressed.

Therefore, the reciprocating device of the invention enables remarkably smooth reciprocating motion, as compared with the prior art, and also can reduce noises during operations.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view illustrating an embodiment of the reciprocating device according to the invention, in which an upper half of the Figure shows a portion lower than a belt and a lower half shows a top view;

FIG. **2** is a side view of a reciprocating device shown in FIG. **1**;

FIG. **3** is a cross section taken along line III—III in FIG. **2**;

FIG. **4** is a schematic view for illustrating a relationship between a ball and a ball rolling groove;

FIG. 5 is a schematic view showing one of tongues provided at opposite ends of recesses;

FIG. 6 is a cross section corresponding to FIG. 3 and illustrating an embodiment different from the reciprocating device shown in FIGS. 1-3;

FIG. 7 is a perspective view illustrating an example of a reciprocating device in the prior art;

FIG. 8 is a cross section taken along line VIII—VIII in FIG. 7;

FIG. 9 is a schematic view for illustrating a relationship between a ball and a ball rolling groove; and

FIG. 10 is a longitudinal section taken along line X—X in FIG. 7.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Specific embodiments of a reciprocating device of the invention will be described below with reference to the accompanying drawings.

A reciprocating device 2 according to the invention is formed, as shown in FIGS. 1-3, a track bed 30, a slider 10 having a bearing casing 6 which is reciprocatively slidable along the track bed 30 and a table member 8 fixed to an upper portion of the bearing casing 6, pulleys mounted at longitudinally opposite ends of the track bed 30 and a belt 24 retained around these pulleys 12 and 14 for driving the slider 10.

The track bed 30 has a C-shaped section and is formed of a base 30*b* and a pair of flanges 30*a* perpendicularly projected from opposite sides of the base 30*b*. At an inner side of each flange 30*a*, one ball rolling groove 34 linearly extends parallel to a running direction of the belt 24 for supporting balls 32 in the bearing casing 6, as will be described later. As shown in FIG. 4, the ball rolling groove 34 is formed of two ball rolling surfaces 34*a* and 34*b* which intersects each other and has a cross section of a Gothic arch shape. In FIG. 3, the base 30*b* and the paired flanges 30*a* of the track bed 30 are formed by an integral member. However, members which have L-shaped cross sections and are provided with the ball rolling grooves 34 may be disposed on the upper surface of the base with the ball rolling grooves 34 faced inwardly.

Brackets 4*a* and 4*b* are fixed at the opposite ends of the track bed 30 for supporting the pulleys 12 and 14, respectively. In the Figure, the pulley 12 is an idle pulley and is rotatably supported by a shaft 16 mounted in the bracket 4*a*. The pulley 14 is a drive pulley, above which an electrical motor 20, i.e., a step motor is disposed and is fastened to the bracket 4*b* by bolts 18. The pulley 14 is fixed to a rotary shaft 22 of the electric motor 20. The belt 24 is retained around the pulleys 12 and 14. The pulleys 12 and 14 are provided at their inner surfaces with a plurality of teeth 26, which engage teeth 26 provided at engagement grooves 28 of the pulleys 12 and 14 for enabling accurate motion control without slip. If the accurate motion control is not required, the teeth 26 of the belt 24 and the engagement grooves 28 of the pulleys 12 and 14 may be eliminated.

The pulley 12 and the belt 24 are covered from the upper side with a cover 36 having a C-shaped section, so that the pulley 12 and the belt 24 may not be exposed to the exterior and an article or member (not shown) on the table member 8 may not fall into the track bed. The cover 36 is fixed at its opposite ends to the brackets 4*a* and 4*b*.

Then, description will be made with respect to a slider which is reciprocated inside the track bed 30 by the belt 24. As shown in FIGS. 2 and 3, this slider is formed of the bearing casing 6 and the table member 8.

The table member 8 is located above the track bed 30 and the bearing casing 6. The table member 8 has a substantially rectangular shape in a top view, and has a hollow rectangular cross section recessed at an upper portion as shown in FIG. 3. The table member 8 may be manufactured from a sheet by a press working. A hollow portion in the table member 8 forms a space through which the belt 24 retained around the pulleys 12 and 14 and the cover 36 pass. The table member 8 reciprocates, surrounding the belt 24 and the cover 36. An elongated fixing block member 38 is fixed onto the bottom portion of the table member 8 by bolts 40. An attaching block 42 is engaged to the fixing block member 38 by bolts 44. The belt 24 has a portion pinched between the fixing block member 38 and the attaching block 42, and thus is fixed to the table member 8.

In FIG. 3, although the cover 36 is located at the hollow portion in the table member 8, it may be located outside the table member 8 covering an opening of the table member 8.

The table member 8 is fixed at a position above the bearing casing 6 by appropriate means such as welding.

The bearing casing 6 is formed of a pair of upper and lower plates 6*a*, each of which is provided with a pair of annularly extending grooves forming upper and lower halves of a pair of endless ball tracks 46. Each track 46 is formed of a linear load ball region 6*b*, a no-load ball region 6*c* and return regions (not shown) connecting them.

Each plate 6*a* is manufactured by a press working of, e.g., a thin steel plate. The bearing casing 6 is an assembly of the paired plates 6*a* which are opposed to each other and are jointed by appropriate means such as spot welding or riveting in the illustrated embodiment. The bearing casing 6 has a wear resistance increased by surface hardening such as nitriding.

The bearing casing 6 is provided at its opposite side walls defining the linear load ball regions 6*b* with windows or recesses 48. The balls 32 located at the linear load ball regions 6*b* partially project outwardly through the recesses 48. The balls 32 projected from the endless ball tracks to the outside of the bearing casing 6 are rotatably fitted with the ball rolling grooves 34 in the track bed 30 described above. Since the ball rolling grooves 34 have the cross sections of the Gothic arch shapes defined by the ball rolling surfaces 34*a* and 34*b*, as described before, each ball 32 projected through the recess 48 contacts the surface of the ball rolling groove 34 through two points, as shown in FIG. 4. Therefore, as compared with the prior art device in which each ball contacts the surface of the ball rolling groove through one point, the illustrated embodiment can increase the stability of movement with respect to-a moment load.

According to the construction described above, since the bearing casing 6 can freely reciprocate in the track bed owing to rolling of the balls 32, the belt 24 fixed to the table member 8 may be rotated through a predetermined extent by the electric motor 20 for applying a reciprocating motion of a stroke corresponding to the rotated extent of the belt 24 to the slider 10.

Further, as shown in FIGS. 2 and 5, at opposite ends of each recess 48 provided at the load ball region in the bearing casing 6, there are provided tongues 50 extending into spaces between the balls 32 located at the endmost positions of the recess 48 and a central portion of the ball rolling groove **34** of the Gothic arch shape. The tongues **50** serves to enable smooth entry of the loaded balls **32**, which are rotated by the movement of the bearing casing **6**, into the no-load region in the endless track **46**. Since the balls are smoothly scooped from the load regions to the no-load regions by the tongues **50** provided at the opposite ends of the recesses, noises which may be caused by collision of the balls can be reduced.

In the above embodiment, the belt **24** is disposed at the hollow portion of the table member **8**. However, as shown in FIG. **6**, the belt **24** may be disposed below the slider **10** formed of the bearing casing **6** and the table member **8** and may be accommodated in the track bed **30**.

What is claimed is:

1. A reciprocating device comprising:

a track bed having a base and a pair of flanges perpendicularly projected from said base with a predetermined space between each flange and each flange is provided at an inner surface with one ball rolling groove extending in a reciprocating direction;

a bearing casing formed of a pair of upper and lower plates provided with annular grooves and coupled together, said coupled plates forming a pair of endless ball tracks each of which is formed of a linear load ball region, a no-load ball region and turning regions connecting them;

a large number of balls which circulate along said endless ball tracks in said bearing casing, said load ball regions being provided with recesses through which said balls partially project and are rotatably fitted in said ball rolling grooves in said track bed for slidably supporting said bearing casing with respect to said track bed;

a plate-like table member fixed to an upper portion of said bearing casing and cooperating with said bearing casing to form a slider; and

drive means including a motor, a continuous drive member driven by said motor, and a pair of pullies with each pulley rotatably mounted at one end of said track with said driven member rounded about each of said pullies and running in a plane parallel to said endless ball tracks; and

means fixing said continuous drive member to said slider, whereby said motor reciprocatively drives said continuous drive member and said slider with respect to said track bed.

2. A reciprocating device as claimed in claim **1** wherein said continuous drive member is a belt.

3. A reciprocating device as claimed in claim **1** wherein each of said ball rolling grooves in the track bed is defined by two ball rolling surfaces intersecting each other, and has a cross section of a Gothic arch shape.

4. A reciprocating device as claimed in claim **1** wherein said bearing casing is provided at opposite ends of said recesses formed in the load ball regions with tongues extending into spaces between said balls and central portions of said ball rolling grooves, respectively.

5. A reciprocating device as claimed in claim **1** wherein said continuous drive member is a chain.

6. A reciprocating device as claimed in claim **1** wherein said continuous drive member is a wire.

7. A reciprocating device as claimed in claim **1** wherein said means fixing said drive member to said slider is fixed to an upper portion of said table member.

8. A reciprocating device as claimed in claim **1** wherein said means fixing said drive member to said slider is fixed to a lower portion of said bearing casing and said drive member rounds said pullies internally of a channel formed by said track bed.

9. A reciprocating device as claimed in claim **1** wherein said pullies are mounted for rotation on vertical spindles.

* * * * *

United States Patent [19]

Teramachi

[11] **Patent Number: 5,076,714**

[45] **Date of Patent: Dec. 31, 1991**

[54] **RECTILINEAR SLIDING BEARING AND ASSEMBLING METHOD THEREOF**

[75] Inventor: **Hiroshi Teramachi**, Tokyo, Japan

[73] Assignee: **THK Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **601,727**

[22] PCT Filed: **Feb. 28, 1990**

[86] PCT No.: **PCT/JP90/00259**

§ 371 Date: **Dec. 26, 1990**

§ 102(e) Date: **Dec. 26, 1990**

[87] PCT Pub. No.: **WO90/10159**

PCT Pub. Date: **Sep. 7, 1990**

[30] **Foreign Application Priority Data**

Mar. 1, 1989 [JP] Japan 1-46439

[51] **Int. Cl.**^{5} **F16C 29/06**; B21D 53/10

[52] **U.S. Cl.** **384/45**; 29/898.03

[58] **Field of Search** 384/43–45, 384/57, 54; 29/898.03, 898.07

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,120,538	10/1978	Headen	384/43
4,527,841	7/1985	Teramachi	384/45
4,527,842	7/1985	Teramachi	384/45
4,630,872	12/1986	Teramachi	384/45

Primary Examiner—Thomas R. Hannon

Attorney, Agent, or Firm—Armstrong, Nikaido, Marmelstein, Kubovcik & Murray

[57] **ABSTRACT**

The rectilinear sliding bearing and its assembling method of the present invention is characterized in that an attaching surface (**14**) of a slider (B) to which a moving body (**5**) such as a table is fixed is made in the form of a curved surface having a small radius of curvature, whereby the elastic deformation of the attaching surface (**14**) which arises upon fixing of the moving body (**5**) acts to absorb or moderate the pitching of the slider (B) resulting from the attaching error of a rail (**2**), so that the positional accuracy of the moving body (**5**) guided by the slider (B) is enhanced.

4 Claims, 13 Drawing Sheets

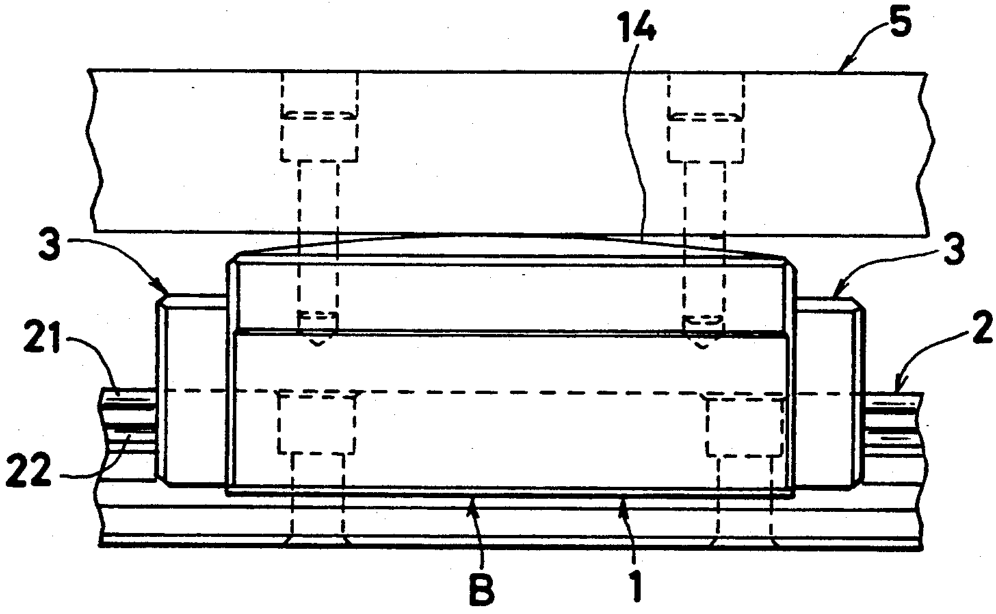


FIG. 1

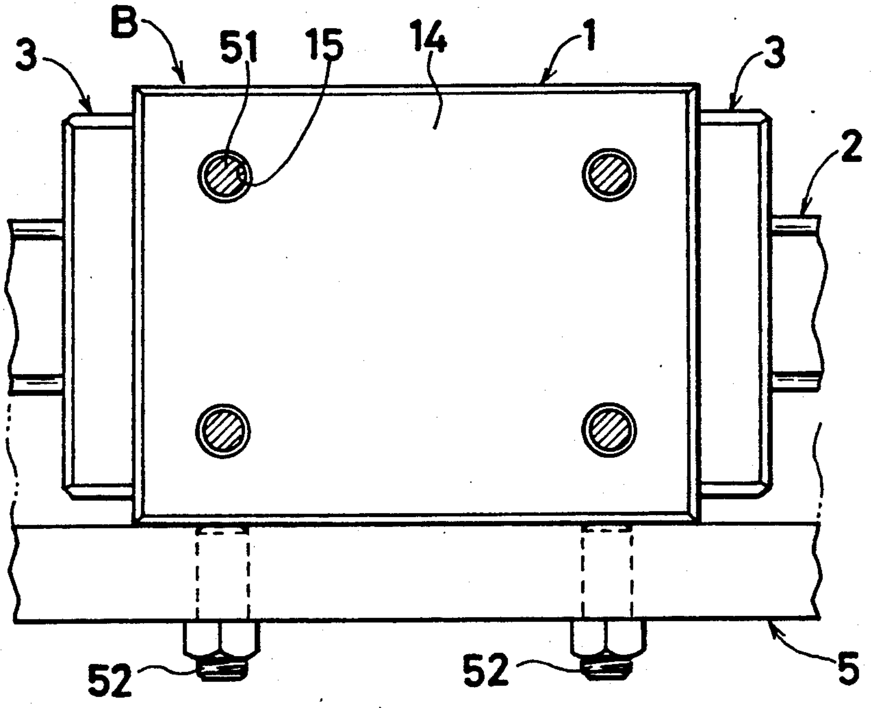


FIG. 2

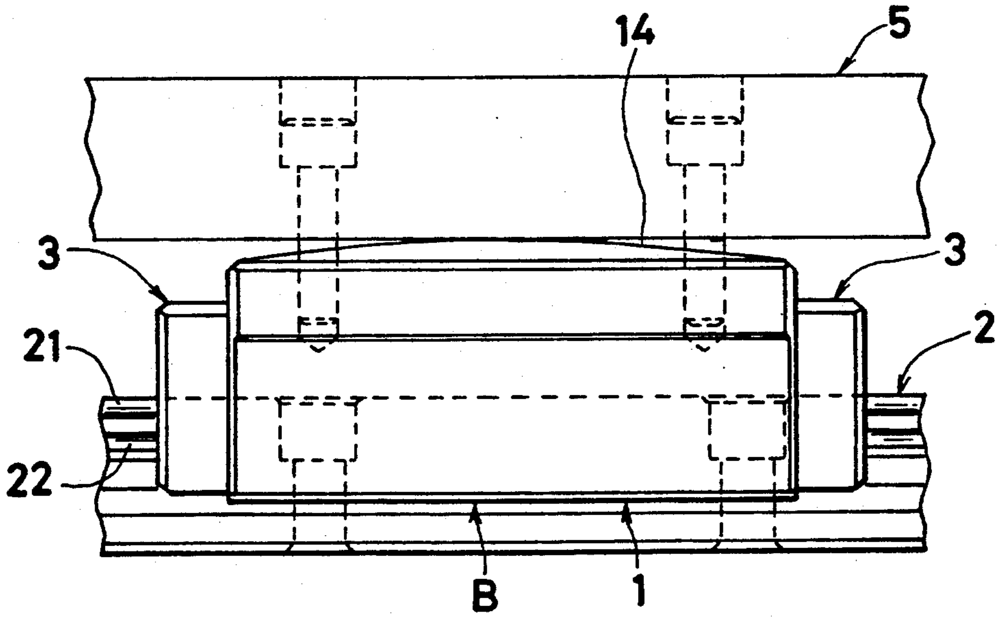


FIG. 3

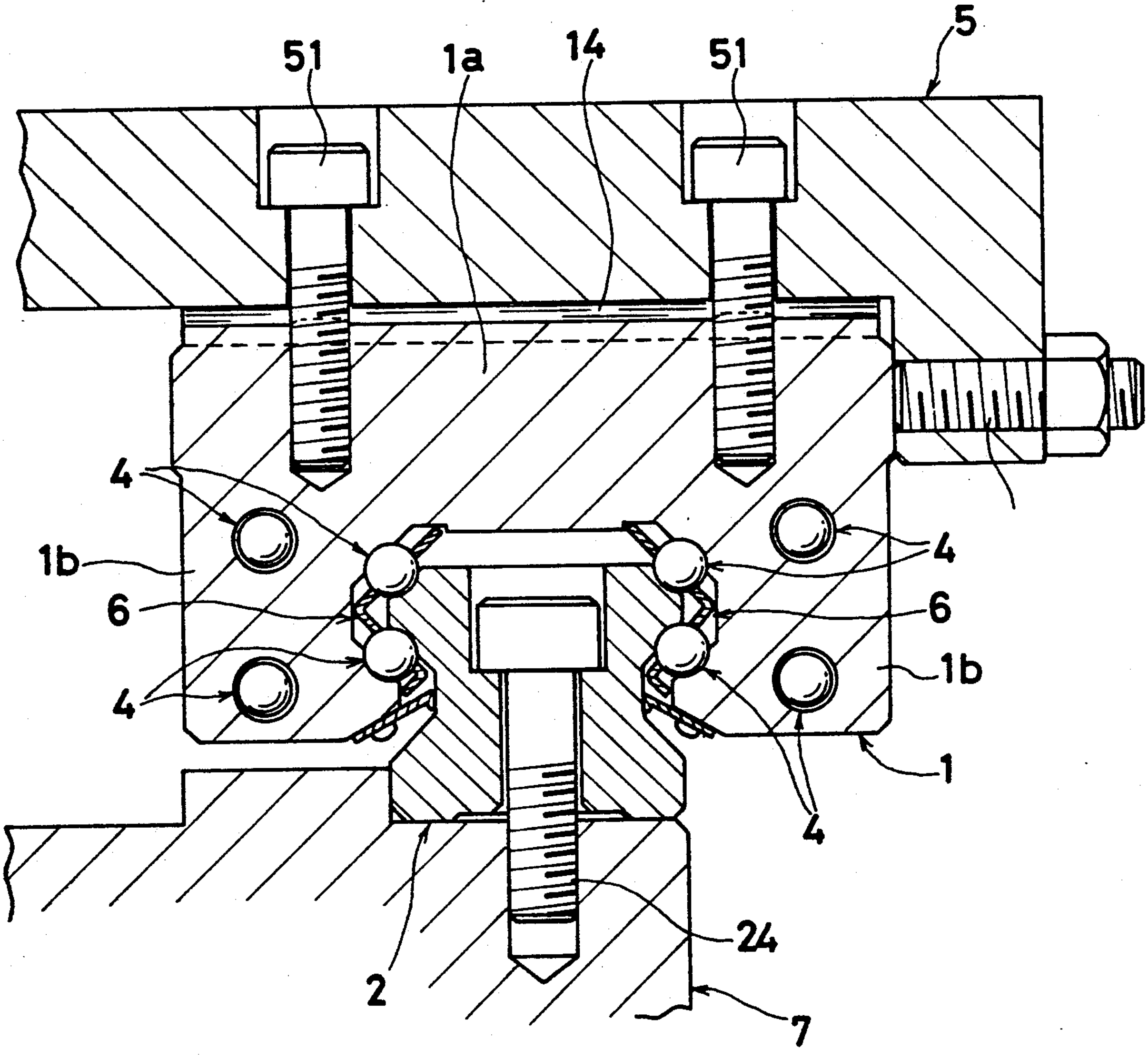


FIG. 4

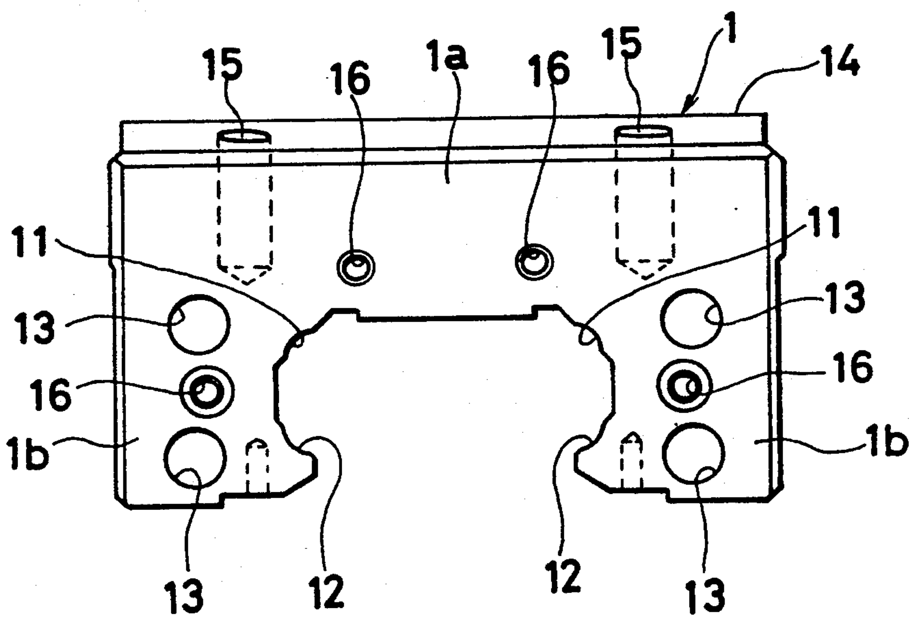


FIG. 5

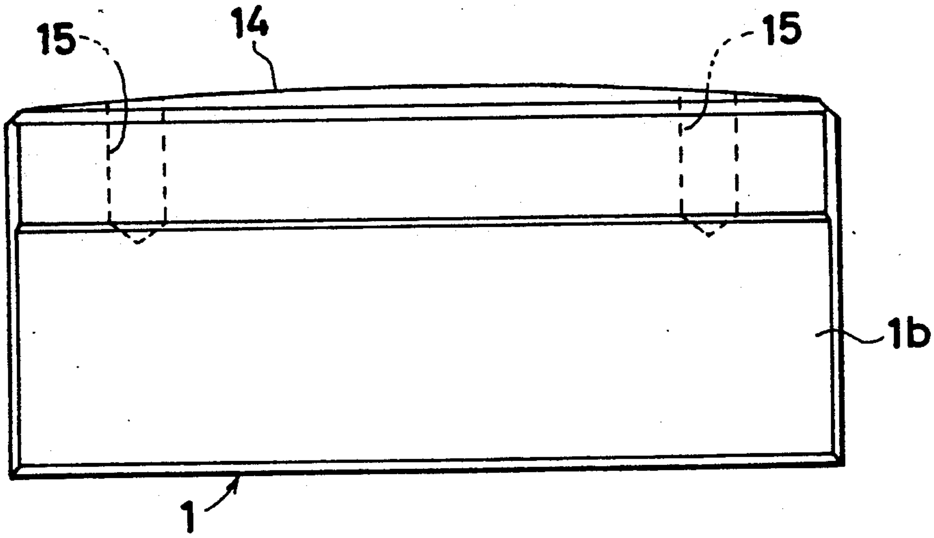


FIG. 6

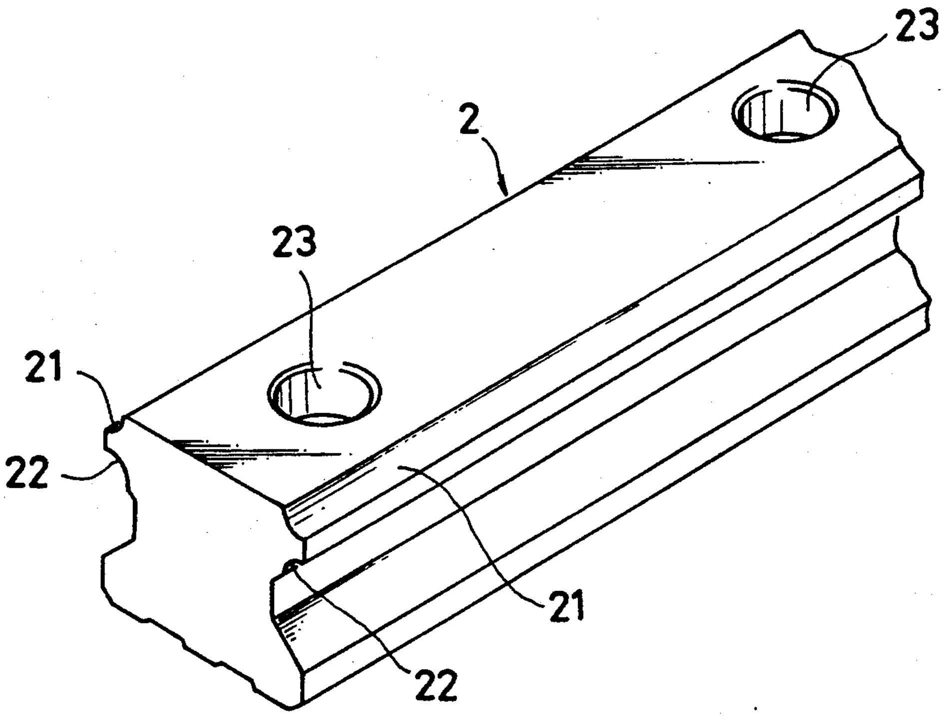


FIG. 7

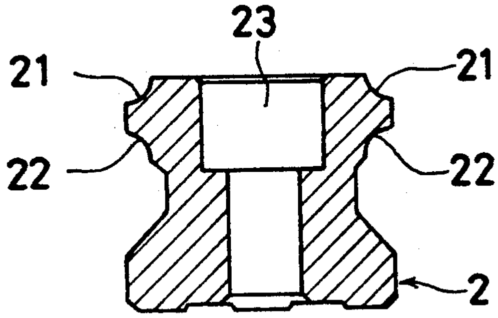


FIG.8

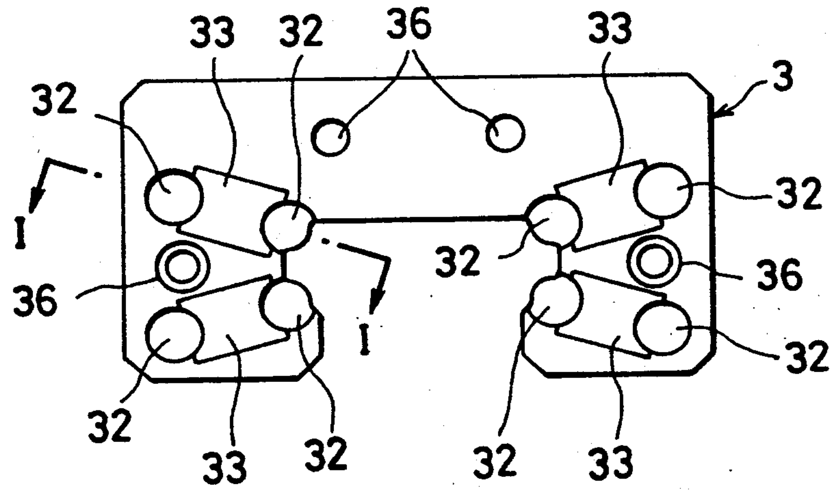


FIG.9

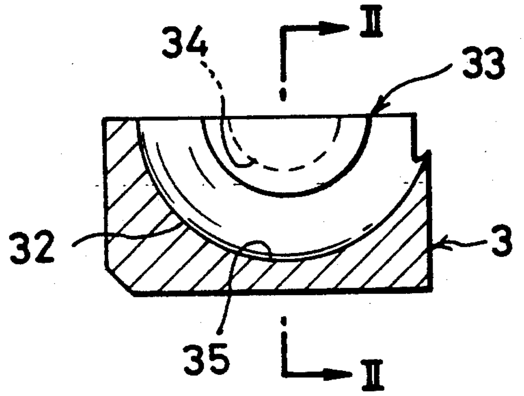


FIG.10

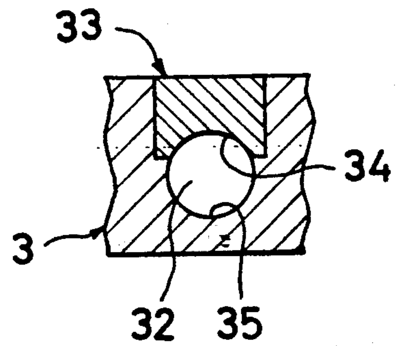


FIG.11

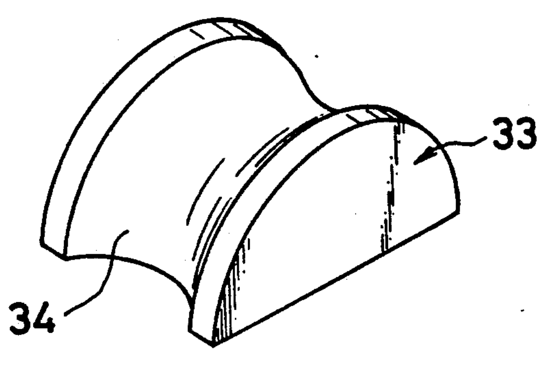


FIG.12

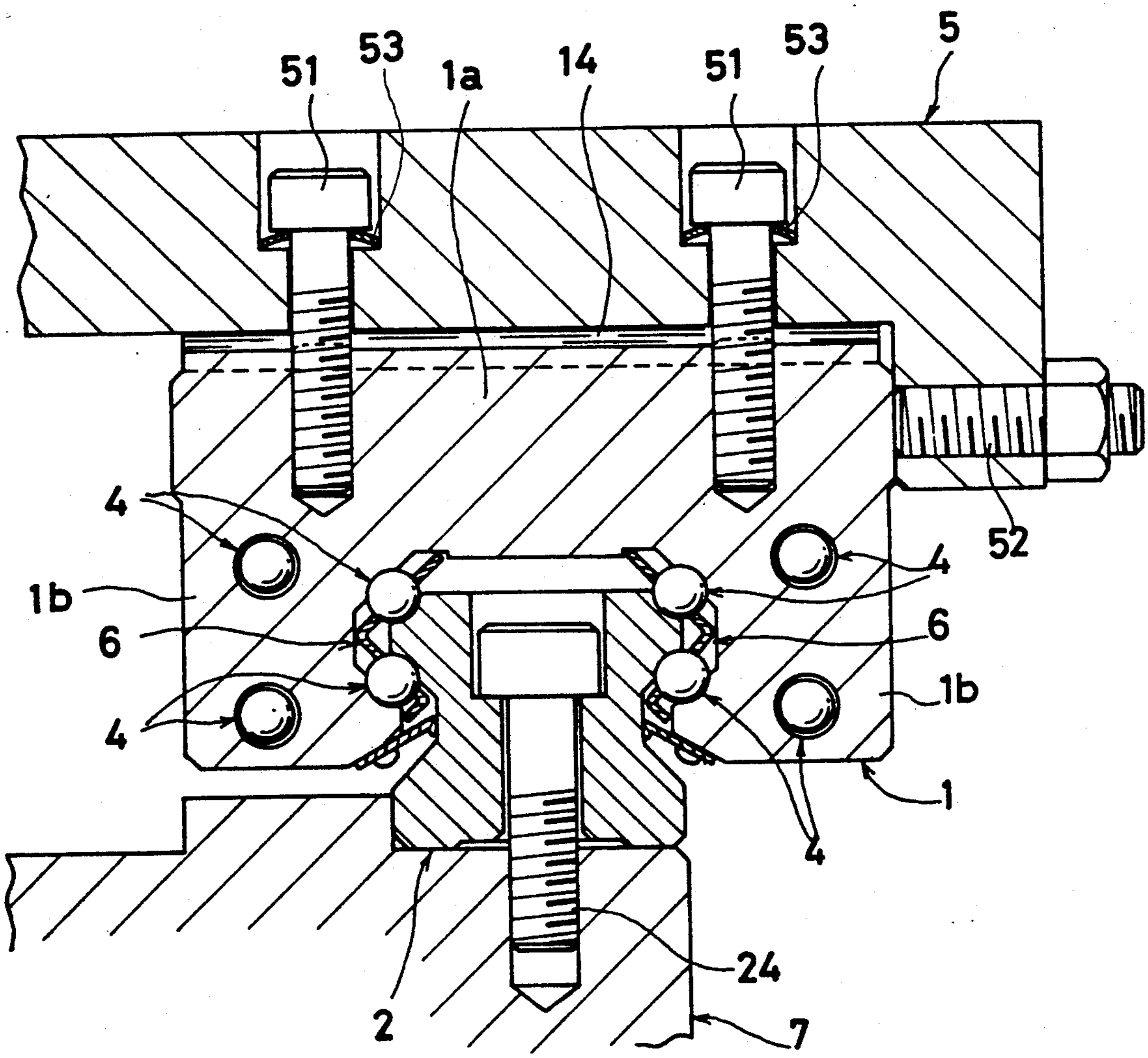


FIG. 13

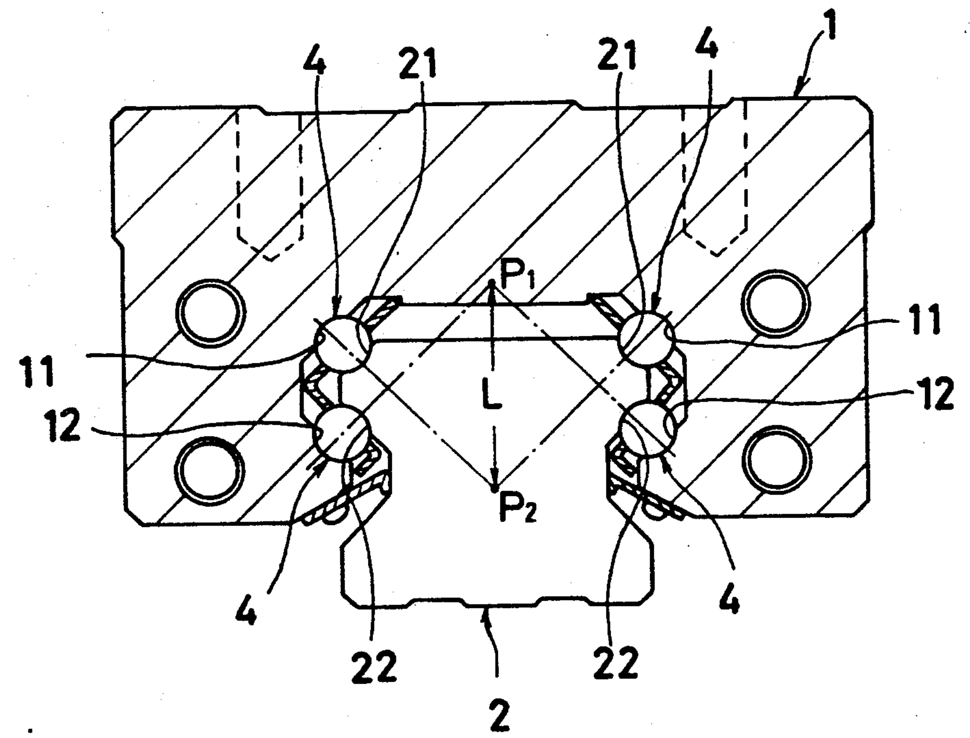


FIG.14

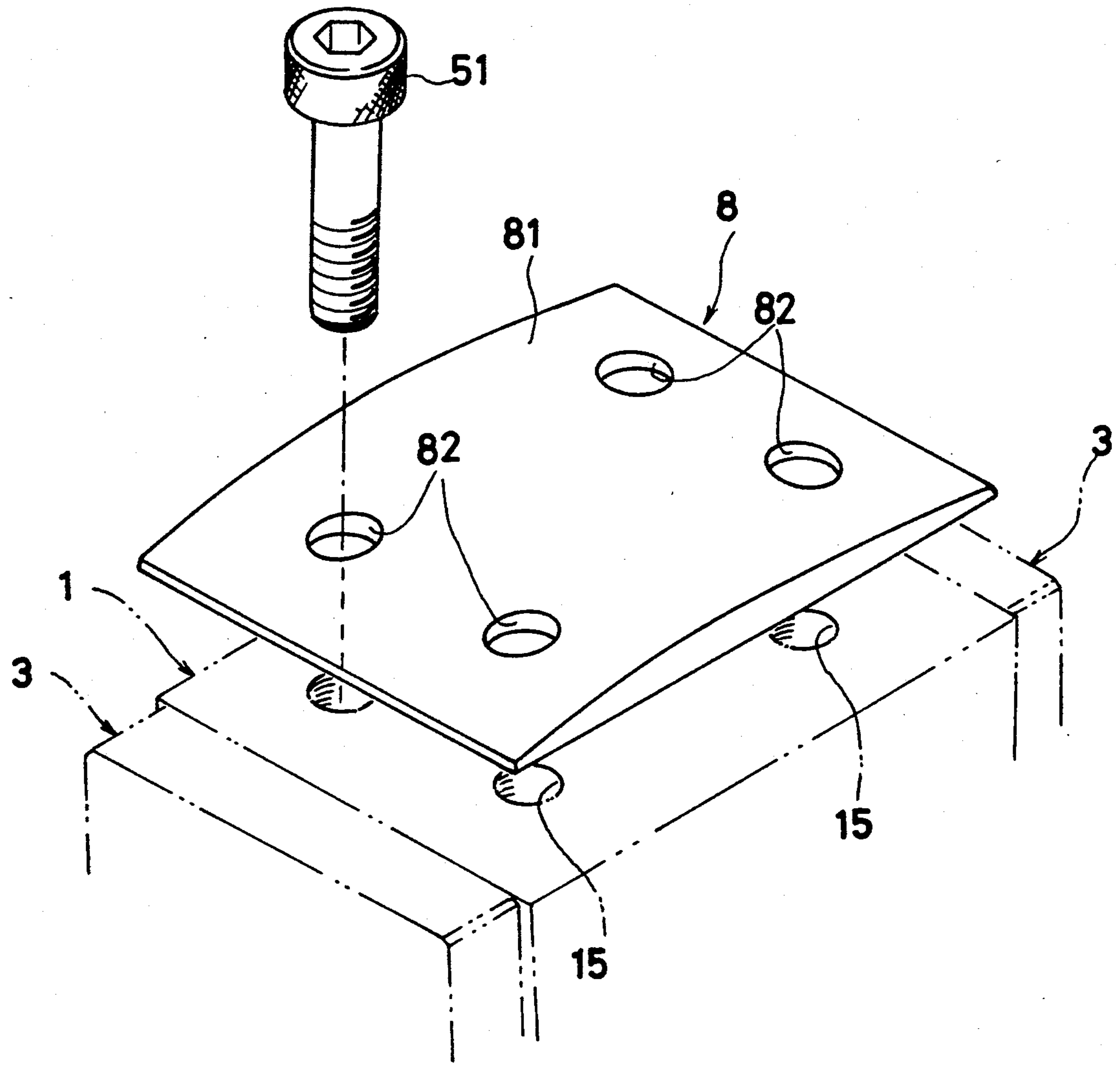


FIG.15

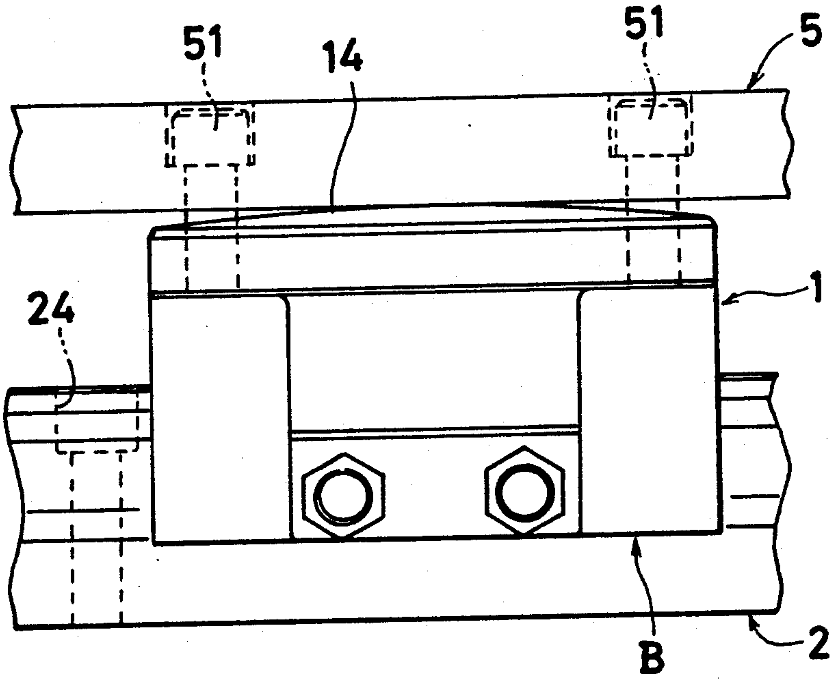


FIG.16

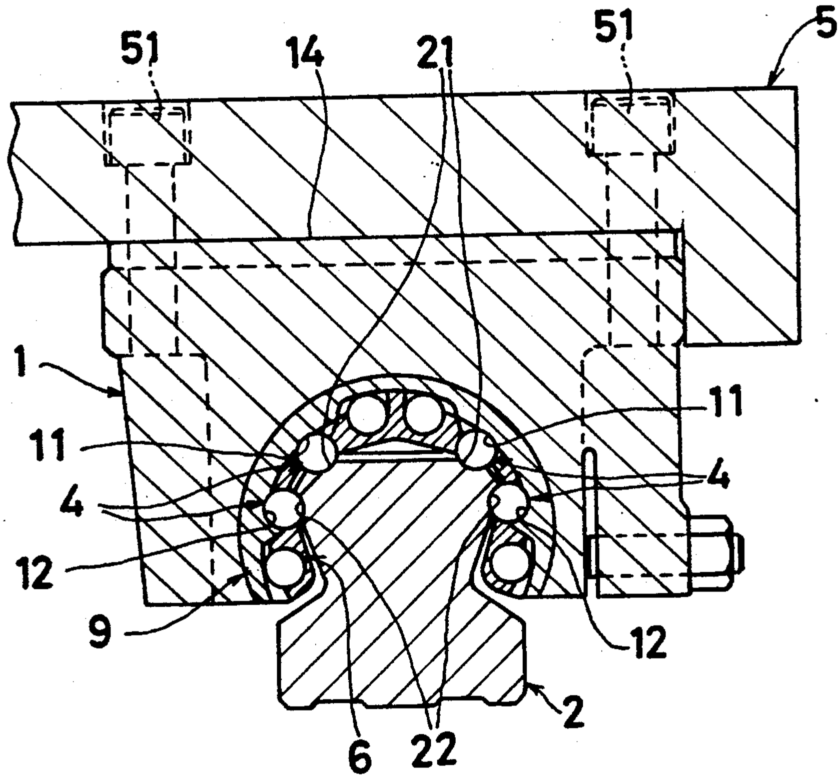


FIG. 17

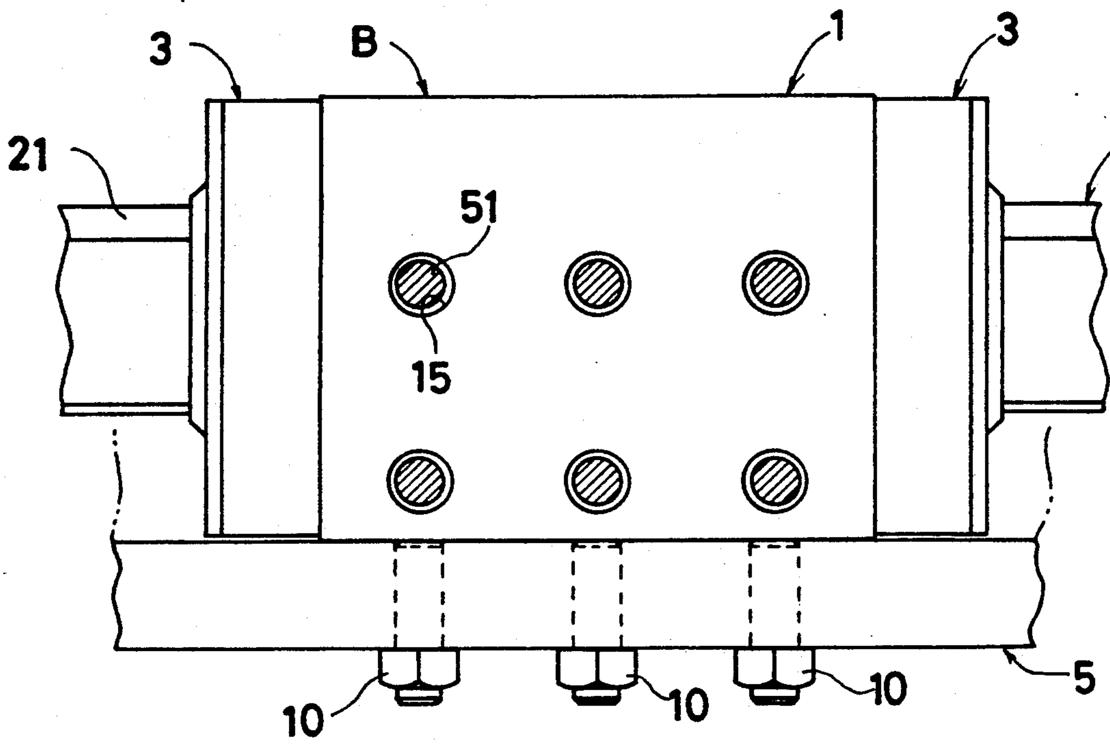


FIG. 18

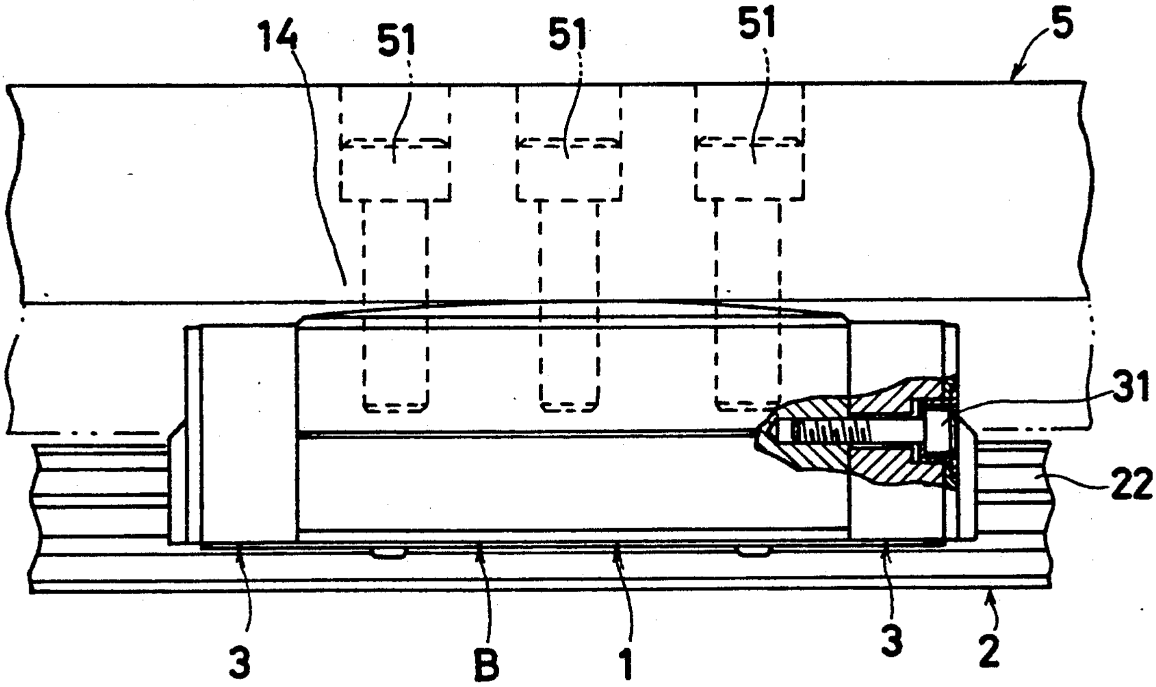


FIG. 19

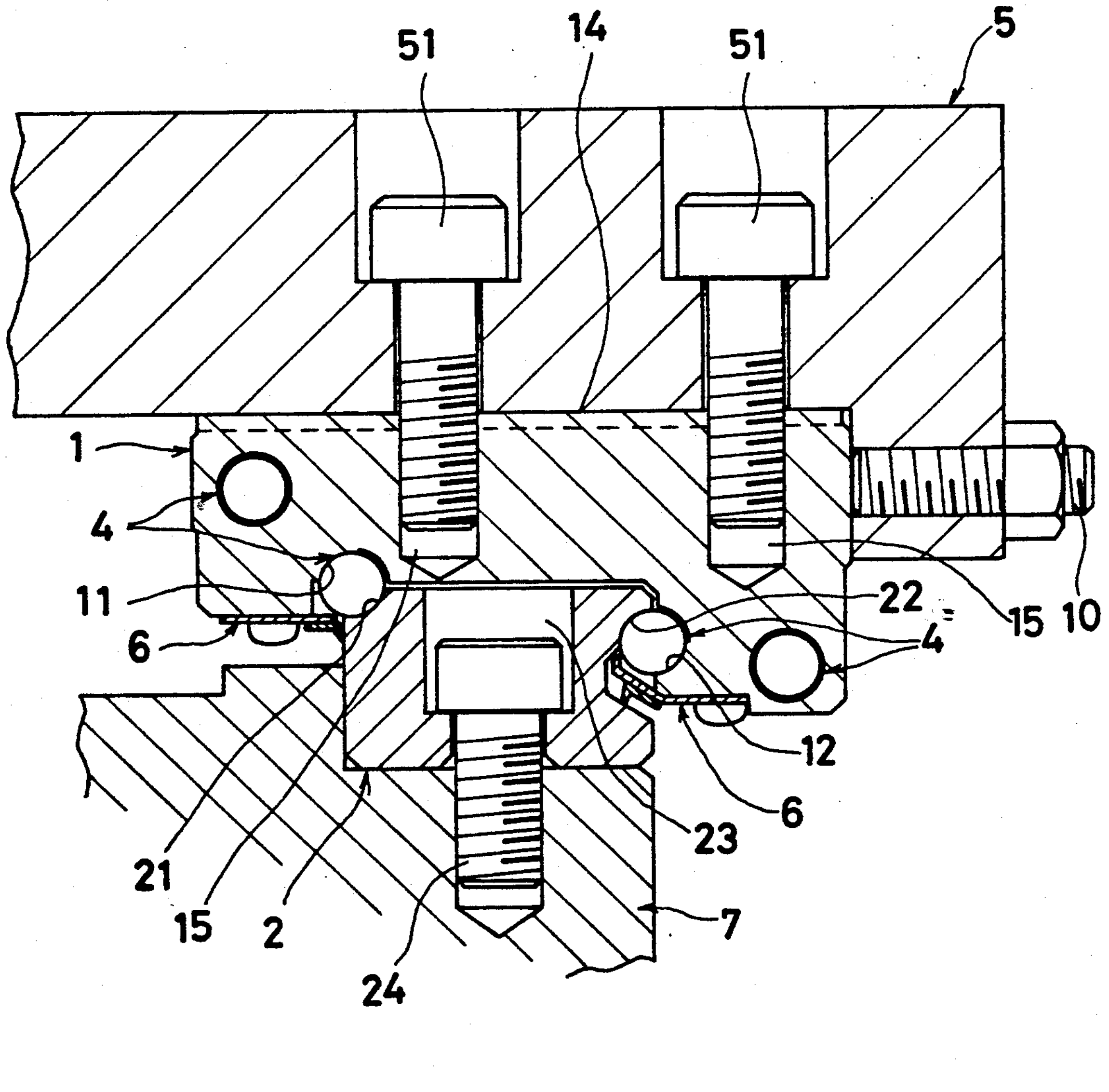


FIG. 20(a)

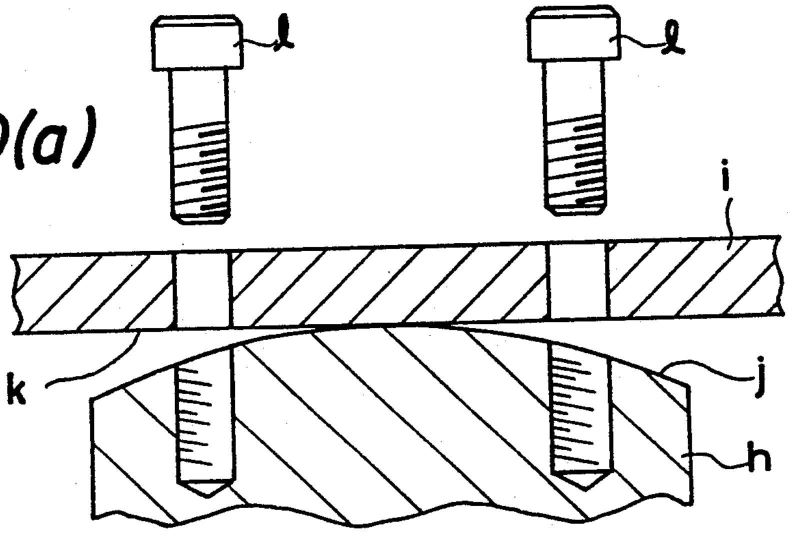


FIG. 20(b)

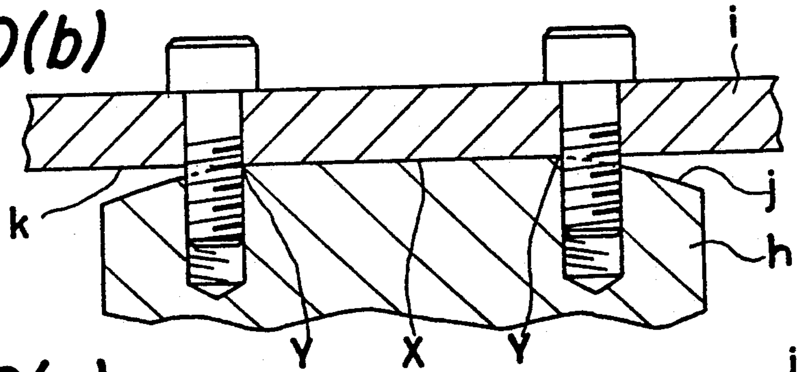


FIG. 20(c)

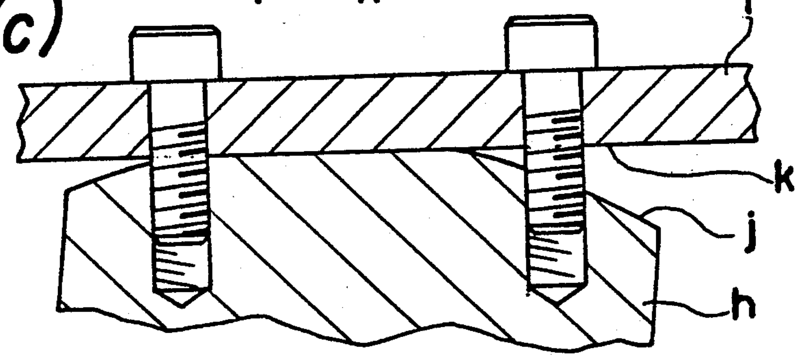


FIG.21

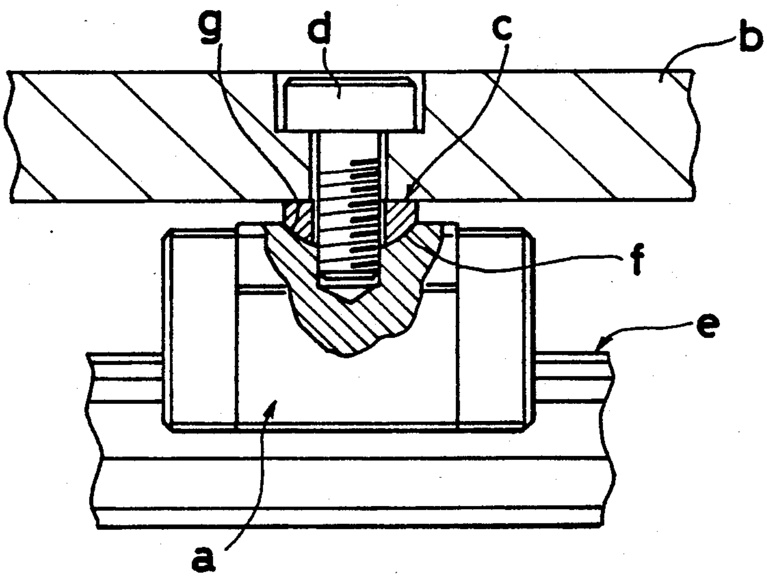
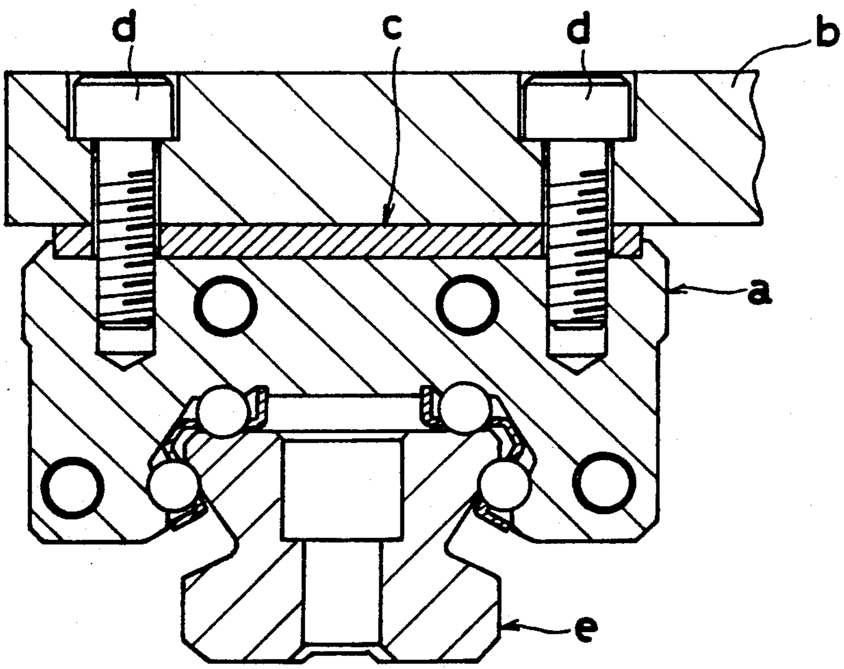


FIG.22



RECTILINEAR SLIDING BEARING AND ASSEMBLING METHOD THEREOF

TECHNICAL FIELD

This invention relates to a rectilinear sliding bearing for rectilinearly guiding a moving body such as a table in a slide section of NC machines, machine tools, industrial robots, etc., and to a method of assembling the rectilinear sliding bearing to the moving body.

BACKGROUND ART

A conventional rectilinear sliding bearing comprises a rail to be fixed to a fixing section of a machine or the like which has axially-extending rolling surfaces on which rolling elements roll, a slider movable along the rail which has a load zone including load rolling surfaces provided in confronting relation to the rolling surfaces of the rail and a no-load zone for connecting both ends of the load zone, the two zones defining endless tracks, and a number of rolling elements for bearing loads between the load rolling surfaces of the slider and the rolling surfaces of the rail while circulating through the endless tracks. In practice, for example, a plurality of such rails are laid in parallel on the fixing section, and a moving body such as a table is connected to the slider.

This type of rectilinear sliding bearing can possess the so-called automatic adjusting function (of reducing a moment load acting on the bearing) by making the angle of contact of the load rolling surface with the rolling element close to the angle of contact of an outer ring with a ball in front combination form of an angular contact ball bearing (which is one type of rotary bearing) to short the distance between two working points appearing when loads act on the bearing. On the other hand, the bearing can also possess the so-called automatic aligning function (of causing a moment load acting on the slider to be effectively absorbed between a bearing race and a block) by dividing the slider having the automatic adjusting function into a substantially cylindrical bearing race having endless tracks and a block having a table attaching surface which is fitted on the bearing race.

In these rectilinear sliding bearings, even when there is the attaching error of the rail relative to the fixing section (such as the error in parallelism or, level of two or more rails), the slider can be smoothly moved and the moving body can be rectilinearly guided with accuracy.

However, where the rail has some vertical waving resulting from the disorder of the surface of the fixing section on which the rail is laid, improper tightening of rail fixing bolts, etc., the slider moving along such a rail undergoes pitching in the moving direction, so that the machining accuracy of a machine tool, for example, mounted on the moving body is degraded.

To overcome such a defect, Japanese Patent Laid-Open No. 62-188636 has proposed a rectilinear guide device. This, as shown in FIGS. 21 and 22, is characterized in that a gap retaining washer (c) is interposed between a slider (a) and a moving body (b) to retain a gap between them, and an attaching bolt (d) is passed through the gap retaining washer (c) and screwed into the slider (a) to connect the slider (a) and the moving body (b) together, whereby the structural error of rail (e) can be absorbed or moderated by means of the relative displacement between the slider (a) and the moving body (d) that results from the elastic deformation of the attaching bolt (d) (specifically, by a sliding contact action between an arcuate convex surface (f) of the gap retaining washer (c) and an arcuate concave surface (g) of the slider (a) or moving body (b)). In this rectilinear guide device, the pitching of the slider (a) is absorbed between the slider (a) and the moving body (b); therefore, the positional accuracy in movement of the moving body (b) is enhanced to overcome the foregoing defect.

However, the proposed rectilinear guide device has other defects. First, since the sliding contact action between the gap retaining washer (c) and the slider (a) or moving body (b) is utilized, when the amount of tightening of the attaching bolt (d) is large or the moving body (b) suffers a large load/weight, the coupling force between the slider (a) and the moving body (b) becomes strong, and a large frictional force acts between the arcuate convex surface (f) and the arcuate concave surface (g), whereby the function of relative displacement owing to sliding contact cannot be exerted sufficiently.

Second, if the area of sliding contact is decreased for the purpose of sufficiently exerting the function of relative displacement owing to sliding contact, a concentrated load acts on the slider (a) and the moving body (b), whereby the individual components (a), (b) tend to be deformed or damaged.

In view of the foregoing defects, it is an object of the present invention to provide a rectilinear sliding bearing of high reliability which can effectively absorb or moderate the attaching error of a rail.

It is another object of the present invention to provide a method of assembling a rectilinear sliding bearing which makes it possible to accomplish the first object.

DISCLOSURE OF THE INVENTION

According to a first feature of the present invention, a rectilinear sliding bearing comprises a slider of substantially C-shape in cross section having a horizontal portion, a pair of wing portions extending downward from both ends of the horizontal portion, a concave portion opened on the lower side which is defined by the horizontal portion and the two wing portions, an attaching surface to which a moving body such as a table is fixed by means of coupling bolts, a downward-facing upper load rolling surface and an upward-facing lower load rolling surface axially formed in the inner surface of each of the wing portions, and no-load rolling paths for defining endless tracks in conjunction with the upper and lower load rolling surfaces; a rail having rolling surfaces formed in confronting relation to the upper and lower load rolling surfaces along which the slider moves; and a number of rolling elements, such as balls or rollers, for bearing loads between the upper and lower load rolling surfaces of the slider and the rolling surfaces of the rail while circulating through the endless tracks; and is characterized in that the attaching surface of the slider is made in the form of a curved surface having a small radius of curvature in the moving direction so that when the moving body is fixed by tightening the coupling bolts, the attaching surface is brought into pressure contact with the moving body to undergo elastic deformation, and the elastic deformation of the attaching surface causes relative displacement between the slider and the moving body, thereby absorbing or moderating the structural error of the rail.

According to a second feature of the present invention, the foregoing first rectilinear sliding bearing is modified so that the slider is composed of a bearing race formed by cutting off an axially-extending portion of a cylindrical body to define the concave portion opened on the lower side, the inner surface of the concave portion having the upper and lower load rolling surfaces; and a block fitted on the bearing race and having the attaching surface to which the moving body such as a table is fixed by means of the coupling bolts.

According to a third feature of the present invention, the foregoing first rectilinear sliding bearing is modified so that the slider has a horizontal portion, tow wing portions extending downward from both ends of the horizontal portion, a concave portion opened in an obliquely downward direction which is defined by the horizontal portion and the two wing portions, an attaching surface to which a moving body such as a table is fixed by means of coupling bolts, a downwardly-inclined load rolling surface axially formed in the inner surface of one wing portion, an upwardly-inclined load rolling surface axially formed in the inner surface of the other wing portion, and no-load rolling paths for defining endless tracks in conjunction with the load rolling surfaces.

According to the present invention, a method of assembling a rectilinear sliding bearing in which a slider moves rectilinearly along a rail with interposition of a number of endlessly-circulatable rolling elements, such as balls or rollers, by fixing a moving body such as a table to the slider, comprises the steps of making the moving-body attaching surface of the slider into the form of a curved surface having a small radius of curvature in the moving direction, and bringing the moving body into pressure contact with the attaching surface by tightening coupling bolts to cause the attaching surface to undergo elastic deformation, whereby the elastic deformation of the attaching surface causes relative displacement between the slider and the moving body to absorb or moderate the structural error of the rail.

The workings of the foregoing technical matter will be described with reference to FIG. 20.

Since either an attaching surface (j) of a slider (h) or a surface (k) to be attached of a moving body (i) is curved (the surface of the slider (h) is curved in the drawing), before tightening coupling bolts (l), only the top of the curved surface (j) is in contact with the flat surface (k) (see FIG. 20(*a*)).

When the coupling bolts (l) are tightened, the slider (h) with the curved surface (j) undergoes elastic deformation if the rigidity of the moving body (i) with the flat surface (k) is sufficiently high, and the area of contact between the slider (h) and the moving body (i) increases with the amount of tightening of the coupling bolts (l) (see FIG. 20(*b*)).

The pressure of surface contact in a contacting zone is the highest at the center X of the curved surface, decreases gradually as departing from the center X, and becomes substantially zero at each Y of the contacting zone. Therefore, when the slider (h) itself causes pitching in the moving direction, the coupling bolts undergo elastic deformation, such as elongation or nontraction, the slider (h) rolls in relation to the moving body (i) to shift the contacting zone between them as shown in FIG. 20(*c*), and thus, pitching is prevented from transferring to the moving body (i).

In FIG. 20, to facilitate understanding of the foregoing fundamental action, the radius of curvature of the attaching surface is shown in exaggerated form.

In the present invention, a small radius of curvature being given to the moving-body attaching surface of the slider is determined on the basis of an estimated magnitude of the attaching error of the rail. When the rail itself causes large vertical waving after being attached to a fixing section, the radius of curvature of the attaching surface is made somewhat larger to make difficult the transfer of the pitching of the slider to the moving body. For example, where the axial or longitudinal length of the slider is 100 mm, the difference between the sectional height at the center of the attaching surface of the slider and the sectional height at either axial end of the slider is set to about 0.01 mm to 0.05 mm.

The assembling method of the present invention is applicable to any slider of the foregoing three kinds of rectilinear sliding bearings, provided that the slider freely slidable on the rail has the endless tracks through which the rolling elements circulate and the curved moving-body attaching surface has a small radius of curvature. To enhance the moving accuracy of the moving body being attached to the slider, it is preferable that each of the two wing portions of the slider should have the downward-facing upper load rolling surface and the upward-facing lower load rolling surface to give the automatic adjusting function to the slider as is the case of the first kind of rectilinear sliding bearing. Further, it is preferable that the slider should be divided into the bearing race and the block to give the automatic aligning function to the slider as is the case of the second kind of rectilinear sliding bearing. Further, the moving-body attaching surface may be formed integrally on the slider, or a separate member having such an attaching surface may be mounted on the slider.

The number of endless tracks, the angle of inclination of the load rolling surface, and the like may be changed or modified depending on the field of applications of the bearing, the structure of the slider, and the like. Further, the no-load rolling path may be provided by boring a no-load rolling hole in the slider or attaching a rolling-element retainer to the slider.

The rolling element which circulates through the endless track may be in the form of a cylindrical roller, barrel-shaped roller, ball, etc.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view showing a first embodiment of a rectilinear sliding bearing according to the present invention;

FIG. 2 is a side view corresponding to FIG. 1;

FIG. 3 is a sectional front view showing the rectilinear sliding bearing in assembled form according to the first embodiment;

FIGS. 4 and 5 are a front view and a side view, respectively, showing a slide body of the rectilinear sliding bearing according to the first embodiment;

FIGS. 6 and 7 are a perspective view and a sectional view, respectively, showing a rail according to the first embodiment;

FIG. 8 is a front view showing a cover according to the first embodiment;

FIG. 9 is a sectional view taken along line I—I in FIG. 8;

FIG. 10 is a sectional view taken along line II—II in FIG. 9;

FIG. 11 is a perspective view showing a guide piece according to the first embodiment;

FIG. 12 is a sectional front view showing the rectilinear sliding bearing according to the first embodiment in which a conical spring washer is attached to a coupling bolt;

FIG. 13 is a sectional view showing a load working point in the slide body according to the first embodiment;

FIG. 14 is a schematic perspective view showing a spacer;

FIGS. 15 and 16 are a side view and a sectional front view, respectively, showing a second embodiment of the rectilinear sliding bearing according to the present invention;

FIGS. 17, 18 and 19 are a plan view, a side view and a sectional front view, respectively, showing a third embodiment of the rectilinear sliding bearing according to the present invention;

FIG. 20 is an explanatory view showing a fundamental method of assembling the rectilinear sliding bearing according to the present invention; and

FIGS. 21 and 22 are a side view and da sectional front view, respectively, showing a conventional bearing.

BEST MODE FOR CARRYING OUT THE INVENTION

A rectilinear sliding bearing and an assembling method thereof of the present invention will now be described in greater detail with reference to the accompanying drawings.

FIRST EMBODIMENT

FIGS. 1 through 11 show a first embodiment of the rectilinear sliding bearing according to the present invention.

The rectilinear sliding bearing comprises a slide body 1 of substantially C-shape in cross section which has a horizontal portion 1*a*, left and right wing portions 1*b* extending downward from both ends of the horizontal portion, and a concave portion opened on the lower side; a pair of covers 3 attached to the front and rear ends of the slide body 1; a pair of ball retainers 6 provided inside the left and right wing portions 1*b* of the slide body 1; a rail 2 fixed to a machine or the like by means of fixing bolts acting as fixing means; and a number of balls 4 for bearing loads between the slide body 1 and the rail 2 while circulating through endless ball tracks defined by the slide body 1 and the covers 3.

As shown in FIGS. 4 and 5, the slide body 1 is substantially C-shaped in cross section, and the inner surface of each of the left and right wing portions 1*b* has upper and lower load rolling surfaces 11 and 12 extending in the axial direction whose radius of curvature is larger than the radius of the balls. The normal line of the upper load rolling surface 11 is inclined downward at 45 degrees to the horizontal and the normal line of the lower load rolling surface 12 is inclined upward at the same angle. Each of the left and right wing portions 1*b* has no-load rolling holes 13 formed therein correspondingly to the upper and lower load rolling surfaces 11 and 12. The slide body 1 has on its upper side an attaching surface 14 which is curved in the moving or axial direction with a small radius of curvature, and attaching holes 15 formed therein in which coupling bolts 51 passing through a moving body 5 from top to bottom are fitted. Reference symbol 16 designates screw holes in which fixing or attaching bolts 31 for the covers 3 are fitted.

Each of the covers 3 made of synthetic resin is fixed to either axial end of the slide body 1 by the fixing bolts 31. As shown in FIGS. 8 through 11, each cover 3 has ball turning paths 32 formed therein for connecting the load rolling surfaces 11 and 12 and the corresponding no-load rolling holes 13 of the slide body 1. Each ball turning path 32 is completed by fitting a semi-circular guide piece 33 (having a guide surface 34 made compatible with the load rolling surface 11, 12) in each ball guide groove 35 formed in each cover 3. Reference symbol 36 designates an attaching hole through which the fixing bolt 31 is passed.

Each of the ball retainers 6 is fabricated by stamping a metal plate as to have a substantially L-shape in cross section and two elongate holes whose width is smaller than the diameter of the balls 4. Each ball retainer 6 acts to eject the balls 4 rolling on the load rolling surfaces 11 and 12 from the elongate holes and bring them into contact with the rolling surfaces of the rail 2, and also to prevent the balls 4 from coming off the load rolling surfaces 11 and 12 of the slide body 1 when a slider B is detached from the rail 2.

The slider B having the endless tracks through which the balls 4 circulate is completed by attaching the covers 3 and the ball retainers 6 to the slide body 1.

The rail 2 is fabricated by cutting off a part of trapezoidal shape in cross section from either lateral side of a raw body of rectangular shape in cross section and cutting off left and right shoulder portions. Each downward-facing oblique surface formed by cutting off the trapezoidal part defines a lower rolling surface 22 corresponding to the lower load rolling surface 12 formed in the inner surface of the wing portion 1*b* of the slide body, and each upward-facing oblique surface formed by cutting off the shoulder portion defines an upper rolling surface 21 corresponding to the upper load rolling surface 11 formed also in the inner surface of the wing portion 1*b* of the slide body. The rail 2 has fixing-bold insertion holes 23 formed in a central portion orthogonally to the upper surface at adequate intervals in the longitudinal direction thereof, through which fixing bolts 24 to be screwed to a fixing section 7 are passed.

To assemble the rectilinear sliding bearing of the foregoing structure to a rectilinear sliding table for guiding a machine in rectilinear reciprocative motion, as shown in FIG. 3, the rail 2 is fixed to the fixing section 7 such as a bed by means of the fixing bolts 24, and the moving body 5 is fixed by means of the coupling bolts 51 to the attaching surface 14 of the slider B capable of moving along the rail 2.

In this assembling process, the attaching surface or curved surface 14 of the slide body 1 is compressed by tightening the coupling bolts 51, whereby the slider B and the moving body 5 are fixed together. At this time, the coupling bolts 51 undergo elastic deformation, such as elongation or contraction, and the slider B and the moving body 5 are brought into rolling contact with each other, thereby causing relative displacement.

Therefore, when the slider B receives external vertical loads because of the presence of the attaching error and the like of the rail 2, relative displacement occurs between the slider B and the moving body 5, whereby fluctuations in posture of the slider B owing to external loads are absorbed or moderated, so that the accuracy in rectilinear motion of the moving body 5 is kept high.

In this embodiment, the angle of contact of the balls 4 with the load rolling surfaces 11 and 12 and with the rolling surfaces 21 and 22 in relation to the horizontal is

45 degrees over the whole length of the endless track; thus, the rectilinear sliding bearing is similar in ball contact angle to a so-called angular contact bearing (which is one type of rotary bearing). Therefore, a load working point when a load acts on the slider B is located at P_1 and P_2 as shown in FIG. **13**, so that the distance L between these working points becomes short. Consequently, even when loads acting at P_1 and P_2 are not in balance, a moment load acting on the slider B can be reduced, that is, the rectilinear sliding bearing has the so-called automatic adjusting function. Accordingly, with the advantage that the moving body **5** and the slider B can undergo relative displacement, the present invention can absorb the attaching error of the rail **2** to smoothly guide the moving body **5** in rectilinear motion with accuracy.

SECOND EMBODIMENT

Although the first embodiment includes the curved attaching surface **14** provided on the slider B of the rectilinear sliding bearing having the automatic adjusting function, this second embodiment is implemented by applying the present invention to a rectilinear sliding bearing having the so-called automatic aligning function.

FIGS. **15** and **16** show a second embodiment of the rectilinear sliding bearing. That is, the slider B comprises a bearing race **9** made of a cylindrical body those axially-extending portion is cut off to define a concave portion opened on the lower side (an upper half portion of the rail **2** is passed through this concave portion with a certain gap left between them), and a block **1** which has an attaching surface **14** for fixing the moving body **4** by means of the coupling bolts **51** and surrounds the bearing race **9** tightly. The angle of contact of the balls **4** with the load rolling surfaces **11** and **12** differs from that of the first embodiment. Other structural points of the second embodiment are substantially identical with those of the first embodiment.

In the bearing race **9**, the inner surface of the concave portion has two upper load rolling surfaces **11** and two lower load rolling surfaces **12** extending in the axial direction, the upper load rolling surface **11** faces downward orthogonally to the horizontal plane, the lower load rolling surface **12** faces upward at 30 degrees to the horizontal plane, and upon contact of the balls **4**, the automatic adjusting function as in the first embodiment acts on the bearing race **9**. A ball retainer **6** is provided inside the concave portion of the bearing race **9** as to cover the load rolling surfaces **11** and **12**, and in conjunction with the inner surface of the bearing race **9**, defines endless ball tracks.

The block **1** has a curved surface on the upper side which defines an attaching surface **14** for the moving body **5** as in the first embodiment, and a concave portion on the lower side which receives the bearing race **9**.

In this second embodiment, when a moment load acts on the slider B, relative displacement occurs between the bearing race **9** and the block **1**, whereby no excessice load is imposed on the balls **4**, so that the balls **4** can slide on the rail **2**.

Therefore, because of the presence of the curved attaching surface **14** of the slider B, the accuracy in rectilinear motion of the moving body **5** is never influenced by the pitching of the slider B resulting from the waving of the rail **2**, and the moving body **5** can be smoothly guided even where the attaching error of the rail **2** is comparatively large.

THIRD EMBODIMENT

This embodiment is substantially identical with the first embodiment, except that the shape of the slider B, the angle of contact of the balls **4**, and the number of endless tracks differ from those of the first embodiment.

As shown in FIGS. **17** through **19**, the slider B comprises a slide body **1** of substantially L-shape in cross section which has a horizontal portion **1***a*, two wing portions **1***b* extending downward from both ends of the horizontal portion, and a concave portion opened in an obliquely downward direction; a pair of covers **3** attached to the front and rear end face of the slide body **1**; and ball retainers **6** attached to the lower ends of the wing portions **1***b*.

The inner surface of each of the wing portions **1***b* of the slide body has a load rolling surface **11, 12**; a no-load rolling hole **13** is formed in each wing portion correspondingly to the load rolling surface **11, 12**; and these load rolling surfaces and no-load rolling holes in conjunction with the ball retainers **6** and ball turning paths formed in the covers **3** define endless ball tracks. A moving-body attaching surface **14** of the slide body **1** is curved as in the first embodiment. Reference symbol **10** designates a sidewise pressure bolt for pressing one side face of the slide body **1** to apply pre-load to the balls **4**.

Therefore, in this third embodiment also, the coupling bolts **51** underto elastic deformation, such as elongation or contraction, and the slider B and the moving body **5** are brought into rolling contact with each other to cause relative displacement, so that because of the presence of the curved attaching surface **14**, the accuracy in rectilinear motion of the moving body **5** is never influenced by the pitching of the slider B resulting from the waving of the rail **2**.

Each of the foregoing embodiments uses the coupling bolts **51** which completely connect the slider B and the moving body **5** together while allowing them to undergo relative displacement. However, where a conical spring washer **53** is interposed between the moving body **5** and the coupling bolt **51** as shown in FIG. **12** and the coupling bolt **51** is fastened to such an extent as not to completely compress the conical spring washer **53**, relative displacement occurs easily between the slider B and the moving body **5**; in this case, even small fluctuations in posture of the slider B can be absorbed or moderated, thereby improving the accuracy in rectilinear motion of the moving body **5**.

As will be appreciated, several components of the second and third embodiments which are identical with or correspond to those of the first embodiment are designated by the same reference symbol, with their description not duplicated.

Each of the foregoing embodiments shows the attaching surface directly provided on the upper side of the slide body. However, the present invention may be implemented by the use of a spacer **8** as shown in FIG. **14**.

This spacer **8** is in the form of a substantially flat plate with through holes **82** for the coupling bolts **51**, whose one face is curved to define a curved surface **81**. To assemble the rectilinear sliding bearing of the present invention, the spacer **8** is interposed between the slide body **1** and the moving body **5** where the respective attaching surfaces of the slide body **1** and the moving body **5** are flat.

Therefore, by the use of the spacer **8**, the assembling method of the present invention can be readily practiced in or applied to the conventional rectilinear sliding bearing whose attaching surface **14** for the moving body **5** is flat, this resulting in the same effect as is the case of the rectilinear sliding bearing according to the present invention.

Here, it is no matter whether the curved surface **81** faces the slider B or the moving body **5**.

In the drawings showing the embodiments, to facilitate understanding of the present invention, the radius of curvature of the attaching surface is shown in exaggerated form to such an extent that anyone can visually perceive it.

INDUSTRIAL APPLICABILITY

As described above, according to the rectilinear sliding bearing and the assembling method thereof of the present invention, the pitching of the slider resulting from the attaching error of the rail can be absorbed or moderated, the positional accuracy of the moving body can be enhanced, and the machining accuracy of a machine tool or the like mounted on the moving body can be improved.

Further, the slider and the moving body are brought into tolling contact with each other to undergo relative displacement, and such relative displacement is not impeded by the frictional force between them; therefore, the foregoing effect can always be exerted.

Further, the curved surface is compressed in proportion to the amount of tightening of the coupling bolt and the amount of load/weight of the moving body to result in a corresponding area of surface contact between the slider and the moving body; therefore, loads never act on one point of the slider concentratedly, and the durability of the slider can be enhanced.

What is claimed is:

1. A rectilinear sliding bearing comprising

a slider of subtantially C-shape in cross section having a horizontal portion, a pair of wing portions extending downward from both ends of the horizontal portion, a concave portion opened on the lower side which is defined by the horizontal portion and the two wing portions, an attaching surface to which a moving body such as a table is fixed by means of coupling bolts, a downward-facing upper load rolling surface and an upward-facing lower load rolling surface axially formed in the inner surface of each of the wing portions, and no-load rolling paths for defining endless tracks in conjunction with the upper and lower load rolling surfaces.

a rail having rolling surfaces formed in confronting relation to the upper and lower load rolling surfaces along which the slider moves, and

a number of rolling elements, such as balls or rollers, for bearing loads between the upper and lower load rolling surfaces of the slider and the rolling surfaces of the rail while circulating through the endless tracks,

chracterized in that the attaching surface of the slider is made in the form of a curved surface having a small radius of curvature in the moving direction so that when the moving body is fixed by tightening the coupling bolts, the attaching surface is brought into pressure contact with the moving body to undergo elastic deformation, and the elastic deformation of the attaching surface causes relative displacement between the slider and the moving body, thereby absorbing or moderating the structural error of the rail.

2. A rectilinear sliding bearing according to claim **1**, wherein the slider is composed of

a bearing race formed by cutting off an axially-extending portion of a cylindrical body to define the concave portion opened on the lower side, the inner surface of the concave portion having the upper and lower load rolling surfaces, and

a block fitted on the bearing race and having the attaching surface to which the moving body such as a table is fixed by means of the coupling bolts.

3. A rectilinear sliding bearing comprising

a slider having a horizontal portion, two wing portions extending downward from both ends of the horizontal portion, a concave portion opened in an obliquely downward direction which is defined by the horizontal portion and the two wing portions, an attaching surface to which a moving body such as a table is fixed by means of coupling bolts, a downwardly-inclined load rolling surface axially formed in the inner surface of one wing portion, an upwardly-inclined load rolling surface axially formed in the inner surface of the other wing portion, and no-load rolling paths for defining endless tracks in conjunction with the load rolling surfaces,

a rail having rolling surfaces formed in confronting relation to the load rolling surfaces along which the slider moves, and

a number of rolling elements, such as balls or rollers, for bearing loads between the load rolling surfaces of the slider and the rolling surfaces of the rail while circulating through the endless tracks,

characterized in that the attaching surface of the slider is made in the form of a curved surface having a small radius of curvature in the moving direction so that when the moving body is fixed by tightening the coupling bolts, the attaching surface is brought into pressure contact with the moving body to undergo elastic deformation, and the elastic deformation of the attaching surfaces causes relative displacement between the slider and the moving body, thereby absorbing or moderating the structural error of the rail.

4. A method of assembling a rectilinear sliding bearing in which a slider moves rectilinearly along a rail with interposition of a number of endlessly-circulatable rolling elements, such as balls or rollers, by fixing a moving body such as a table to the slider, comprising the steps of

making the moving-body attaching surface of the slider into the form of a curved surface having a small radius of curvature in the moving direction, and

bringing the moving body into pressure contact with the attaching surface by tightening coupling bolts to cause the attaching surface to undergo elastic deformation,

whereby the elastic deformation of the attaching surface causes relative displacement between the slider and the moving body to absorb or moderate the structural error of the rail.

* * * * *

United States Patent [19]

Teramachi

[11] **Patent Number: 5,044,780**

[45] **Date of Patent: Sep. 3, 1991**

[54] **LINEAR SLIDING BEARING AND LINEAR SLIDING TABLE**

[75] Inventor: **Hiroshi Teramachi**, Tokyo, Japan

[73] Assignee: **THK Co, Ltd.**, Tokyo, Japan

[21] Appl. No.: **469,464**

[22] PCT Filed: **Aug. 15, 1989**

[86] PCT No.: **PCT/JP89/00828**

§ 371 Date: **Apr. 3, 1990**

§ 102(e) Date: **Apr. 3, 1990**

[87] PCT Pub. No.: **WO90/02270**

PCT Pub. Date: **Mar. 8, 1990**

[30] **Foreign Application Priority Data**

Aug. 16, 1988 [JP] Japan 63-202666

[51] **Int. Cl.**^{5} **F16C 29/06**

[52] **U.S. Cl.** **384/44**

[58] **Field of Search** 384/44, 45, 43; 464/168

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,505,525	3/1985	Wolzenburg	384/565
4,659,238	4/1987	Teramachi	384/44
4,715,729	12/1987	Tanaka .	
4,730,945	3/1988	Luther et al.	384/44
4,953,988	9/1990	Tsukada	384/45

FOREIGN PATENT DOCUMENTS

3742965	7/1988	Fed. Rep. of Germany .
2546587	11/1984	France .

Primary Examiner—Lenard A. Footland

Attorney, Agent, or Firm—Armstrong, Nikaido, Marmelstein, Kubovcik & Murray

[57] **ABSTRACT**

Herein disclosed are a linear sliding bearing and a linear sliding table, in which rollers have their sides pressed to suppress their rolling motions by the frictional force so that the sliding resistance of a sliding bed sliding on a track base may be increased. Since a predetermined rigidity can be attained even in the axial direction of the track base by increasing or decreasing the sliding resistance arbitrarily, a workpiece of high machining precision can be achieved when the bearing or table is used in a machine apparatus such as a machine tool.

6 Claims, 12 Drawing Sheets

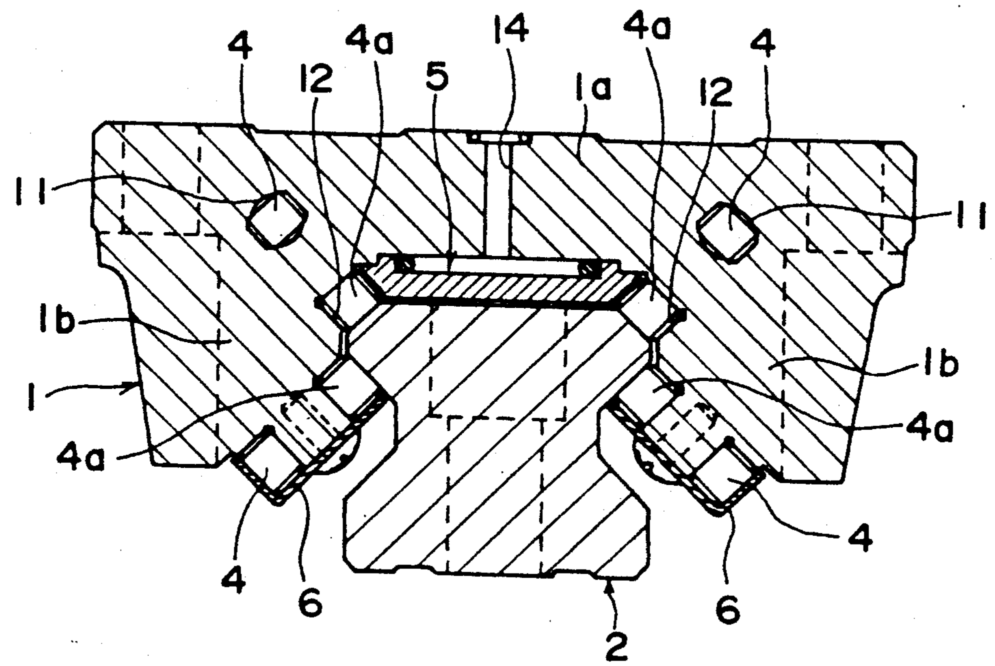


FIG. 1

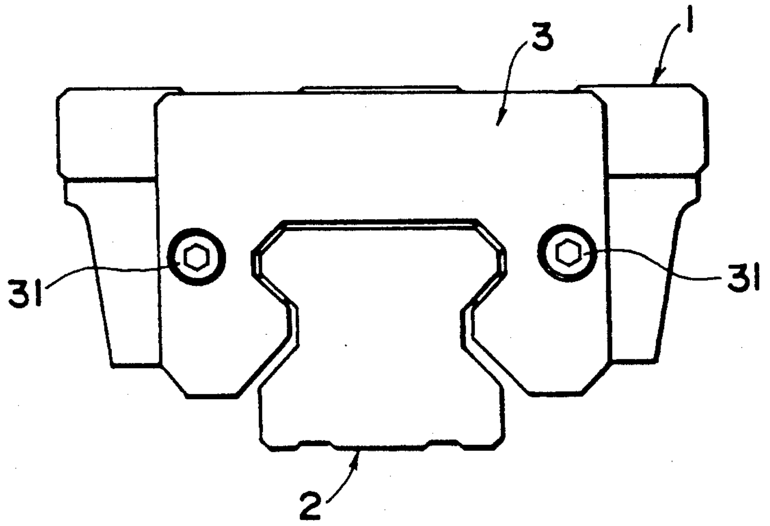


FIG. 2

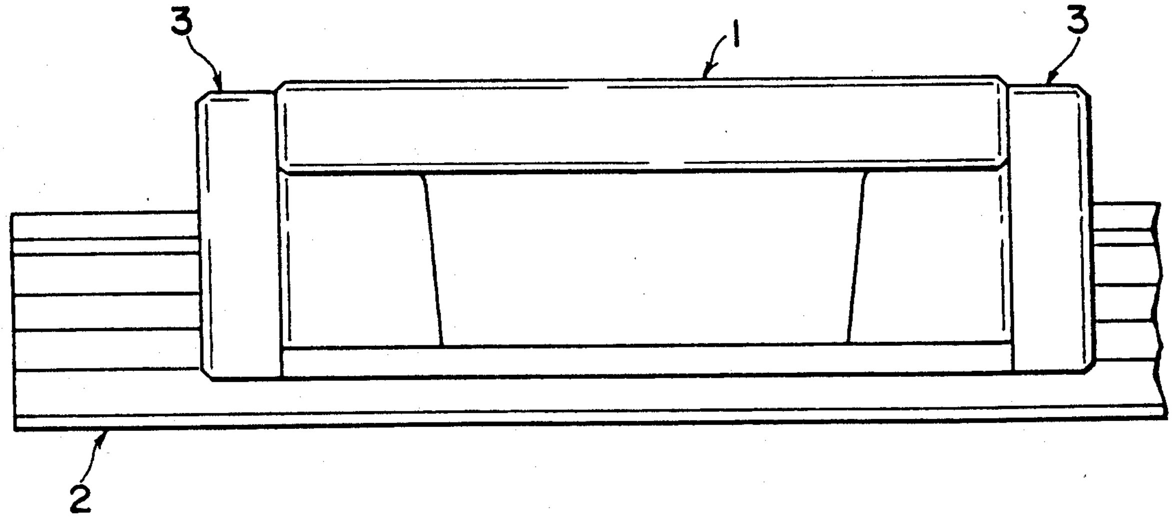


FIG.3

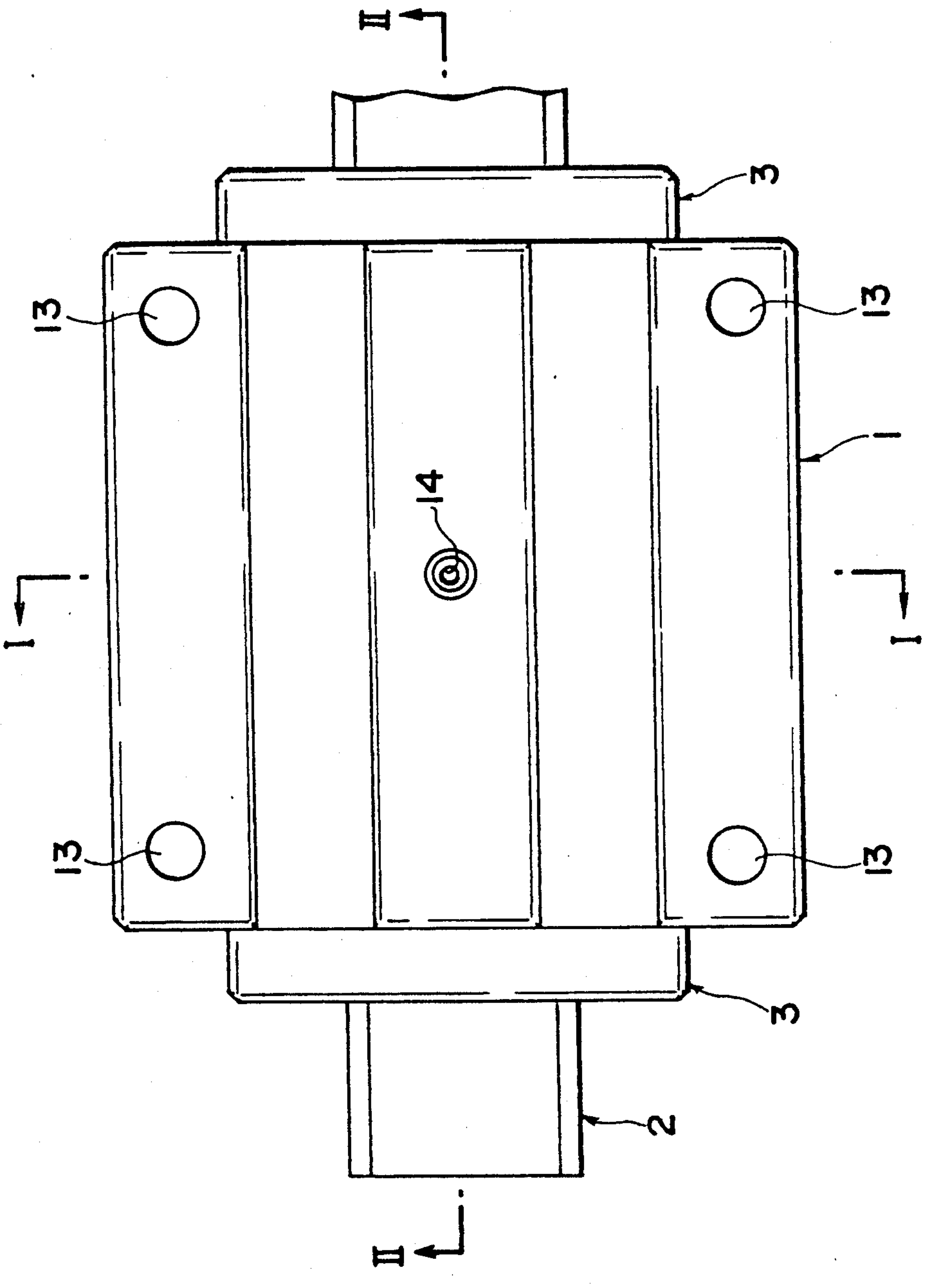


FIG.4

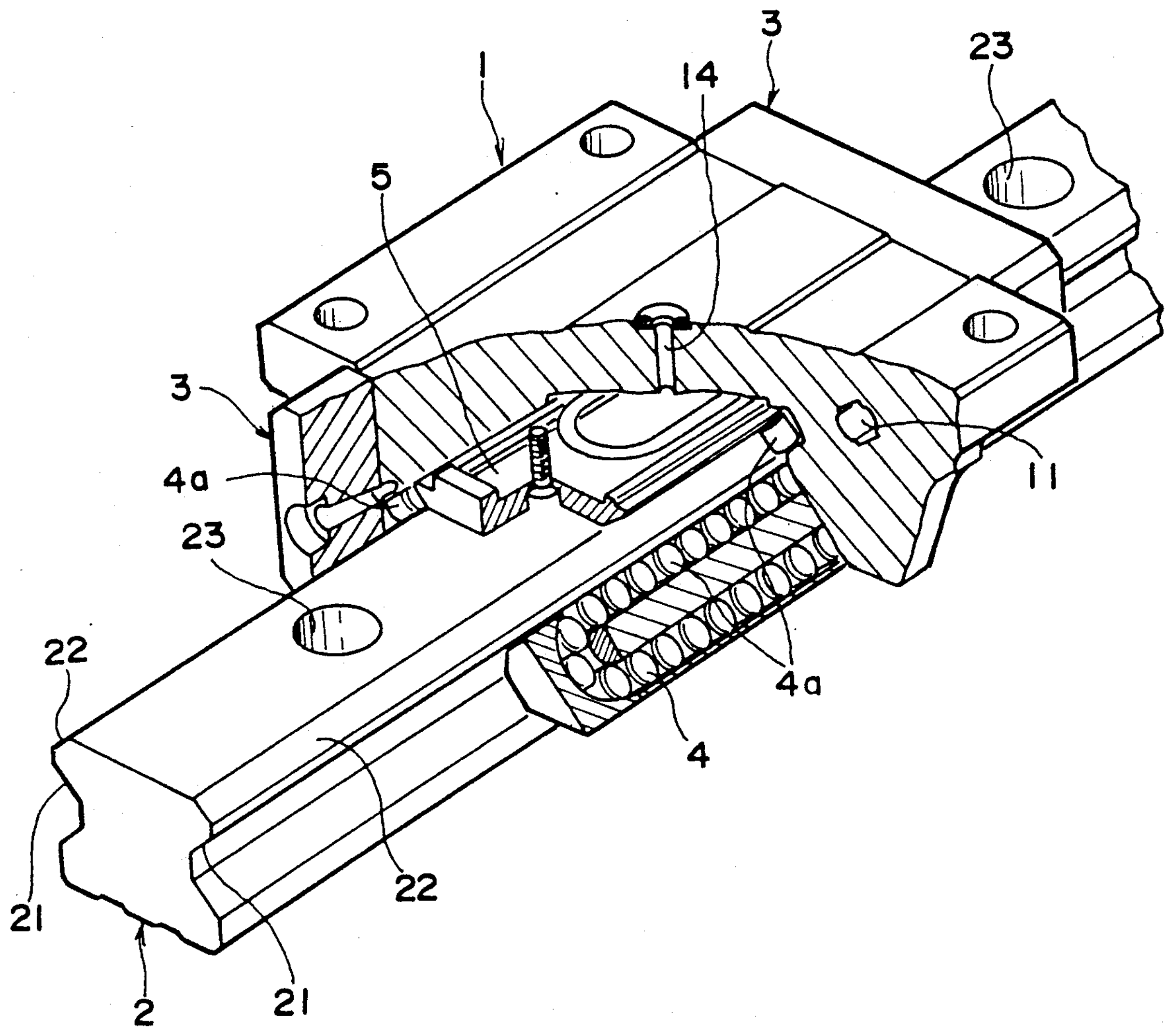


FIG. 5

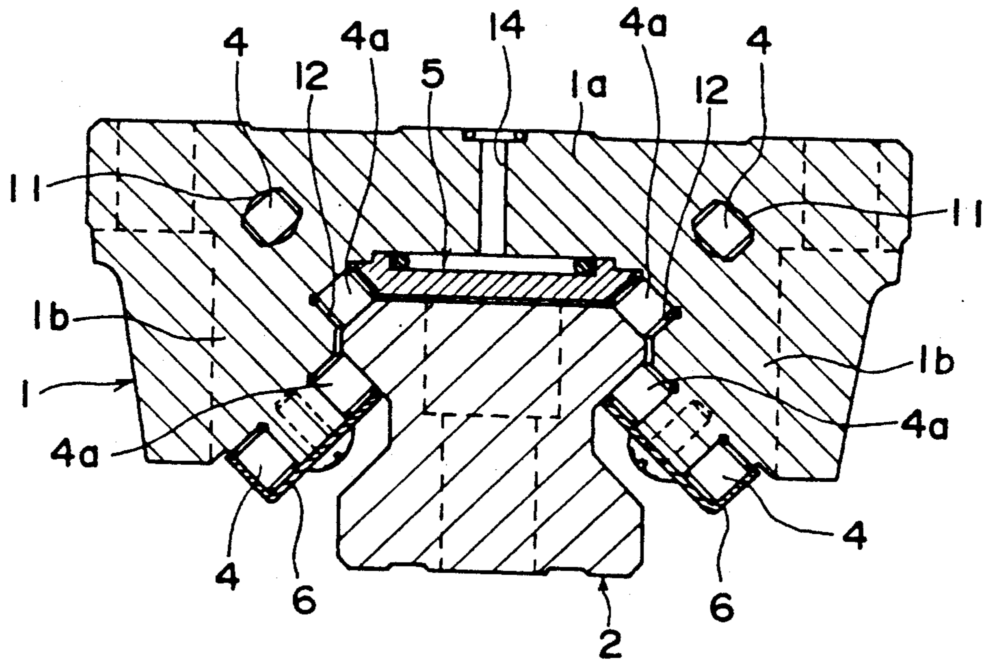


FIG. 6

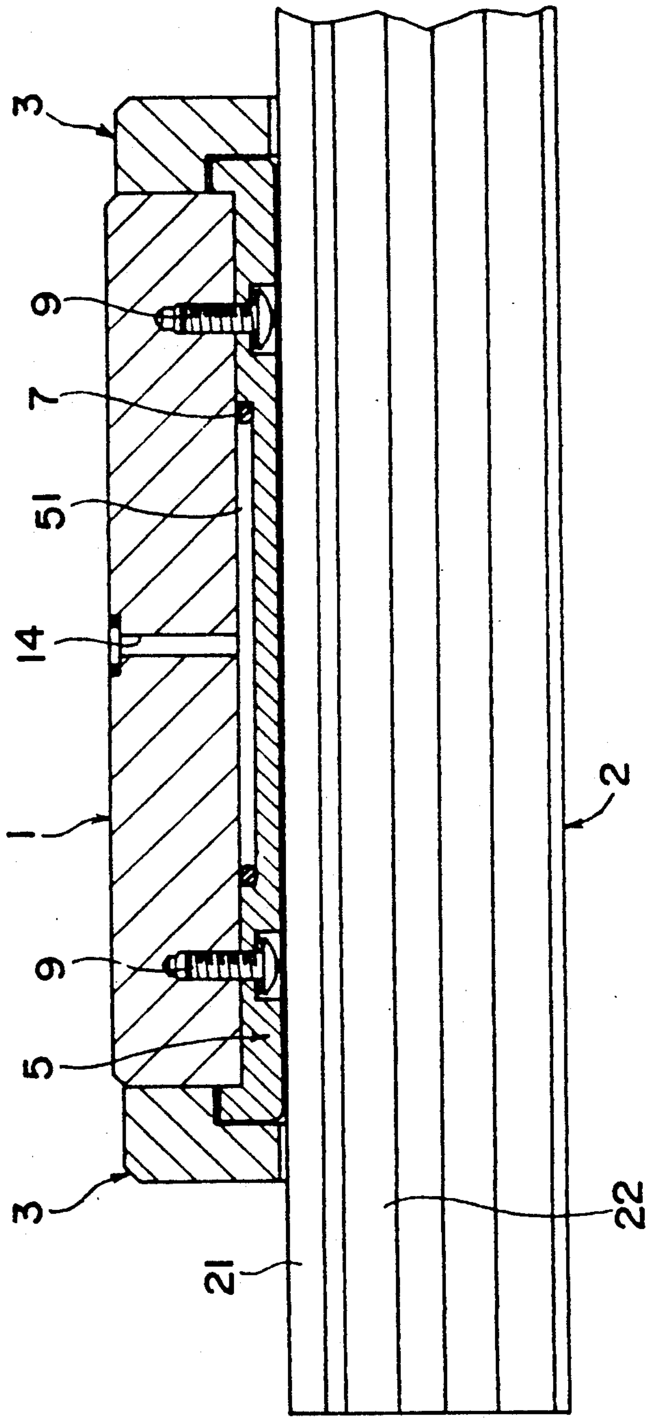


FIG. 7

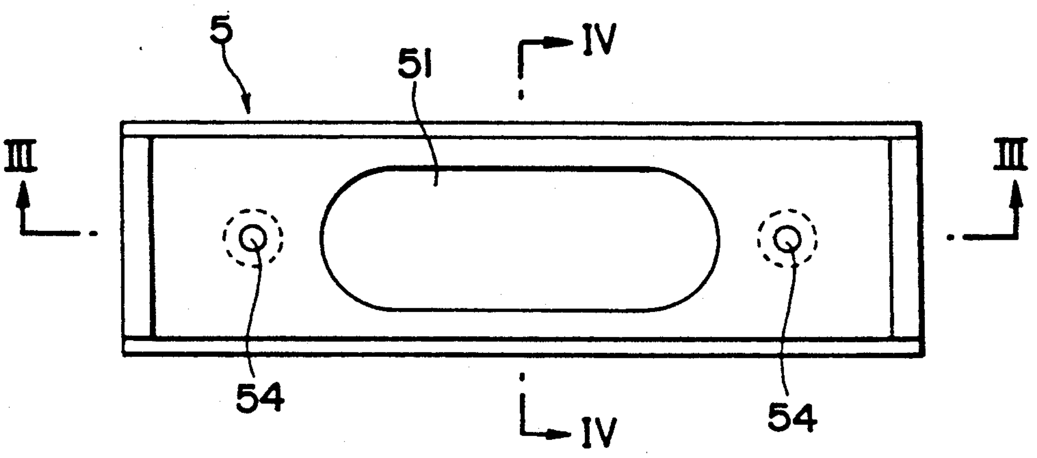


FIG. 8

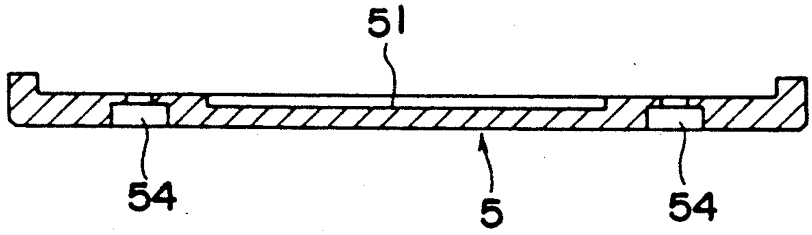


FIG. 9

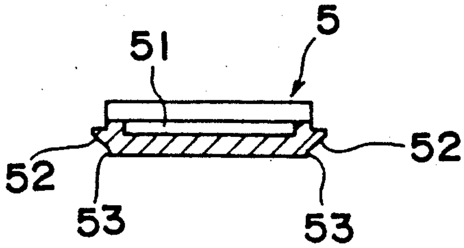


FIG. 10

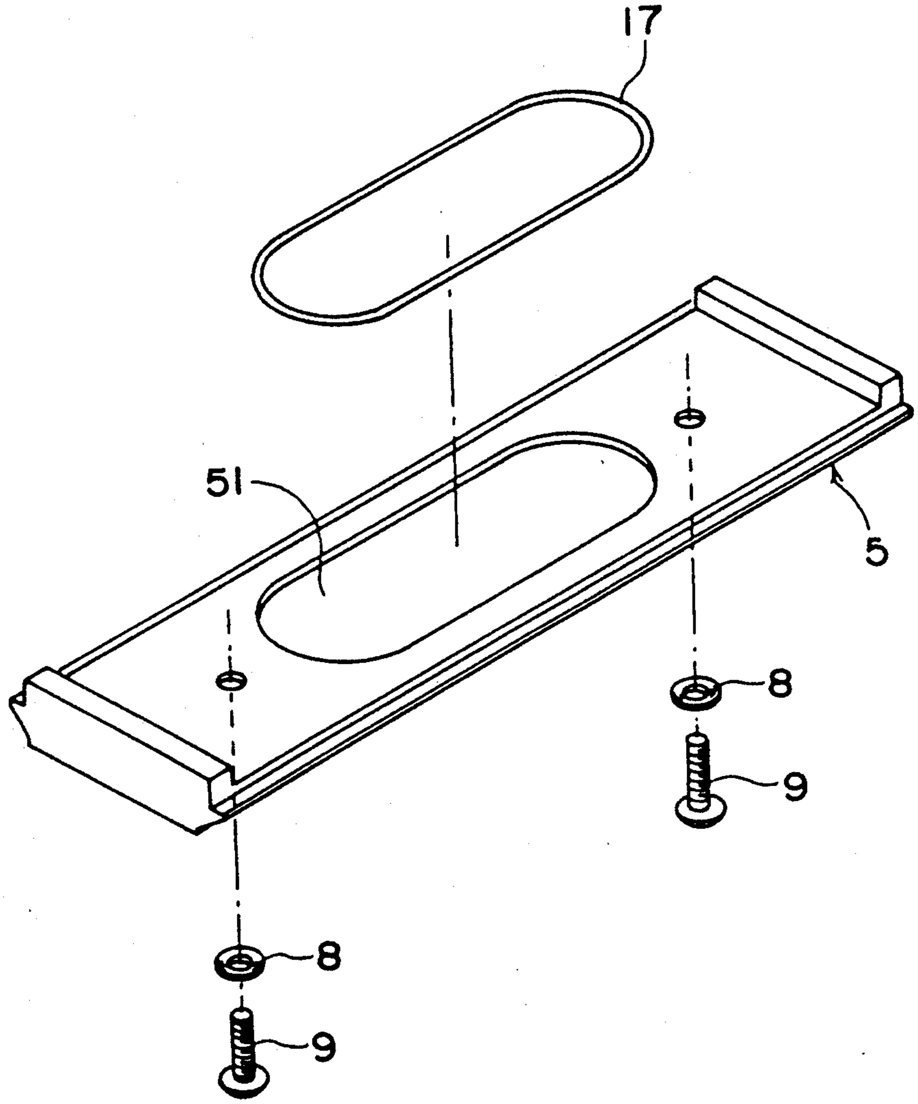


FIG. 11

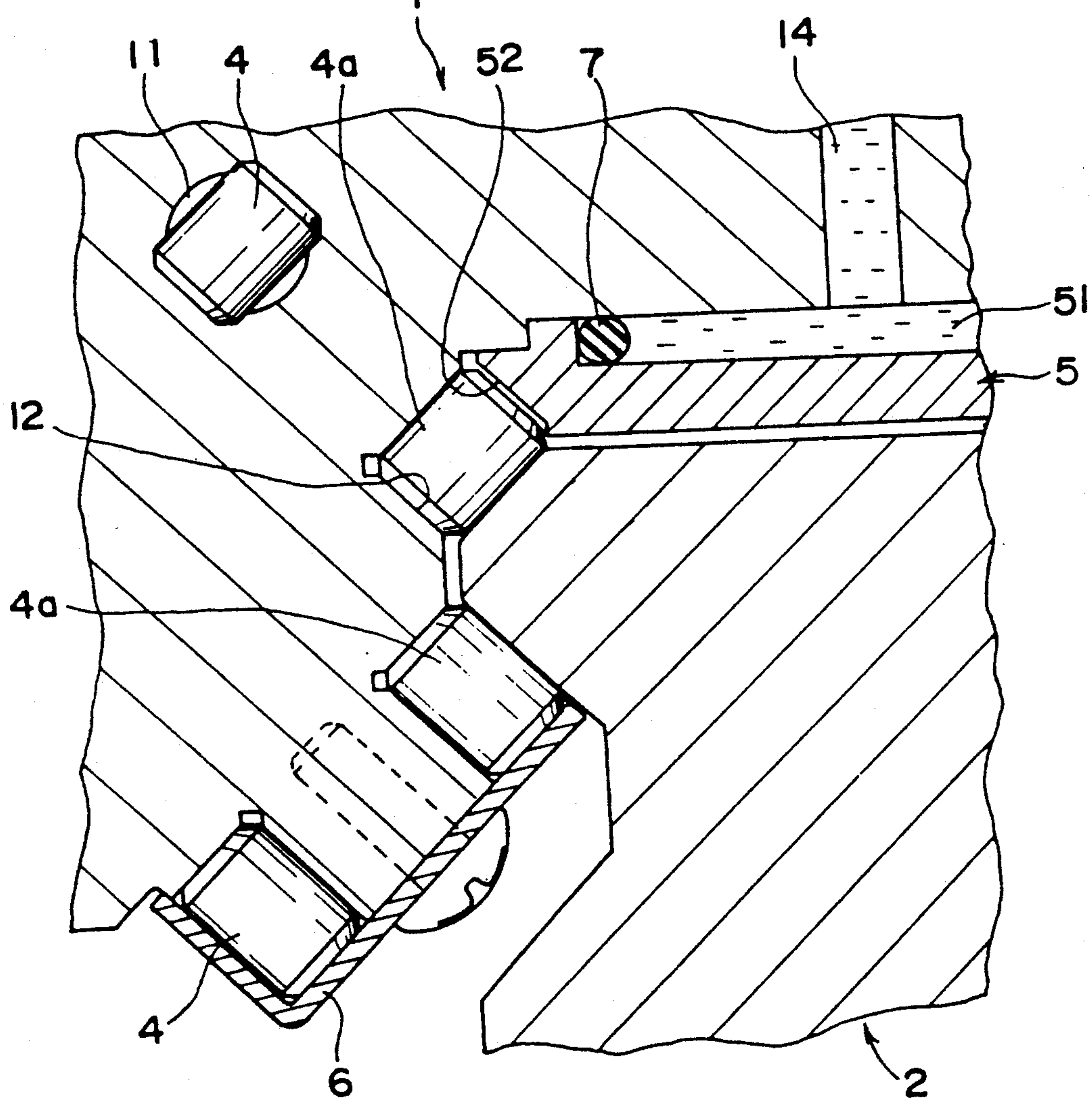


FIG. 12

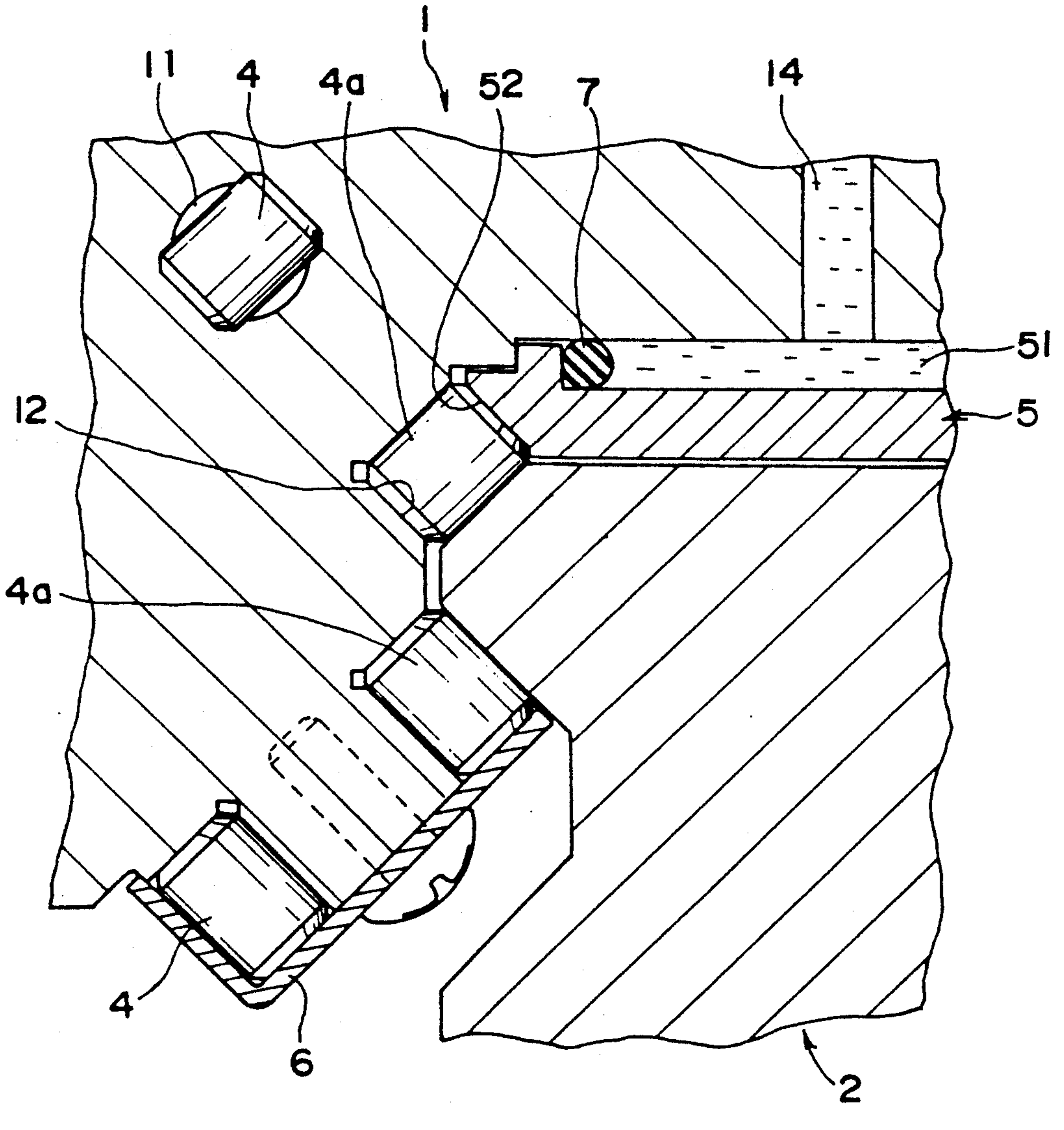


FIG. 13

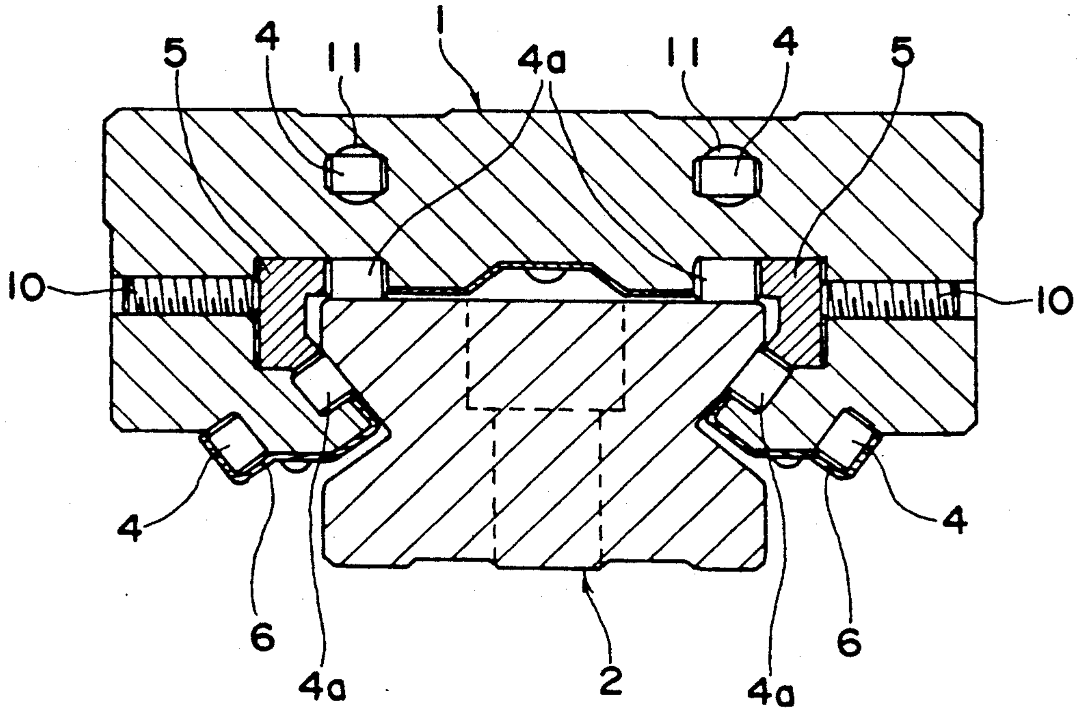


FIG. 14

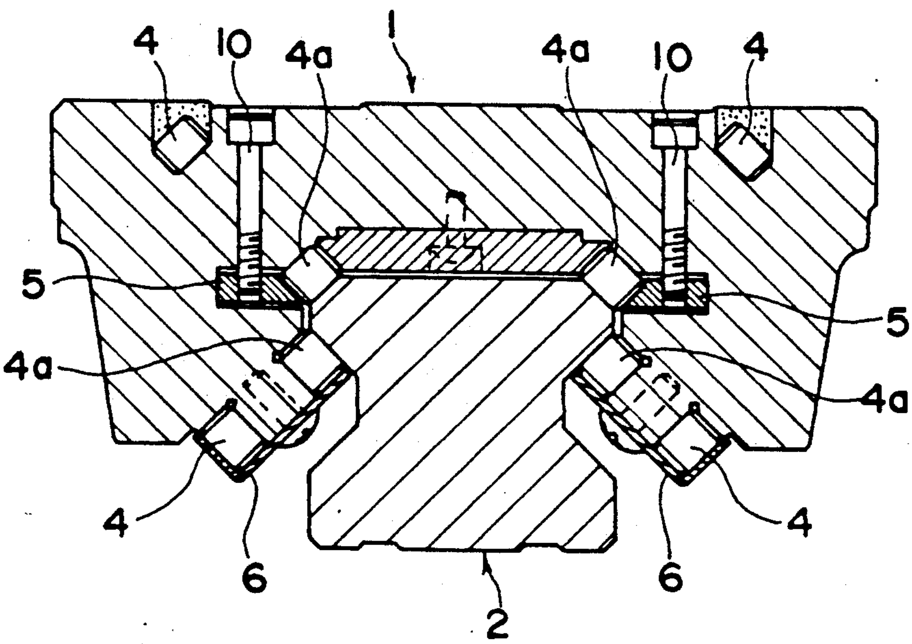


FIG. 15

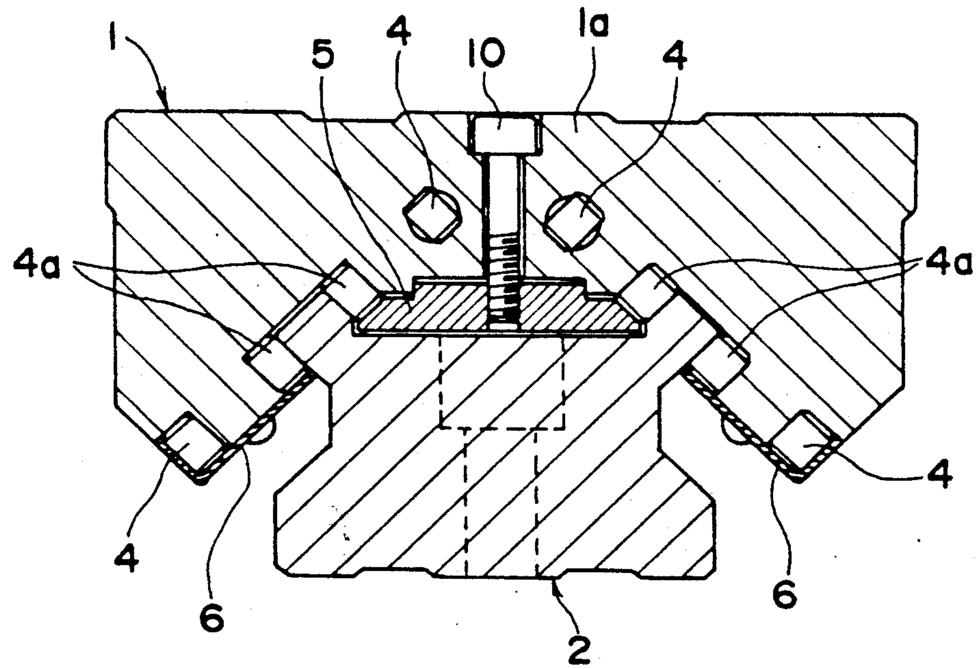
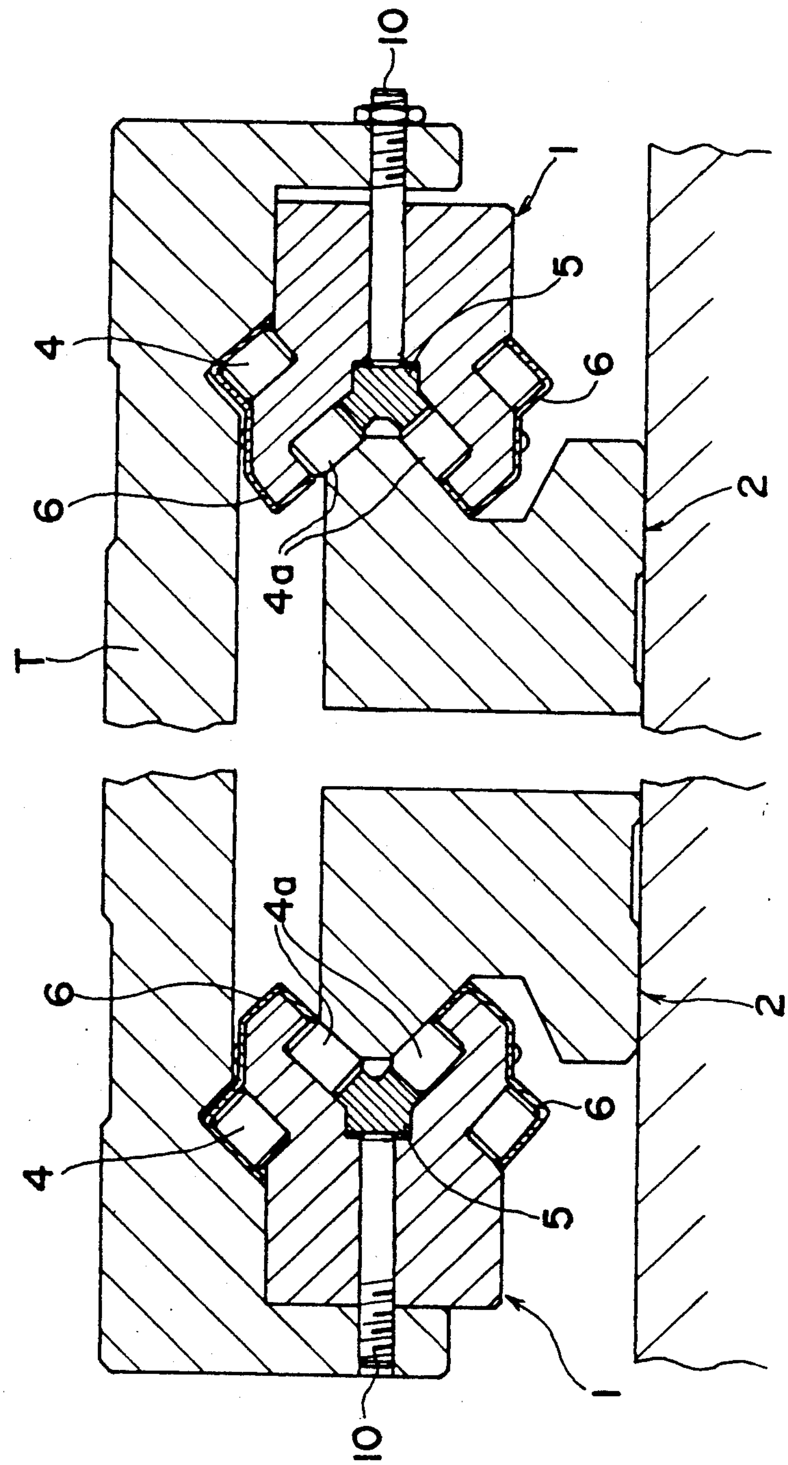


FIG.16



LINEAR SLIDING BEARING AND LINEAR SLIDING TABLE

TECHNICAL FIELD

The present invention relates to a linear sliding bearing for linearly guiding a moving member to be slid in a machine tool such as a NC machine or a slide of an industrial robot.

BACKGROUND ART

In case a workpiece is to be machined by a machine tool, for example, loads accompanying the machining in various directions are generally exerted between the machine tool and the workpiece, although depending upon the kinds of machining such as cutting or polishing, the material of the workpiece or the machining conditions. The loads act as reaction forces upon the machine tool and the workpiece. If the machine tool and the workpiece are completely fixed at the instant of machining against the loads, the machining can be ideally accomplished in a drastically improved precision.

In the case of machining of the workpiece using such machine tool, one of the machine tool or the workpiece is fixed whereas the other is moved by means of a mechanism such as a linear sliding bearing.

The linear sliding bearing known to used for this purpose is constructed to include: a track base having axial races; a sliding bed having endless tracks which are formed of load regions having load races facing the races of the track base and no-load regions providing the communicating connections between the two ends of the load regions; and rollers circulating in the endless tracks for bearing the loads between the races of the track base and the load races of the sliding bed. Thus, the linear sliding bearing can bear the loads in the four directions, i.e., radial, inversely radial and rightward and leftward directions. In the linear sliding bearing of this kind, moreover, the rigidities in the four directions are enhanced by applying a prepressure to the rollers to bear the four-directional loads to be generated between the machine tool and the workpiece during the machining, so that the accompanying chatter marks and vibrations may be suppressed as much as possible to improve the machining precision. In connection with the axial direction of the track base, on the other hand, frictions in the movements are suppressed with a view to lightening the loads upon the feeding drive system such as a feeder of screw and nut type or a motor mechanism. The rigidity necessary for the machining in the axial direction of the track base relies exclusively upon that of the feeding drive system.

Incidentally, the rigidity of the feeding drive system is determined, if the system is the feeder of screw and nut type, by the rigidity of the feed screw or nut itself, the rigidity of the support of the feed screw or nut, and the rigidity of the motor for applying a rotating force to the feed screw. In order to increase the rigidity of the feeding drive system, it is necessary to enlarge the size of the feed screw or nut or to raise the output of the motor. Thus, the increase in the rigidity of the feeding drive system is intrinsically limited by the problems which are caused by increasing the size of the apparatus or by raising the cost for the feeding drive system.

As various products are required to be the more precise in the industry of recent years, a machine apparatus such as the machine tool for machining the products is required to have its machining precision improved the better. Thus, the linear sliding bearing taking a leading role for the machining precision of the various machine apparatus is requested to improve the machining precision.

It is, therefore, an object of the present invention to provide a linear sliding bearing which can have not only the rigidities of four directions, i.e., the radial, inversely radial, rightward and leftward directions but also a predetermined rigidity in the axial direction of the track base.

Another object of the present invention is to provide a linear sliding bearing which can apply the rigidity in the axial direction of the track base, if necessary, and adjust the level of the rigidity.

Still another object of the present invention is to provide a linear sliding table which can mount a machine apparatus such as a machine tool for machining of high precision.

DISCLOSURE OF THE INVENTION

According to the present invention, there is provided a linear sliding bearing comprising: a track base having axial roller races and fixed to a machine apparatus or the like; a sliding bed formed with endless tracks, which have load regions having load races facing said roller races and no-load regions for effecting the communicating connections between the two ends of said load regions, and made movable along said track base; and a multiplicity of rollers circulating in said endless tracks for bearing the load between the load races of said sliding bed and the races of said track base, wherein the improvement resides in that said sliding bed includes: side walls extending along one-end sides of said load races for regulating the axial movements of load rollers rolling on said load races; and pressure means for pressing the one-end sides of said load rollers in the axial direction and the other sides onto said side walls.

According to the present invention, there is provided a linear sliding table placed on the upper surface of a sliding bed of a bearing which comprises: a track base having axial roller races and fixed to a machine apparatus or the like; a sliding bed formed with endless tracks, which have load regions having load races facing said roller races and no-load regions for effecting the communicating connections between the two ends of said load regions, and made movable along said track base; and a multiplicity of rollers circulating in said endless tracks for bearing the load between the load races of said sliding bed and the races of said track base, said sliding bed including: side walls extending along one-end sides of said load races for regulating the axial movements of load rollers rolling on said load races; and pressure means for pressing the one-end sides of said load rollers in the axial direction and the other sides onto said side walls.

In these linear sliding bearing and table, moreover, the pressure means presses the one-end sides of the load rollers in the axial direction and the other sides to the side walls formed on the sliding bed or beds. As a result, the rollers have their two-end sides pressed onto the pressure means and the sliding bed or beds so that their rolling motions are suppressed by the frictional forces to increase the sliding resistances of the sliding bed or beds rolling on the track base or bases.

In this technical means, the sliding bed can be selected from a suitable structure if it has the endless tracks for circulating the rollers and can slide freely on the track base and if it has the side walls for regulating the axial movements of the load rollers. The structure conceivable can be exemplified in various manners: by one including a horizontal portion and a pair of skirts depending from the two sides of the horizontal portion to form a recess in its lower side and formed with a pair of righthand and lefthand upper load races and lower load races extending axially on their inner sides; by a generally inverted L-shape which has a horizontal portion and skirts depending from one end of the horizontal portion and which has load regions extending along the lower side of the horizontal portion and the inner sides of the skirts and depends from the tack base; or by a generally rectangle having load regions extending axially along its sides and arranged along the sides of the track base. Incidentally, the aforementioned side walls to be given to the sliding bed may be formed directly on the sliding bed or indirectly on another member to be attached to the sliding bed.

On the other hand, the aforementioned endless tracks may be suitably exemplified by changing the designs of their numbers or the angle of inclination of the load races in accordance with the usage of the bearings or the structure of the sliding bed. Moreover, the no-load regions may be suitably exemplified by forming the no-load rolling holes in the sliding bed or the no-load rolling tracks by roller retainers to be attached from the outside to the sliding bed.

On the other hand, the rollers to be circulated in the aforementioned endless tracks may be suitably selected from cylindrical rollers or barrel-shaped rollers. In the former case using the cylindrical rollers, the load races of the sliding bed and the races of the track base are planar along the circumferences of the rollers. In the latter case using the barrel-shaped rollers, the load races and the races are curved.

On the other hand, the pressure means may be suitably exemplified by changing the designs of the structure or shape if it can press the one-end sides of the load rollers in their axial direction and the other sides to the aforementioned side walls. In order to simplify the apparatus structure, it is preferable to form the retaining surfaces for preventing the load rollers from coming out under non-pressure conditions, at the leading ends of the pressure surfaces for pressing the sides of the load rollers. In order to make the linear sliding bearing compact, moreover, the pressure means may preferably be so attached to the sliding bed as is positioned in the gap between the track base and the sliding bed and as will press the load rollers of two rows simultaneously. In order to prevent the pressed load rollers from being abruptly locked, still moreover, the pressure means may preferably press the load rollers of that of several rows, which must bear the highest load. Incidentally, the method for the pressure means to apply the pressure may be exemplified by changing the designs, e.g., by actuating the pressure means continuously by means of the fastening forces of bolts or the elastic forces of springs, or by actuating the pressure means instantly in the required place of the track base by means of a fluid such as oil.

Furthermore, the bearings of the aforementioned linear sliding table may be suitably exemplified by deciding the number of bearings to be disposed below the table in dependence upon the width of the table or the load to be exerted upon the table.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a front elevation showing a first embodiment of a linear sliding bearing according to the present invention; FIGS. **2** and **3** are a side elevation and a top plan view of the linear sliding bearing of the first embodiment; FIG. **4** is a cut-away perspective view showing the linear sliding bearing according to the first embodiment; FIG. **5** is a section taken along line I—I of FIG. **3**; FIG. **6** is a section taken along line II—II of FIG. **3**; FIG. **7** is a top plan view showing a braking plate exemplifying the pressure means of the linear sliding bearing according to the first embodiment; FIG. **8** is a section taken along line III—III of FIG. **7**; FIG. **9** is a section taken along line IV—IV of FIG. **7**; FIG. **10** is an exploded perspective view showing the assembly of the braking plate of the linear sliding bearing according to the first embodiment; FIG. **11** is a section showing an essential portion in the state, in which no oil pressure is applied to the braking plate while the linear sliding bearing according to the first embodiment is used; FIG. **12** is a section showing an essential portion in the state, in which an oil pressure is applied to the braking plate while the linear sliding bearing according to the first embodiment is used; FIG. **13** is a sectional front elevation showing a second embodiment of the linear sliding bearing of the present invention; FIG. **14** is a sectional front elevation showing a third embodiment of the linear sliding bearing of the present invention; FIG. **15** is a sectional front elevation showing a fourth embodiment of the linear sliding bearing of the present invention; and FIG. **16** is a sectional front elevation showing an embodiment of the linear sliding table according to the present invention.

DESIGNATIONS OF THE REFERENCE CHARACTERS

1—Sliding Bed; **1***a*—Horizontal Portion; **1***b*—Housing; **2**—Track Base; **3**—Cover; **4**—Rollers; **4***a*—Load Rollers; **5**—Braking Plate; **6**—Roller Guides; **7**—0-Ring; **8**— Dish-Spring Washers; **9**—Screws; **10**—Pressure Bolts; **11**—Relief Roller Track; **12**—Side Walls; **13**—Mounting Holes; **14**—Oil Hole; **21**—Lower Rolling Surfaces; **22**—Upper Rolling Surfaces; **51**—Oil Pocket; **52**—Pressure Surfaces; **53**—Retaining Surfaces; and T—Table.

BEST MODE FOR CARRYING OUT THE INVENTION

A linear sliding bearing and a linear sliding table will be described in detail in the following with reference to the accompanying drawings.

First Embodiment

The linear sliding bearing according to the present embodiment is constructed, as shown in FIGS. **4** and **5**, to include: a sliding bed **1** formed generally into a C-shaped section having a horizontal portion **1***a* and righthand and lefthand skirts **1***b* depending from the two ends of the horizontal portion **1***a* to leave a groove in its lower side; a pair of roller guides **6** mounted on the lower ends of the righthand and lefthand skirts **1***b* of the sliding bed **1**; a track base **2** fixed to a machine apparatus by fixing means such as fixing bolts; a number of rollers **4** circulating in an endless roller race formed in the sliding bed **1** for bearing a load between the sliding bed **1** and the track base **2**; and a braking plate **5** positioned between the lower side of the horizontal portion **1***a* and the upper surface of the track base **2** and made suitably movable up and down in accordance with the pressure of a fluid introduced from the sliding bed **1** for pushing the sides of load rollers **4***a* rolling on a load race formed on the sliding bed **1**.

The sliding bed **1** constitutes load regions of an upper endless roller track and a lower endless roller track in the axial direction, respectively, on the two ends of the lower side of the horizontal portion **1***a* and the lower ends of the inner surfaces of the righthand and lefthand skirts **1***b*. The load regions are formed with load races on which the rollers **4** are caused to roll. Above the righthand and lefthand skirts **1***b*, moreover, there are formed relief roller tracks **11** which correspond to the load regions of the upper endless roller tracks. On the other hand, the righthand and lefthand skirts **1***b* are formed at their lower ends with no-load regions which correspond to the load regions of the lower endless roller tracks. At the lower ends of the load races of the righthand and lefthand upper endless roller tracks, moreover, there are formed side walls **12** for regulating the axial movements of the load rollers **4***a* which are caused to roll on those load races. Incidentally, the aforementioned load regions are inclined at such predetermined angles that their four races are parallel with the upper races and the lower races of the track base **2** when the bearing of the present invention is assembled. The sliding bed **1** is formed at its two widthwise end portions with mounting holes **13** into which mounting bolts are inserted from the lower to upper surfaces. On the other hand, the lower side of the horizontal portion **1***a* of the sliding bed **1** provides a portion for mounting the braking plate **5** acting as pressure means for pushing the sides of the load rollers **4***a* and is formed at its center with an oil hole **14** which extends vertically therethrough to admit the oil for applying the pressure to the braking plate **5**. The lower side of the horizontal portion **1***a* is further formed with mounting holes **15** which are to be engaged with screws extending through the braking plate **5**.

To each of the longitudinal end portions of the sliding bed **1** described above, there is fixed by fixing bolts **31** a cover **3** which is made of a synthetic resin. These covers **3** are formed with grooves for establishing the communicating connections between the load regions formed in the sliding bed **1** and the corresponding relief roller tracks **11** or the no-load regions.

On the other hands, the aforementioned roller guides **6** are formed to have a generally L-shaped section by pressing a metallic plate or injection-molding a hard synthetic resin, as shown in FIG. **5**, and are secured to the lower ends of the righthand and lefthand skirts 1b of the sliding bed **1** by means of screws. Thus, the load and no-load regions formed at the lower ends of the righthand and lefthand skirts **1***b* form the endless roller tracks to guide the individual rollers, together with the roller turning portions which are formed in the covers **3**.

On the other hand, the aforementioned track base **2** is formed into such a section that a rectangle has its two sides notched to form a trapezoid whose two side shoulders further notched to form downward slopes and upward slopes. Of these slopes, the lower ones provide lower races **21** which correspond to the lower endless roller tracks formed a the lower ends of the skirts **1***b* of the sliding bed **1**, whereas the upper ones provide upper races **22** which correspond to the upper endless roller tracks formed at the two ends of the lower side of the horizontal portion **1***a* of the sliding bed **1**. Moreover, the track base **2** is formed at its central portion with fixing bolt mounting holes **23** for receiving fixing bolts which are fastened to a stationary portion. The bolt mounting holes **23** are vertically extended in the upper surface of the track base **2** and are bored at a suitable spacing in the longitudinal direction of the track base **2**.

As shown in FIG. **5** or **6**, the aforementioned braking plate **5** is a generally plane plate having a rectangular shape, which is positioned, when assembled, in the gap between the lower side of the horizontal portion **1***a* of the sliding bed **1** and the upper surface of the track base **2**. The braking plate **5** is made of a softer material such as brass than that of the rollers and is given functions to push, if necessary, the sides of the load rollers **4***a* rolling on the upper races of the track base **2** and to align and retain the load rollers **4***a*. As better seen from FIGS. **7**, **8** and **9**, the braking plate **5** its upper surface recessed to form an oil pocket **51** which is to be filled up with the oil flowing into and out of the oil hole **14** formed in the center of the horizontal portion **1***a* of the sliding bed **1**. The braking plate **5** is formed on its two widthwise end portions with pressure surfaces **52** which are sloped to face downward the sides of the load rollers **4***a*, when the bearing is assembled, thereby to suitably press the sides of the load rollers **4***a* rolling on the upper races of the track base **2**. Those pressure surfaces **52** are longitudinally formed at their lower ends with retaining surfaces **53** for preventing the load rollers **4***a* rolling on the upper roller tracks of the track base **2** from coming out so that they may be associated with the side walls **12** formed in the sliding bed **1**, to prevent the load rollers **4***a* from coming out. Moreover, the braking plate **5** is formed at its widthwise center with through holes **54** which are vertically extended from the bottom to the top for receiving screws to be fastened to the lower side of the horizontal portion **1***a* of the sliding bed **1**. Here, the lower side and pressure surfaces **52** of the braking plate **5** are so finished that the gap between the lower side of the braking plate **5** and the upper surface of the track base **2** may be larger, when the bearing is assembled, than that between the pressure surfaces **52** and the sides of the load rollers **4***a* belonging to the upper endless roller tracks.

The braking plate **5** thus constructed is mounted in the sliding bed **1**, as better seen from FIG. **10**, by fitting an 0-ring **7** in the inner periphery of the aforementioned oil pocket **51** for preventing the oil leakage, by inserting screws **9** together with dishspring washers **8** into the lower sides of the aforementioned through holes **54** and by fastening the screws **9** in the mounting holes formed in the lower side of the horizontal portion **1***a* of the sliding bed **1**. At this time, the fastening forces of the screws **9** are decided: such that the dish-spring washers **8** sandwiched between the heads of the screws **9** and the lower side of the braking plate **5** are freely subjected to elastic deformations by the pressures exerted upon the braking plate **5** whereas the aforementioned 0-ring **7** is always retained in close contact with the lower side of the horizontal portion **1***a;* and such that the braking plate **5** is pushed up to the lower side of the horizontal portion **1***a* of the sliding bed **1** by the elastic forces of the dish-spring washers **8** when no pressure is applied to the braking plate **5**.

The linear sliding bearing thus constructed according to the present embodiment is used by fixing the track base **2** to the machine apparatus by means of the fixing bolts, by mounting a table carrying a variety of machine tools on the sliding bed **1** sliding along the track base **2** by means of the mounting bolts, by connecting a hydraulic apparatus (although not shown) to be driven in response to an instruction signal outputted from a control unit (although not shown) to the oil hole **14** of the sliding bed **1**, and by applying an arbitrary pressure to the oil which fills up the oil pocket **51** of the braking plate **5** in a necessary place over the track base **2**.

In case, at this time, no oil pressure is applied to the oil pocket **51**, the braking plate **5** is raised to the lower side of the horizontal portion **1***a* of the sliding bed **1** by the elastic forces of the dish-spring washers **8** to keep its pressure surfaces **52** away from contact with the sides of the load rollers **4***a* rolling on the upper races of the track base **2**, so that the load rollers **4***a* can freely roll on the races of the track base **2** to slide the sliding bed **1** on the track base **2** with a slight sliding resistance (as seen from FIG. **11**). In case, on the contrary, the oil pressure P is applied to the oil pocket **51**, it pushes the braking plate **5** downward so that the pressure surfaces **52** of the braking plate **5** push the one-end sides of the load rollers **4***a* in the axial direction to bring the other sides of the load rollers **4***a* into contact with the side walls **12** formed on the sliding bed **1**. As a result, fricitonal forces are established between the sides of the load rollers **4***a* and the pressure surfaces **52** and the side walls **12** to increase the rolling resistances of the load rollers **4***a* so that high sliding resistances are exerted upon the sliding bed **1** sliding on the tack base **2** (as seen from FIG. **12**).

Thus, in the linear sliding bearing of the present embodiment, the sliding resistance of the sliding bed **1** can be increased by applying the pressure to the oil pocket **51** of the braking plate **5**, thereby to strengthen the axial rigidity of the track base **2** of the linear sliding bearing.

In the linear sliding bearing of the present embodiment, moreover, the oil pressure to be applied to the oil pocket **51** can be suitably adjusted to establish the axial rigidity of the track base **2**, if necessary, and to adjust it to an arbitrary level.

Second Embodiment

A linear sliding bearing according to the present embodiment is substantially identical to that of the first embodiment except in that two braking plate **5** are disposed at the inner sides of the righthand and lefthand skirts **1***b* of the sliding bed **1** to push the sides of two rows of load rollers **4***a* rolling on the upper and lower races of the track base **2**, as shown in FIG. **13**.

The sliding bed **1** is formed between the load regions of the upper endless roller track and the lower endless roller track with grooves for housing the braking plates **5** and at its righthand and lefthand skirts **1***b* with bolt mounting through holes in which are fastened pressure bolts **10** for pressing the braking plates **5**.

Thus, the braking plates are housed in the grooves, and the pressure bolts **10** fitted in their mounting holes are driven forward internally of the skirts. Then, the fastening forces of the pressure bolts **10** are exerted as the pressures upon the braking plates **5** so that the braking plates **5** push the sides of the load rollers **4***a* rolling in the load regions. As a result, the sliding resistance of the sliding bed **1** is increased as in the first embodiment.

Thus, in the linear sliding bearing of the present embodiment, the axial rigidity of the track base **2** can be strengthened by adjusting the turns of the pressure bolts **10**.

Third Embodiment

A linear sliding bearing according to the present embodiment is substantially identical to that of the first embodiment except in that adjust bolts **10** are extended through the sliding base **1** from the to horizontal surface to engage with the braking plates **5** positioned at the inner sides of the righthand and lefthand skirts of the sliding bed **1** so that they may be fastened to raise the braking plates **5** to push the sides of the load rollers **4***a* rolling on the upper races of the track base **2**, as shown in FIG. **14**. The axial rigidity of the track base **2** can also be strengthened according to the present embodiment.

Fourth Embodiment

A linear sliding bearing according to the present embodiment is a modification of the third embodiment and is substantially identical to that of the third embodiment except in that the angle of inclination of the load races of the upper endless roller tracks whereas the braking plate **5** is arranged at the lower side of the horizontal portion **1***a* of the sliding bed **1**, as shown in FIG. **15**, so that the sides of the righthand and lefthand upper load rollers **4***a* may be pushed by the single adjust bolt **10**.

Fifth Embodiment

FIG. **16** shows an embodiment of the linear sliding table according to the present invention. A pair of righthand and lefthand track bases **2** are arranged in parallel at a suitable spacing, and a pair of righthand and lefthand sliding beds **1** having braking plates **5** are slid along the external sides of the track bases **2**. A table T is mounted to ride over the paired sliding beds **1** so that it may linearly guide a machine apparatus carried thereon.

According to the linear sliding table of the present embodiment, like the linear sliding bearings of the foregoing embodiments, the sliding resistance can be increased, while the sliding beds **1** are sliding on the track bases **2**, to strengthen the rigidity of the linear sliding table in the axial direction of the track bases.

Industrial Applicability

As has been described hereinbefore, according to the linear sliding bearing of the present invention, the sliding resistance of the sliding bed siding on the track base can be adjusted to apply or adjust the rigidity in the axial direction of the track base, if necessary.

By applying a strong pressure to the load rollers by the pressure means to prevent the load rollers from rolling, moreover, the sliding bed can be continuously fixed in one portion on the tack base so that the pressure means can function as the locking mechanism of the linear sliding bearing.

According to the linear sliding table of the present invention, still moreover, like the aforementioned linear sliding bearing, the rigidity in the axial direction of the track bases can be applied to the table or adjusted so that a workpiece can be machined highly precisely in case the machine apparatus such as a machine tool is placed on the table.

I claim:

1. A linear sliding bearing comprising: a track base having axial roller races and fixed to a machine apparatus; a sliding bed formed with endless tracks, which have load regions having load races facing said roller races and no-load regions for effecting the communicating connections between the two ends of said load regions, and made movable along said track base; and a multiplicity of rollers circulating in said endless tracks for bearing the load between the load races of said sliding bed and the races of said track base, wherein the improvement resides in that said sliding bed includes: side walls extending along one-end sides of said load races for regulating the axial movements of load rollers rolling on said load races; and pressure means for pressing the one-end sides of said load rollers in the axial direction and the other sides onto said side walls.

2. A linear sliding bearing as set forth in claim **1**, wherein said sliding bed includes a horizontal portion and a pair of skirts depending from the two dies of said horizontal portion to form a recess in its lower side, said skirts being formed with a pair of righthand and lefthand upper load races and lower load races extending axially on their inner sides, and wherein said pressure means arranged at the lower side of said horizontal portion for pressing the load rollers rolling on said righthand and lefthand load races.

3. A linear sliding bearing as set forth in claim **1**, wherein said sliding bed includes a horizontal portion and a pair of skirts depending from the two dies of said horizontal portion to form a recess in its lower side, said skirts being formed with a pair of righthand and lefthand upper load races and lower load races extending axially on their inner sides, and wherein said pressure means arranged at the inner side of said skirt portion for pressing at least either those of the load rollers, which roll on said upper load races and said lower load races.

4. A linear sliding bearing as set forth in claim **1**, wherein said sliding bed is formed into a generally rectangular shape and longitudinally along its one side with a pair of upper and lower load races, and wherein said pressure means arranged between said upper load races and said lower load races for pressing at least either those of the load rollers, which roll on said upper load races and said lower load races.

5. A linear sliding bearing as set forth in any one of claims **1** to **4**, wherein said pressure means is formed, at the leading end of a pressure surface for pressing the sides of said load rollers, with a retaining surface for preventing said load rollers under a non-pressure condition from coming out.

6. A linear sliding table placed on the upper surface of a sliding bed of a bearing which comprises: a track base having axial roller races and fixed to a machine apparatus or the like; a sliding bed formed with endless tracks, which have load regions having load races facing said roller races and no-load regions for effecting the communicating connections between the two ends of said load regions, and made movable along said track base; and a multiplicity of rollers circulating in said endless tracks for bearing the load between the load races of said sliding bed and the races of said track base, said sliding bed including: side walls extending along one-end sides of said load races for regulating the axial movements of load rollers rolling on said load races; and pressure means for pressing the one-end sides of said load rollers in the axial direction and the other sides onto said side walls.

* * * * *

United States Patent [19]

Teramachi

[11] **Patent Number: 5,011,300**

[45] **Date of Patent: Apr. 30, 1991**

[54] **LINEAR SLIDING BEARING**

[75] Inventor: **Hiroshi Teramachi,** Tokyo, Japan

[73] Assignee: **THK Co., Ltd.,** Tokyo, Japan

[21] Appl. No.: **469,465**

[22] PCT Filed: **Aug. 15, 1989**

[86] PCT No.: **PCT/JP89/00829**

§ 371 Date: **Apr. 3, 1990**

§ 102(e) Date: **Apr. 3, 1990**

[87] PCT Pub. No.: **WO90/02271**

PCT Pub. Date: **Mar. 8, 1990**

[30] **Foreign Application Priority Data**

Aug. 16, 1988 [JP] Japan 63-202668

[51] **Int. Cl.**[5] **F16C 21/00;** F16C 29/06

[52] **U.S. Cl.** **384/25;** 384/45

[58] **Field of Search** 384/25, 43–45, 384/49, 50

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,417,771	11/1983	Teramachi	384/45
4,527,842	7/1985	Teramachi	384/45
4,773,770	9/1988	Osawa et al.	384/45
4,940,339	7/1990	Amano	384/25
4,953,988	9/1990	Tsukada	384/45

FOREIGN PATENT DOCUMENTS

2546995	12/1984	France .
60-185273	12/1985	Japan .
61-34934	8/1986	Japan .
61-223325	10/1986	Japan .
61-48009	10/1986	Japan .

Primary Examiner—Thomas R. Hannon
Attorney, Agent, or Firm—Armstrong, Nikaido, Marmelstein, Kubovcik, & Murray

[57] **ABSTRACT**

A linear sliding bearing which is composed of a ball-and-roller bearing mechanism and a sliding bearing mechanism. The gap between a track base and a sliding bed is adjusted by gap adjusting bolt, to adjust the pressure of contact between the two faces constituting the sliding bearing mechanism thereby to adjust the sliding resistance of the sliding bed to the track base at will. As a result, a rigidity can be given even in the axial direction of the track base so that the machining precision of a workpiece can be improved when a machine apparatus such as a machine tool is to be used.

2 Claims, 6 Drawing Sheets

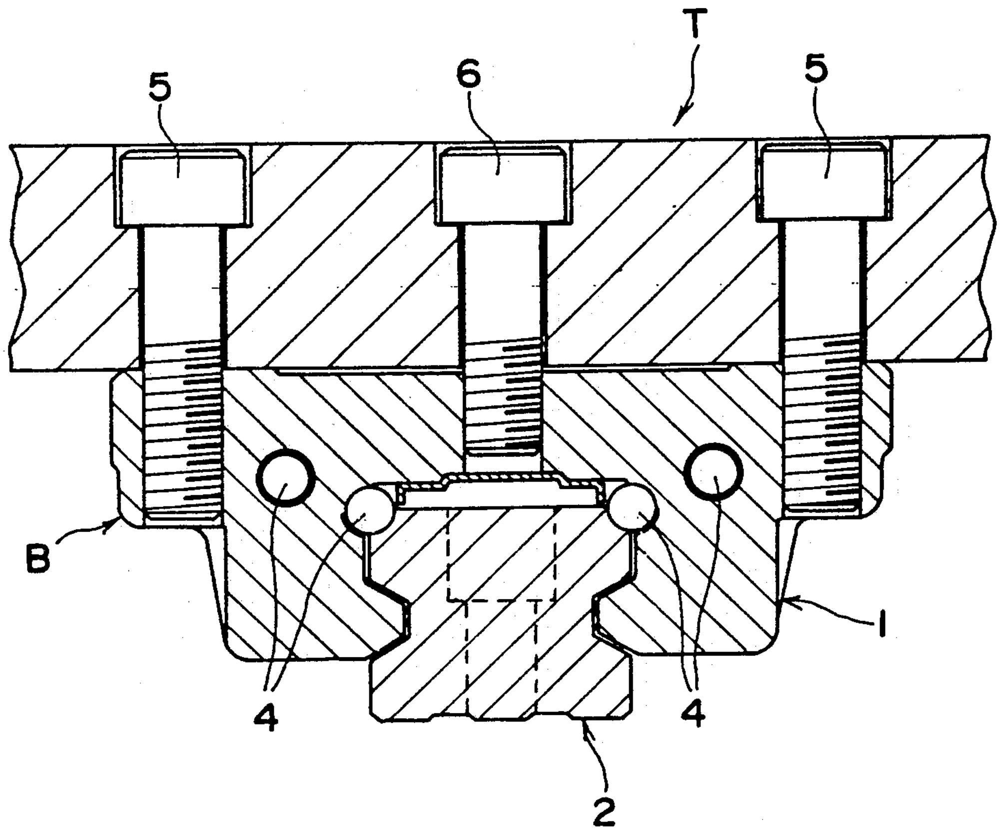


FIG. 1

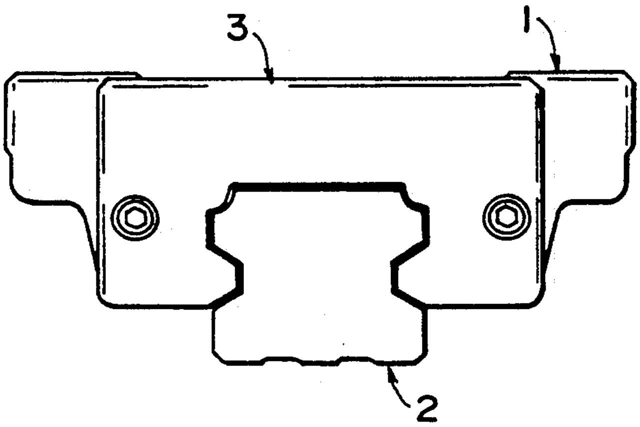


FIG. 2

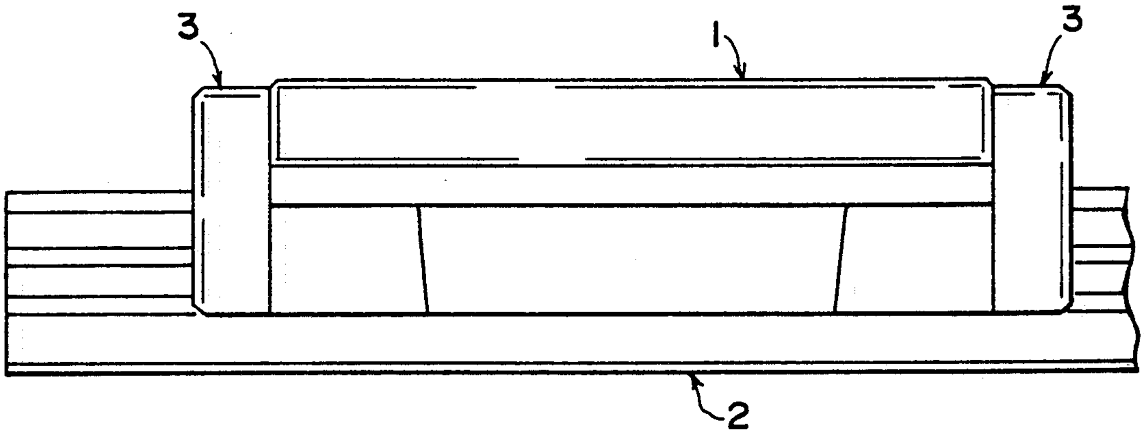


FIG.3

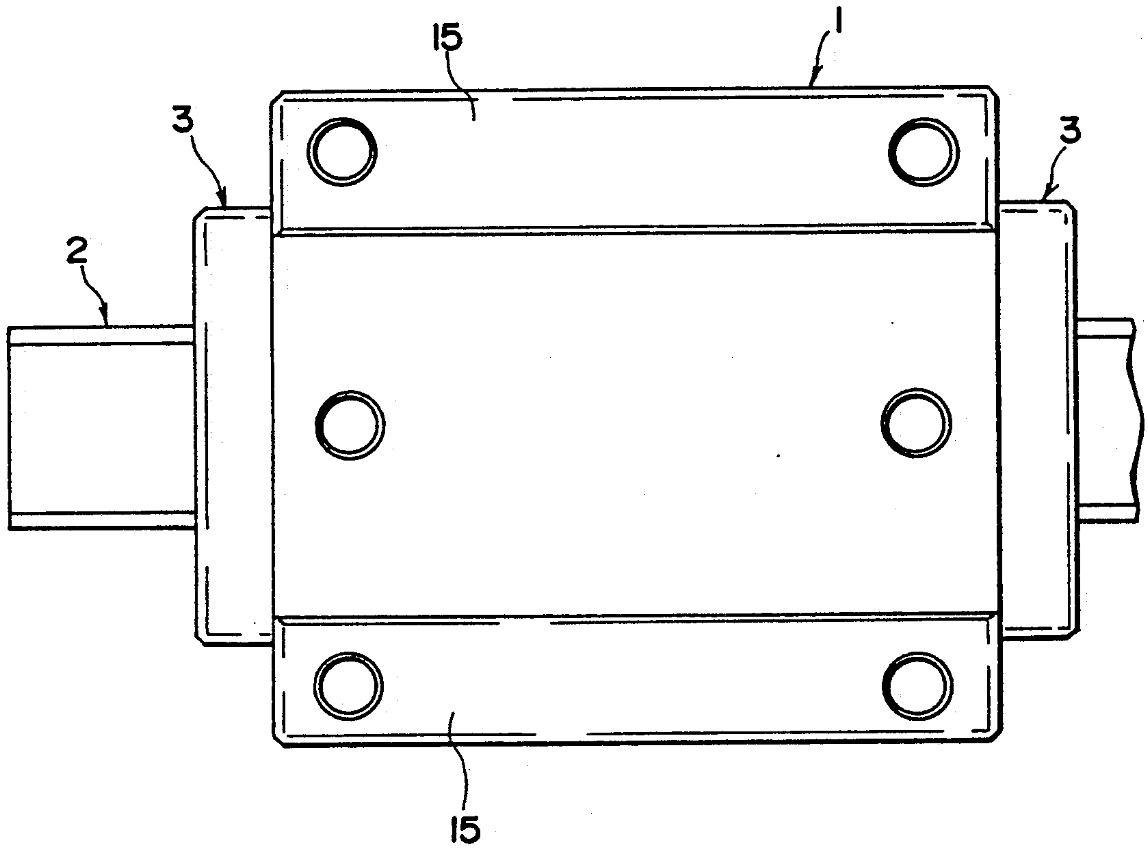


FIG. 4

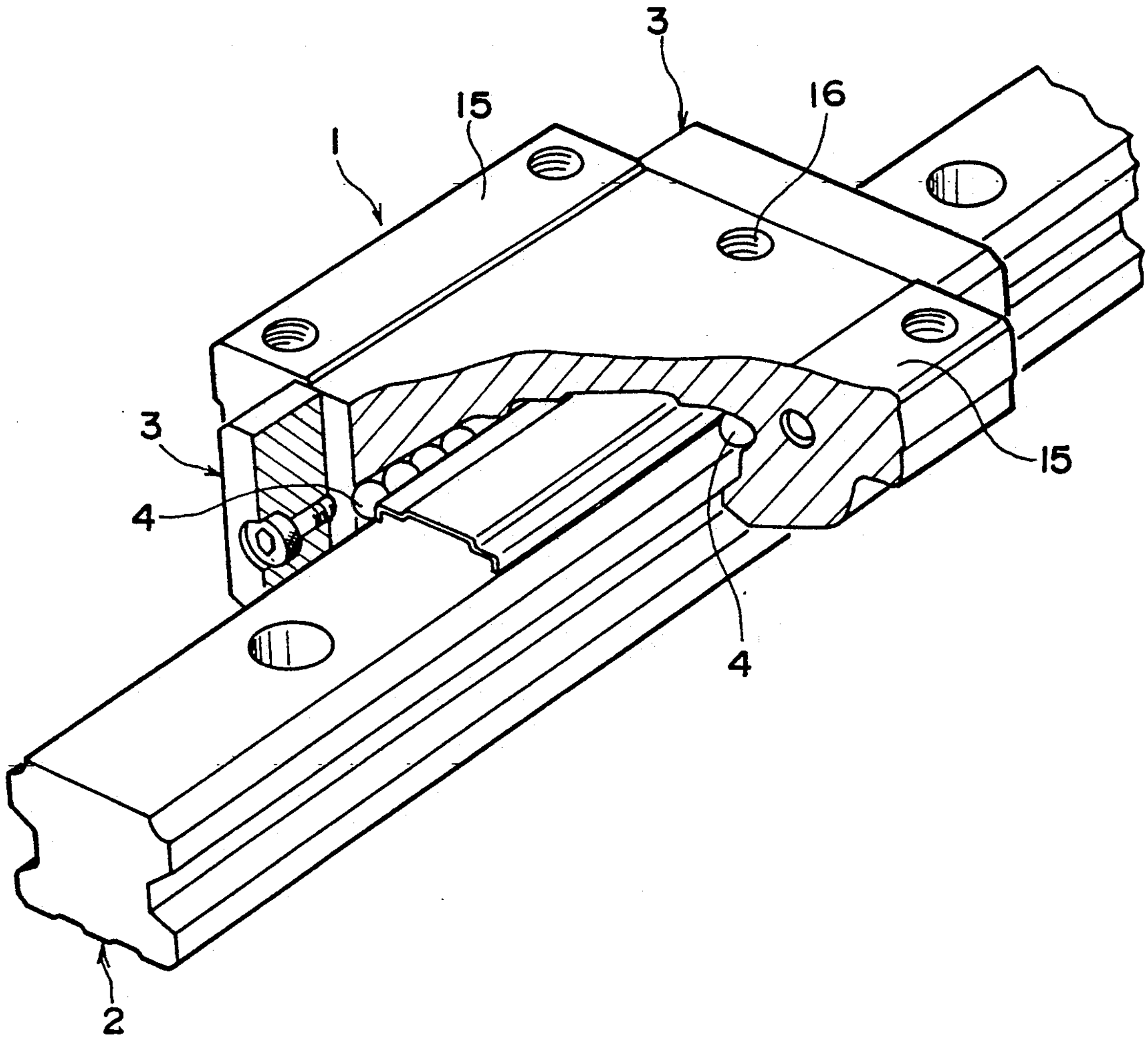


FIG. 5

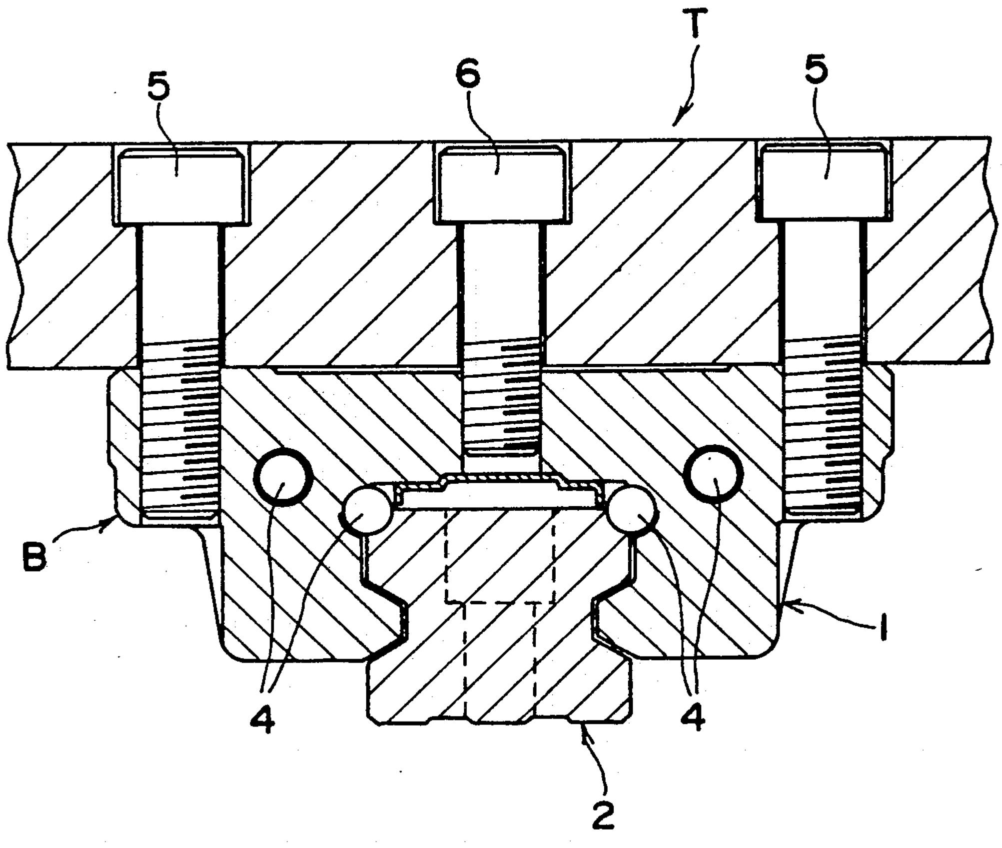


FIG. 6

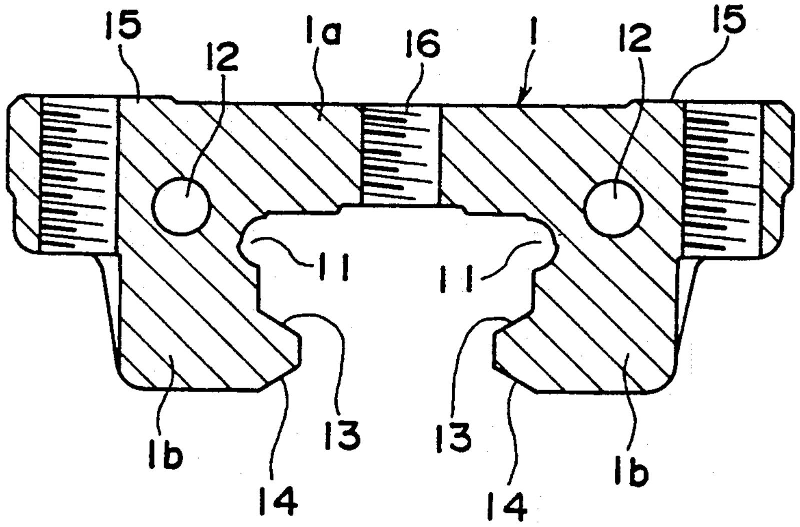


FIG. 7

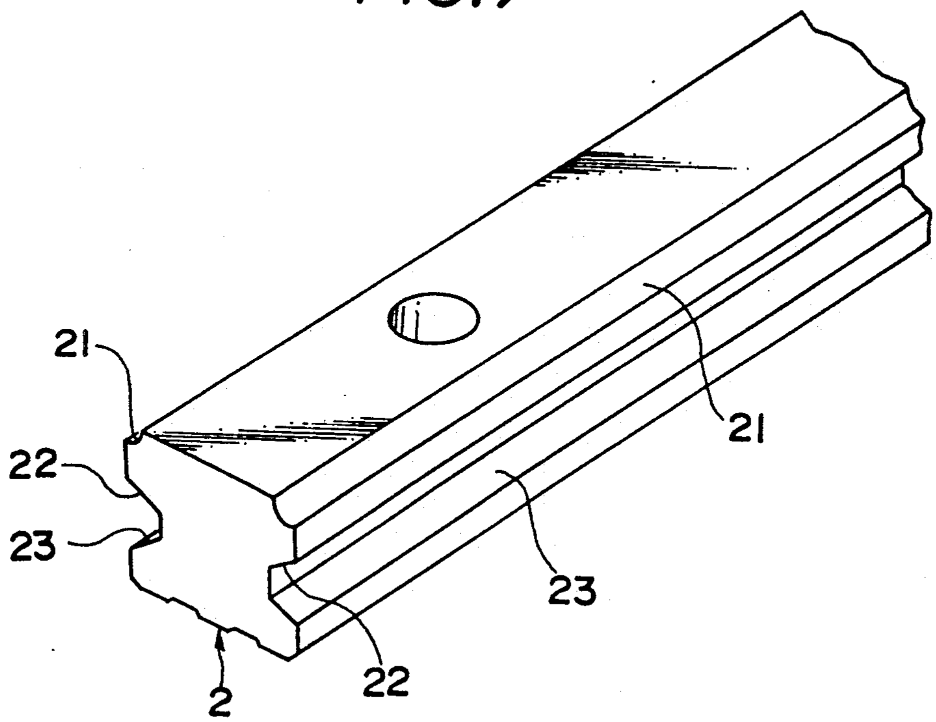


FIG. 8

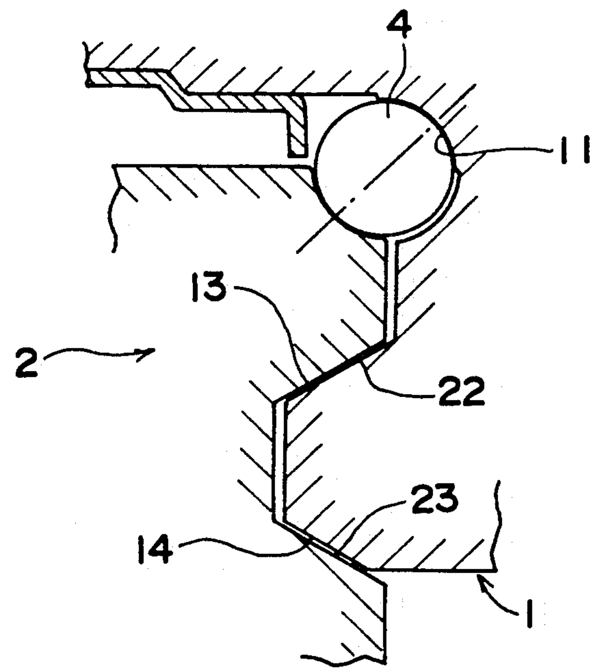
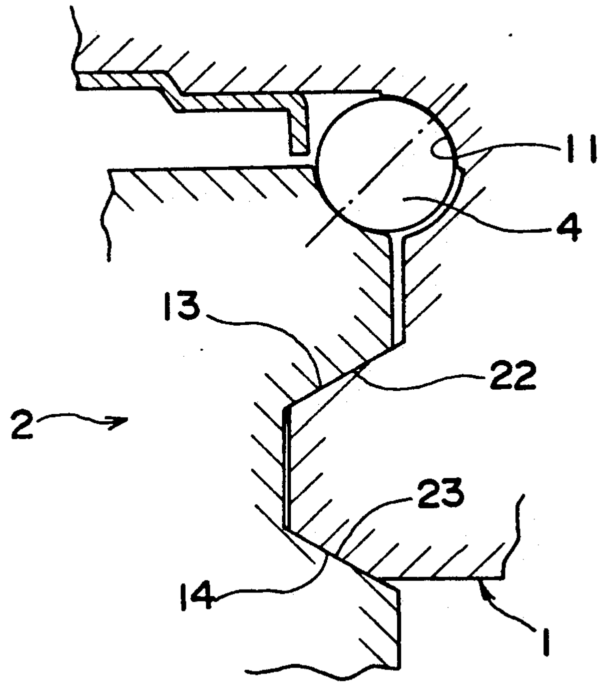


FIG. 9



LINEAR SLIDING BEARING

TECHNICAL FIELD

The present invention relates to a linear sliding bearing for linearly guiding a moving member to be slid in a machine tool such as a NC machine or a slide of an industrial robot.

BACKGROUND ART

In case a workpiece is to be machined by a machine tool, for example, loads accompanying the machining in various directions are generally exerted between the machine tool and the workpiece, although depending upon the kinds of machining such as cutting or polishing, the material of the workpiece o the machining conditions. The loads act as reaction forces upon the machine tool and the workpiece. If the machine tool and the workpiece are completely fixed at the instant of machining, the machining can be ideally accomplished in a drastically improved precision.

In the case of machining of the workpiece using such machine tool, one of the machine tool or the workpiece is fixed whereas the other is moved by means of a mechanism such as a linear sliding bearing.

The linear sliding bearing to be used for this purpose is exemplified by one which comprises: a sliding bed having a section of generally inverted C-shape and including a horizontal portion and a pair of skirts depending downward from the two ends of the horizontal portion to form a recess at its lower side and formed in its inner sides with a pair of upper and lower load races extending longitudinally thereof and with relief ball tracks corresponding to the load races; a track base having its upper portion fitted in the recess of said sliding bed, while maintaining a predetermined spacing inbetween, and formed with rolling races corresponding to said load races; a pair of covers attached to the front and rear end faces of said sliding bed and formed in their inner sides with guide grooves for providing the communicating connections between the end portions of the load races and the relief ball tracks of said sliding bed to form endless ball tracks; a multiplicity of balls circulating in said endless ball tracks to bear the loads between the load races of said sliding bed and the rolling grooves of said track base; and gap adjusting means for adjusting the gap between said sliding bed and said track base to apply and adjust a pilot pressure (as disclosed in Japanese Patent Publications Nos. 61-34,934 and 61-48,009). Thus, the linear sliding bearing can bear the loads in the four directions, i.e., radial, inversely radial and rightward and leftward directions. In the linear sliding bearing of this kind, moreover, the rigidities in the four directions are enhanced by applying or adjusting the pilot pressure to the rollers to bear the four-directional loads to be generated between the machine tool and the workpiece during the machining, so that the accompanying chatter marks and vibrations may be suppressed as much as possible to improve the machining precision. In connection with the axial direction of the track base, on the other hand, what is principally aimed at is to lighten the loads upon the feeding drive system such as a feeder of screw and nut type or a linear motor mechanism. The rigidity necessary for the machining in the axial direction of the track base relies exclusively upon that of the feeding drive system.

Incidentally, the rigidity of the feeding drive system is determined, if the system is the feeder of screw and nut type, by the rigidity of the feed screw or nut itself, the rigidity of the support of the feed screw or nut, and the rigidity of the servo-motor for applying a rotating force to the feed screw. In order to increase the rigidity of the feeding drive system, it is necessary to enlarge the size of the feed screw or nut or to raise the driving force of the servo-motor. Thus, the increase in the rigidity of the feeding drive system is intrinsically limited by the problems which are caused by increasing the size of the apparatus or by raising the cost for the feeding drive system.

As various products are required to be the more precise accurate in the industry of recent years, a machine apparatus such as the machine tool for machining the products is required to have its machining precision improved the better. Thus, the linear sliding bearing taking a leading role for the machining precision of the various machine apparatus is requested to improve the machining precision.

It is, therefore, an object of the present invention to provide a linear sliding bearing which can have not only the rigidities of four directions, i.e., the radial, inversely radial, rightward and leftward directions but also a predetermined rigidity in the axial direction of the track base.

Another object of the present invention is to provide a linear sliding bearing which can apply the rigidity in the axial direction of the track base, if necessary, and adjust the level of the rigidity.

Still another object of the present invention is to provide a linear sliding bearing which is equipped with a lock mechanism capable of fixing the sliding bed in a target position when the sliding bed is moved along the track base to that position.

A further object of the present invention is to provide a linear sliding bearing which is enabled to accomplish the machining of high precision by adopting a machine apparatus such as a machine tool.

DISCLOSURE OF THE INVENTION

According to the present invention, there is provided a linear sliding bearing comprising: a sliding bed having a section of generally inverted C-shape and including a horizontal portion and a pair of skirts depending downward from the two ends of the horizontal portion to form a recess at its lower side and formed in its inner sides with a pair of load races extending longitudinally thereof and with relief ball tracks corresponding to the load races; a track base having its upper portion fitted in the recess of said sliding bed, while maintaining a predetermined spacing inbetween, and formed with rolling races corresponding to said load races; a pair of covers attached to the front and rear end faces of said sliding bed and formed in their inner sides with guide grooves for providing the communicating connections between the end portions of the load races and the relief ball tracks of said sliding bed to form endless ball tracks; and a multiplicity of rolling members circulating in said endless ball tracks to bear the loads between the load races of said sliding bed and the rolling grooves of said track base, wherein the improvement resides: in that the load races of said sliding bed are formed in the inner sides and at the roots of said skirts; in that the races of said track base corresponding to the load races of said sliding bed are formed at the shoulders of said track base; in that there is formed, between each of the leading ends of the inner sides of the skirts of said sliding bed and each of the two sides of the track base facing the former, a sliding bearing mechanism which include convex and concave portions having upward taper surfaces and downward taper surfaces shaped to be fitted in a wedged manner; and in that there is interposed, between said sliding bed and a table to be mounted on the upper surface of said sliding bed, gap adjusting means which includes a suspension or pressure mechanism for elastically deforming the horizontal portion of said sliding bed, whereby the pressure of contact between the upward and downward taper surfaces of said sliding bed and the downward and upward taper surfaces of said track base is adjusted by adjusting the gap between said sliding bed and said track base by said gap adjusting means.

Thus, in the linear sliding bearing according to the present invention, a ball-and-roller bearing mechanism having a low sliding resistance is constituted by the load races of the sliding bed, the races of the track base, and the rolling members rolling between these races, and a sliding bearing mechanism is constituted by the convex and concave portions having upward and downward taper surfaces positioned in the lower portions of the sliding bed and the track base and facing each other. By adjusting the gap between the sliding bed and the track base by the gap adjusting means, the pressure of contact between the upward and downward taper surfaces of the sliding bed and the downward and upward taper surfaces of the track base can be adjusted to give and adjust a rigidity to the ball-and-roller bearing mechanism and to adjust the sliding resistance of the sliding bearing mechanism thereby to give and adjust the rigidity in the axial direction of the track base. In necessary, moreover, the sliding bearing mechanism can be acted as a lock mechanism.

In the present invention, the rolling members for rolling between the sliding bed and the track base while bearing the loads may be exemplified by balls or rollers, but the former balls are preferable from the standpoint of smoothening the gap adjustment.

In the sliding bearing mechanism to be formed between the leading ends of the inner sides of the skirts of the sliding bed and the two sides of the track base, moreover, the convex portions or the concave portions may be formed in either of the sliding bed and the track base. From the standpoint of better smoothening the gap adjustment, it is preferable that the leading ends of the inner sides of the skirts of the sliding bed are formed with the convex portions of a generally trapezoidal section having the upward and downward taper surfaces whereas the two sides of the track base are formed with the convex portions of the shape having the downward and upward taper surfaces and corresponding to the convex portions.

Still moreover, the gap adjusting means for adjusting the gap between the sliding bed and the track base may be the suspension or pressure mechanism which can apply a suspension or pressure and accordingly an elastic deformation to the central portion of the sliding bed to adjust the gap between the sliding bed and the track base. The suspension or pressure mechanism may be specifically exemplified by forming a pair of mounting faces on the upper surface of the horizontal portion of the sliding bed over and longitudinally of the two skirts of the sliding bed, by mounting a table on the paired mounting faces by a plurality of fastening bolts to leave a predetermined gap between the upper surface of the horizontal portion and the lower side of the table and between the mounting faces, by equipping the table with gap adjusting bolts for applying suspending or pressing forces to the horizontal portion through the table at an intermediate position of the paired mounting faces, and by turning the gap adjusting bolts to elastically deform the horizontal portion of the sliding bed thereby to adjust the gap between the sliding bed and the track base according to the elastic deformation. The gap adjusting bolts may be a suspending bolt to be fastened in a gap adjusting screw hole formed in an intermediate position of the horizontal portion of the sliding bed, pressing bolts extending downward to abut against the intermediate position of the horizontal portion of the sliding bed, or a combination of plural suspending and pressing bolts of which the suspending bolt is arranged between a pair of the pressing bolts along the intermediate position of the horizontal portion of the sliding bed.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a front elevation showing a first embodiment of a linear sliding bearing according to the present invention;

FIGS. **2** and **3** are a side elevation and a top plan view of the linear sliding bearing of the first embodiment;

FIG. **4** is a cut-away perspective view showing the linear sliding bearing according to the first embodiment;

FIG. **5** is a section showing the state in which the linear sliding bearing according to the first embodiment is used;

FIG. **6** is a section showing the sliding bed of the linear sliding bearing according to the first embodiment;

FIG. **7** is a perspective view showing the track base of the linear sliding bearing according to the first embodiment;

FIG. **8** is a section showing an essential portion in the state in which the concave portion at the sliding bed of the sliding bearing mechanism of the linear sliding bearing according to the first embodiment has no pressure of contact with the concave portion of the track base;

and FIG. **9** is a section showing an essential portion in the state in which the concave portion at the sliding bed of the sliding bearing mechanism of the linear sliding bearing according to the first embodiment has pressure of contact with the concave portion of the track base.

DESIGNATIONS OF THE REFERENCE CHARACTERS

1 - Sliding Bed;
2 - Track Base;
3 - Covers;
4 - Balls;
5 - Fastening Bolts
6 - Suspending Bolts;
11 - Load Races;
12 - No-Load Ball Holes;
13 - Upward Taper Surfaces (at Sliding Bed Side);
14 - Downward Taper Surfaces (at Sliding Bed Side);
15 - Mounting Faces;
16 - Gap Adjusting Screw Hole;
21 - Races;
22 - Downward Taper Surfaces (at Track Base Side);
23 - Upward Taper Surfaces (at Track Base Side);
T - Table;
and B - Bearing.

BEST MODE FOR CARRYING OUT THE INVENTION

The linear sliding bearing according to the present invention will be specifically described in the following in connection with th embodiment thereof with reference to the accompanying drawings.

A linear sliding bearing B according to the present invention is shown in FIGS. 1 to 4. This bearing B is constructed to comprise: a sliding bed 1 of a generally inverted C-shaped section including a horizontal portion 1a and a pair of skirts 1b depending downward from the two sides of the horizontal portion 1a to leave a recess at the lower side; a track base 2 having its upper portion fitted in the recess of the sliding bed 1 at a predetermined gap inbetween; a pair of covers 3 attached to the front and rear end faces of the sliding bed 1; and a number of balls 4 rolling between the sliding bed 1 and the track base 2 while bearing the loads.

The sliding bed 1 is formed with an arcuately-curved load race 11, which is extended longitudinally along the root of the inner side of each of the skirts 1b, and a no-load ball hole 12 constituting a no-load track corresponding to the load race 11. On the other hand, the track base 2 is formed at its two shoulders with races 21 which correspond to the load races 11 of the sliding bed 1. Moreover, each of the covers 3 is formed in its inner side with a guide groove for providing the communicating connections between the load races 11 of the sliding bed 1 and the end portions of the no-load ball holes 12 to form an endless track. The aforementioned numerous balls 4 are circulated to roll in each of the endless tracks thereby to bear the loads between the load races 11 of the sliding bed 1 and the races 21 of the track base 2.

On the other hand, the inner side of each of the skirts 1b of the sliding bed 1 is formed at its leading end with the convex portion having a generally trapezoidal section composed of an upward taper surface 13 and a downward taper surface 14. Moreover, the track base 2 is formed at each of its two sides with a convex portion which is composed of such an downward taper surface 22 and an upward taper surface 23 as are matched by the aforementioned convex portion. These convex and concave portions are fitted in such a wedged manner to constitute a sliding bearing mechanism that their upward and downward taper surfaces face each other.

As shown in FIG. 5, moreover, there is interposed, between the sliding bed 1 and the table T to be mounted on the upper surface of the sliding bed 1, gap adjusting means for elastically deforming the horizontal portion 1a of the sliding bed 1. Since the gap between the sliding bed 1 and the track base 2 is adjusted by that means, the pressure of contact between the upward and downward tape surfaces 13 and 14 of the sliding bed 1 and the downward and upward taper surfaces 22 and 23 of the track base 2 can be accordingly adjusted.

In this embodiment, the gap adjusting means is constructed by forming a pair of mounting faces 15 on the upper surface of the horizontal portion 1a of the sliding bed 1 in the longitudinal direction over the two skirts 1b, by mounting the table T to the mounting faces 15 by means of the plural fastening bolts 5 while leaving the predetermined gap between the upper surface of the horizontal portion 1a and the lower side of the table T, by equipping the table T with a gap adjusting bolt or the suspending bolt 6 which is extended through the table T and fitted in a gap adjusting screw hole 16 formed in an intermediate position between the paired mounting faces 15, and by turning the suspending bolt 6 to apply the suspending force to the horizontal portion 1a of the sliding bed 1 thereby to deform the horizontal portion 1a elastically so that the gap between the sliding bed 1 and the track base 2 may be adjusted according to the elastic deformation.

Thus, according to the linear sliding bearing B of the present embodiment, the pressure of contact between the upward and downward taper surfaces 13 and 14 of the sliding bed 1 and the downward and upward taper surfaces 22 and 23 of the track base 2 can be adjusted by turning the suspending bolt 6 which is fastened in the gap adjusting screw hole 16 of the sliding bed 1, while the sliding bed 1 is being assembled with the table T, as shown in FIG. 5. If, at this time, the suspending bolt 6 is loosened, the pressure of contact between the taper surfaces of the track base 2 and the taper surfaces of the sliding bed 1 is dropped until it disappears, so that the sliding bed 1 can slide on the track base 2 with a slight sliding resistance (as shown in FIG. 8). If, on the contrary, the suspending bolt 6 is fastened, the pressure of contact between the taper surfaces of the track base 2 and the sliding bed 1 is raised to increase the frictional forces between the upward and downward taper surfaces 13 and 14 of the sliding bed 1 and the downward and upward taper surfaces 22 and 23 of the track base 2 so that a high sliding resistance is exerted when the sliding bed 1 slides on the track base 2 (as shown in FIG. 9).

Thus, in the linear sliding bearing B according to the present embodiment, the sliding resistance of the sliding bed 1 can be increased by fastening the gap adjusting bolt 6, to apply the rigidity of the axial direction of the track base 2 to the linear sliding bearing B.

In the linear sliding bearing B of the present embodiment, moreover, the degree of fastening the gap adjusting bolt 6 can be suitably adjusted to apply the rigidity of the axial direction of the track base 2, if necessary, and to adjust the level of the rigidity at will.

INDUSTRIAL APPLICABILITY

As has been described hereinbefore, according to the linear sliding bearing of the present invention, the sliding resistance when the sliding bed slides on the track base can be adjusted to apply or adjust the rigidity of the axial direction of the track base, if necessary.

Since, moreover, the sliding bearing mechanism is constructed of the convex and concave portions fitted in the wedged manner, the loads to be exerted in the radial or inversely radial direction upon the sliding bed can be auxiliarily borne. Especially when the impacting load of the radial direction is exerted upon the sliding bed, the rolling members can be prevented from being broken while protecting the load races of the sliding bed and the races of the track base.

If necessary, a high pressure of contact can be applied between the taper surfaces of the sliding bed and the taper surfaces of the track base by the gap adjusting means to exert an excessive sliding resistance to the sliding bed so that the sliding bed can be continuously fixed in a portion on the track base, whereby the sliding bearing mechanism can be acted as a lock mechanism.

I claim:

1. A linear sliding bearing comprising: a sliding bed having a section of generally inverted C-shape and including a horizontal portion and a pair of skirts depending downward from the two ends of the horizontal portion to form a recess at its lower side and formed in

its inner sides with a pair of load races extending longitudinally thereof and with relief ball tracks corresponding to the load races; a track base having its upper portion fitted in the recess of said sliding bed, while maintaining a predetermined spacing inbetween, and formed with rolling races corresponding to said load races; a pair of covers attached to the front and rear end faces of said sliding bed and formed in their inner sides with guide grooves for providing the communicating connections between the end portions of the load races and the relief ball tracks of said sliding bed to form endless ball tracks; and a multiplicity of rolling members circulating in said endless ball tracks to bear the loads between the load races of said sliding bed and the rolling grooves of said track base,

wherein the improvement resides: in that the load races of said sliding bed are formed in the inner sides and at the roots of said skirts; in that the races of said track base corresponding to the load races of said sliding bed are formed at the shoulders of said track base; in that there is formed, between each of the leading ends of the inner sides of the skirts of said sliding bed and each of the two sides of the track base facing the former, a sliding bearing mechanism which include convex and concave portions having upward taper surfaces and downward taper surfaces shaped to be fitted in a wedged manner; and in that there is interposed, between said sliding bed and a table to be mounted on the upper surface of said sliding bed, gap adjusting means which includes a suspension or pressure mechanism for elastically deforming the horizontal portion of said sliding bed, whereby the pressure of contact between the upward and downward taper surfaces of said sliding bed and the downward and upward taper surfaces of said track base is adjusted by adjusting the gap between said sliding bed and said track base by said gap adjusting means.

2. A linear sliding bearing as set forth in claim **1**, wherein said sliding bed includes a convex portion of a generally trapezoidal section having an upward taper surface and a downward taper surface at the leading end of the inner side of each of the skirts thereof, and wherein said track base includes a concave portion shaped to correspond to said convex portion and to have a downward taper surface and an upward taper surface at each of the two sides thereof.

* * * * *

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 024 305 A2

(12) # EUROPEAN PATENT APPLICATION

(43) Date of publication:
02.08.2000 Bulletin 2000/31

(51) Int. Cl.^{7}: **F16C 33/38**, F16C 29/04

(21) Application number: **00101288.9**

(22) Date of filing: **27.01.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **29.01.1999 JP 2247699**

(71) Applicant: **THK CO. LTD.**
Tokyo 141 (JP)

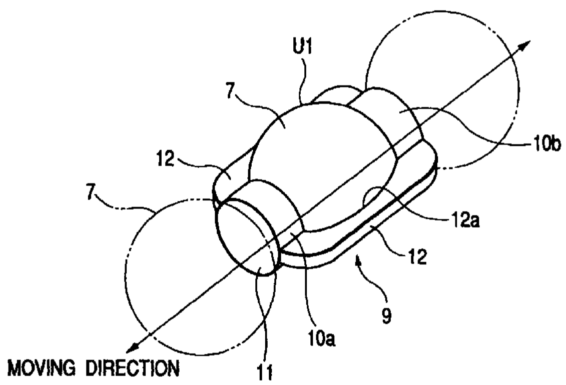
(72) Inventor: **Shirai, Takeki**
Shinagawa-ku, Tokyo (JP)

(74) Representative: **HOFFMANN - EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(54) **Rolling element and rectilinearly-movable apparatus using the rolling element**

(57) A rolling-element hold spacer (9) includes a spherical indent (11) which is formed in either side of a rolling element (7) so as to match the curved surface of the rolling element (7); thick hold sections (10a,10b) to be interposed between the rolling elements (7); and thin bent sections (12) for interconnecting only one thick hold section pair (10a,10b) in which the rolling element (7) is to be interposed. The thin bent section (12) is deflected or twisted in a curved portion of a rolling-element circulation path. Further, the rolling-element hold spacers which are adjacent to each other with a single rolling element interposed therebetween mutually perform pivotal movement around the rolling element (7), thereby enabling smooth circulation of the rolling elements (7). Clearance arises between the rolling element (7) and the thick hold sections (10a,10b) as a result of bent of the thin bent section (12). Lubricant enters the clearance, to thereby sufficiently lubricate the rolling elements (7). So long as a rolling-element hold spacer (9) is placed around every other rolling element (7), all the rolling elements (7) are eventually held by the rolling-element hold spacers (9). Consequently, the number of rolling-element hold spacers (9) can be reduced to one-half the number of the rolling elements (7), and the number of rolling elements (7) can be increased correspondingly.

FIG. 2A



EP 1 024 305 A2

Description

BACKGROND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a rolling-element hold spacer for retaining, in a rotatable and slidable manner, rolling elements used in a rectilinearly-movable apparatus, such as a rectilinearly-rolling guide apparatus, a ball screw, and a ball spline, as well as a rectilinearly-movable apparatus using the rolling element hold spacer.

2. Description of the Related Art

[0002] As shown in FIG. 15, a single-element retainer 2 for individually holding a ball 1 has already been known as a rolling-element hold spacer for a holding ball (corresponding to a rolling element) used in a rectilinearly-movable apparatus (see, for example, Japanese Patent Publication No. 33774/1993). The ball 1 is held, in a rotatable and slidable manner, within a housing hole 2a formed in the single-element retainer 2 while the upper and lower portions of the ball 1 are partially exposed. The single-element retainer 2 is incorporated in the rectilinearly-movable apparatus. A fittingly-insert section 2b is bulgily formed in the single-element retainer 2 on either side of the ball 1 and is to be inserted into a guide channel formed in a slide member. The single-element retainers 2, each housing the ball 1, are inserted in a circulation path of the slide member. The single-element retainers 2 travel in the direction designated by A shown in the drawing. The opposite ends of the single-element retainer 2, which come into contact with the corresponding ends of the adjoining single-element retainers 2 while the single-element retainers 2 are traveling along the circulation path, are formed so as to assume a circular-arc shape 2c. The distance between the centers of the adjacent balls 1 is maintained constantly. Since the balls 1 are arranged and held in a circulation path while being held by the respective single-element retainers 2, the balls 1 are prevented from rubbing against each other during circulation, thus preventing generation of a collision sound or abrasion, which would otherwise be caused by rubbing action.

[0003] Such a known single-element retainer 2 is suitable for being arranged and housed in the circulation path of the rectilinearly-rolling guide apparatus, as well as for effecting two-dimensional change between linear travel direction A and U-shaped travel direction B, as shown in FIG. 15. However, there may be a case where a ball screw requires three-dimensional change of direction and torsional movement with respect to a travel direction, as well as two-dimensional change of direction. The single-element retainer 2 is difficult to effect such complicated movements. Further, the circumference of the ball 1 exclusive the upper and lower portions thereof is covered with the single-element retainer 2. It is difficult for a lubricant to enter the space between the single-element retainer 2 and the ball 1, thus insufficiently lubricating the ball 1. Further, since one single-element retainer 2 is used for holding a single ball 1, space for the circular-arc portions 2c of the adjacent single-element retainers 2 must be ensured between the adjacent balls 1. For this reason, the single-element retainers 2 occupy space within the circulation path, thus imposing a limitation on the number of balls 1 to be inserted into the circulation path. Therefore, the rectilinearly-rolling guide apparatus cannot assume a large load-carrying capacity. The portion of the single-element retainer 2 which comes into contact with the corresponding portion of the adjacent single-element retainer 2 assumes a circular-arc protrudent shape 2c, and hence the adjacent single-element retainers 2 come into substantial line contact with each other, thus increasing a contact pressure. Consequently, there is a case where the single-element retainers 2 repeatedly come into collision with each other during the course of circulating operation, thus causing a collision sound. Further, the single-element retainer 2 has the bulgily-formed fittingly-insert sections 2b and hence has an irregular thickness with respect to the circulating direction of the single-element retainer 2 (i.e., direction A). Therefore, the single-element retainers 2 may cause pitching during a circulating operation.

SUMMARY OF THE INVENTION

[0004] Accordingly, the present invention is aimed at providing a rolling-element hold spacer which ensures smooth circulating operation even in the case of a complicated movement mode such as that effected in a three-dimensional change-of-direction path and which can increase the load-carrying capacity of a rectilinearly-movable apparatus by means of increasing the number of rolling elements inserted in a circulation path.

[0005] Also, the present invention is aimed at providing a rectilinearly-movable apparatus equipped with the rolling element hold spacer.

[0006] To achieve the above objects, according to a first aspect of the invention, there is provided a rolling-element hold spacer comprising:

> a thick hold section having spherical indents formed on both sides thereof, said thick hold sections being adapted to be interposed between rolling elements so that the spherical indents match the curved surface of the rolling elements; and
> thin bent sections for interconnecting only one thick hold section pair in which the rolling element is to be interposed.

[0007] In the first aspect of the present invention, the thin bent section is deflected or twisted in a curved portion of a rolling-element circulation path. Further, the rolling-element hold spacers which are adjacent to each other with a single rolling element interposed therebetween mutually perform pivotal movement around the rolling element, thereby enabling smooth circulation of the rolling elements. Clearance arises between the rolling element and the thick hold sections as a result of bent of the thin bent section. Lubricant enters the clearance, to thereby sufficiently lubricate the rolling elements. So long as the rolling-element hold spacer is placed every other the rolling elements, all the rolling elements are eventually held by the rolling-element hold spacers. Consequently, the number of rolling-element hold spacers can be reduced to one-half the number of the rolling elements.

[0008] More specifically, the number of rolling-element hold spacers to be inserted into the rolling-element circulation path is reduced, and the number of rolling element can be increased correspondingly. As a result, the load-carrying capacity of a rectilinearly-movable apparatus employing the rolling-element hold spacers can be increased. Further, the thick hold sections of the rolling-element hold spacer hold the rolling element by way of the spherical indents, and hence a contact pressure developing between the rolling-element hold spacer and the rolling element can be diminished. Accordingly, there can be prevented generation of a collision sound, which would arise during the circulation of the rolling elements, thus enabling smooth circulation of the rolling elements. The thin bent section interconnecting the thick hold sections has a strip shape and a uniform thickness in the traveling direction of the rolling-element hold spacer. So long as the width of a guide groove formed in the slide member for the purpose of guiding the thin bent section is set to be slightly greater than the thickness of the thin bent section, the rolling-element hold spacer is stably guided without involvement of a pitching problem, thus ensuring smooth circulation of the rolling elements.

[0009] Preferably, the thin bent section is provided on either side of the rolling element.

[0010] By means of such a configuration of the present invention, the thin bent section provided on either side of the rolling element stably holds the rolling element, thus prolonging the life of the rolling-element hold spacer.

[0011] Preferably, the thin bent section is provided only on one side of the rolling element.

[0012] By means of such a configuration of the present invention, even when the rolling elements are circulated through a warped circulation path, the thin bent section can be freely deflected so as to match the warped path. Therefore, the rolling elements can be smoothly circulated in the circulation path.

[0013] Also, according to a second aspect of the invention, there is provided a rectilinearly-movable apparatus comprising:

a track shaft having rolling-element travel surfaces;

a slide member having load travel surfaces corresponding to the rolling-element travel surfaces and attached to said track shaft so as to freely perform movement relative thereto;

a plurality of rolling elements arranged and housed in the rolling-element travel circulation path and are circulated in association with the movement of said slide member relative to said track shaft; and

a plurality of rolling-element hold spacers, each of which rotatively holds each of the rolling elements;

wherein said rolling-element hold spacer comprises a thick hold section having spherical indents formed on both sides thereof, said thick hold sections being adapted to be interposed between rolling elements so that the spherical indents match the curved surface of the rolling elements; and thin bent sections for interconnecting only one thick hold section pair in which the rolling element is to be interposed.

[0014] As mentioned above, in the present invention, so long as the rolling-element hold spacer is placed every other the rolling elements, all the rolling elements are eventually held by the rolling-element hold spacers. Consequently, the number of rolling-element hold spacers can be reduced to one-half the number of the rolling elements. More specifically, the number of rolling-element hold spacers to be inserted into the rolling-element circulation path is reduced, and the number of rolling elements can be increased correspondingly. As a result, the load-carrying capacity of a rectilinearly-movable apparatus employing the rolling-element hold spacers can be increased. Further, particularly in a warped portion of the rolling-element circulation path, the thin bent section is deflected, thus making smooth circulation of the rolling elements. Clearance is arises between the rolling element and the thick hold sections as a result of bent of the thin bent section. Lubricant enters the clearance, to thereby sufficiently lubricate the rolling elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

FIG. 1 is a perspective view showing a rectilinearly-rolling guide apparatus having incorporated therein a ball hold spacer according to a first embodiment of the present invention;

FIGs. 2A to 2C show a ball hold spacer of the first embodiment, wherein FIG. 2A is a perspective view showing the ball hold spacer, FIG. 2B is a side view showing the same, and FIG. 2C is a plan view showing the same;

FIGs. 3A to 3C show the rectilinearly-rolling guide apparatus, wherein FIG. 3A is a cross-sectional view taken in the direction perpendicular to the axial direction of a rail and FIGS. 3B and 3C are enlarged views showing a load travel path;

FIG. 4 is a cross-sectional view which is taken in the axial direction of the rail and shows circulation of balls within a ball circulation path;

FIGs. 5A and 5B show a ball hold spacer according to a second embodiment of the present invention, wherein FIG. 5A is a perspective view showing the ball hold spacer and FIG. 5B is a plan view showing the same;

FIGs. 6A to 6C show a rectilinearly-rolling guide apparatus having incorporated therein the ball hold spacer of the second embodiment, wherein FIG. 6A is a cross-sectional view taken in the direction perpendicular to the axial direction of the rail and FIGS. 6B and 6C are enlarged views showing a load travel channel;

FIG. 7 is a perspective view showing a ball screw having incorporated therein the ball hold spacer of the second embodiment;

FIG. 8 is a perspective view showing a return pipe provided in the ball screw shown in FIG. 7;

FIG. 9 is a side view showing a return pipe, a screw shaft, and balls, which correspond to the principal elements of the balls screw shown in FIG. 7;

FIG. 10 is an operation diagram showing raising of a ball within the return pipe shown in FIG. 8;

FIGs. 11A and 11B show the movement of the ball hold spacer when the ball hold spacer changes direction, wherein FIG. 11A is a perspective view showing a deflected state of a thin bent section and FIG. 11B is a perspective view showing mutual pivotal movement arising between the ball hold spacers;

FIG. 12 is a perspective view including a partial cross section of a ball screw of deflector type to which the ball hold spacer of the present invention is applied;

FIG. 13 is a cross-sectional view which shows the principal section of the ball screw shown in FIG. 12 and is taken in the direction perpendicular to the axial direction of a screw shaft;

FIG. 14 is an illustration of the ball screw when viewed in direction G-G shown in FIG. 13; and

FIG. 15 is a perspective view showing a single retainer which serves as a known rolling-element hold spacer.

DETTAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] Now, a description will be given in more detail of preferred embodiments of the present invention with reference to the accompanying drawings.

[0017] FIG. 1 shows a rectilinearly-rolling guide apparatus 5 incorporating a ball-retaining spacer as a rolling-element hold spacer according to a first embodiment of the present invention. The rectilinearly-rolling guide apparatus 5 guides a movable member, such as a table, on a stationary section, such as a bed or a saddle. The rectilinearly-rolling guide apparatus 5 is placed on the stationary section and includes a guide rail 8 (serving as a "track spindle"); a movable block (slide member) 6; and a plurality of balls 7. Ball travel grooves 8a, each serving as a ball rolling surface, are formed in the guide rail 8 in the longitudinal direction thereof. A ball circulation path (i.e., a rolling-element circulation path) including load travel grooves 6a, which serve as load rolling surfaces and correspond to the respective ball travel grooves 8a of the guide rail 8, is formed in the movable block 6. The movable block 6 is also attached to the guide rail 8 so as to cause relative movement with respect to the guide rail 8. The balls 7 serve as rolling elements which are to be arranged and housed within the ball circulation path and which are circulated in association with the movement of the movable block 6 relative to the guide rail 8. In association with infinite circulation of the balls 7, the movable block 6 supporting a movable member is linearly moved along the guide rail 8.

[0018] FIGS. 2A to 2C show a ball hold spacer 9 serving as a rolling-element hold spacer to be incorporated into the rectilinearly-rolling guide apparatus 5. The ball hold spacers 9 are placed such that a single ball hold spacer 9 is provided in every other balls 7 and hold, in a rotatable and sliding manner, the plurality of balls 7 rotating between the movable block 6 and the guide rail 8. Each of the ball hold spacers 9 has thick hold sections 10a and 10b, which are to be placed between the balls 7 that are arranged in a row. The thick hold sections 10a and 10b are formed so as to assume a substantially cylindrical shape. Further, the outer diameter of the thick hold section 10a and the outer diameter of the thick hold section 10b are set to be smaller than the diameter of the ball 7. A spherical indent 11 is formed in either side of the thick hold section 10a so as to correspond to the ball 7 with respect to the axial direction thereof. Similarly, the spherical indent 11 is formed in either side of the thick hold section 10b so as to correspond to the ball 7 with respect to the axial direction thereof. The spherical indent 11 is formed as a curved-surface indent whose curvature radius is substantially identical with the radius of the ball 7. When the ball hold spacer 9 is placed between the balls 7, the axis of the thick hold section 10a and the axis of the thick hold section 10b are brought into line with an extension of an imaginary line interconnecting the centers of the balls 7. As shown in FIG. 2B, the axial width of the thick hold section 10a and the axial width of the thick hold section 10b are set to a small value, as indicated by W, thus shortening the distance between the balls 7. An oil reservoir hole may be formed in the center of the spherical indent 11 as a lubricant hold section which penetrates the thick hold sections 10a and 10b in the axial direction.

[0019] A thick hold section pair which comprises the thick hold sections 10a and 10b and is placed so as to sandwich the ball 7 therebetween is formed by interconnecting the thick hold sections 10a and 10b by means of strip-shaped thin bent sections 12. The thin bent section 12 has a uniform thickness and interconnects one side surface of the thick hold section 10a and the corresponding side surface of the thick hold section 10b while extending across the ball 7 placed therebetween. The portion of the thin bent section 12 which is to interfere with the ball 7 is formed into a recessed section 12a whose curvature radius is substantially equal to the radius of the ball 7. Corners formed on the opposite longitudinal ends of the thin bent section 12 are formed into round corners 12b (see FIG. 2C). The thin bent sections 12 are placed on opposite sides of the ball 7 so as to constitute a single plane. The thick hold sections 10a and 10b and the thin bent section 12 are formed integrally from synthetic resin or a like material by means of injection molding.

[0020] As shown in FIGS. 1 and 3, the guide rail 8 has an elongated shape and a substantially-rectangular cross section. As mentioned above, the ball travel groove 8a, acting as a track along which the balls 7 roll, is formed on either longitudinal side of the guide rail 8 so as to extend over the entire length of the guide rail 8. Although the illustrated guide rail 8 has a linear geometry, two ball travel grooves 8a are formed in either side of the guide rail 8 (i.e., a total of four ball travel grooves 8a are formed), the number of ball travel grooves may be changed variously according to the purpose of the rectilinearly-rolling guide apparatus 5.

[0021] The movable block 6 is substantially constituted by connecting a movable main unit 13 to a pair of side covers 14 provided on the opposite ends thereof, by means of bolts. Four load travel grooves 6a are formed in the movable main unit 13 so as to correspond to the respective ball travel grooves 8a. Four load travel channels C are formed between the guide rail 8 and the movable block 6, by combination of the load travel grooves 6a and the ball travel grooves 8a. Four return channels D-which extend in parallel with the load travel channels C-and change-of-direction channels for connecting the return channels D with the load travel channels C are formed in the movable block 6. A single ball circulation path is formed by combination of the load travel channel C, the return channel D, and the direction-of-change channel interconnecting the load travel channel C and the return channel D.

[0022] As shown in FIG. 3, the movable main unit 13 comprises a main unit block 16 and molded bodies 17a and 17b. The main unit block 16 is a highly-ridge structural body which is formed from steel or like material so as to be able to bear the load imposed on the movable block 6. Screw holes are formed in the upper surface of the main unit block 16 for securing an object which is to be guided by the rectilinearly-rolling guide apparatus 5. The molded bodies 7a and 7b are molded integrally with the main unit block 16 by means of injecting resin melt into a mold in which the main unit block 16 is placed; that is, by means of a so-called insert molding technique. The molded bodies 17a and 17b may be formed by means of die-cast molding while metal, such as aluminum, is used in place of resin. Further, the movable main unit 13 may be assembled not only by means of insert molding but also by means of assembly of the main unit block 16 and the molded bodies 17a and 17b, which are formed separately. Alternatively, the main unit block 16 and the molded bodies 17a and 17b may be formed integrally with each other by means of metal injection molding (MIM).

[0023] As shown in FIGS. 3 and 4, the above-mentioned load travel grooves 6a are formed in the main unit block 6, and the return channels D are formed in the molded body 17a. Four through holes extending in parallel with the load travel channels 6a are formed in the main unit block 16. Tube-like sections of the molded body 17a are formed integrally with the through holes. The return channel D for returning the balls 7 and a guide grove 18 for guiding the thin bent sections 12 are formed in the tube-like section of the molded body 17a. A pair of ball hold sections 19 are formed in each of the areas of the molded body 17b opposing the load travel channels C such that the load travel channel 6a is interposed between the ball hold section pair 19. When the movable block 6 is removed from the guide rail 8, the ball hold section pair 19 prevents dislodging of the balls 7 from the load travel channels C. The thin bent sections 12 are guided through the space defined between the ball hold section pairs 19 and the main unit block 16 (see FIGS. 3B and 3C).

[0024] In the ball circulation path constituted of the load travel channel C, the change-of-direction channel E, and the return channel D, the width of the guide groove 18 for guiding the thin bent section 12 is maintained at a constant width slightly greater than the thickness of the thin bent section 12. The horizontal center of the guide groove 18 is displaced toward the main unit block 16 from the horizontal center of track along which the balls 7 travel, by only X. As a result, the curvature radius of the change-of-direction section of the ball circulation path can be made small, thus making the rectilinearly-rolling guide apparatus 5 compact.

[0025] As shown in FIG. 4, each of the molded bodies 17a comprises arch-shaped inner radius sections 17c which protrude from the opposite ends of the main unit block 16. In each of the side covers 14, there are formed outer radius sections 14a, each of which constitutes the change-of-direction channels E together with the inner radius section 17c formed in the corresponding molded body 17a. When the side covers 14 are attached to the main unit block 16, the inner radius guide section 17c and the outer radius guide section 14c in combination constitute the change-of-direction channel E. Further, as a result of combination of the inner radius guide section 17c with the outer radius guide section 14c, the guide groove 8 for guiding the thin bent sections 12 is also formed in the change-of-direction channel E.

[0026] The ball 7 is fitted into the space defined between the thick hold sections 10a and 10b of the ball hold spacer 9, thus forming one unit U1 (see FIGS. 2A and 4). At this time, the ball 7 is held in the ball hold spacer 9 so as to be freely rotatable. The units U1 and the balls 7 are alternately inserted into the ball circulation path while the thin bent sections 12 of the ball hold spacer 9 are fitted into the guide groove 18. In association with the movable block 6 traveling along the guide rail 8, the balls 7 travel the load travel channel C from one end to the other end thereof while undergoing the load imposed by the movable block 6. Subsequently, the balls 7 enter one of the change-of-direction channels E and are guided to the return channel D. The balls 7 are then returned to one end of the load travel channel C by way of the other change-of-direction channel E. Since the thin bent section 12 of the ball hold spacer 9 is moved along the ball circulation path along a track defined by the guide groove 18, the balls 7 held in the ball hold spacers 9 are orderly circulated in the ball circulation path without involving a snaking action.

[0027] As mentioned above, the ball hold spacer 9 is placed in every other balls 7, and the ball 7 is held in the space of the thick hold sections 10a and 10b which forms a pair. The ball 7 which is not held in the ball hold spacer 9 is retained between the adjacent ball hold spacers 9 such that one side of the ball 7 is in contact with either the thick hold section 10a or 10b of one adjacent ball hold spacer 9 and the other side of the same is in contact with a thick hold section of another adjacent ball hold spacer 9 which is to oppose the thick hold section 10a or 10b of the one adjacent ball hold spacer 9. As mentioned above, so long as the ball hold spacer 9 is placed in every other balls 7, all the balls 7 are eventually retained by the ball hold spacers 9. Consequently, the number of the ball hold spacers 9 can be reduced to one-half the balls 7. More specifically, the number of ball hold spacers 9 to be inserted into the ball circulation path is reduced, and the number of balls 7 can be increased correspondingly. Consequently, the load-carrying capacity of the rectilinearly-rolling guide apparatus 5 can be increased. Further, the ball 7 is retained between the spherical indent 11 formed in the thick hold section 10a and the spherical indent 11 of the thick hold section 10b, thus reducing the contact pressure developing between the ball hold spacer 9 and the ball 7. As a result, there is reduced a collision sound, which would arise during the circulation of the balls 7, whereby the balls 7 are circulated smoothly.

[0028] The thin bent section 12 is set to have a uniform thickness in the traveling direction thereof, and the width of the guide groove 18 for guiding the thin bent section 12 is set to be slightly greater than the thickness of the thin bent section 12. Accordingly, the ball hold spacers 9 are guided stably without occurrence of pitching. In the change-of-direction section E, the guide groove 18 for guiding the thin bent section 12 is also curved into a circular-arc shape in parallel with the change-of-direction channel E. Therefore, the thin bent sections 12 are also moved on a curved path along the guide groove 18, and a clearance can be formed between the ball 7 and the thick hold sections 10a and 10b in the change-of-direction channel E. Lubricant enters the clearance, thus sufficiently lubricating the balls 7.

[0029] In the rectilinearly-rolling guide apparatus 5 of the present embodiment, the ball hold spacers 9 change direction two-dimensionally at the time of circulation of the balls 7. More specifically, the direction of the ball hold spacers 9 is changed by way of the route comprising the linear load travel channel C, the U-shaped change-of-direction channel E, the linear return channel D, and the U-shaped change-of-direction channel. As is evident from FIG. 4, since the thin bent section 12 of the ball hold spacer 9 is freely bent, smooth circulation of the balls 7 is ensured.

[0030] Although in the present embodiment the movable block 6 performs linear movement relative to the guide rail 8, the present invention can also be applied to and is suitable for use with a guide apparatus configured so as to cause curved relative movement.

[0031] FIG. 5 shows a ball hold spacer 20 according to a second embodiment of the present invention. The ball hold spacer 20 is formed from the same material as that from which the ball hold spacer 9 of the first embodiment is formed. Even with regard to configuration, the ball hold spacer 20 is placed between the balls 7 aligned in a row in the same manner as is the ball hold spacer 9. Further, the ball hold spacer 20 has thick hold sections 22a and 22b, as in the case of the ball hold spacer 9. The thick hold sections 22a and 22b are formed into a substantially cylindrical shape, and the outer diameter of the thick hold sections 22a and 22b is set to be smaller than the diameter of the ball 7. A spherical indent 23 is formed so as to correspond to the ball 7 in either side of the thick hold section 22a with respect to its axial direction. The spherical indent 23 is formed so as to correspond to the ball 7 in either side of the thick hold section 22b with respect to its axial direction. The spherical indent 23 has a curvature radius substantially equal to the radius of the ball 7. The thickness of the thick hold section 22a and the thickness of the thick hold section 22b with respect to the axial direction thereof are set to be a small value, thus shortening the distance between the balls 7 (see FIG. 5B). The thick hold sections 22a and 22b, which constitute a pair, are interconnected by means of a strip-shaped thin bent section 21. In comparison with the ball hold spacer 9 of the first embodiment, the ball hold spacer 20 of the second embodiment has a single thin bent section 21 provided on only one side of the ball 7. The thin bent section 21 has a uniform thickness and interconnects the side surface of the thick hold section 22a and the side surface of the thick hold section 22b. A notch 21a whose curvature radius is substantially equal to the radius of the ball 7 is formed in an area of the thin bent section 21 which would interfere with the ball 7. Further, either longitudinal end of the thin bent section 21 is rounded into a round corner 21b.

[0032] As shown in FIG. 5, an overhanging section 22a1 is provided in an area on the side surface of the thick hold section 22a opposite to the side surface where the end of the thin hold section 21 is attached, with respect to the diameter of the thick hold section 22a. Similarly, an overhanging section 22b1 is provided in an area on the side surface of the thick hold section 22b opposite to the side surface where the end of the thin hold section 21 is attached, with respect to the diameter of the thick hold section 22b. The overhanging sections 22a1 and 22b1 extend outwardly. Such a configuration ensures holding of the ball 7 even when there is used only the single thin bent section 21.

[0033] FIG. 6 shows a rectilinearly-rolling guide apparatus 25 having incorporated therein the ball hold spacer 20 of the second embodiment. Even in the rectilinearly-rolling guide apparatus 25, a movable block 26 is supported on a guide rail 27 by way of the plurality of balls 7. A total of four ball travel channels 27a along which the balls 7 will travel are formed in the guide rail 27 so as to extend over the entire length thereof; specifically, two ball travel channels 27a being formed in the upper surface of the guide rail 27 and one ball travel channel 27a being formed in either side of the same.

[0034] Four load travel channels 26a are formed in the movable block 26 so as to correspond to the respective ball travel channels 27a. The load travel channels 26a and the ball travel channels 27a in combination constitute four load travel channels C between the movable block 26 and the guide rail 27. Further, a guide groove 28 for guiding the thin bent section 21 is formed in each of the load travel channels 26a (see FIGS. 6B and 6C). The width of the guide groove 29 is set to be slightly greater than the thickness of the thin bent section 21.

[0035] Four through-holes are formed in the movable block 26 so as to extend in parallel with the load travel channels 26a, and a tube-like section of a molded body is formed integrally with each of the through-holes. The return channel D for returning the balls 7 and the guide groove 28 for guiding the thin bent section 21 are formed within the tube-like section. The width of the guide channel 28 is also set to be slightly greater than the thickness of the thin bent section 21. The guide grooves 28 and 29 are formed in only the inner radius side of the ball circulation path.

[0036] The thin bent section 21 has a strip-shaped profile and is set to have a uniform thickness in the traveling direction thereof, and the width of the guide groove 18 for guiding the thin bent section 21 is set to be slightly greater than the thickness of the thin bent section 21. Accordingly, the ball hold spacers 20 are guided stably without occurrence of pitching. Further, the thin bent section 21 is provided on only one side of the ball 7, thus enabling free bent of the ball hold spacer 20. Accordingly, the ball hold spacers 20 and the balls 7 are smoothly circulated not only when the ball hold spacers 20 and the balls 7 are circulated along a two-dimensionally-warped change-of-direction channel but also when the ball hold spacers 20 and the balls 7 are circulated along a three-dimensionally-warped change-of-direction channel. Such a configuration is suitable for use with a twisted circulation path or a circulation path involving a sharp change in direction; for example, a ball screw and a nut thereof. As in the case of the ball hold spacer 9 of the first embodiment, in a case where the thin bent section 12 is provided on either side of the ball 7, the balls 7 are held stably, and the life of the ball hold spacer 20 becomes longer. Further, in a case where the radius of the cross section of the ball travel channel 26a is set to be greater than the radius of the ball 7, the balls 7 that are being circulated may cause a swinging action in the widthwise direction of the ball travel channel 26a (in direction Y shown in FIGS. 6B and 6C). In this case, since the guide grooves 28 and 29 are formed in along the inner radius side of the circulation path, the thin bent section 21 is prevented from undergoing repeated expanding and contracting action. Thus, the thin bent section 21 can be prevented from being susceptible to fatigue.

[0037] FIG. 7 shows a ball screw 30 having incorporated therein the ball hold spacers 20 of the second embodiment. The ball screw 30 comprises a screw shaft 31 (corresponding to a "track spindle"), a nut member 32 (corresponding to a "slide member"), and a plurality of balls. A ball travel channel 31a serving as a rolling-element travel surface is helically formed in the exterior circumferential surface of the screw shaft 31. A ball circulation path (corresponding to a "rolling-element circulation path") is formed in the interior circumferential surface of the nut member 32 so as to include a load travel channel 32a which serves as a load travel surface and is helically formed so as to correspond to the ball travel channel 31a. The nut member 32 is attached to the screw shaft 31 so as to be able to cause movement relative thereto. The balls serve as rolling elements and are circulated through the ball circulation path in association with the relative movement (rotation) arising in between the screw shaft 31 and the nut member 32. The load travel channel of the ball circulation path is defined between the ball travel channel 31a of the screw shaft 31 and the load travel channel 32a of the nut member 32. The nut member 32 has two return pipes 36, and the return pipe 36 constitutes a no-load return channel which connects one end and the other end of the load travel channel. As shown in FIGS. 8 and 9, either end of the return pipe 36 is folded toward the screw shaft 31, and both ends of the return pipe 36 are fitted into the load travel channel so as to be spaced at several pitches apart from each other. Further, the return pipes 36 are secured to the nut member 32 by means of a pipe presser 34 (see FIG. 7).

[0038] The ball travel channel 31a formed in the screw shaft 31 is formed so as to assume; for example, a circular-arc cross section, by means of grinding or rolling.

[0039] As shown in FIG. 7, the main unit of the nut member 32 has a substantially cylindrical shape, and a flange 35 to be connected to a corresponding component is provided at one end of the nut member 32. A flat-face section 40 is formed in the nut member 32 by removal of a portion of the exterior circumference of the nut member 32 by means of machining. Four return pipe fitting holes 41 are formed in the flat-face section 40, and the respective ends of the return pipes 36 are fitted into the return pipe fitting holes 41. The return pipe fitting hole 41 extends to the inside of the load travel channel 32a.

[0040] As is evident from FIG. 8, the return pipe 36 has a circular cross section, and either end portion of the return pipe 36 is bent at an angle of about 90° with respect to the nut member 32. Specifically, the return pipe 36 is formed into a substantially arch-shaped form and comprises a pair of legs 36a and 36b and a horizontal portion 36c interconnecting the legs 36a and 36b. As illustrated in the drawing, the legs 36a and 36b are not in parallel with each other and are twisted so as to form a torsional angle $\theta 1$ (which changes in accordance with a lead angle). A guide groove 37 is formed in the interior surface of the return pipe 36 so as to extend in the axial direction and over the entire length of the return pipe 36. The width of the guide groove 37 is set to be slightly greater than the thickness of the thin bent section 21. Both ends of the return pipe 36; that is, the legs 36a and 36b, are obliquely cut into cuts 38. The width of the cut 38 is gradually narrower with respect to the depthwise direction of the return pipe 36.

[0041] FIG. 9 shows the balls 7 and the ball hold spacers 20, which are to be inserted into the load travel channel and the return pipes 36. This drawing shows only the ball hold spacers 20 which can be viewed in cross section, and the other rolling-element hold spacers are omitted from the drawing. The ball hold spacer 20 is placed in every other balls 7, and the ball 7 is retained in one thick hold section pair comprising the thick hold sections 10a and 10b. The ball 7 that is not housed in the ball hold spacer 20 is held between the thick hold sections 10a and 10b of the adjacent ball hold spacers 20 which mutually oppose. So long as the spherical indent 23 of the ball hold spacer 20 is formed so that the ball hold spacers 20 and the balls 7 can be arranged in substantially an annular pattern, there can be prevented application of undue force to the ball hold spacers 20 and the balls 7, which would otherwise be caused during circulation of the ball hold spacers 20 and the balls 7.

[0042] As shown in FIG. 9, a guide groove 33 to be used for guiding the thin bent section 21 of the ball hold spacer 20 is formed in a ball travel channel 32a of a nut member 32. The guide groove 33 is helically formed so as to run along the ball travel channel 32a of the nut member 32, and the width of the guide groove 33 is set to be slightly greater than the thickness of the thin bent section 21. Further, the guide groove 33 is formed so as to protrude outward from a row of balls 7 arranged in an annular pattern.

[0043] FIG. 10 shows a change in the cross-sectional shape of each of the legs 36a and 36b of the return pipe 36. Reference numeral 0 designates the cross-sectional view of the tip end of the leg, and cross-sectional views designated by reference numerals 1 through 9 are taken progressively toward a deeper and inner portion of the return pipe 36. As illustrated in the drawing, in the cross-sectional view designated by 0, the cross section of each of the legs 36a and 36b assumes a substantially semi-circular shape whose both ends slightly exceed beyond the center line D by only size "h." The cross-section of each of the legs 36a and 36b becomes closer to a circular cross section toward a deeper and inner portion of the return pipe 36 (i.e., when the ball 7 travels from position 1 to position 10), and distance W between the inner edges of the cuts 38 becomes gradually smaller. In the cross-sectional views designated by 0 through 4, the distance W between the cuts 38 is greater than the diameter of the ball 7. Thus, the ball 7 is not raised by the cuts 38 and can be rolled around the screw shaft 31. However, when the ball 7 travels from position 0 to position 4, a clearance 39 formed between the interior surface of each of the legs 36a and 36b and the surface of the ball 7 opposing the interior surface becomes slightly greater. When the ball 7 travels further upward to position 5, the opposite ends of the ball 7 start to be raised by the cuts 38. Since the distance W between the cuts 38 is gradually smaller toward an inner and deeper portion of the return pipe 36, the ball 7 is guided by the cuts 38 from position 6 to position 10 and is introduced into the return pipe 36 having a circular cross section.

[0044] As shown in FIG. 9, when the screw shaft 31 is rotated, the balls 7 which are rolled under load along the inside of the ball travel channel 31a in the circumferential direction are raised by the tip end of the leg 36a. The thus-raised balls 7 pass through the return pipe 36 and return to the ball travel channel 31a from the leg 36b which is spaced several pitches apart from the leg 36a. When the screw shaft 31 is rotated reversely, the balls 7 are circulated along the above-described path in a reverse direction. The balls 7 are circulated in the same manner in a case where the nut member 32 is rotated while the screw shaft 31 is secured.

[0045] The load travel channel of the ball screw 30 is helically formed, as mentioned previously. Further, the return pipe 36 changes the direction of the balls 7 which are raised by the tip end of the return pipe 36. As has been described by reference to FIG. 8, the return pipe 36 is twisted with respect to the traveling direction of the ball 7 (at torsional angle $\theta 1$). In the ball screw 30, the balls 7 and the ball hold spacers 20 three-dimensionally change direction and move in a complicated manner.

[0046] The ball hold spacer 20 is optimal for performing such a complicated movement.

[0047] As shown in FIG. 11A, the thin bent section 21 of the ball hold spacer 20 can be considerably, freely bent within a virtual plane 50 extending in the thicknesswise direction of the thin bent section 21. In the drawing, an angle through which the thin bent section 21 can be bent is designated by θ2. Further, the thin bent section 21 can also be bent slightly in the direction perpendicular to the virtual plane 50 and can be twisted with respect to the traveling direction of the ball hold spacer 20. In the drawing, in a case where a front end section 21d of the thin bent section 21 with respect to the traveling direction thereof is at right angles to the virtual plane 50, reference symbol θ3 designates an angle formed between the virtual plane 50 and a virtual plane 51 to which a rear end section 21e of the thin bent section 21 with respect the traveling direction thereof is at right angles.

[0048] As shown in FIG. 11B, the ball hold spacers 20 that are consecutively arranged are separated from one another and are not continuous. The ball hold spacers 20 are pivotable relative to one another within a virtual plane 52 perpendicular to the virtual plane 50. In the drawing, a relative pivotable angle between the ball hold spacers 20 is designated by θ4. In a case where the rolling element corresponds to a ball, the ball hold spacers 20 are pivotable relative to one another in every direction within the virtual plane 52. In a case where the rolling element corresponds to a roller, the ball hold spacers 20 can be pivotable within only the virtual plane 52, and a limitation is imposed on the mutual pivotable movement of the ball hold spacers 20 in another direction.

[0049] By means of flexible and twisting action of the thin blade section 21 as well as of mutual pivotal movement between the ball hold spacers 20, the ball hold spacers 20 and the balls 7 freely change direction three-dimensionally, thus enabling complicated movement such as that required by the ball screw 30 of the second embodiment. Such flexible and twisting action of the thin bent section 21 and the mutual pivotal movement between the ball hold spacers are also achieved by the ball hold spacer 9 of the first embodiment shown in FIGS. 1 through 4.

[0050] When the thin bent section 21 is bent, there can be formed a clearance between the ball 7 and the thick hold sections 22a and 22b. Lubricant enters the clearance, thus sufficiently lubricating the balls 7.

[0051] In the embodiment relating to the ball screw 30, the balls 7 that are rolling over the ball travel channel 31a of the screw shaft 31 are raised through use of the return pipe 36 and returned to a position spaced several pitches away from the position where the balls 7 have been raised. As shown in FIGS. 12 through 14, in another conceivable configuration, a deflector 61 for raising the balls 7 is provided on the nut member 32. The balls 7 which are rolling over the ball travel channel 31a of the screw shaft 31 are departed from the ball travel channel 31a by the deflector 61. The thus-departed balls 7 run beyond the outer diameter section of the screw shaft 31 and go back to the ball travel channel 31a by a lead angle. Although not illustrated in the drawing, there may also be employed a ball screw of so-called side cover type. Specifically, the nut member 32 comprises a nut body having formed therein a ball travel channel 32a and side covers attached to the respective ends of the nut body. The ball travel channel 32a and a communication channel interconnecting the return channels are formed in each of the side covers.

[0052] The ball screw equipped with the deflector 61 will now be described in detail by reference to FIGS. 12 through 14. As shown in FIGS. 13 through 14, a substantially S-shaped ball return channel 61a is formed in the deflector 61, and a guide channel 61b for guiding the thin bent section 21 of the ball hold spacer 20 is longitudinally formed in the center of the ball return channel 61a. In order to enable the balls 7 which have entered the ball return channel 61a to go beyond the outer circumference of the screw shaft 31, the ball return channel 61a has the deepest recess that is formed at the longitudinal center of the deflector 61.

[0053] In the ball screw of the present embodiment, when relative rotation arises between the screw shaft 31 and the nut member 32, the balls 7 and the ball hold spacers 20 are circulated through the ball circulation path defined in the nut member 32. Next will be described in detail the configuration of the ball circulation path and the balls 7 and the ball hold spacers 20, which are circulated in the ball circulation path.

[0054] Although the ball circulation path is formed in a substantially annular pattern so as to surround the screw shaft 31, the portion of the screw shaft 31 where the deflector 61 is provided bulges outwardly with respect to the radial direction of the screw shaft 31. In FIG. 13, reference symbol R1 designates the radius of a circular path along which the center of the ball 7 moves during the course of the ball 7 rolling over the ball travel channel 31a of the screw shaft 31a; and R2 designates the radius of a circular path along which the center of the ball 7 moves during the course of the ball 7 passing through a circular-arc section bulged by the deflector 61.

[0055] When passing through the ball return channel 61a of the deflector 61 in conjunction with the ball 7, the ball hold spacer 20 goes beyond the outer diameter of the screw shaft 31 along the portion of the ball circulation path which bulges in a radially outward direction. The ball hold spacer 20 travels along an S-shaped zigzag path along the ball return channel 61a and goes back to the ball travel channel 31a by only a lead angle (designated by reference symbol R shown in FIG. 14) with respect to the axial direction of the screw shaft 31. As a result, the ball 7 and the ball hold spacer 20 go back to the ball travel channel 31a by one turn and are circulated around the screw shaft 31.

[0056] In FIG. 13, since the ball hold spacers 20 are mutually pivotable, the ball hold spacers 20 travel so as to well follow the balls 7 when the balls 7 roll such that their centers travel from radius R1 to radius R2. The thin bent section 21 of the ball hold spacer 20 is flexibly bent in the thicknesswise direction. Even in a case where the ball hold spacer 20 is guided along the S-shaped path within the deflector 61 shown in FIG. 14; that is, a case where the ball hold spacer 20 changes direction so as to have a point of inflection, the ball hold spacer 20 can smoothly pass the guide. As mentioned above, by means of free bent (and twisting action) of the thin bent section 21 and the mutual pivotal movement between the ball hold spacers 20, the ball hold spacers 20 and the balls can freely change direction three-dimensionally, thus enabling complicated movement such as that required in the present embodiment.

[0057] Even when the present invention is applied to the previously-described ball screw of side cover type, there is yielded the same advantage as that mentioned above.

[0058] The ball hold spacers 9 and 20 of the present invention can not be limited to a rectilinearly-rolling guide apparatus or a ball screw but can be applied to a ball spline machine. The term "ball spline machine" refers to a machine comprising a spline shaft serving as a track member and an outer casing which serves as a slide member and is movably attached to the spline shaft by way of a plurality of balls. Although in the previous embodiments balls are used as rolling elements, rollers can also be employed.

[0059] As has been described above, the present invention provides a rolling-element hold spacer including: a thick hold section having spherical indents formed on both sides thereof, said thick hold sections being adapted to be interposed between rolling elements so that the spherical indents match the curved surface of the rolling elements; and thin bent sections for interconnecting only one thick hold section pair in which the rolling element is to be interposed.

[0060] Even in a case where a rolling-element circulation path requires three-dimensional change in direction, the thin bent section is flexibly deflected. Further, the rolling-element hold spacers which are adjacent to each other with a single rolling element interposed therebetween mutually perform pivotal movement around the rolling element, thereby enabling smooth circulation of the rolling elements. Clearance arises between the rolling element and the thick hold sections as a result of bent of the thin bent section. Lubricant enters the clearance, to thereby sufficiently lubricate the rolling elements. So long as the rolling-element hold spacer is placed every other the rolling elements, all the rolling elements are eventually held by the rolling-element hold spacers.

[0061] Consequently, the number of rolling-element hold spacers can be reduced to one-half the number of the rolling elements. More specifically, the number of rolling-element hold spacers to be inserted into the rolling-element circulation path is reduced, and the number of rolling elements can be increased correspondingly. As a result, the load-carrying capacity of a rectilinearly-movable apparatus employing the rolling-element hold spacers can be increased. Further, the thick hold sections of the rolling-element hold spacer hold the rolling element by way of the spherical indents, and hence a contact pressure developing between the rolling-element hold spacer and the rolling element can be diminished.

[0062] Accordingly, there can be prevented generation of a collision sound, which would arise during the circulation of the rolling elements, thus enabling smooth circulation of the rolling elements. The thin bent section interconnecting the thick hold sections has a strip shape and a uniform thickness in the traveling direction of the rolling-element hold spacer. So long as the width of a guide groove formed in the slide member for the purpose of guiding the thin bent section is set to be slightly greater than the thickness of the thin bent section, the rolling-element hold spacer is stably guided without involvement of a pitching problem, thus ensuring smooth circulation of the rolling elements.

Claims

1. A rolling-element hold spacer comprising:

   a thick hold section having spherical indents formed on both sides thereof, said thick hold sections being adapted to be interposed between rolling elements so that the spherical indents match the curved surface of the rolling elements; and
   thin bent sections for interconnecting only one thick hold section pair in which the rolling element is to be interposed.

2. The rolling-element hold spacer as defined in claim 1, wherein said thin bent sections are provided on both sides of the rolling element.

3. The rolling-element hold spacer as defined in claim 1, wherein said thin bent sections are disposed on only one side of the rolling element.

4. The rolling-element hold spacer as defined in claim 1, wherein said thick hold section is substantially circular.

5. The rolling-element hold spacer as defined in claim 1, wherein the outer diameter of said thick hold section is smaller than the diameter of the rolling element.

6. A rectilinearly-movable apparatus comprising:

a track shaft having rolling-element travel surfaces;

a slide member having load travel surfaces corresponding to the rolling-element travel surfaces and attached to said track shaft so as to freely perform movement relative thereto;

a plurality of rolling elements arranged and housed in the rolling-element travel circulation path and are circulated in association with the movement of said slide member relative to said track shaft; and

a plurality of rolling-element hold spacers, each of which rotatively holds each of the rolling elements;

wherein said rolling-element hold spacer comprises a thick hold section having spherical indents formed on both sides thereof, said thick hold sections being adapted to be interposed between rolling elements so that the spherical indents match the curved surface of the rolling elements; and thin bent sections for interconnecting only one thick hold section pair in which the rolling element is to be interposed.

FIG. 1

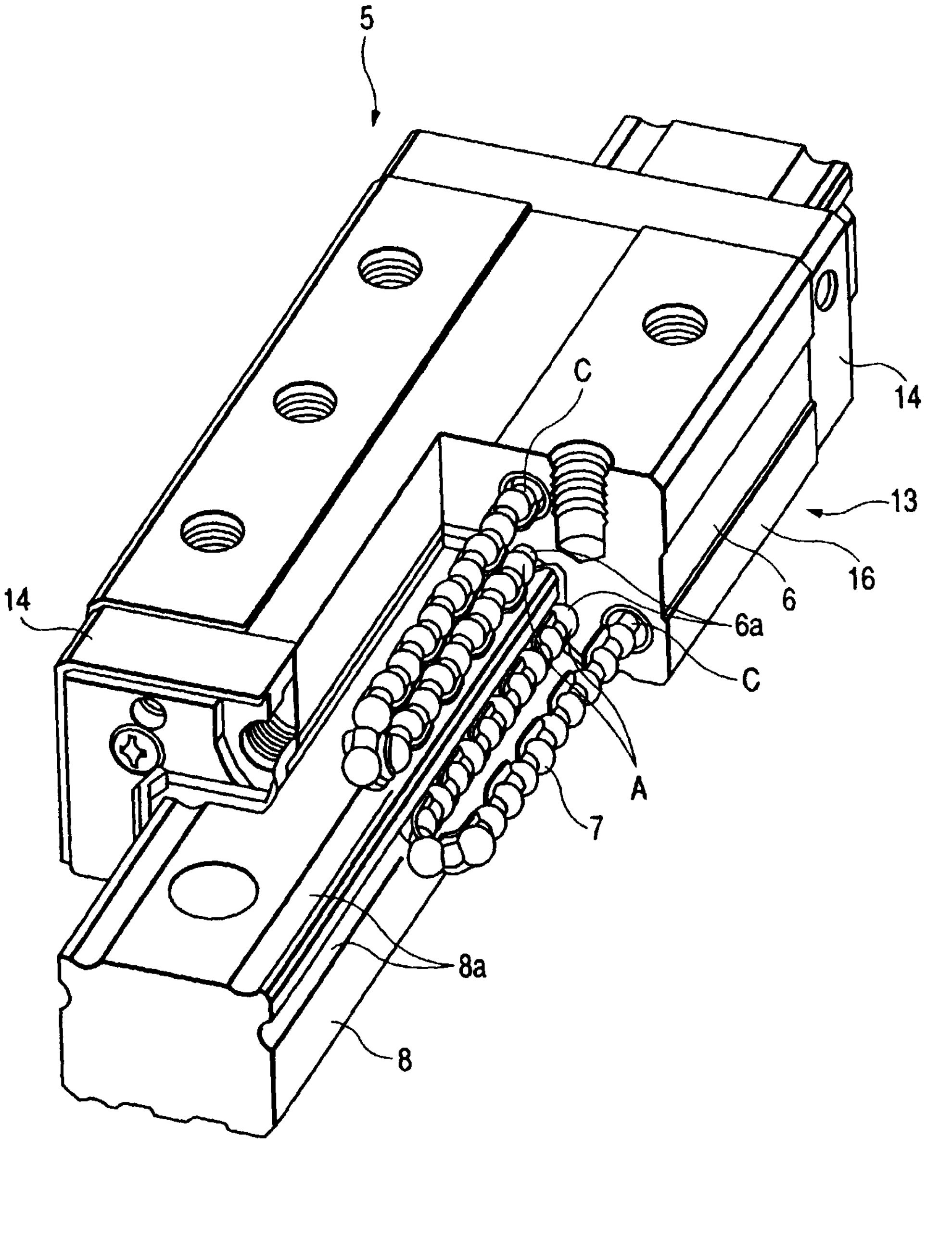


FIG. 2A

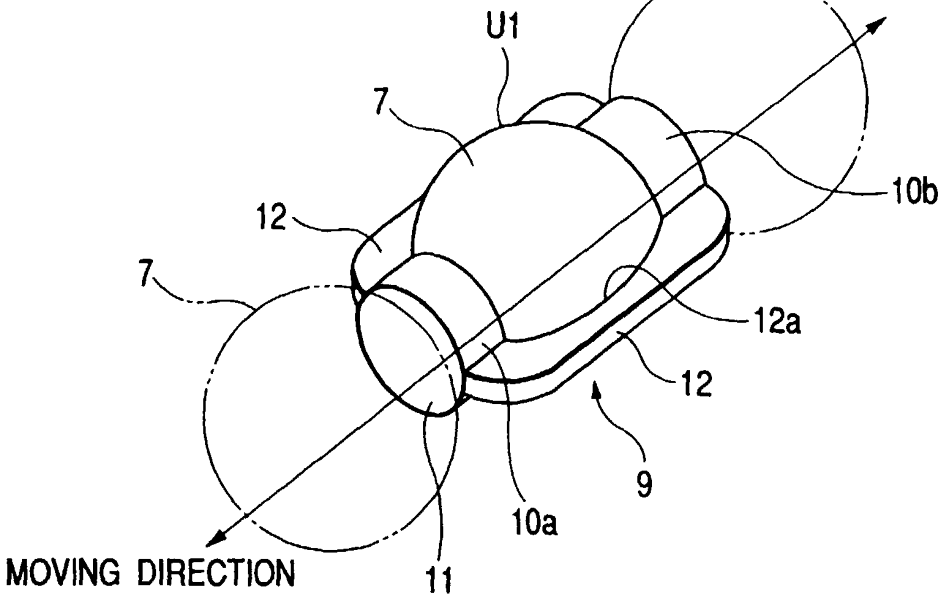


FIG. 2B

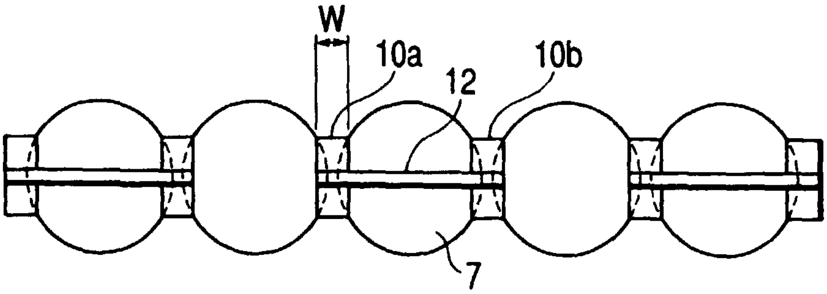


FIG. 2C

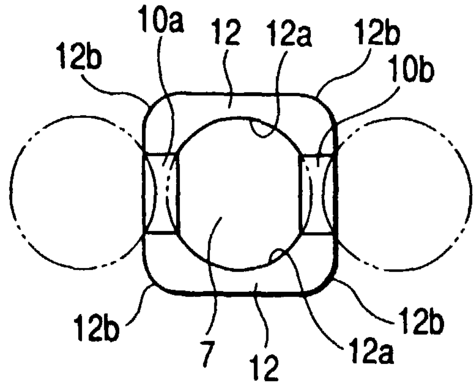


FIG. 3A

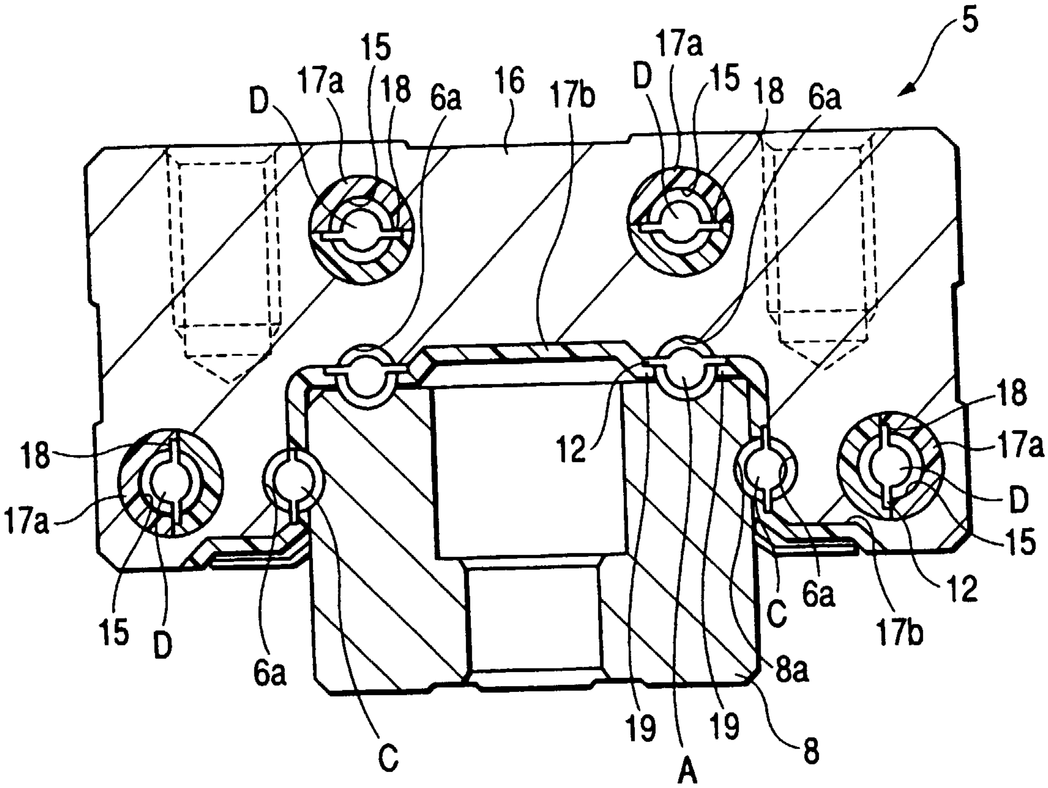


FIG. 3B

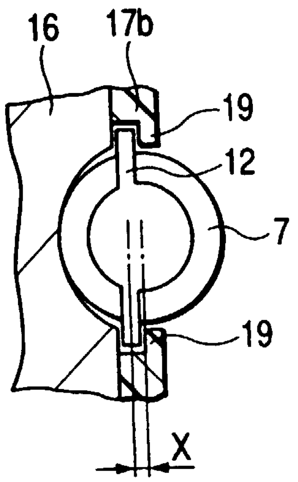


FIG. 3C

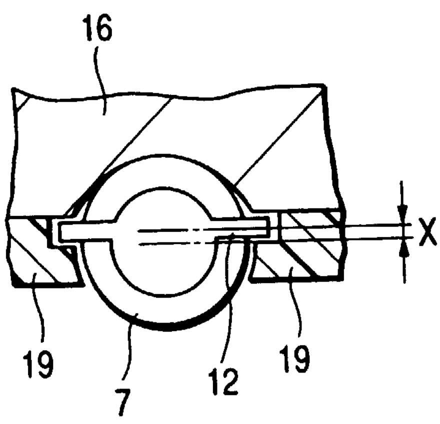


FIG. 4

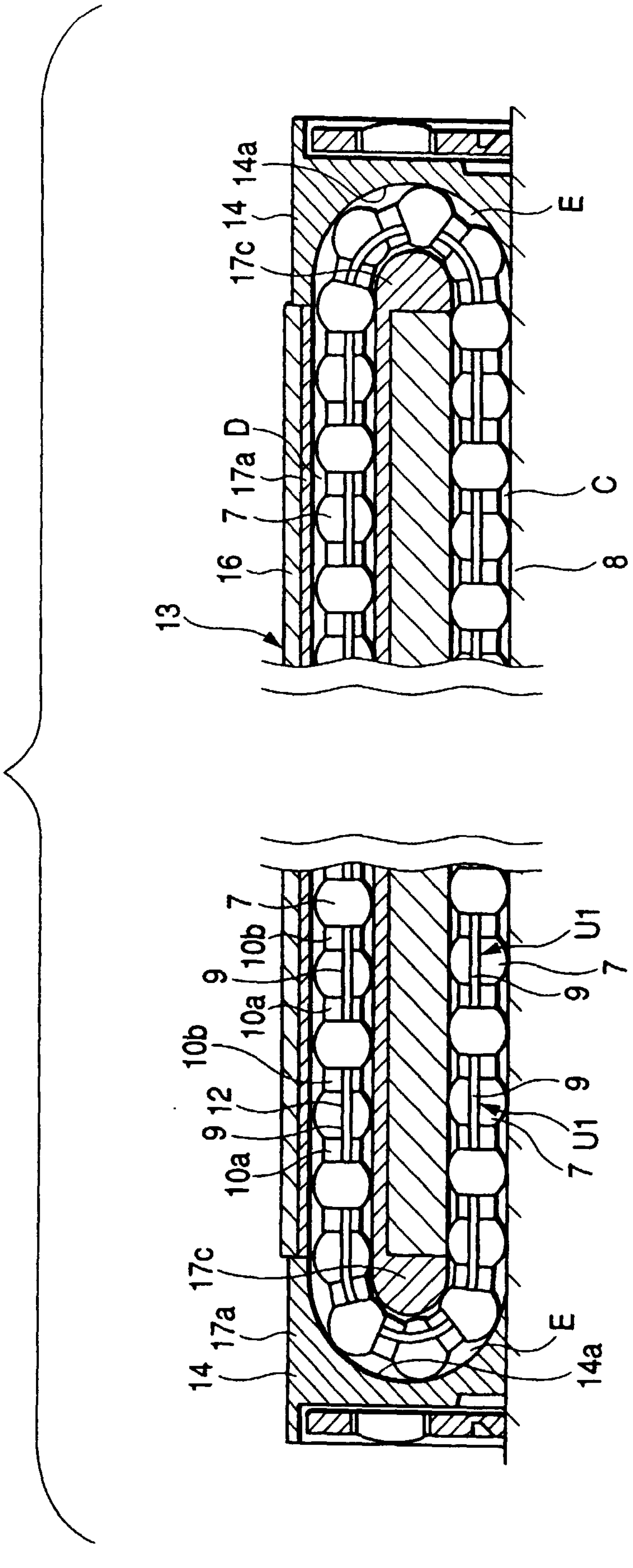

13
16
7
17a
D
17c
14
14a
E
C
8
14
17a
17c
10a
9
12
10b
10a
9
10b
7
E
14a
7
U1
9
9
7
U1

FIG. 5A

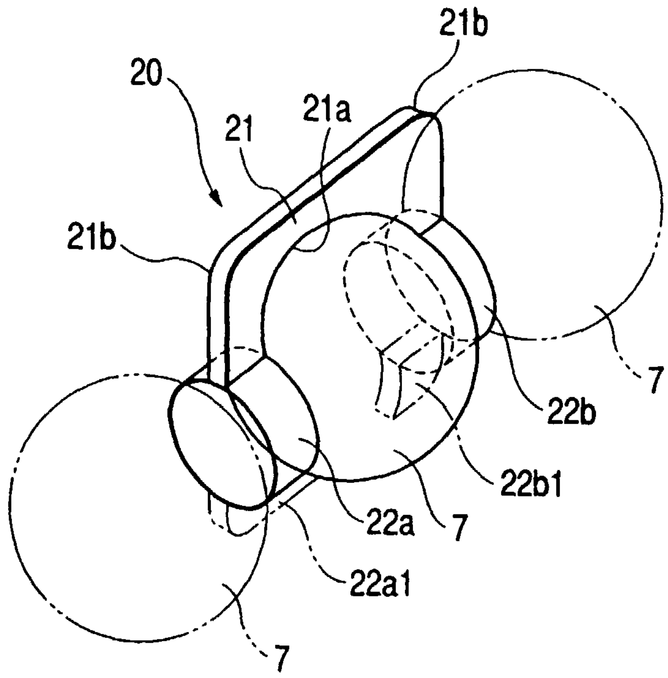

20
21
21a
21b
21b
7
22b
22b1
22a
7
22a1
7

FIG. 5B

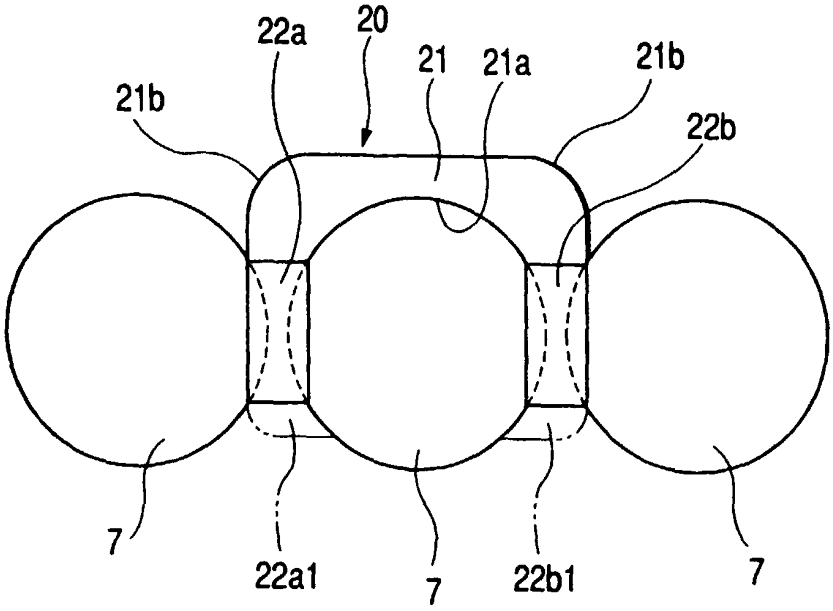

22a
20
21
21a
21b
21b
22b
7
22a1
7
22b1
7

FIG. 6A

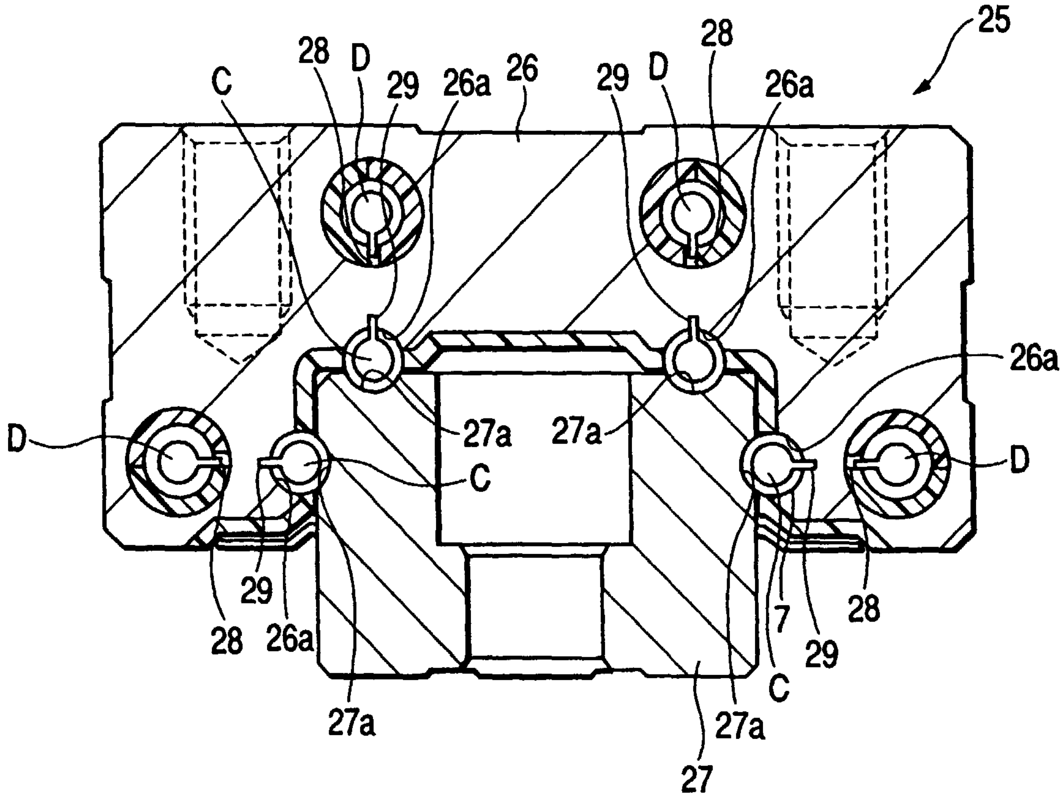


FIG. 6B

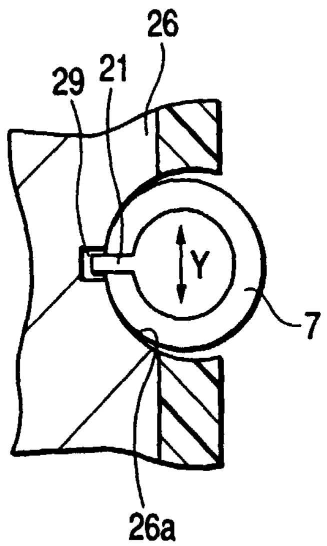


FIG. 6C

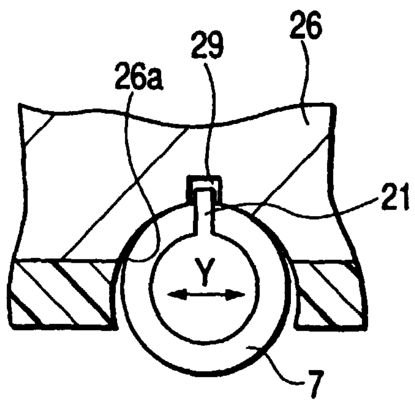


FIG. 7

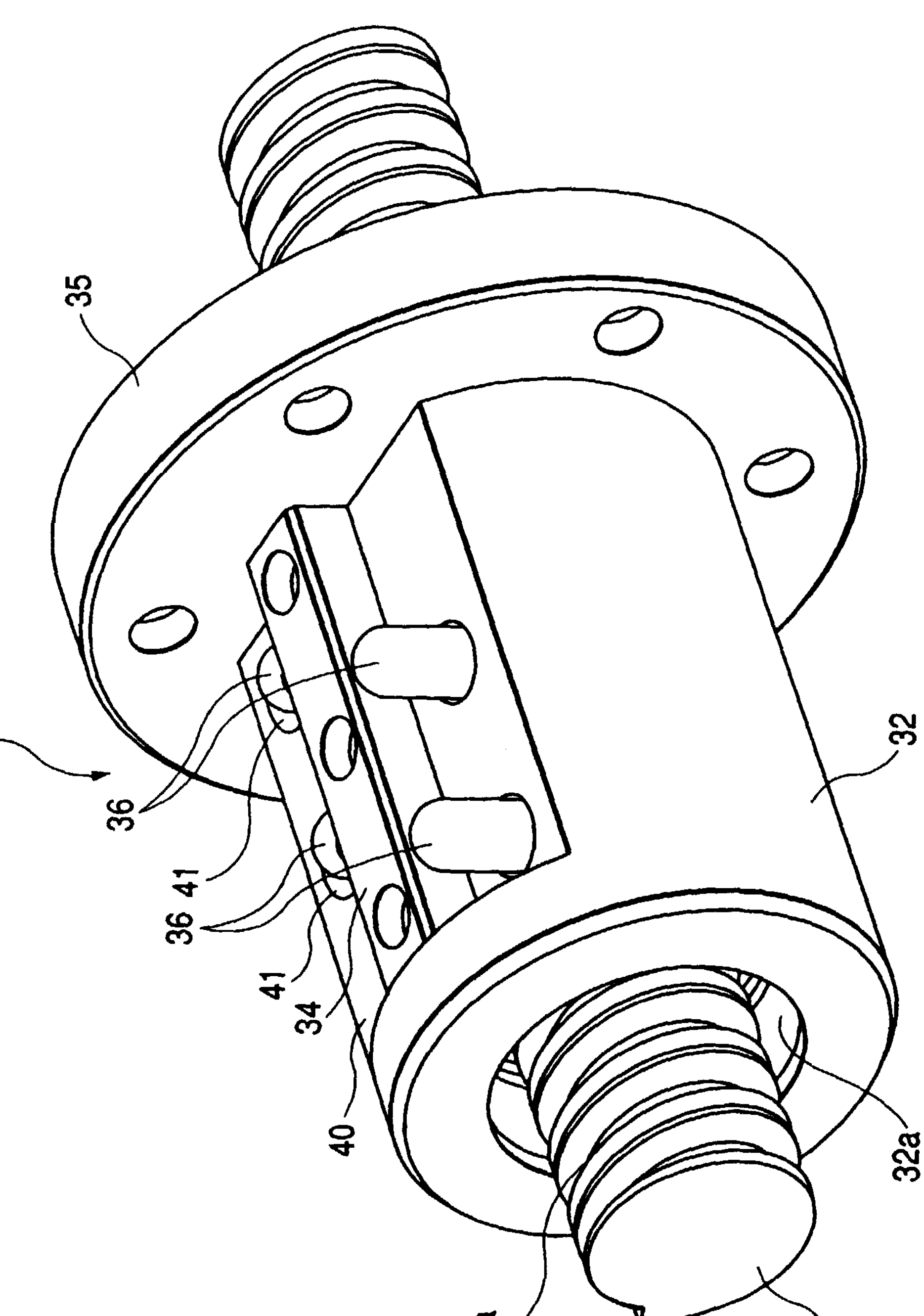


FIG. 8

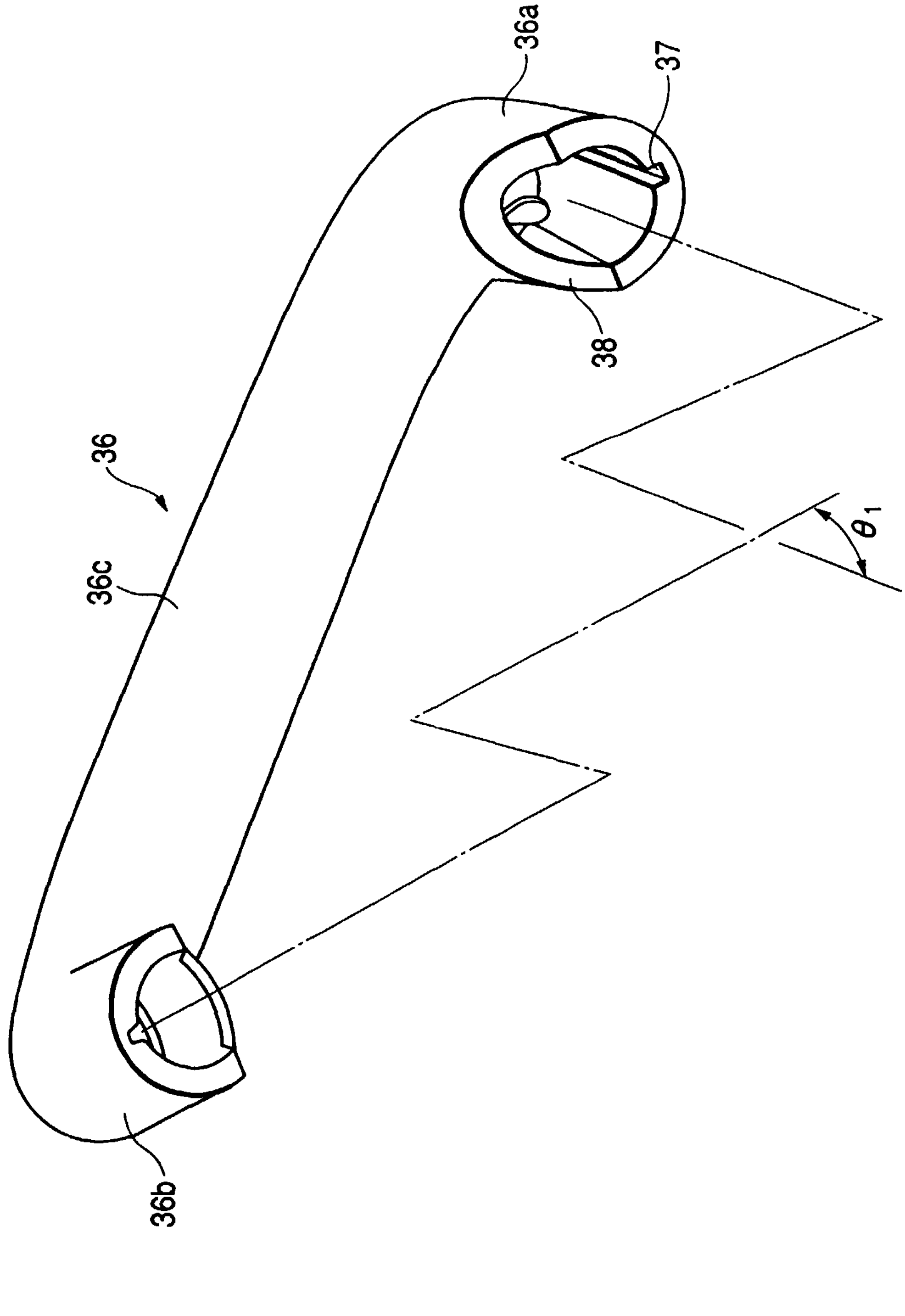


FIG. 9

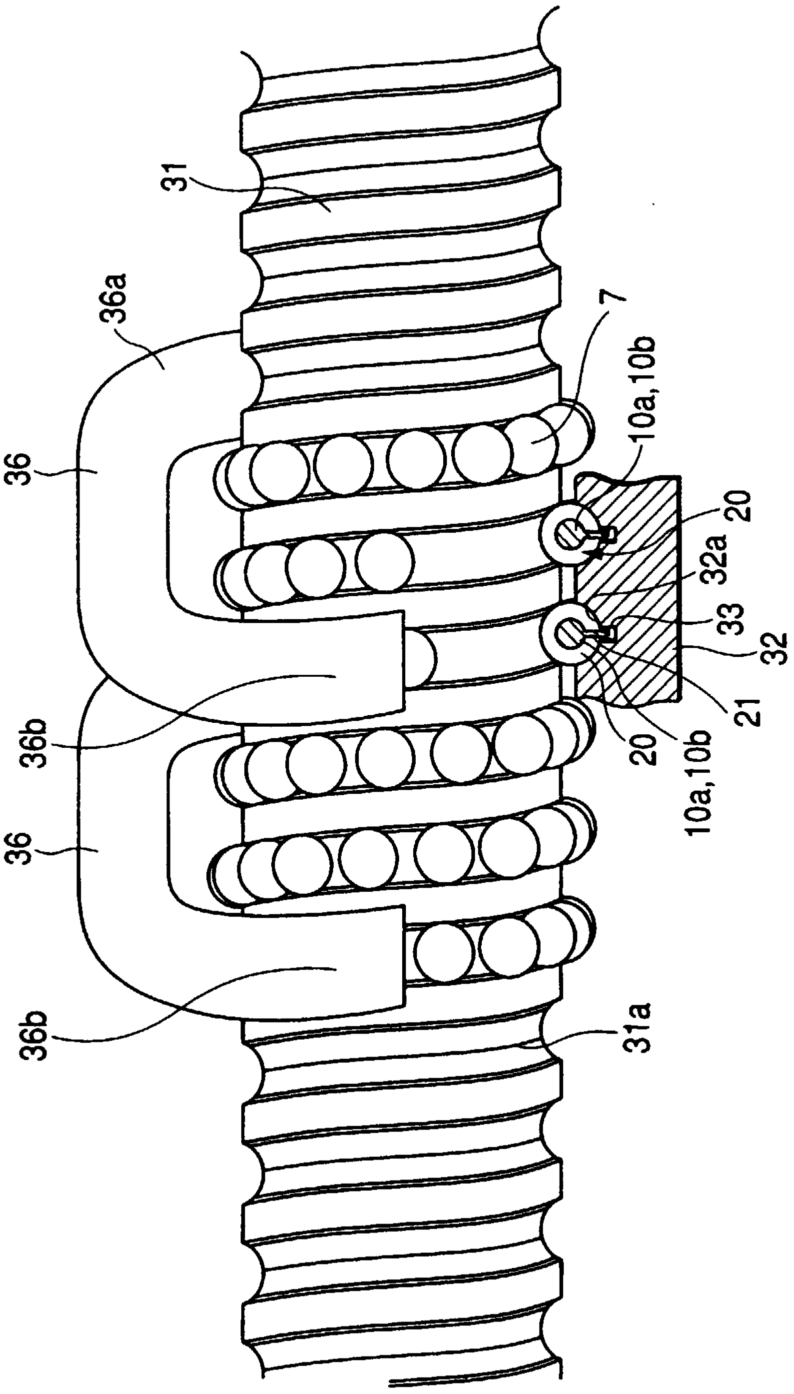


FIG. 10

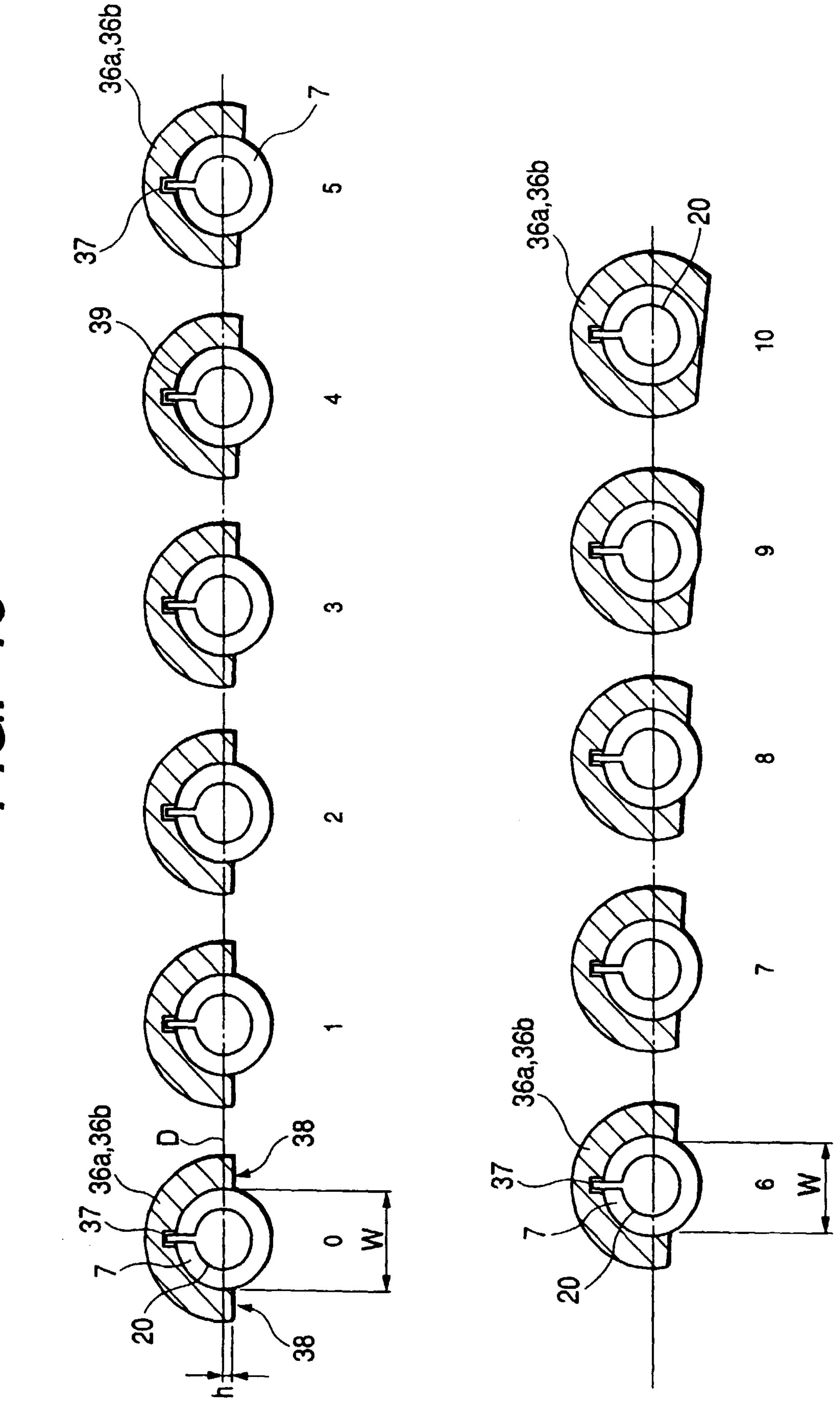


FIG. 11A

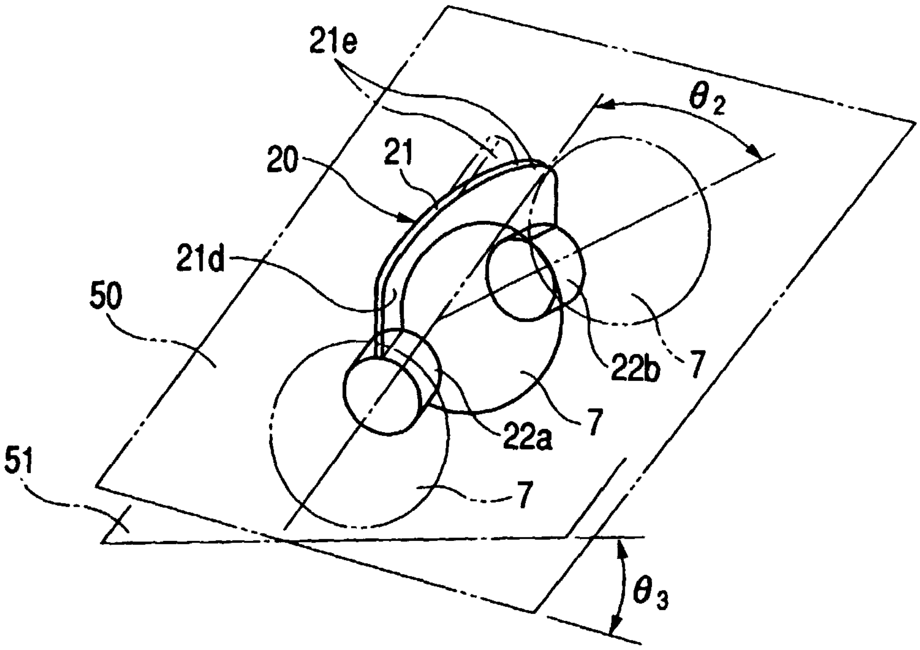


FIG. 11B

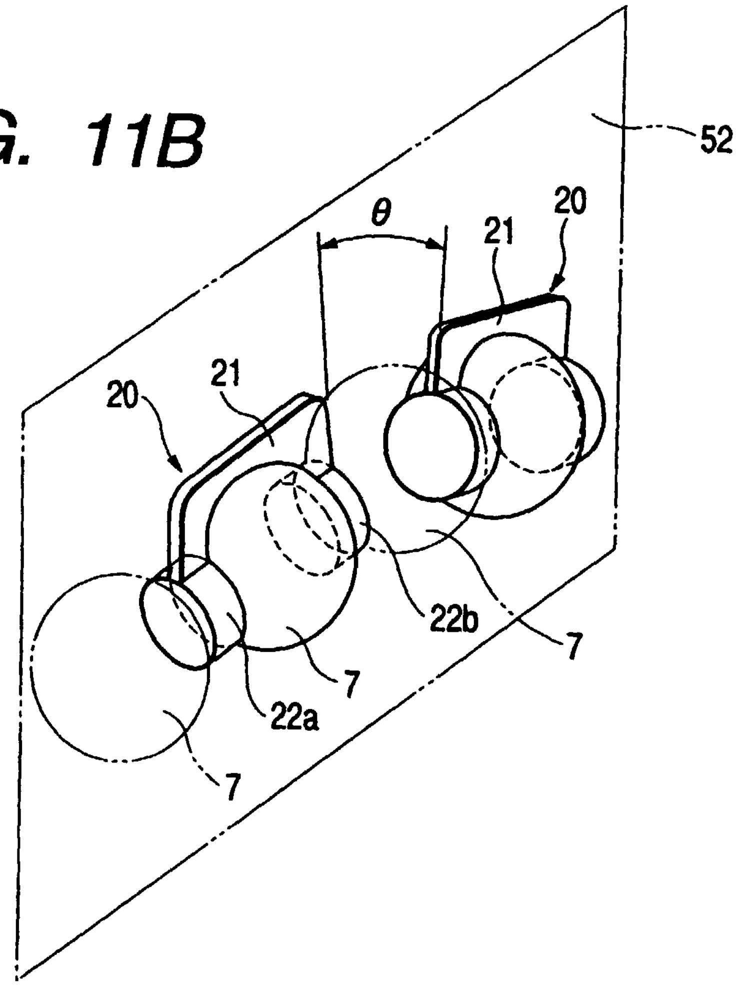


FIG. 12

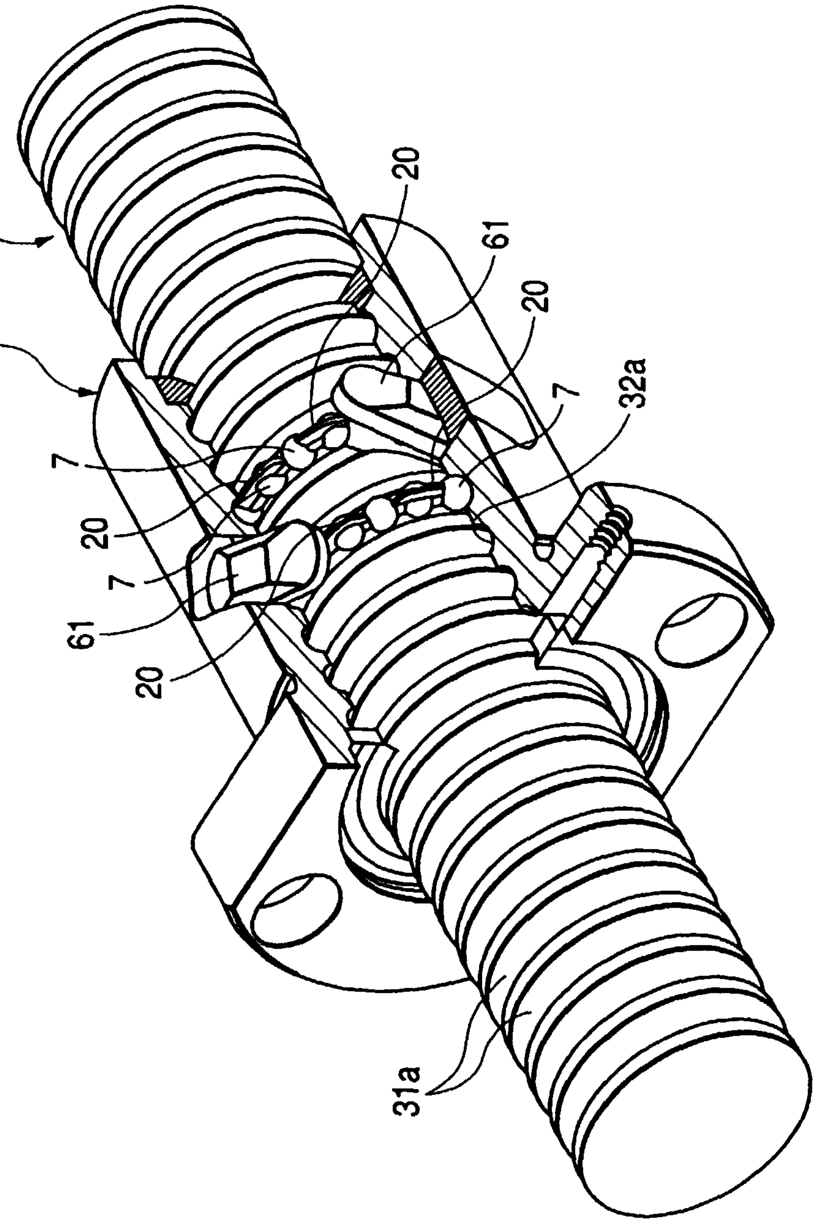
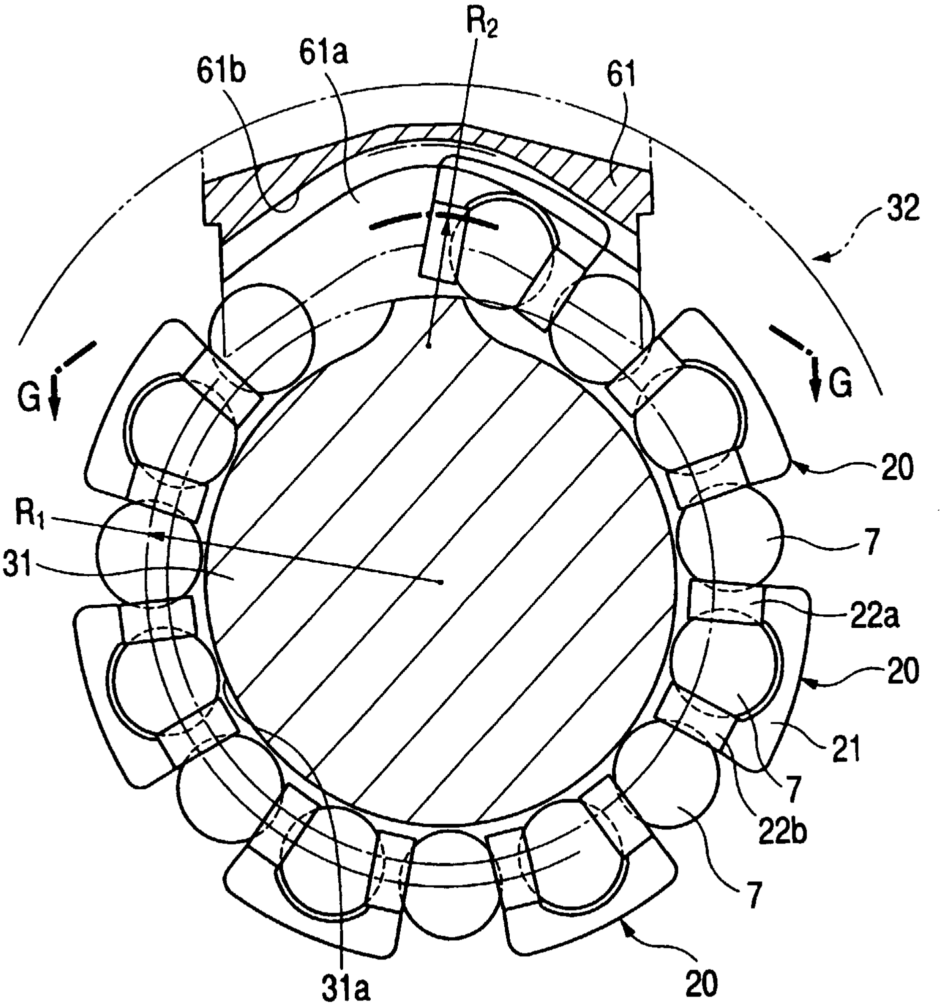
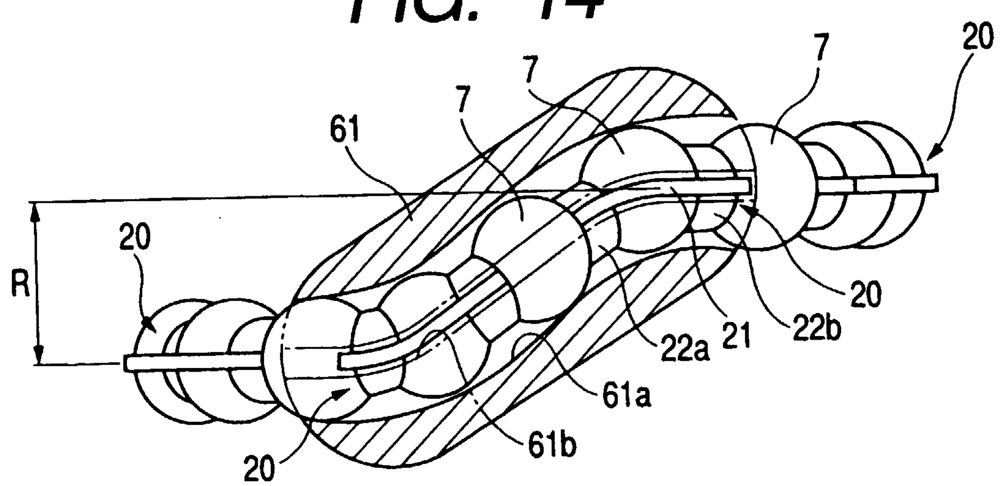


FIG. 13



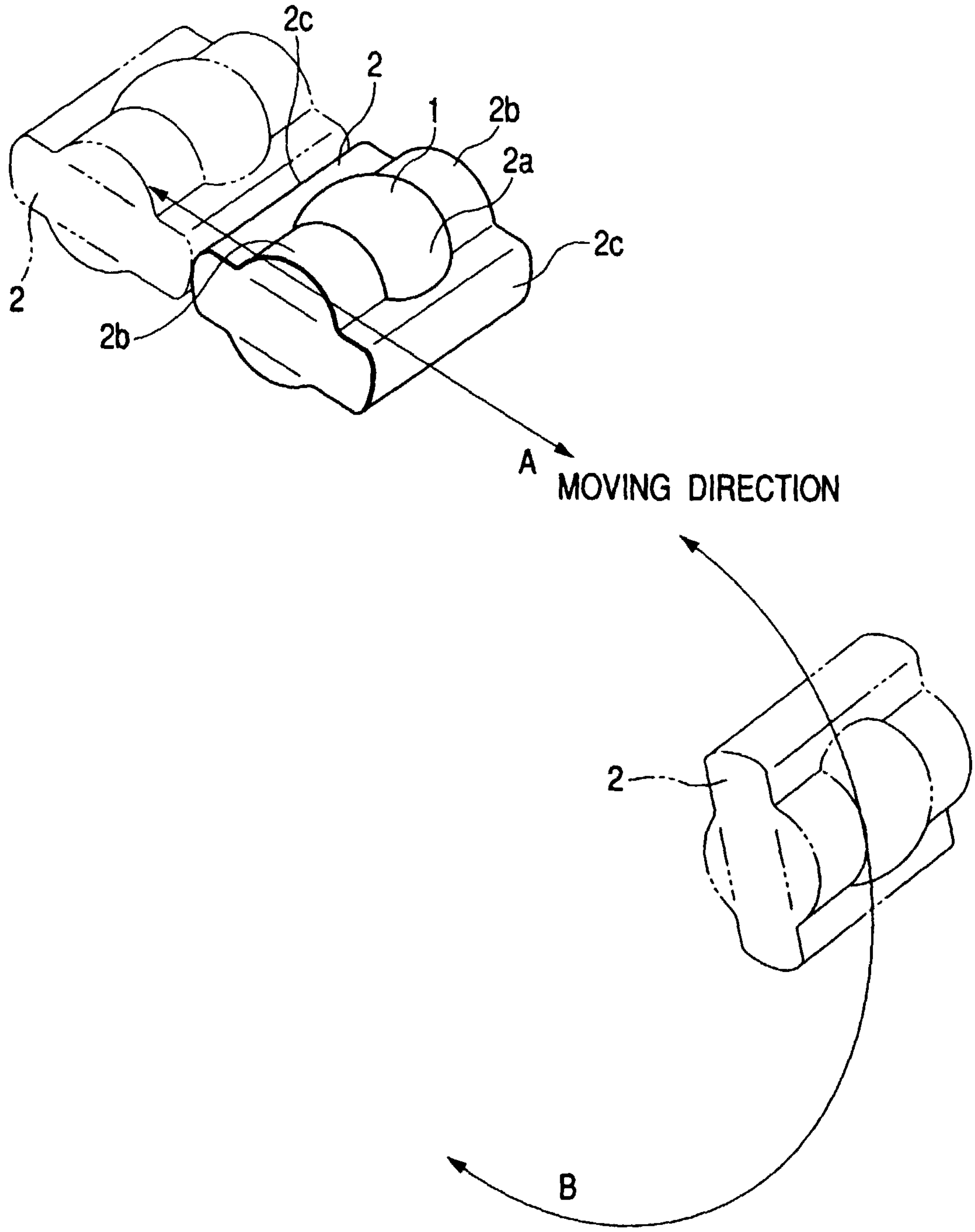
R2
61b
61a
61
32
G
G
20
7
R1
31
22a
20
21
7
22b
7
31a
20

FIG. 14



7
7
7
20
61
7
20
R
20
22a
21
22b
61a
20
61b

FIG. 15



PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification [6] :
F16C 41/04

A1

(11) International Publication Number: WO 95/25909

(43) International Publication Date: 28 September 1995 (28.09.95)

(21) International Application Number: PCT/US95/03586

(22) International Filing Date: 23 March 1995 (23.03.95)

(30) Priority Data:
08/216,428 23 March 1994 (23.03.94) US

(71)(72) Applicant and Inventor: HATTORI, Kenichi [JP/US]; 3472 Hill Street, Fairfax, VA 22030 (US).

(74) Agent: QUINTOS, Mel, R.; Armstrong, Westerman, Hattori, McLeland & Naughton, Suite 1000, 1725 K Street, N.W., Washington, DC 20006 (US).

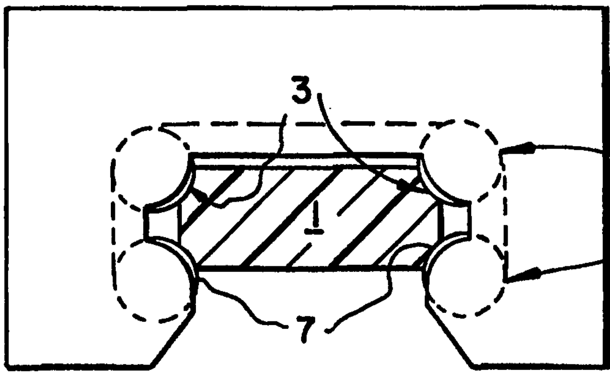
(81) Designated States: DE, GB, JP, KR, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: A RETAINERLESS LINEAR MOTION BEARING

(57) Abstract

A ball holder (1) for a retainerless saddle (6) having an elongated shaft (2) and a plurality of contact surfaces (3) therearound to hold steel balls (7) in cooperation with a bearing body (4) only when the saddle (6) is withdrawn from a rail (R). The shaft can be made of a hollow tube (41) or a pair of cantilever projections (52 or 62) so that the size of its cross-sectional area can be adjusted. Due to this adjustability, the size of the raceways can also be adjusted to enable to reassemble the steel balls (7) into the saddle (6) at a working site.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**GB**	United Kingdom	**MR**	Mauritania
AU	Australia	**GE**	Georgia	**MW**	Malawi
BB	Barbados	**GN**	Guinea	**NE**	Niger
BE	Belgium	**GR**	Greece	**NL**	Netherlands
BF	Burkina Faso	**HU**	Hungary	**NO**	Norway
BG	Bulgaria	**IE**	Ireland	**NZ**	New Zealand
BJ	Benin	**IT**	Italy	**PL**	Poland
BR	Brazil	**JP**	Japan	**PT**	Portugal
BY	Belarus	**KE**	Kenya	**RO**	Romania
CA	Canada	**KG**	Kyrgystan	**RU**	Russian Federation
CF	Central African Republic	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CG	Congo			**SE**	Sweden
CH	Switzerland	**KR**	Republic of Korea	**SI**	Slovenia
CI	Côte d'Ivoire	**KZ**	Kazakhstan	**SK**	Slovakia
CM	Cameroon	**LI**	Liechtenstein	**SN**	Senegal
CN	China	**LK**	Sri Lanka	**TD**	Chad
CS	Czechoslovakia	**LU**	Luxembourg	**TG**	Togo
CZ	Czech Republic	**LV**	Latvia	**TJ**	Tajikistan
DE	Germany	**MC**	Monaco	**TT**	Trinidad and Tobago
DK	Denmark	**MD**	Republic of Moldova	**UA**	Ukraine
ES	Spain	**MG**	Madagascar	**US**	United States of America
FI	Finland	**ML**	Mali	**UZ**	Uzbekistan
FR	France	**MN**	Mongolia	**VN**	Viet Nam
GA	Gabon				

Title of the Invention

A Retainerless Linear Motion Bearing

Background of the Invention

A conventional linear motion bearing shown in USP 4,253,709 has a large rigidity and can sustain a heavy load at a high speed with a high accuracy. Due to those excellent properties, it has been widely used especially in a field of machine tools.

One of the main features of the linear motion bearing is that it can provide a preload in the steel balls since the diameter of the steel ball is slightly larger than that of the raceway formed between the complementary grooves of the bearing body and the rail. Due to the preload, the assembled rigidity of the structure becomes larger which, in turn, enables to attain high accuracy.

On the other hand, one of the shortcomings of the linear motion bearing is in the usage of a retainer which holds or maintains the steel balls from falling off from the bearing body when it is withdrawn out of the rail.

The shape of the retainer can be either a plate structure as shown in Figure 8 in USP 4,253,709 or a piano wire-like structure extending along the grooves as shown in USP 4,929,095.

These retainers are attached either to the bearing body or to the end caps. Because of this, the structure of the linear motion bearing becomes more complicated and more difficult to assemble a saddle from bearing body with steel balls by an automatic process.

Further, if the retainer dislocates its position, it may contact the steel balls and increases the friction. The retainer will be damaged or destroyed eventually. It also increases the cost of the linear motion bearing.

Another problem of the retainer lies in that the size of the radius of the curvature of the groove is inevitably limited due to existence of the retainer in the narrow raceway and so is the load rating.

It is well known that the retainer loses its function and becomes useless once the saddle is fit onto the rail since the steel balls are held solely by the complementary grooves.

Nevertheless, there must be a retainer since if the retainer is eliminated from the linear motion bearing, there is no way to maintain the steel balls within the bearing body of the saddle when it is withdrawn from the rail.

Yet another problem is how to fit the saddle onto the rail while maintaining the loose steel balls.

Summary of the Invention

This invention is directed to a retainer-less linear motion bearing in which a retainer is completely eliminated from a bearing body. Instead, a ball holder independent of the bearing body, or a saddle, is used only when the saddle is withdrawn from the rail to retain the steel balls within the bearing body so as to prevent them from falling off when it is withdrawn from the rail.

This invention is also directed to a method for automatically assembling a complete saddle from a bearing body, end caps, steel balls and a ball holder.

Another object of the invention is to provide an adjustable ball holder which enables to reassemble the saddle at a working site without using any special devices.

Brief Description of the Drawings

Figure 1 illustrates a cross-sectional view of a saddle 6 with a ball holder 1 of the present invention.

Figure 2 illustrates a perspective view of saddle 6.

Figure 3 illustrates a perspective view of ball holder 1.

Figure 4 illustrates a method to assemble saddle 6 onto rail R.

Figure 5 illustrates a cross-sectional view of retainer-less linear bearing along X-X in Figure 4.

Figure 6 illustrates a perspective view of ball holder 1′ made of rubber.

Figure 7 illustrates a process to automatically assemble a saddle 6 from bearing body 4, end caps 5, 5, steel balls 7..., and ball holder 1.

Figure 8 illustrates a ball holder 11 provided with end plate 15.

Figure 9 illustrates a detachable end plate 12.

Figure 10 illustrates a ball holder 11′ with a friction plate 14′.

Figure 11 illustrates a ball holder 11" with an end plate 15" and a step portion 14".

Figure 12 illustrates an adjustable ball holder 21.

Figure 13 illustrates the unassembled state of adjustable ball holder 21.

Figure 14 illustrates a contracted state of adjustable ball holder 21.

Figure 15 illustrates a stop cover 28 for adjustable ball holder 21.

Figure 16 illustrates second shaft 22′ having fit plate 14′.

Figure 17 illustrates adjustable ball holder 21" having tapered recess 24" and tapered projection 25".

Figure 18 illustrates adjustable tubular ball holder 33 having a slit 35.

Figure 19 illustrates adjustable tubular ball holder 43 made of a metal.

Figure 20 illustrates adjustable tubular ball holder 43′ having slits 46.

Figure 21 illustrates a state when adjustable tubular ball holder 33 is placed within bearing body 4.

Figure 22 illustrates insertion member 40 for adjustable tubular ball holder 33.

Figure 23 illustrates insertion member 42 having recess 43 for adjustable ball holder 33 or 53 or 65.

Figure 24 illustrates adjustable ball holder 53 having end plate 55.

Figure 25 illustrates adjustable ball holder 53 having fit plate 65.

Figure 26 illustrates another insertion member 70 with tapered recess 73.

Figure 27 illustrates short insertion member 80 with recess 83.

Description of the Preferred Embodiments

The first embodiment is directed to a ball holder 1 in which the raceway space formed by bearing body 4 and ball holder 1 is not adjustable.

Figure 1 illustrates a cross-sectional view of a retainerless saddle 6 with a ball holder 1 according to this invention. Figure 2 shows a perspective view of saddle 6. Figure 3 shows a perspective view of ball holder 1. The cross-section of ball holder 1 is almost identical to that of track shaft part T, which is a top part of the rail R as shown in Figures 4 and 5. Ball holder 1 is formed by elongated shaft 2 and a plurality of grooves 3... at about four corners of elongated shaft 2. The number of the grooves 3... can be two or more depending upon that of track shaft part T or that of saddle 6.

The material of shaft 2 is preferably an elastic one such as soft plastic as shown in Figure 3.

When saddle 6 is withdrawn from rail R, steel balls 7 are maintained by ball holder 1. The diameter of the raceway formed by a complementary groove 8 of bearing body 4 and a complementary grooves 3 of ball holder 1 is slightly smaller than that of a steel ball 7. Therefore, the grooves 3... of ball holder 1 are slightly compressed by steel balls 7... such that ball holder 1 is press fitted within saddle 6.

Also, since ball holder 1 is smaller than the cavity within bearing body 4 of saddle 6, in storing a plurality of saddles 6... each having ball holder 1 therein, they can be placed one upon another. Thus, the storage of a plurality of saddles 6... is very convenient and occupies less space according to this invention.

As shown in Figure 4, in order to assemble saddle 6 onto rail R, saddle 6 is held by one hand of an operator while fitting the inner opening of end cap 5 onto track shaft part T of rail R and is moved toward rail R. As saddle 6 moves leftward in Figure 4, steel balls 7... are successively held within the raceways between the complementary grooves 8... of saddle 6 and those of rail R, thus are preloaded since the diameter of each raceway is smaller than that of steel ball 7. Eventually ball holder 1 is completely removed from saddle 6 since it is stopped by the end surface of track shaft part T.

Thus, steel balls 7... are maintained between rail R and bearing body 4 without a retainer as shown in Figure 5.

In order to remove saddle 6 from rail R, ball holder 1 is first positioned at the end surface of track shaft part T. Then saddle 6 is moved rightward in Figure 4 from rail R over ball holder 1 such that steel balls 7... are successively held between the complementary grooves of saddle 6 and ball holder 1.

If shaft 2 is made of a material with a plenty of elasticity such as rubber, grooves 3 may be eliminated and instead they can be flat surfaces 3′ as shown in Figure 6.

Also shaft 2 can be made of a transparent material such that the steel balls 7 can be observed through the transparent body of shaft 2.

The length of ball holder 1 is at least the same to that of bearing body 4 or longer.

Figure 7 illustrates the process for assembling saddle 6 from bearing body 4, end caps 5, steel balls 7... and ball holder 1.

The process proceeds as follows:

Step 1. End cap 5 is attached at one end, preferably at a bottom end, of bearing body 4. Then it is fed, with, preferably, the attached end cap facing downward and an open end of bearing body 4 facing upward.

Step 2. Raceway Spacer A is inserted into the open cavity within bearing body 4 by Raceway Spacer Moving Device B. Raceway Spacer A is provided with a plurality of grooves 30... each corresponding to each of grooves 8... of bearing body 4. The diameter of each raceway space 9 formed by complementary grooves 30 and 8 is same or slightly larger than that of steel ball 7.

Step 3. Steel balls 7 are fed into raceway spaces 9... and escape-ball through holes 10... Due to end cap 5 attached at the bottom of bearing body 4, steel balls 7... are easily fed by Ball Feed Device C into raceway spaces 9..., escape-ball through holes 10... and ball-recirculating grooves in end cap 5.

Step 4. Close top open end surface of bearing body 4 by a second end cap 5. It is preferable that ball-recirculating grooves in second end cap 5 are previously filled with steel balls 7... At this stage saddle 6 is formed by bearing body 4 and a pair of end caps 5, 5, Raceway Spacer A, and a plurality of steel balls 7..., however, there is no preload provided in any of steel balls 7... yet.

Step 5. Ball holder 1 is positioned at beneath of bottom end cap 5 and then saddle 6 is slid down onto ball holder 1. Since the material of ball holder 1 is much softer than that of steel balls 7 and of bearing body 4, ball holder 1 is slightly compressed without imparting much preload in steel balls 7... so that it is firmly maintained within saddle 6 by friction.

It is preferable that ball holder 11 is further provided with end plate 15 at its one end as shown in Figure 8 . End plate 15 has a peripheral configuration substantially identical to the overall configuration of end cap 5.

Shaft 2 of the ball holder 2 can be made longer than that of saddle 6 and be provided at both distal ends with detachable end plates 12, 12 as shown in Figure 9. Each of end plates 12, 12 has a shape substantially identical to the size of overall configuration of end cap 5 and is provided with a window 13 through which the distal end of shaft 2 fits with friction. Then the ball holder 1 can be maintained within saddle 6 with certainty since end plates 12, 12 holds saddle 6 therebetween.

One of end plates 12, 12 can be permanently fixed at a distal end of shaft 2.

Further, as shown in Figure 10, a fit plate 14′ can be provided at one end of shaft 2. Or step portion 14" can be provided between end plate 15" and shaft 20" as shown in Figure 11. Fit plate 14′ or step portion 14" abuts within the inner opening of end cap 5 in order to reinforce the frictional gripping. One advantage of the embodiments shown in Figure 10 and 11 is that it is easy to align the shaft with accuracy within the bearing body due to friction plate 14′ or step portion 14" such that it makes it easier to reassemble saddle 6, the steel balls 7... and ball holder 11′ after saddle 6 was accidentally removed from the rail R without using ball holder 11′ and steel balls 7... fell off to the ground.

Next embodiments shown in Figures 12 through 20 are directed to the ball holder capable to provide adjustable raceway spaces.

Figure 12 illustrates adjustable ball holder 21 composed of a pair of independent first and second shaft parts 22 and 23. First shaft part 22 is provided with a concave 24. Concave 24 is provided with a inclined bottom surface 28. On the other hand, second shaft 23 has inclined projection 25 which fits into concave 24. When first and second shaft 22 and 23 are assembled with both end surfaces flushing each other, they rest with a small clearance 26 therebetween and their combined end surfaces form a configuration substantially identical to that of track shaft part T of rail R.

As first and second shaft parts 22 and 23 are slightly dislocated from each other along their axial direction, clearance 26 is eliminated. Adjustable ball holder 21 of this contracted state is first inserted into the cavity of bearing body 4 and steel balls 7... are fed into enlarged raceway spaces 9.... Each of raceway spaces 9... formed by grooves 31... of adjustable ball holder 21 and grooves 8... of bearing body 4 is slightly larger than steel balls 7... so that filling of steel balls 7... is easily accomplished.

After all raceway spaces 9... and escape-ball through holes 10... and ball-recirculating grooves in end cap 5 are filled with steel balls 7..., another end cap 5 is fixed to cover the opening end of bearing body 4. Then first and second shaft parts 22 and 23 are axially slid until both end surfaces flush each other. The relative position of first and second shaft parts 22 and 23 is maintained by friction, or preferably by detachable screw 27. Alternatively, stop cover 28 as shown in Figure 15 can be used instead of screw 27.

Figure 16 shows another embodiment of second shaft 22′ provided with fit plate 14′ which fits into the inner opening of end cap 5.

Figure 17 shows still another embodiment of first and second shaft 22" and 23" in which concave 24′ and projection 25′ are both tapered in their cross-sections.

Figure 18 illustrates still further embodiment in which shaft 33 is somewhat tubular and has a cross-sectional configuration almost identical to that of track shaft part T of rail R except it has a cut opening 35 at its bottom formed by a pair of lips 34, 34. Provided at the four corners of ball holder 33 are grooves 35... substantially identical to those of track shaft part T of rail R.

Figures 19 and 20 show different embodiments of such ball holder which are here made of metal. In Figure 20, ball holder 43′ is provided with windows 46 which enable easy holding of the steel balls 7...

In each of those embodiments, the outer configuration of ball holder 33... is substantially identical to that of track shaft part T, however, becomes smaller when lips 34 and 34 are held to contact each other as shown in Figure 21 such that the diameter of each raceway space 9 formed therein becomes slightly larger than that of steel ball 7. After steel balls 7... are filled in the raceway spaces, lips 34 and 34 are released so that ball holder 33 springs back to its original shape and steel balls 7... are held between bearing body 4 and ball holder 33.

Figure 22 illustrates insertion member 40 to be inserted into clearance 35 between lips 34 and 34. Since the width of projection 41 of stop member 40 is slightly larger than clearance 35 between lips 34 and 34 after the steel balls 7... are filled, ball holder 33 is even more firmly held in saddle 6 when stop insertion 40 is inserted.

Further, insertion member 40 prevents ball holder 33 from being deformed due to the resistance from preloaded steel balls 7... when saddle 6 slides onto rail R and thus also prevents steel balls 7... from falling off due to the possible deformation.

Figure 23 illustrates another insertion member 42 having recess 43 and projection 44. Recess 43 works to hold lips 34 and 34 to contact each other.

Figure 24 illustrates another embodiment of adjustable ball holder 53 having end plate 55 and a pair of separated cantilever projections 52, 52 projecting therefrom.

The outer configuration of end plate 55 is substantially identical to that of end cap 5 or of bearing body 4. Therefore, when ball holder 53 is inserted into saddle 6, with the position of side plate 55 exactly coincides with end cap 5, the positions of separated cantilever projections 52 and 52 are also determined in the exact locations to provide the raceways 9... each slightly smaller than the diameter of steel balls 7...

Then the central clearance 57 between separated cantilever projections 52 and 52 is narrowed by holding lips 54 and 54 to contact each other in order to fill the steel balls 7... into the slightly widened raceways 9.... After completion of filling steel balls 7..., lips 54 and 54 are released so that separated cantilever projections 52 and 52 hold steel balls 7... against the grooves 8... of bearing body 4.

Figure 25 illustrates another embodiment of ball holder 63 provided with fit plate 65 which abuts with the inner opening of end cap 5 with friction. Also, cantilever projections 62, 62 are separated from fit plate 65 with clearance 66 such that cantilever projections 62 and 62 can be easily inclined.

Figure 26 illustrates insertion member 70 having a projection 71 and tapered recess 73. The outer cross-section of insertion member 70 is identical to the inner cross-section of the inner cavity between cantilever projections 52 and 52 or 62 and 62.

First, clearance 57 or 67 is narrowed by moving tapered recess 73 onto lips 54 and 54 or 64 and 64. After steel balls 7... are supplied, insertion member 70 is withdrawn from the lips. Then whole insertion member 70 is inserted into the inner cavity of cantilever projections 52 and 52 or 62 and 62 such that ball holder 53 or 63 hold steel balls 7... more firmly.

Figure 27 illustrates short insertion member 80 with recess 83. The length L of recess 83 is much shorter than the distance between the outer edges of the lips 54 and 54 or 64 and 64 in order to close clearance 57 or 67.

The width W of short insertion member 80 is slightly substantially identical to clearance 57 or 67. Thus when saddle 6 is assembled, short insertion member 80 is inserted into narrowed clearance 57 or 67 by steel balls 7... so as to push the cantilever projections outwardly.

What is claimed is:

1. A retainerless linear motion bearing assembly having a bearing body, a pair of end caps, a rail, and rows of steel balls; characterized in that said bearing body has a substantially C-shaped recess provided with a plurality number of grooves therein and same number of through holes in said bearing body; each of said pair of end caps is fixed at each end surface of said bearing body and provided with same number of ball-recirculating grooves; said rail is provided with same number of grooves positioned adjacent to said plurality number of grooves of said bearing body so as to form raceways such that said raceways, said ball-recirculating grooves and said through holes form same number of independent recirculating loop channels; each of said same number of rows of steel balls is placed within each of said independent recirculating loop channels; and a diameter of each of said balls is slightly larger than a diameter of each of said raceways such that said balls within said raceways are preloaded.

2. A ball holder for a retainerless saddle having a bearing body, a pair of end caps attached to said bearing body, an elongated shaft, and a plurality of contact surfaces; characterized in that said elongated shaft has an axial length at least equal to that of the bearing body; said plurality of contact surfaces is provided at the circumstantial surface of said elongated shaft along the axis thereof; each of said contact surfaces positioned adjacent to each of grooves provided within the bearing body such that each of said contact surfaces of said shaft and each of said grooves of the bearing body form an independent raceway, and the outer configuration of the cross-section of said ball holder is substantially identical to that of the cross-section of a track shaft part of a rail.

3. The ball holder of claim 2, characterized in that each of said contact surfaces has a groove.

4. The ball holder of claim 2, characterized in that each of said contact surfaces has a slit.

5. The ball holder of claim 3, characterized in that a material of the ball holder is an elastic member.

6. The ball holder of claim 4, characterized in that a material of the ball holder is a metal.

7. The ball holder of claim 2, characterized in that the diameter of said raceway is substantially identical to that of a steel ball.

8. The ball holder of claim 2, characterized in that the diameter of said raceway is slightly smaller than that of the steel ball.

9. The ball holder of claim 2, characterized in that said shaft is provided with an end plate at one distal end thereof, and that said end plate has an outer configuration substantially identical to the overall outer configuration of said end cap.

10. The ball holder of claim 2, characterized in that said shaft is provided with a fit plate at one distal end thereof, and that said fit plate has an outer configuration substantially identical to the inner peripheral configuration of an opening of said end cap.

11. The ball retainer of claim 10, characterized in that said fit plate is provided with an end plate.

12. The ball holder of claim 2, characterized in that said shaft is composed of a plurality of shaft parts.

13. The ball holder of claim 12, characterized in that said plurality of shaft parts are a pair of first and second shaft parts, and that said first and second shaft parts are engageable with each other.

14. The ball holder of claim 13, characterized in that said first shaft part is provided with an open recess and said second shaft part is provided with a projection, and that the cross-sectional configurations of said open recess and said second shaft are substantially identical.

15. The ball holder of claim 14, characterized in that said open recess has an inclined bottom surface, and that said projection has an inclined top surface.

16. The ball holder of claim 14, characterized in that each of said open recess and said projection has a tapered cross-section.

17. The ball holder of claim 14, characterized in that said first and second shaft parts are attached with a detachable screw.

18. The ball holder of claim 14, characterized in that said second shaft part has a fit plate.

19. The ball holder of claim 14, characterized in that said first and second shaft part are held by a stop member.

20. The ball holder of claim 2, characterized in that said shaft is a hollow tube having a pair of lips with a slit therebetween.

21. The ball holder of claim 20, characterized in that said shaft is made of a metal.

22. The ball holder of claim 21, characterized in that each of said contact surfaces is provided with a window.

23. The ball holder of claim 20, characterized in that said slit between the pair of lips have an insertion member inserted thereinto.

24. The ball holder of claim 12, characterized in that said plurality of shaft parts are a pair of cantilever projections connected at the root thereof.

25. The ball holder of claim 24, characterized in that each of said cantilever projections is provided with a lip.

26. The ball holder of claim 24, characterized in that a space between said lips accommodate therein an insertion member inserted therein.

27. The ball holder of claim 26, characterized in that said ball holder further has a recess.

28. The ball holder of claim 26, characterized in that said insertion member has a projection at one side and a recess at the other side, and that said insertion member has a cross-section substantially identical to a space between said cantilever projections and said lips.

29. The ball holder of claim 28, characterized in that the width of said recess is tapered.

30. The ball holder of claim 24, characterized in that at least said lips are directly connected to a common plate.

31. The ball holder of claim 30, characterized in that said common plate is an end plate having an outer configuration substantially identical to that of said end cap.

32. The ball holder of claim 30, characterized in that said common plate is a fit plate having an outer configuration substantially identical to the inner configuration of an open cavity of said end plate.

33. The ball holder of claim 30, characterized in that each of said cantilever projections is separated from said common plate.

34. A process for assembling a retainerless saddle for a linear motion bearing having a bearing body, steel balls, a pair of end caps and a ball holder; characterized in that said assembling process attaches one of said end caps at one end surface of said bearing body; provides raceways within said bearing body, the diameter of the raceway being slightly larger than that of the steel ball; feeds said steel balls into said raceways and escape-ball through holes in said bearing body; covers an open end of said bearing body by the other end cap so as to form a saddle; and holds said balls between said saddle and said ball holder.

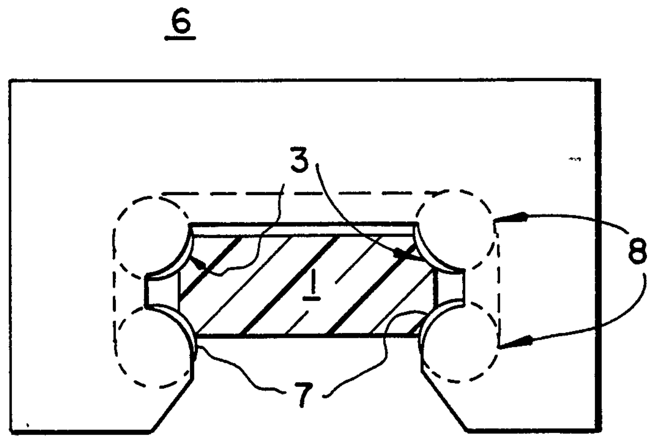


FIG. 1

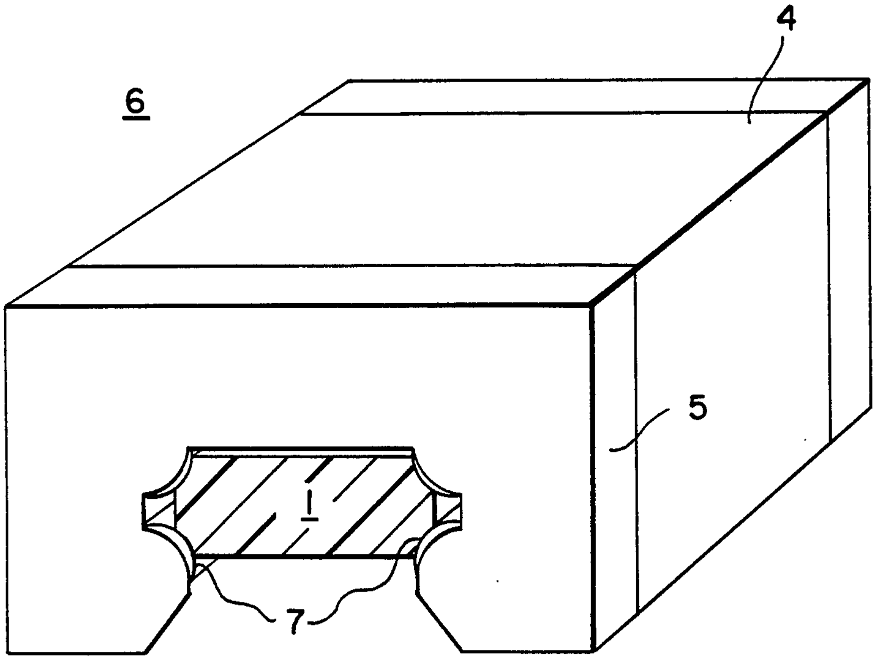


FIG. 2

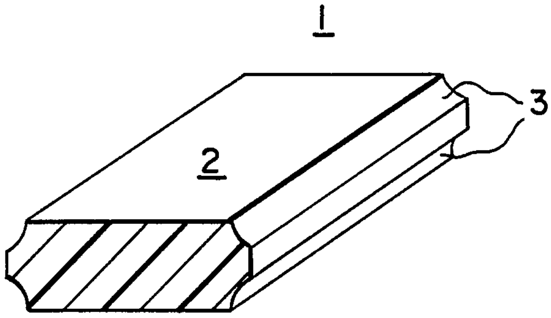


FIG. 3

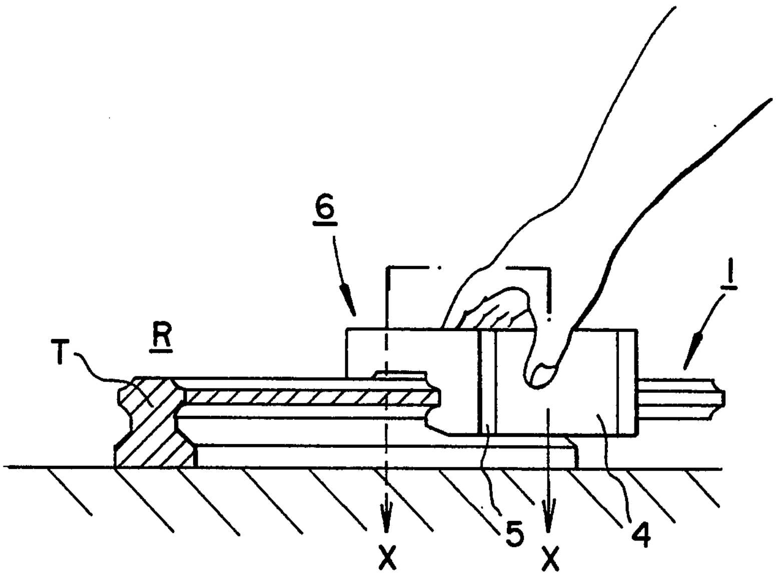


FIG. 4

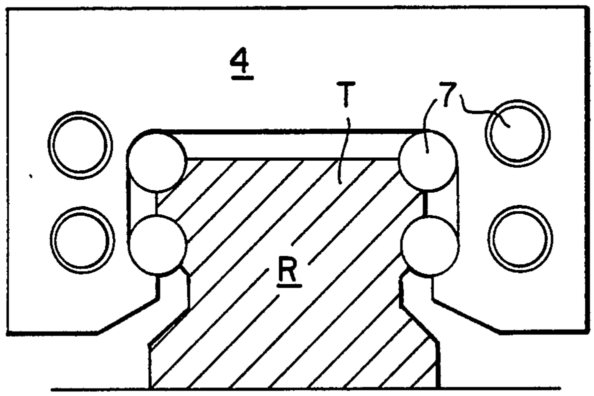


FIG. 5

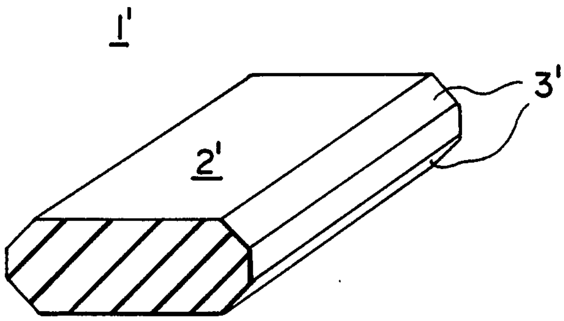


FIG. 6

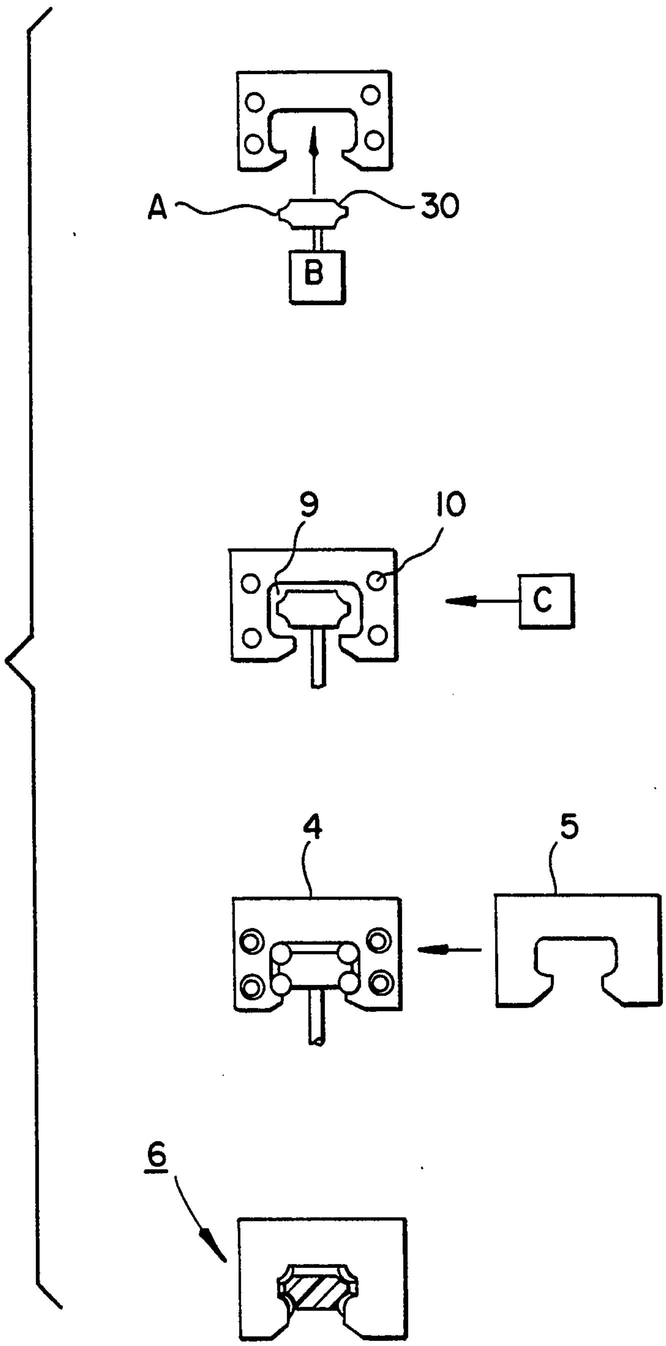


FIG. 7

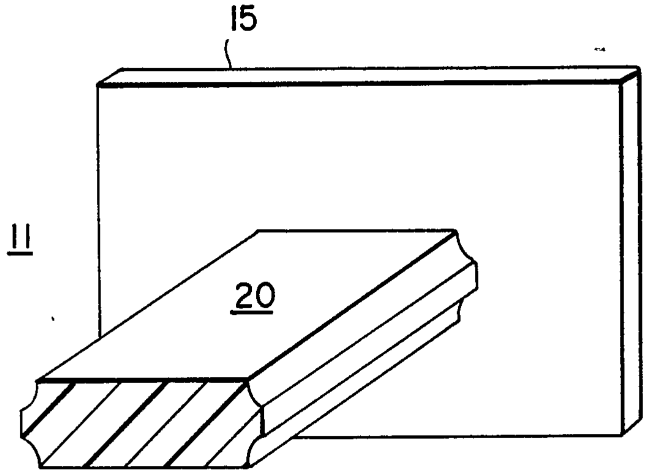


FIG. 8

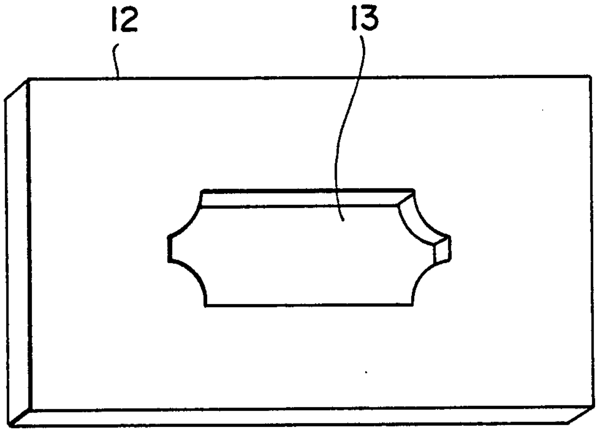


FIG. 9

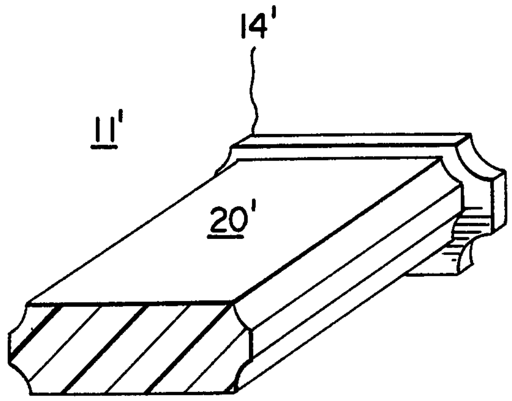


FIG. 10

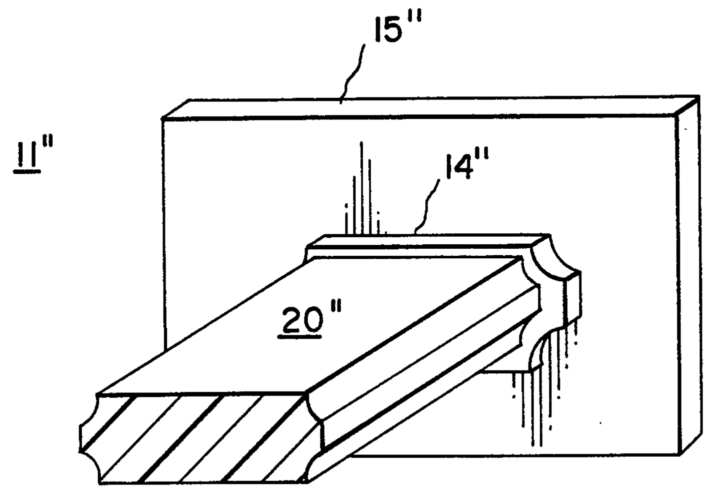


FIG. 11

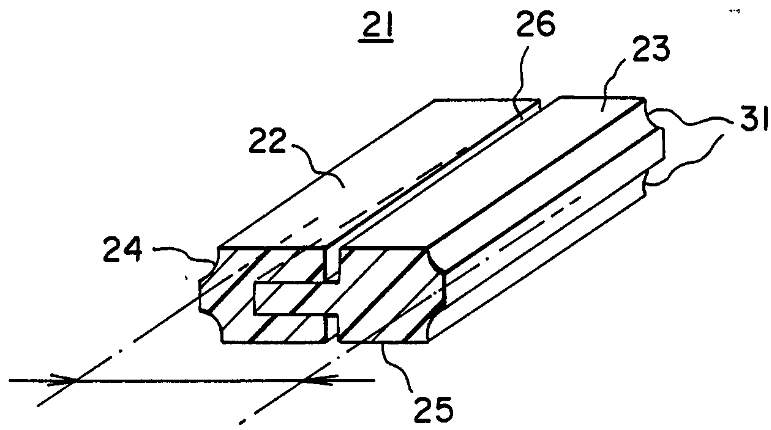


FIG. 12

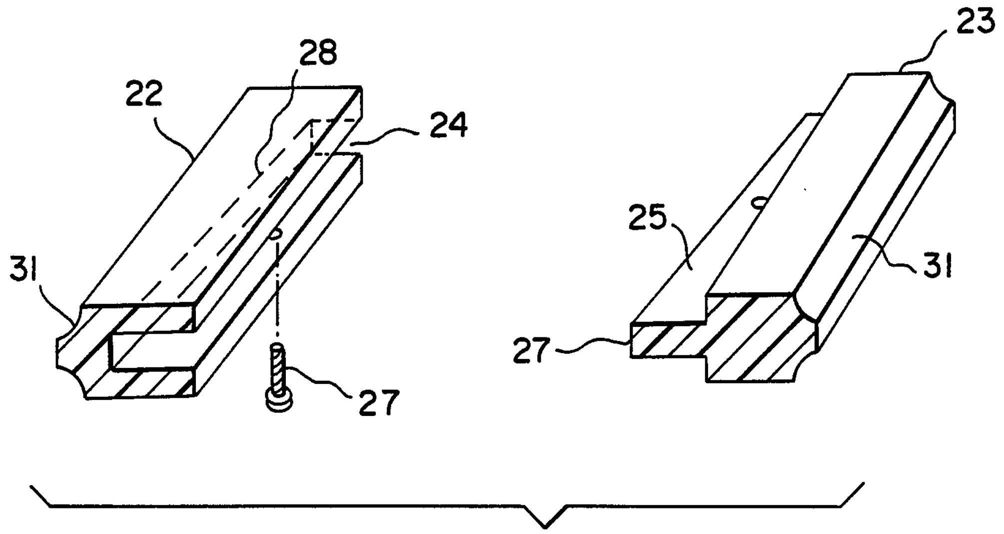


FIG. 13

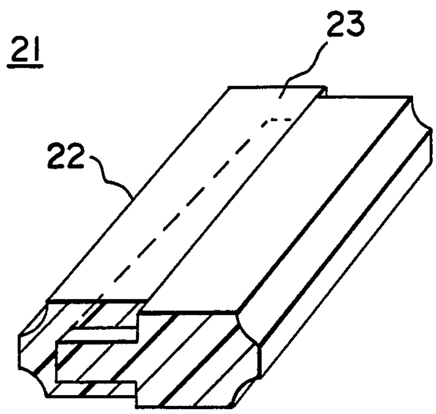


FIG. 14

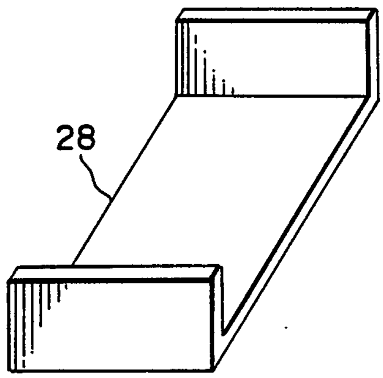


FIG. 15

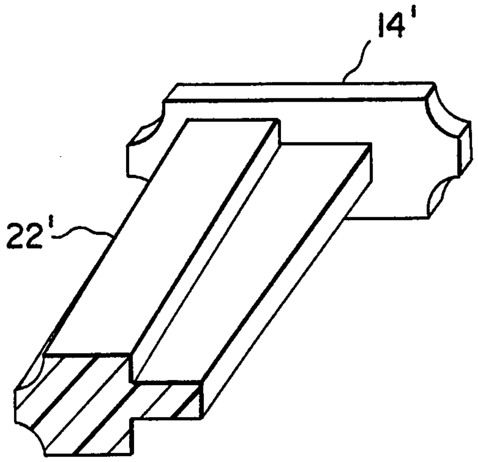


FIG. 16

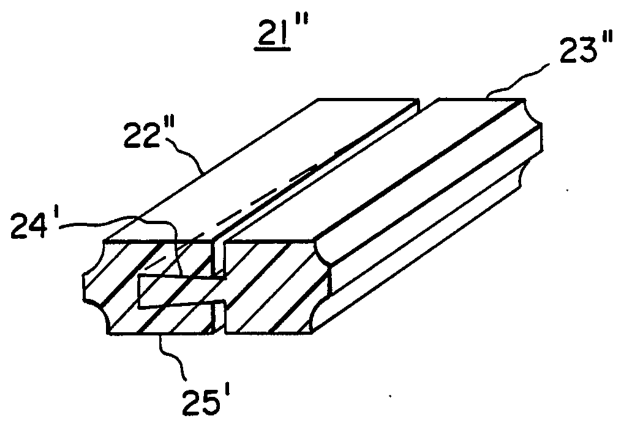


FIG. 17

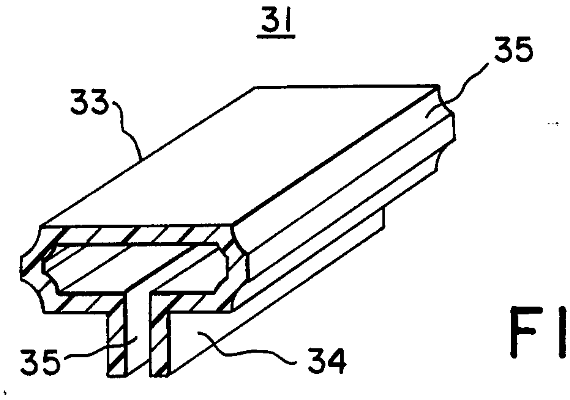


FIG. 18

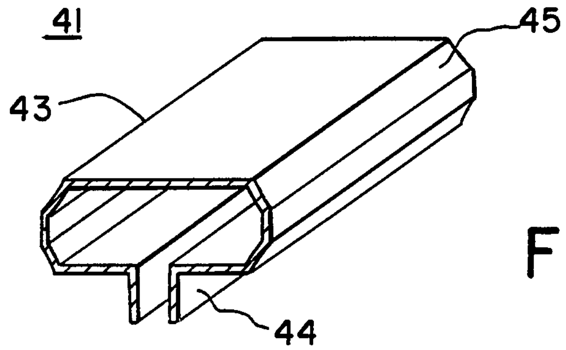


FIG. 19

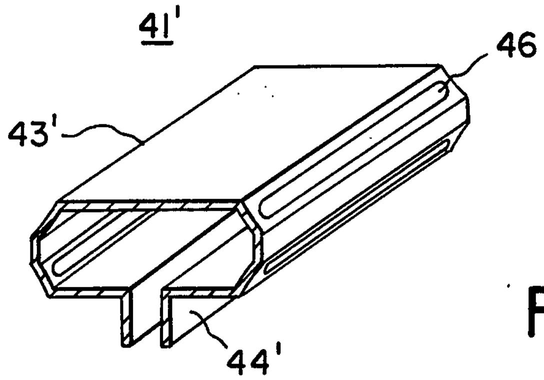


FIG. 20

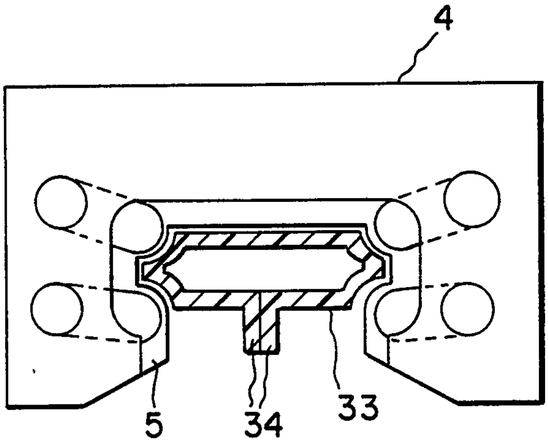


FIG. 21

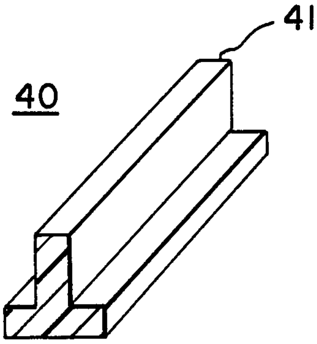


FIG. 22

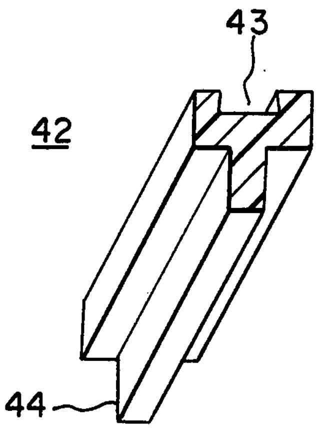


FIG. 23

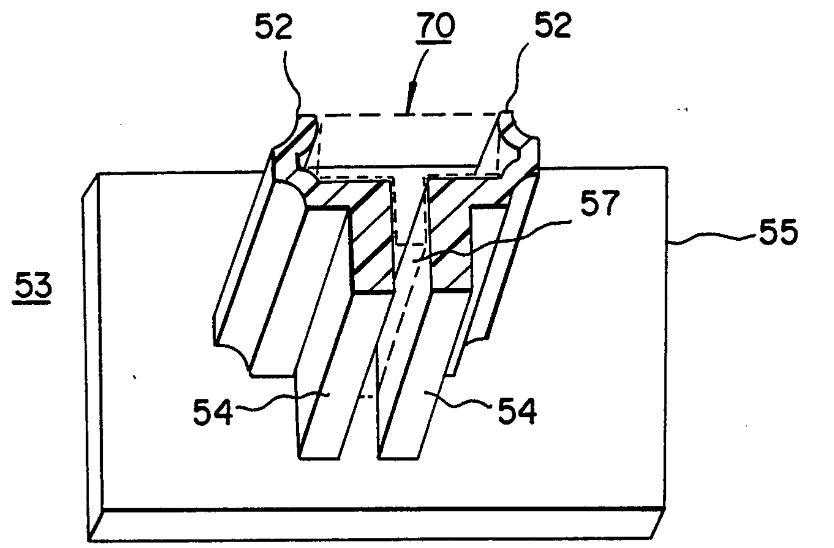


FIG. 24

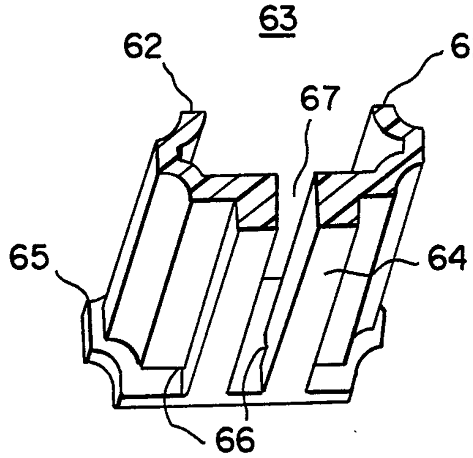


FIG. 25

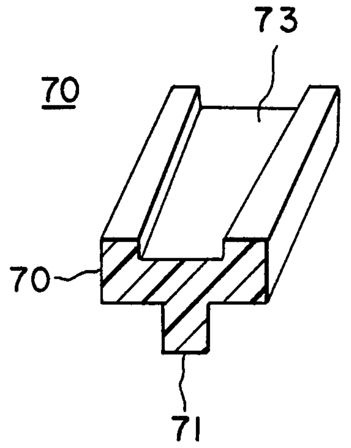


FIG. 26

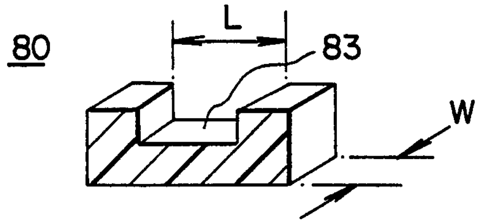


FIG. 27

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/03586

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :F16C 41/04
US CL : 384/43
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 384/43, 44, 45, 45, 59, 448; 29/898.062, 898.06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US, A, 5,238,309 (Ise) 24 August 1993, col. 4, lines 54-68.	1, 34 ----- 2-12
X --- Y	US, A, 4,692,038 (Kasai) 08 September 1987, col. 3, lines 1-23.	1, 34 ----- 2-12
Y	US, A, 4,976,551 (Scharting et al.) 11 December 1990, col. 1, lines 43-48,	2-12. 34

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 JUNE 1995	05 JUL 1995

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	THOMAS R. HANNON
Facsimile No. (703) 305-3230	Telephone No. (703) 308-2691

Form PCT/ISA/210 (second sheet)(July 1992)★

(19) Bundesrepublik Deutschland
Deutsches Patent- und Markenamt

(10) **DE 10 2005 010 633 A1** 2006.09.14

(12) **Offenlegungsschrift**

(21) Aktenzeichen: **10 2005 010 633.1**
(22) Anmeldetag: **08.03.2005**
(43) Offenlegungstag: **14.09.2006**

(51) Int Cl.[8]: ***F16C 29/04*** (2006.01)

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

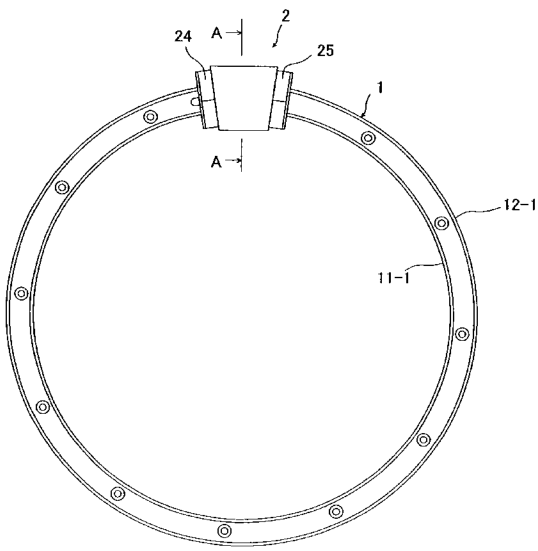
(74) Vertreter:
TBK-Patent, 80336 München

(72) Erfinder:
Ishikawa, Hirokazu, Tokio/Tokyo, JP; Hoshide, Kaoru, Tokio/Tokyo, JP; Ogata, Takashi, Tokio/Tokyo, JP; Matsutomi, Shunji, Tokio/Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Bezeichnung: **Führungsvorrichtung**

(57) Zusammenfassung: Eine Führungsvorrichtung ist mit einer geteilten Standardendplatte ausgerüstet, wobei die beiden Endplattenhälften mit hoher Genauigkeit zueinander positioniert werden können und an jedem axialen Ende eines bewegbaren Blockkörpers zuverlässig befestigt werden, so daß keine Gefahr des Verschiebens beider zueinander bei Verwendung der Führungsvorrichtung besteht. Auf der Spurschiene der Führungsvorrichtung ist ein relativ zu dieser bewegbarer Block angeordnet. Der Körper des bewegbaren Blocks hat rechtwinklig zur axialen Richtung eine Geometrie, welche die Montage des Blocks an einem Zwischenstück der Spurschiene auf diese ermöglicht. Die Endplatte ist in Breitenrichtung im wesentlichen aus einer linken und einer rechten Hälfte zusammengesetzt. Aus der Verbindungsfläche einer der beiden Endplattenhälften ragt ein positionierzapfen. Die Verbindungsfläche der anderen Endplattenhälfte ist mit einer Positionierbohrung versehen. Beim Zusammenfügen der beiden Endplattenhälften zu einer Einheit gleitet der Positionierzapfen in die Positionierbohrung. Zum Befestigen der auf diese Weise zusammengefügten Endplatte in Richtung der Relativbewegung an einem Ende des bewegbaren Blockkörpers werden durch die an den Endplattenhälften vorhandenen Befestigungsbohrungen Schrauben in diesen gedreht.



Beschreibung

HINTERGRUND DER ERFINDUNG

[0001] Die vorliegende Erfindung betrifft eine Führungsvorrichtung mit einer Spurschiene, einem auf dieser angeordneten und relativ zu dieser bewegbaren Block und mehreren zwischen der Spurschiene und dem bewegbaren Block angeordneten Rollelementen (Kugeln oder Walzen). Genauer ausgedrückt, die vorliegende Erfindung betrifft eine Führungsvorrichtung, bei welcher der bewegbare Block auf eine endlose Spurschiene in Ringform oder eine Spurschiene mit einer zu deren beiden Enden hin ansteigenden Rollbahn für Rollelemente montiert wird.

[0002] Anzumerken ist, daß der Begriff „relativ bewegbar" sich auf die relative Bewegbarkeit des Blocks und der Spurschiene zueinander bezieht und für zwei Fälle gilt, den Fall, bei welchem die Spurschiene fest angeordnet und der Block bewegbar ist, und den Fall, bei welchem der Block fest angeordnet und die Spurschiene bewegbar ist.

[0003] Bei der nachfolgend beschriebenen Führungsvorrichtung ist der Block bewegbar auf der Spurschiene angeordnet und zwischen beiden sind zahlreiche Rollelemente angeordnet.

[0004] Bei einer solchen Führungsvorrichtung kann ein herkömmlicher Block nicht von oben auf die Spurschiene (rittlings auf diese) montiert werden. Aus diesem Grund wird der bewegbare Block von einem Ende der Schiene aus auf diese geschoben.

[0005] Im Falle einer Spurschiene in Form eines endlosen Rings oder im Falle einer Spurschiene mit einer zu deren beiden Enden hin ansteigenden Rollbahn kann der bewegbare Block nicht von einem Ende der Spurschiene auf diese geschoben werden.

[0006] Demzufolge wird auf herkömmliche Weise ein Abschnitt der Spurschiene mit einer bestimmten Länge als separat bewegbares Segment ausgeführt. Zum Montieren des bewegbaren Blocks auf die Spurschiene wird dieses Segment entfernt und der bewegbare Block von einem Ende der jetzt offenen Spurschiene auf diese geschoben. Danach wird das Segment wieder eingesetzt und an der Spurschiene befestigt.

Stand der Technik

[0007] Es besteht aber auch die Möglichkeit, den bewegbaren Block so zu konfigurieren, daß dieser von oben auf die Spurschiene geschoben werden kann, und jede Endplatte in Breitenrichtung (d.h. rechtwinklig zur Bewegungsrichtung) in zwei Hälften zu teilen, wie im japanischen Dokument Sho 58-142017 (KOKAI) offenbart. In diesem Fall werden nach dem Aufsetzen des beweglichen Blocks auf die Spurschiene paarige Endplattenhälften in Bewegungsrichtung an jedem Ende des Blocks befestigt. Durch eine solche Anordnung kann der bewegbare Block auch auf eine endlose ringförmige Spurschiene oder auf eine Spurschiene mit einer zu deren beiden Enden hin ansteigenden Rollbahn montiert werden.

[0008] Im japanischen Dokument Hei 8-21440 (KOKAI) ist eine Führungsvorrichtung offenbart, bei welcher ein entsprechend konfigurierter bewegbarer Block von der Seite auf eine Spurschiene in Form eines endlosen Rings montiert werden kann.

[0009] Gemäß dem zuerst erwähnten herkömmlichen Verfahren ist in Breitenrichtung jede Endplatte in zwei Hälften geteilt, wobei nach dem Aufsetzen des bewegbaren Blocks auf die Spurschiene die aus zwei Hälften zusammengesetzte Endplatte in Bewegungsrichtung am Blockkörper befestigt wird, wie im Dokument Sho 58-142017 (KOKAI) offenbart. Nach diesem Verfahren können die beiden Endplattenhälften nicht oder nur unter Schwierigkeiten mit hoher Genauigkeit zueinander positioniert werden. Selbst wenn es gelingt, beide Hälften der Endplatte genau zueinander zu positionieren, besteht während der Nutzung der Führungsvorrichtung die Wahrscheinlichkeit, daß diese sich verschieben.

[0010] Bei der im japanischen Dokument Hei 8-21440 (KOKAI) offenbarten Führungsvorrichtung müssen der bewegbare Block und die Endplatten so konfiguriert sein, daß der bewegbare Block von der Seite auf die Spurschiene montiert und von dieser demontiert werden kann. Ein herkömmlicher Standardblockkörper und herkömmliche Endplatten können bei einer Führungsvorrichtung gemäß dem Stand der Technik nicht verwendet werden.

Aufgabenstellung

ZUSAMMENFASSUNG DER ERFINDUNG

[0011] Die Aufgabe der vorliegenden Erfindung besteht darin, die bei einer Führungsvorrichtung gemäß dem Stand der Technik auftretenden Probleme zu beseitigen und eine Führungsvorrichtung bereitzustellen, bei welcher die beiden Hälften einer Standardendplatte mit hoher Genauigkeit zueinander positioniert werden können und eine solche aus zwei Hälften zusammengesetzte Endplatte an jedem axialen Ende eines bewegbaren Blockkörpers sicher befestigt werden kann, ohne daß bei Nutzung der Führungsvorrichtung die Gefahr des Verschiebens der beiden Endplattenhälften besteht.

[0012] Diese Aufgabe erfüllt eine Führungsvorrichtung mit einer Spurschiene, in welche eine längs sich erstreckende Rollbahn für Rollelemente eingearbeitet ist, und einem auf der Spurschiene bewegbar zu dieser angeordneten bewegbaren Block. In den Körper dieses bewegbaren Blocks ist eine Lastaufnahmerollbahn eingearbeitet, welche zusammen mit der Rollbahn an der Spurschiene einen Rollkanal für die Lastaufnahmeelemente bildet. Der Blockkörper ist außerdem mit einer Entlastungsbohrung versehen, welche zur Rollbahn an der Spurschiene Verbindung hat. In Bewegungsrichtung des bewegbaren Blocks ist an jedem Ende des Blockkörpers eine Endplatte befestigt. Die Endplatte ist mit einer Richtungsumkehr-Rollbahn versehen, welche zusammen mit dem Rollkanal und der Entlastungsbohrung einen Zirkulationskanal für die Rollelemente bildet. Im Zirkulationskanal sind mehrere Rollelemente untergebracht, welche bei einer Relativbewegung zwischen dem bewegbaren Block und der Spurschiene in diesem zirkulieren.

[0013] Gemäß einem ersten Merkmal der vorliegenden Erfindung hat der bewegbare Blockkörper in einem Abschnitt rechtwinklig zur axialen Richtung eine Geometrie, welche dessen Montage auf die Spurschiene an einem bestimmten Schienenabschnitt ermöglicht. Die Endplatte ist in Breitenrichtung im wesentlichen aus zwei Hälften, d.h. einer rechten und einer linken Hälfte zusammengesetzt. Beide Endplattenhälften können durch Verbindungselemente mit hoher Genauigkeit zueinander positioniert werden. Die über die Verbindungselemente zusammengesetzte Endplatte wird in Bewegungsrichtung des Blocks mit Befestigungselementen an einem Ende des Blockkörpers befestigt.

[0014] Gemäß einem zweiten Merkmal der vorliegenden Erfindung gehören zu den Verbindungselementen entsprechend dem ersten Merkmal ein aus der Verbindungsfläche an einer der beiden Endplattenhälfte ragender Positionierzapfen und eine in der Verbindungsfläche der anderen Endplattenhälfte vorhandene Positionierbohrung. Mit dem Einführen des Positionierzapfens in die Positionierbohrung werden die beiden Hälften zu einer Einheit zusammengefügt. Zu den erwähnten Befestigungselementen gehören Befestigungsbohrungen in den Endplattenhälften und Befestigungsschrauben. Die Befestigungsschrauben werden durch die Befestigungsbohrungen geführt und in Bewegungsrichtung des Blockes in ein Ende des Blockkörpers gedreht.

[0015] Gemäß einem dritten Merkmal der vorliegenden Erfindung gehören zu den Verbindungselementen entsprechend dem ersten Merkmal eine in jede Endplattenhälfte in einem bestimmten Abstand von deren Verbindungsfläche eingebrachte Positionierbohrung und ein U-förmiges Positionierelement, dessen Schenkel in die Positionierbohrungen gedrückt werden. Das Positionierelement wird eingesetzt, nachdem die beiden Endplattenhälften gegeneinander gedrückt wurden und deren Verbindungsflächen sich berühren. Zu den erwähnten Befestigungselementen gehören Befestigungsbohrungen in den Endplattenhälften und Befestigungsschrauben. Die Befestigungsschrauben werden durch die Befestigungsbohrungen geführt und in Bewegungsrichtung des Blockes in ein Ende des Blockkörpers gedreht.

[0016] Gemäß einem vierten Merkmal der vorliegenden Erfindung gehört zu den Befestigungselementen entsprechend dem ersten Merkmal ein U-förmiges Halteelement. Nach dem Gegeneinanderdrücken der beiden Endplattenhälften an den Verbindungsflächen werden die Schenkel des U-förmigen Verbindungselements über die Außenfläche jeder Endplattenhälfte geschoben, um die beiden Hälften zu einer Einheit zusammenzufügen. Zu den erwähnten Befestigungselementen gehören Befestigungsbohrungen in den Endplattenhälften und Befestigungsschrauben. Die Befestigungsschrauben werden durch die Befestigungsbohrungen geführt und in Bewegungsrichtung des Blockes in ein Ende des Blockkörpers gedreht.

[0017] Gemäß einem fünften Merkmal der vorliegenden Erfindung gehören zu den Verbindungselementen entsprechend dem ersten Merkmal ein Vorsprung und eine Vertiefung an der entsprechenden Verbindungsfläche jeder Endplattenhälfte. Der Vorsprung und die Vertiefung an der einen Endplattenhälfte werden mit der Vertiefung und dem Vorsprung an der anderen Endplattenhälfte ineinandergeschoben, um die beiden Endplattenhälften zu einer Einheit zusammenzufügen und deren Auseinanderdriften in Breitenrichtung zu verhindern. Zu den erwähnten Befestigungselementen gehören Befestigungsbohrungen in den Endplattenhälften und Befestigungsschrauben. Die Befestigungsschrauben werden durch die Befestigungsbohrungen geführt und in Bewegungsrichtung des Blockes in ein Ende des Blockkörpers gedreht.

[0018] Gemäß einem sechsten Merkmal der vorliegenden Erfindung gehört zu den Verbindungselementen entsprechend dem ersten Merkmal ein unbearbeiteter zylindrischer Stopfen, welcher in die Aussparung an der Verbindungsfläche einer Endplattenhälfte gedrückt wird und teilweise aus dieser Verbindungsfläche ragt. Die Verbindungsfläche der anderen Endplattenhälfte ist mit einer Aussparung versehen, in welche der aus der Verbindungsfläche der ersten Endplattenhälfte ragende Teil des unbearbeiteten zylindrischen Stopfens paßt. Beim Gegeneinanderdrücken der beiden Endplattenhälften an den Verbindungsflächen gleitet der aus der einen Verbindungsfläche ragende Teil des unbearbeiteten zylindrischen Stopfens in die Aussparung an der anderen Verbindungsfläche, um die beiden Endplattenhälften zu einer Einheit zusammenzufügen. Zu den erwähnten Befestigungselementen gehören Befestigungsbohrungen in den Endplattenhälften und Befestigungsschrauben. Die Befestigungsschrauben werden durch die Befestigungsbohrungen geführt und in Bewegungsrichtung des Blockes in ein Ende des Blockkörpers gedreht.

[0019] Gemäß einem siebenten Merkmal der vorliegenden Erfindung hat die Endplatte entsprechend dem ersten Merkmal rechtwinklig zur axialen Richtung einen annähernd U-förmigen Querschnitt und wird rittlings auf die Spurschiene gedrückt. In diesem Fall sind die beiden Endplattenhälften über einen Steg teilweise miteinander verbunden. Beim Montieren dieser Endplatte werden die beiden Hälften über den Steg auseinander geschwenkt, so daß die von den Schenkeln der Endplatte gebildete Öffnung in Breitenrichtung größer wird und die Endplatte über den Schienenkopf geschoben werden kann. Zu den erwähnten Befestigungselementen gehören Befestigungsbohrungen in den Endplattenhälften und Befestigungsschrauben. Die Befestigungsschrauben werden durch die Befestigungsbohrungen geführt und in Bewegungsrichtung des Blockes in ein Ende des Blockkörpers gedreht.

[0020] Gemäß einem achten Merkmal der vorliegenden Erfindung ist die Spurschiene entsprechend einem der Merkmale eins bis sieben als endloser Ring ausgeführt.

[0021] Gemäß einem neunten Merkmal der vorliegenden Erfindung hat die Spurschiene entsprechend einem der Merkmale eins bis sieben eine zu deren beiden Enden hin ansteigende Rollbahn für Rollelemente.

[0022] Die vorliegende Erfindung ist auch auf eine Führungsvorrichtung übertragbar, in deren Spurschiene eine längs sich erstreckende Rollbahn für Rollelemente eingearbeitet ist. Auf dieser Spurschiene ist ein relativ zu dieser bewegbarer Block angeordnet. In den Blockkörper ist eine Lastaufnahmerollbahn eingearbeitet, welche zusammen mit der Rollbahn an der Spurschiene einen Rollkanal für die Lastaufnahmerollelemente bildet. Der Blockkörper ist außerdem mit einer Entspannungsbohrung versehen, welche zur Lastaufnahmerollbahn Verbindung hat. An jedem Ende des bewegbaren Blockkörpers wird in dessen Bewegungsrichtung eine Endplatte befestigt. Die Endplatte ist mit einem Richtungsumkehrkanal versehen, welcher zusammen mit dem Lastaufnahmerollkanal und der Entspannungsbohrung einen Zirkulationskanal für die Rollelemente bildet. Im Zirkulationskanal sind zahlreiche Rollelemente untergebracht, welche bei einer Relativbewegung zwischen der Spurschiene und dem bewegbaren Block in diesem Kanal zirkulieren.

[0023] Gemäß einem zehnten Merkmal der vorliegenden Erfindung hat der bewegbare Blockkörper rechtwinklig zur axialen Richtung eine Geometrie, welche dessen Montage auf die Spurschiene an einem bestimmten Abschnitt an dieser ermöglicht. Die Endplatte ist aus einem elastischen Material gefertigt und hat rechtwinklig zur axialen Richtung einen nahezu U-förmigen Querschnitt. Wenn die Endplatte von oben über den Schienenkopf gedrückt wird, weitet deren Öffnung sich. Die Endplatte wird in der Endstellung in Bewegungsrichtung mit Befestigungselementen an einem Ende des Blockkörpers befestigt.

[0024] Gemäß dem ersten bis neunten Merkmal der vorliegenden Erfindung ist jede Endplatte in Breitenrichtung aus zwei Hälften zusammengesetzt. Demzufolge muß die Endplatte nicht von einem Ende der Spurschiene aus auf diese gesetzt, sondern kann an einem Zwischenstück von der Seite auf diese geschoben werden. Die beiden Hälften können mit hoher Genauigkeit zueinander positioniert und anschließend zuverlässig am Blockkörper befestigt werden, so daß die Gefahr der Verschiebens beider während der Nutzung der Führungsvorrichtung nicht besteht. Demzufolge kann der bewegbare Körper auch auf eine Spurschiene in Form eines endlosen Rings, auf eine Spurschiene mit einer zu deren beiden Enden hin ansteigenden Rollbahn oder auf eine Spurschiene mit einer Begrenzung am Ende montiert werden, da die Montage an einem Zwischenstück der Spurschiene auf diese erfolgt.

[0025] Gemäß dem zehnten Merkmal der vorliegenden Erfindung ist die Endplatte aus einem elastischen Material gefertigt, so daß Breite der Öffnung an dieser durch elastisches Verformen vergrößert wird. Demzufolge kann eine solche einfach konfigurierte Endplatte problemlos auf die Spurschiene gedrückt werden. Demzufolge kann der bewegbare Körper auch auf eine Spurschiene in Form eines endlosen Rings, auf eine Spurschiene mit einer zu deren beiden Enden hin ansteigenden Rollbahn oder auf eine Spurschiene mit einer Begrenzung am Ende montiert werden, da die Montage an einem Zwischenstück der Spurschiene auf diese erfolgt.

Ausführungsbeispiel

KURZBESCHREIBUNG DER ZEICHNUNGEN

[0026] Fig. 1 zeigt die Draufsicht eines Beispiels der Führungsvorrichtung gemäß der vorliegenden Erfindung.

[0027] Fig. 2 zeigt die Schnittansicht A-A der in Fig. 1 dargestellten Führungsvorrichtung.

[0028] Fig. 3 zeigt die Konfiguration einer herkömmlichen Endplatte.

[0029] Fig. 4 zeigt ein Beispiel des bewegbaren Blocks der Führungsvorrichtung gemäß der vorliegenden Erfindung.

[0030] Die Fig. 5A, Fig. 5B und Fig. 5C zeigen ein Beispiel der bei der Führungsvorrichtung gemäß der vorliegenden Erfindung verwendeten Endplatte des bewegbaren Blockes (erste Ausführungsform).

[0031] Die Fig. 6A, Fig. 6B, Fig. 6C, Fig. 6D und Fig. 6E zeigen ein weiteres Beispiel der bei der Führungsvorrichtung gemäß der vorliegenden Erfindung verwendeten Endplatte des bewegbaren Blocks (zweite Ausführungsform).

[0032] Die Fig. 7A, Fig. 7B, Fig. 7C und Fig. 7D zeigen noch ein weiteres Beispiel der bei der Führungsvorrichtung gemäß der vorliegenden Erfindung verwendeten Endplatte des bewegbaren Blocks (dritte Ausführungsform).

[0033] Die Fig. 8A, Fig. 8B und Fig. 8C zeigen noch ein weiteres Beispiel der bei der Führungsvorrichtung gemäß der vorliegenden Erfindung verwendeten Endplatte des bewegbaren Blocks (vierte Ausführungsform).

[0034] Die Fig. 9A, Fig. 9B, Fig. 9C und Fig. 9D zeigen noch ein weiteres Beispiel der bei der Führungsvorrichtung gemäß der vorliegenden Erfindung verwendeten Endplatte des bewegbaren Blocks (fünfte Ausführungsform).

[0035] Fig. 10 zeigt die Schnittansicht einer weiteren Führungsvorrichtung gemäß der vorliegenden Erfindung (sechste Ausführungsform).

[0036] Fig. 11 zeigt ein weiteres Beispiel der Führungsvorrichtung gemäß der vorliegenden Erfindung (siebente Ausführungsform).

[0037] Die Fig. 12A, Fig. 12B und Fig. 12C zeigen ein weiteres Beispiel der bei der Führungsvorrichtung gemäß der vorliegenden Erfindung verwendeten Endplatte des bewegbaren Blocks (achte Ausführungsform).

[0038] Die Fig. 13A und Fig. 13B zeigen ein weiteres Beispiel der Führungsvorrichtung gemäß der vorliegenden Erfindung (neunte Ausführungsform).

[0039] Die Fig. 14A und Fig. 14B zeigen noch ein weiteres Beispiel der Führungsvorrichtung gemäß der vorliegenden Erfindung (zehnte Ausführungsform).

[0040] Fig. 15 zeigt vergrößert den in Fig. 14B angedeuteten Abschnitt C.

[0041] Fig. 16 zeigt ein weiteres Beispiel der bei der Führungsvorrichtung gemäß der vorliegenden Erfindung verwendeten Endplatte des bewegbaren Blocks (elfte Ausführungsform).

[0042] Fig. 17 zeigt vergrößert die Schnittansicht D-D der in Fig. 14A dargestellten Führungsvorrichtung.

[0043] Fig. 18 zeigt ein System, in welchem die Führungsvorrichtung gemäß der vorliegenden Erfindung verwendet wird.

BESCHREIBUNG DER BEVORZUGTEN AUSFÜHRUNGSFORMEN

[0044] Nachfolgend werden anhand der beiliegenden Zeichnungen Ausführungsformen der vorliegenden Erfindung beschrieben. Die Fig. 1 bis Fig. 4 zeigen den Aufbau einer Führungsvorrichtung gemäß der vorliegenden Erfindung. Von diesen vier Figuren zeigt Fig. 1 die Draufsicht der Führungsvorrichtung, Fig. 2 die Schnittansicht A-A dieser Führungsvorrichtung, Fig. 3 die Vorderansicht einer herkömmlichen Endplatte und Fig. 4 die Draufsicht eines bewegbaren Blockes. Wie aus diesen Figuren hervor geht, weist die Führungsvorrichtung gemäß der vorliegenden Erfindung eine endlose ringförmige Spurschiene **1** und einen auf dieser bewegbar angeordneten Block **2** auf.

[0045] Rechtwinklig zur axialen Richtung (d.h. zur Bewegungsrichtung des Blocks **2**) hat die Spurschiene **1** einen rechteckigen Querschnitt. Auf der linken und auf der rechten Seite der Spurschiene **1** ist im Mittelabschnitt eine Nut vorhanden. Der über der Nut liegende Abschnitt hat links einen Kamm **11** und rechts einen Kamm **12**.

[0046] Die obere Kante der Kämme **11** und **12** ist als Rollbahn **11-1** bzw. **12-1**, deren untere Kante **11** und **12** als Rollbahn **11-2** bzw. **12-2** für Rollelemente (Kugeln bei diesem Beispiel) ausgeführt.

[0047] Der bewegbare Block **2** hat einen U-förmigen Hauptkörper **21** mit einem linken Schenkel **22** und einem rechten Schenkel **23**, welche sich über die Hauptkörperöffnung gegenüber liegen.

[0048] Die Breite L1 der Öffnung (d.h. der Abstand zwischen der Innenseite des Schenkels **22** und der Innenseite des Schenkels **23**) im Hauptkörper **21** ist größer als die Breite L2 zwischen den Kämmen **11** und **12** der Spurschiene **1** (L1>L2). Dadurch kann der Blockkörper **21** von oben (oder von der Seite) auf die Spurschiene geschoben werden.

[0049] Die Innenseite des Schenkels **22** ist mit Axiallastrollbahnen **22-1** und **22-2**, die Innenseite des Schenkel **23** mit Axiallastrollbahnen **23-1** und **23-2** versehen, welche den entsprechenden Rollbahnen **11-1**, **11-2**, **12-1** und **12-2** an der Spurschiene **1** gegenüber liegen.

[0050] Der Schenkel **22** ist mit Entlastungsbohrungen **22-3** und **22-4**, der Schenkel **23** mit Entlastungsbohrungen **23-3** und **23-4** versehen, welche mit den Axiallastrollbahnen **22-1** und **22-2** bzw. **23-1** und **23-2** in Verbindung stehen.

[0051] Die Rollbahnen **11-1** und **11-2** an der Spurschiene **1** und die Axiallastrollbahnen **22-1** und **22-2** am Blockkörper **21** bilden einen Rollkanal R1 bzw. R2, die Rollbahnen **12-1** und **12-2** an der Spurschiene **1** und die Axiallastrollbahnen **23-1** und **23-2** am Blockkörper **21** einen Rollkanal R3 bzw. R4 für die Lastaufnahmerollelemente.

[0052] An einer der beiden axialen Stirnseiten des Blockkörpers **21** ist eine Endplatte **24**, an der anderen eine Endplatte **25** befestigt. Die beiden Endplatten **24** und **25** sind mit Richtungsumkehrkanälen R5, R6, R7 und R8 versehen, welche die in den Rollkanälen R1, R2, R3 und R4 rollenden Rollelemente (Kugeln) **3** in die entsprechende der vier Entlastungsbohrungen **22-3**, **22-4**, **23-3** und **23-4** gleiten lassen und dabei deren Bewegungsrichtung umkehren.

[0053] Mit anderen Worten, beim Bewegen des Blockes **2** zirkulieren die zahlreichen Rollelemente (Kugeln) **3** in jedem der aus dem entsprechenden Rollkanal R1, R2, R3, R4, der entsprechenden Entlastungsbohrung **22-3**, **22-4**, **23-3**, **23-4** und dem entsprechenden Umkehrkanal R5, R6, R7, R8 gebildeten Zirkulationskanälen.

[0054] Wie bereits erwähnt, ist die Breite L1 der Öffnung im Blockkörper **21** größer als der Abstand zwischen den Kämmen **11** und **12** der Spurschiene **1** (L1>L2), so daß auch bei einer endlosen ringförmigen Spurschiene **1** der Blockkörper **21** von oben (oder von der Seite) auf diese geschoben werden kann.

[0055] Im Gegensatz dazu haben die Endplatten **24** und **25** im allgemeinen die in Fig. 3 dargestellte Konfiguration. Das heißt, die Breite L3 der Öffnung dieser beiden Endplatten **24**, **25** ist kleiner als der Abstand L2 zwischen den beiden Kämmen **11** und **12** der Spurschiene **1** (L2>L3). Demzufolge können auch die Endplatten **24** und **25** nicht von oben (oder von der Seite) auf die Spurschiene **1** geschoben werden.

[0056] Unter diesen Gegebenheiten wurden gemäß der vorliegenden Erfindung die Endplatten **24** und **25** konstruktiv so verbessert, daß diese von oben auf die Spurschiene **1** geschoben werden können.

[0057] Nachfolgend wird nur die Endplatte **24** detailliert beschrieben, da die Endplatte **25** und die Endplatte **24** identisch sind.

[Erste Ausführungsform]

[0058] Die Fig. 5A, Fig. 5B und Fig. 5C zeigen ein Beispiel der Endplatte **24**. Fig. 5A zeigt die Draufsicht dieser Endplatte in Explosivdarstellung, Fig. 5B deren Vorderansicht in Explosivdarstellung und Fig. 5C deren Seitenansicht. In diesen Figuren tragen Elemente, welche den in den Fig. 1 bis Fig. 4 gezeigten identisch sind, die gleichen Bezugszeichen wie diese. Das gilt auch für die anderen Zeichnungen.

[0059] Wie aus den Fig. 5A, Fig. 5B und Fig. 5C hervor geht, hat die Endplatte **24** von vorn auf diese gesehen annähernd eine U-Form und ist aus zwei Hälften **24-1** und **24-2** zusammengesetzt, wobei die Verbindungslinie der Mittellinie der Endplattenöffnung entspricht.

[0060] Die Verbindungsfläche a der Endplattenhälfte **24-1** ist mit einem Positionierzapfen **26**, die Verbindungsfläche b der Endplattenhälfte **24-2** mit einer Positionierbohrung **27** als Aufnahme für den Positionierzapfen **26** versehen. Außerdem ist die Endplattenhälfte **24-1** mit einer Bohrung **28-1**, die Endplattenhälfte **24-2** mit einer Bohrung **28-2** für eine Befestigungsschraube versehen.

[0061] Diese beiden Endplattenhälften **24-1** und **24-2** werden von der Seite auf die Spurschiene **1** geschoben, wobei der Positionierzapfen **26** in die Positionierbohrung **27** gleitet. Das Zusammenfügen der beiden Endplattenhälften zur Endplatte **24** ist beendet, wenn deren Verbindungsflächen a und b einander berühren.

[0062] Dann werden durch die Bohrungen **28-1** und **28-2** Schrauben in den Blockkörper **21** gedreht, um die Endplatte **24** an diesem zu befestigen. Das Bezugszeichen **29** kennzeichnet eine Ölbohrung.

[0063] Wie bereits beschrieben, werden die beiden Endplattenhälften **24-1** und **24-2** von der Seite auf die Spurschiene **1** geschoben, bis deren Verbindungsflächen a und b einander berühren, wobei der Positionierzapfen **26** in die Positionierbohrung **27** gleitet und dadurch beide Endplattenhälften mit hoher Genauigkeit zusammengefügt werden können. Durch die Bohrungen **28-1** und **28-2** werden Schrauben in den Blockkörper **21** gedreht und auf diese Weise die beiden Endplattenhälften exakt und zuverlässig an diesem befestigt und können sich während der Benutzung der Führungsvorrichtung nicht verschieben.

[Zweite Ausführungsform]

[0064] Die Fig. 6A, Fig. 6B, Fig. 6C, Fig. 6D und Fig. 6E zeigen ein weiteres Beispiel der Endplatte **24**. Fig. 6A zeigt die Draufsicht, Fig. 6B die Vorderansicht, Fig. 6C die Seitenansicht dieser Endplatte. Fig. 6D zeigt die Vorderansicht und Fig. 6E die Seitenansicht eines Positionierelements.

[0065] Die Endplatte **24** ist aus einer linken Hälfte und einer rechten Hälfte **24-2** zusammengesetzt. Die obere Fläche der beiden Hälften **24-1** und **24-2** sind in einem bestimmten Abstand von der Verbindungsfläche a bzw. b mit einer Positionierbohrung **30-1** bzw. **30-2** und mit einer Bohrung **28-1** bzw. **28-2** für Befestigungsschrauben versehen.

[0066] Eine Metallplatte oder einer ähnlichen Platte wurde U-förmig zu einem Positionierelement **31** gebogen, dessen Schenkel in die Positionieröffnungen **30-1** und **30-2** gedrückt werden können. Die beiden Endplattenhälften **24-1** und **24-2** werden von der Seite auf die Spurschiene **1** geschoben, bis deren Verbindungsflächen a und b einander berühren. In diesem Zustand werden die Schenkel des Positionierelements **31** wie beschrieben in die Positionieröffnungen **30-1** und **30-2** gedrückt.

[0067] Danach werden durch die Bohrungen **28-1** und **28-2** Befestigungsschrauben in den Blockkörper **21** gedreht, um die auf diese Weise zusammengesetzte Endplatte an einer Seite des Blockkörpers zu befestigen. Diese Konstruktion ermöglicht wie die Konstruktion der Endplatte gemäß der ersten Ausführungsform exaktes Verbinden der beiden Endplattenhälften miteinander und sicheres Befestigen der Endplatte **24** am Blockkörper **21**, so daß während der Benutzung der Führungsvorrichtung keine Verschiebung eintritt.

[0068] Bei dieser Ausführungsform sind die Positionieröffnungen **30-1** und **30-2** an der oberen Fläche der Endplattenhälfte **24-1** bzw. **24-2** vorhanden und in diese werden von oben die Schenkel des Positionierelements **31** gedrückt. Es besteht aber auch die Möglichkeit, die Positionieröffnungen **30-1** und **30-2** in die Stirnseite der Endplattenhälfte **24-1** bzw. **24-2** einzubringen und die Schenkel des Positionierelements **31** von der Seite in diese zu drücken.

[Dritte Ausführungsform]

[0069] Die Fig. 7A, Fig. 7B, Fig. 7C und Fig. 7d zeigen ein weiteres Beispiel der Endplatte **24**. Fig. 7A zeigt die Draufsicht dieser Endplatte **24** und ein Halteelement **32**. Fig. 7B zeigt die Seitenansicht und Fig. 7C die Vorderansicht dieser Endplatte **24**. Fig. 7D zeigt die Vorderansicht des Halteelements **32**.

[0070] Die Endplatte **24** ist aus einer linken Hälfte **24-1** und einer rechten Hälfte **24-2** zusammengesetzt. Die linke Hälfte **24-1** ist mit einer Bohrung **28-1**, die rechte Hälfte mit einer Bohrung **28-2** für Befestigungsschrauben versehen.

[0071] Eine Metallplatte oder ähnliche Platte wurde zu einem U-förmigen Halteelement **32** gebogen. Die beiden Hälften **24-1** und **24-2** werden von der Seite auf die Spurschiene **1** geschoben, bis deren Verbindungsflächen a und b einander berühren. In diesem Zustand wird das U-förmige Halteelement **32** über die Stirnflächen der beiden Hälften geschoben, um eine Einheit zu erhalten.

[0072] Durch die beiden Bohrungen **28-1** und **28-1** werden Schrauben den Blockkörper **21** gedreht, um die Einheit an diesem zu befestigen.

[0073] Auf diese Weise werden die beiden Endplattenhälften **24-1** und **24-2** exakt zueinander positioniert und an einer Seite des Blockkörpers befestigt, so daß diese sich wie bei der ersten und bei der zweiten Ausführungsformen während der Benutzung der Führungsvorrichtung nicht verschieben.

[0074] Bei dieser Ausführungsform wird das Halteelement **32** an der Vorderseite der Endplatte **24** befestigt, kann aber auch an deren Rückseite oder deren Oberseite befestigt werden.

[Vierte Ausführungsform]

[0075] Die Fig. 8A, Fig. 8B und Fig. 8C zeigen ein weiteres Beispiel der Endplatte **24**. Fig. 8A zeigt diese Endplatte in Explosivdarstellung, Fig. 8B deren Vorderansicht und Fig. 8C deren Seitenansicht.

[0076] Die Endplatte **24** ist ebenfalls aus einer linken Hälfte **24-1** und einer rechten Hälfte **24-2** zusammengesetzt. Beide Hälften haben Verbindungsflächen c und d und rechtwinklig zu diesen eine Verbindungsfläche e.

[0077] Die linke Endplattenhälfte **24-1** ist an der Grenzlinie der beiden Verbindungsflächen c und e mit einer Vertiefung f und an der Grenzlinie der beiden Verbindungsflächen d und e mit einem Vorsprung g versehen. Die rechte Endplattenhälfte **24-2** ist an der Grenzlinie der beiden Verbindungsflächen c und e mit einer Vertiefung i und an der Grenzlinie der beiden Verbindungsflächen d und e mit einem Vorsprung h versehen.

[0078] Beim Zusammenfügen der beiden Hälften **24-1** und **24-2** gleitet der Vorsprung g in die Vertiefung i und der Vorsprung h in die Vertiefung f. Auf diese Weise werden die beiden Hälften exakt zueinander positioniert und in Breitenrichtung fixiert.

[0079] Die beiden Endplattenhälften **24-1** und **24-2** werden von der Seite auf die Spurschiene **1** geschoben, bis deren Verbindungsflächen c und deren Verbindungsflächen d einander berühren. Dann werden die beiden Hälften axial gegeneinander gedrückt, wobei der Vorsprung g in die Vertiefung i und der Vorsprung h in die Vertiefung f gleitet. In diesem Zustand werden durch die Bohrungen **28-1** und **28-2** Schrauben in den Blockkörper **21** gedreht, um die Einheit an diesem zu befestigen.

[0080] Auf diese Weise werden die beiden Endplattenhälften exakt zueinander positioniert und an einer Seite des Blockkörpers **21** befestigt, so daß diese sich wie bei der ersten, der zweiten und der dritten Ausführungsform während der Benutzung der Führungsvorrichtung nicht verschieben.

[0081] Die Verbindungsflächen können aber auch anders konfiguriert werden, müssen sich aber berühren und mit einer Vertiefung und einem Vorsprung versehen sein, um ein relatives Verschieben der beiden Endplattenhälften in Breitenrichtung zueinander zu verhindern.

[Fünfte Ausführungsform]

[0082] Die Fig. 9A, Fig. 9B, Fig. 9C und Fig. 9D zeigen ein weiteres Beispiel der Endplatte **24**. Fig. 9A zeigt die Vorderansicht dieser Endplatte, Fig. 9B die Vorderansicht der einen Hälfte dieser Endplatte und Fig. 9C die Vorderansicht der anderen Hälfte dieser Endplatte.

[0083] Wie aus Fig. 9A hervor geht, ist diese Endplatte **24** mit einer Ölbohrung **29** versehen. Die Verbindungslinie der beiden Hälften **24-1** und **24-2** verläuft aber nicht mittig durch diese Ölbohrung **29**, sondern etwas versetzt zu dieser, wie aus den Fig. 9B und Fig. 9C zu erkennen ist.

[0084] Wie aus Fig. 9D hervor geht, wird an der Endplattenhälfte **24-2** ein unbearbeiteter zylindrischer Stopfen **33** in die Ölbohrung **29** gedrückt.

[0085] Die beiden Endplattenhälften **24-1** und **24-2** werden von der Seite auf die Spurschiene **1** geschoben, bis der Verbindungsflächen j einander berühren, wobei die Ölbohrung **29** an der Endplattenhälfte **24-1** über den in die Ölbohrung **29** an der Endplattenhälfte **24-2** eingesetzten unbearbeiteten zylindrischen Stopfen **33** gleitet.

[0086] Durch die Bohrungen **28-1** und **28-2** der auf diese Weise zusammengefügten Einheit werden Schrauben in den Blockkörper **21** gedreht.

[0087] Dadurch können wie bei der ersten bis zur vierten Ausführungsform die beiden Hälften exakt zueinander positioniert und an einer Seite des Blockkörpers **21** befestigt werden, so daß diese sich bei Benutzung der Führungsvorrichtung nicht verschieben.

[Sechste Ausführungsform]

[0088] Bei den Ausführungsformen eins bis fünf der vorliegenden Erfindung wird der Block **2** rittlings auf die Spurschiene **1** montiert. Die Führungsvorrichtung gemäß der vorliegende Erfindung ist aber nicht auf die beschriebene Konfiguration beschränkt, sondern kann auch wie in Fig. 10 dargestellt ausgeführt werden. Bei dieser Ausführungsform hat die Spurschiene **1** einen U-förmigen Querschnitt und in deren Öffnung wird der Block **2** bewegbar eingesetzt.

[0089] Bei der Führungsvorrichtung dieser Konfiguration kann der Blockkörper **21** von oben in die Spurschiene **1** gelegt werden, wobei die Breite der in Bewegungsrichtung an beiden Seiten des Blockkörpers **21** befestigten Endplatten größer ist als die Breite L4 der Spurschienenöffnung.

[0090] Auch in diesem Fall kann durch Verwendung von Endplatten in zwei Hälften **24-1** und **24-2** wie in den Fig. 5A bis Fig. 9D gezeigt der bewegbare Block **2** in die Öffnung der Spurschiene **1** eingesetzt werden. Das heißt, daß die beiden Endplattenhälften **24-1** und **24-2** in der Öffnung der Spurschiene **1** zueinander positioniert, zu einer Einheit zusammengefügt und an einer Seite des Blockkörpers **21** befestigt werden.

[0091] Eine Spurschiene **1** in Form eines endlosen Rings ist an einer Stelle mit einer Aussparung versehen, über welche der Block **2** in die Spurschiene **1** eingesetzt werden kann.

[Siebente Ausführungsform]

[0092] Fig. 11 zeigt die Draufsicht einer weiteren Führungsvorrichtung gemäß der vorliegenden Erfindung. Wie aus Fig. 11 hervor geht, weist diese Führungsvorrichtung eine Spurschiene **1** auf, deren Rollbahnen **11-1** und **11-2** (dargestellt) und Rollbahnen **12-1** und **12-2** (nicht dargestellt an beiden Enden nach oben ansteigen.

[0093] Bei einer Führungsvorrichtung dieser Art kann der bewegbare Block **2** von keiner Seite der Spurschiene **1** aus auf diese geschoben werden.

[0094] Demzufolge muß der Blockkörper **21** entsprechend konfiguriert werden, um diesen wie in Fig. 2 dargestellt von oben auf die Spurschiene **1** montieren zu können. Auch in diesem Fall ermöglicht eine aus zwei Hälften **24-1** und **24-2** zusammengesetzte Endplatte **24** bzw. **25** eine einfache Montage des bewegbaren Blockes **2** auf die Spurschiene **1**.

[Achte Ausführungsform]

[0095] Die Fig. 12A, Fig. 12B und Fig. 12C zeigen noch ein weiteres Beispiel der Endplatte **24**. Fig. 12A zeigt die Draufsicht dieser Endplatte, Fig. 12B deren Vorderansicht und Fig. 12C deren Vorderansicht bei voneinander geschwenkten Hälften.

[0096] Wie aus diesen Figuren hervor geht, sind die beiden Endplattenhälften **24-1** und **24-2** an einem

Steg **34** teilweise miteinander verbunden, so daß die Öffnung dieser Endplatte in Breitenrichtung vergrößert werden kann.

[0097] Die zusammenhängenden Hälften **24-1** und **24-2** der Endplatte **24** werden in Uhrzeigerrichtung bzw. entgegen Uhrzeigerrichtung um den Steg **34** geschwenkt, um die Öffnung der Endplatte **24** zu vergrößern. Dieser Zustand ist in Fig. 12C dargestellt. In diesem Zustand wird die Endplatte **24** über die Spurschiene **1** gestülpt. Danach werden die beiden Hälften **24-1** und **24-2** wieder zurückgeschwenkt.

[0098] Danach werden durch die Bohrungen **28-1** und **28-2** Schrauben in eine Seite des Blockkörper **21** eingeführt, um die Endplatte **24** an diesem zu befestigen.

[0099] Auf diese Weise werden die beiden Endplattenhälften **24-1** und **24-2** exakt zueinander positioniert und am Blockkörper **21** befestigt und können sich wie bei den Ausführungsformen eins bis sechs bei Nutzung der Führungsvorrichtung nicht verschieben.

[Neunte Ausführungsform]

[0100] Die Fig. 13A und Fig. 13B zeigen eine weitere Ausführungsform der Führungsvorrichtung gemäß der vorliegenden Erfindung. Fig. 13A zeigt die Draufsicht, Fig. 13B die Seitenansicht dieser Führungsvorrichtung. Diese Führungsvorrichtung wird in einem Drehtischsystem verwendet.

[0101] Die Führungsvorrichtung dieser Ausführungsform unterscheidet sich von der in Fig. 1 dargestellten darin, daß auf einer ringförmigen Spurschiene **1** mehrere Blöcke, in diesem Fall die Blöcke **2-1**, **2-2** und **2-3** bewegbar montiert sind.

[0102] Jeder dieser drei bewegbaren Blöcke hat einen Blockkörper **21** mit der in Fig. 2 dargestellten Konfiguration. An beiden Axialenden des Blockkörpers **21** werden Endplatten **24** und **25** mit einer der in den Fig. 5A bis Fig. 9D und Fig. 12A bis Fig. 12C Konfiguration befestigt.

[0103] Durch Befestigen eines Tisches **35** auf den drei bewegbaren Blöcken **2-1**, **2-2** und **2-3** kann das in Fig. 13B dargestellte Drehtischsystem erzeugt werden.

[0104] Dieses Drehtischsystem kann nahe dem Belastungspunkt eine Last und demzufolge ein Drehmoment zuverlässig aufnehmen.

[Zehnte Ausführungsform]

[0105] Die Fig. 14A, Fig. 14B und Fig. 15 zeigen noch ein weiteres Beispiel der Führungsvorrichtung gemäß der vorliegenden Erfindung. Fig. 14A zeigt die Draufsicht dieser Führungsvorrichtung, Fig. 14B deren Schnittansicht B-B und Fig. 15 den in Fig. 14B durch das Bezugszeichen C gekennzeichneten Abschnitt vergrößert dargestellt.

[0106] Die Führungsvorrichtung dieser Ausführungsform hat eine endlose Spurschiene **4** in Ringform und mehrere Blöcke **5** (**6**), welche auf deren Oberseite und Unterseite bewegbar montiert sind.

[0107] Die Spurschiene **4** hat rechtwinklig zur axialen Richtung (Bewegungsrichtung der Blöcke) einen annähernd rechteckigen Querschnitt und ist im Mittelabschnitt auf der linken und auf der rechten Seite ausgespart, so daß links oben und unten ein Kamm **41** und recht oben und unten ein Kamm **42** entstanden sind. Auf der linken Seite ist in den oberen linken Kamm **41** der Spurschiene **4** (periphere Innenseite) eine Rollbahn **41-1**, in den unteren Kamm **41** eine Rollbahn **41-2** und auf der rechten Seite (periphere Außenseite) der Spurschiene **4** in den oberen Kamm **42** eine Rollbahn **42-1**, in den unteren Kamm **42** eine und Rollbahn **42-2** für Rollelemente (bei diesem Beispiel Kugeln) eingearbeitet.

[0108] Der bewegbare Block **5** hat einen U-förmigen Hauptkörper **51**, dessen Schenkel **52** und **53** sich gegenüber liegen und eine Öffnung bilden.

[0109] Der bewegbare Block **6** hat einen U-förmigen Hauptkörper **61**, dessen Schenkel **62** und **63** sich gegenüber liegen und eine Öffnung bilden.

[0110] Die Öffnung im Hauptkörper **51** und die im Hauptkörper **61** sind breiter als der Abstand zwischen den Kämmen **41** und **42** an der Spurschiene **4**. Das heißt, daß die Hauptkörper **51** und **61** von oben bzw. unten auf die Spurschiene **4** geschoben werden können.

[0111] Der Rollbahn **41-1** an der Spurschiene **4** gegenüber ist in die Innenfläche des Schenkels **52** eine Rollbahn **52-1**, der Rollbahn **42-1** an der Spurschiene **4** gegenüber in den Schenkel **53** eine Rollbahn **53-1** eingearbeitet.

[0112] Auf gleiche Weise ist der Rollbahn **42-1** an der Spurschiene **4** gegenüber in die Innenfläche des Schenkels **62** eine Rollbahn **62-1**, der Rollbahn **42-2** an der Spurschiene **4** gegenüber in die Innenfläche des Schenkels eine Rollbahn **63-1** eingearbeitet.

[0113] Die beiden Schenkel **52** und **53** des Blockkörpers **51** sind mit i einer Entlastungsbohrung **52-2** bzw. **53-2**, die beiden Schenkel **62** und **63** des Blockkörpers **61** mit einer Entlastungsbohrung **62-2** bzw. **63-2** als Verbindungsbohrung zur jeweiligen Rollenbahn **52-1**, **53-1**, **62-1** bzw. **63-1** versehen.

[0114] In Axialrichtung (Bewegungsrichtung der Blöcke) wird an der Vorderseite und der Rückseite der beiden Blockkörper **51** und **61** eine Endplatte **24'** bzw. **25'** mit einer der in den Fig. 5A bis Fig. 9D und Fig. 12A bis Fig. 12C dargestellten Konfigurationen befestigt.

[Elfte Ausführungsform]

[0115] Die in Fig. 16 gezeigte Endplatte **24'** könnte als Endplatte **24'** bzw. **25'** normalerweise nicht von oben auf die Spurschiene **4** der in den Fig. 14A bis Fig. 15 dargestellte Führungsvorrichtung geschoben werden, da der Abstand L6 zwischen den beiden schöpflöffelförmigen Vorsprüngen **24'-1** und **24'-2** an der entsprechenden Innenfläche der Öffnung in dieser kleiner ist als die Breite L5 (Fig. 15) des oberen Kopfes der Spurschiene **4** (L6<L5).

[0116] Um die Montage dieser Endplatte **24'** von oben zu ermöglichen, wird diese aus einem elastischen Material, zum Beispiel aus Kunstharz gefertigt.

[0117] Die Endplatte **24'** wird von oben auf die Spurschiene **4** gesetzt, dann in Pfeilrichtung F (Fig. 17) nach unten gedrückt und über die vom oberen Schienenkopf berührten Vorsprünge **24'-1** und **24'-2** wie in Fig. 17 durch die Strich-Punkt-Linie E angedeutet elastisch verformt, bis die durch die durchgehende Linie gekennzeichnete Endstellung erreicht ist und deren Vorsprünge **24'-1** und **24'-2** sich in Höhe der Rollbahnen an der Spurschiene **4** befinden.

[0118] Genauer ausgedrückt, beim Herunterdrücken der Endplatte **24'** wird diese elastisch verformt und dadurch der ursprüngliche Abstand zwischen den Vorsprüngen **24'-1** und **24'-2** ausreichend vergrößert (auf L5), damit diese über den Schienenkopf und in die an der Spurschiene **4** vorhandenen Rollbahnen **41-1** und **42-1** gleiten können. Mit dem Erreichen der durch die durchgehende Linie gekennzeichneten Endstellung ist die Montage der Endplatte **24'** auf die Spurschiene **4** abgeschlossen.

[0119] Wie bereits erwähnt, ist die Endplatte **24'** aus einem elastischen Material gefertigt und kann innerhalb des zulässigen Elastizitätsbereichs so verformt werden, daß der Öffnungsabschnitt mit der kleinsten Breite über den Schienenkopf gleiten kann.

[0120] Auf diese Weise können auch einstückig gefertigte Endplatten **24'** mit der in Fig. 16 gezeigten Konfiguration über den oberen und den unteren Kopf auf die Spurschiene **4** geschoben werden, wie aus Fig. 17 hervor geht.

[0121] Anzumerken ist, daß Fig. 17 die Schnittansicht entlang der in Fig. 14A angedeuteten Linie D-D vergrößert zeigt. Da die Endplatte **25'** ebenfalls aus einem elastischen Material gefertigt ist, kann diese auf die gleiche Weise wie die Endplatte **24'** über den oberen und den unteren Schienenkopf der Spurschiene **4** geschoben werden, so daß auf eine Darstellung der Montage dieser Endplatte verzichtet wird.

[0122] Fig. 18 zeigt ein Beispiel der Verwendung der in den Fig. 14A bis Fig. 15 dargestellten Führungsvorrichtung. In diesem Fall handelt es sich um eine Führungsvorrichtung **70**, welche zwischen einer Grundplatte **81** und einer Grundplatte **82** mit einem darauf montierten Roboter **80** angeordnet ist. Auf der Spurschiene **4** dieser Führungsvorrichtung **70** sind mehrere obere Blöcke **5** und mehrere untere Blöcke **6** bewegbar angeordnet.

[0123] Diese Anordnung ermöglicht das Drehen der Spurschiene **4** und der Grundplatte **82** unabhängig voneinander. Wenn an der Spurschiene **4** zum Beispiel ein Werkzeugtisch **83** befestigt wird, können Werkzeuge oder Bauteile ausgewechselt werden, ohne daß der Arm des Roboters **80** geschwenkt werden muß.

[0124] Durch Drehen des Roboters **80** und des Werkzeugtischs **83** zueinander kann die Werkzeugwechselzeit verkürzt werden.

[0125] Die vorliegende Erfindung ist jedoch nicht auf die beschriebenen Ausführungsformen beschränkt, sondern kann vielfältig modifiziert werden. Bei den beschriebenen Ausführungsformen dienen Kugeln als Rollelemente **3**, doch anstatt Kugeln können auch Rollen verwendet werden.

[0126] Bei einer Führungsvorrichtung wird als Standardendplatte eine aus zwei Hälften zusammengesetzte Endplatte verwendet, wobei die beiden Hälften mit hoher Genauigkeit zueinander positioniert und an beiden axialen Enden eines bewegbaren Blocks befestigt werden können, ohne daß bei Nutzung der Vorrichtung die Gefahr des Verschiebens beider zueinander besteht. Der auf der Spurschiene der Vorrichtung angeordnete und bezüglich dieser bewegbare Block hat rechtwinklig zur axialen Richtung einen entsprechenden Querschnitt und kann an einem Zwischenstück der Spurschiene auf diese montiert werden. Die Endplatte ist im wesentlichen aus einer linken und einer rechten Hälfte zusammengesetzt, wobei die eine Hälfte mit einer Befestigungsbohrung und an der Verbindungsfläche mit einem Positionierzapfen, die andere Hälfte mit einer Befestigungsbohrung und an der Verbindungsfläche mit einer Positionierbohrung zur Aufnahme des Positionierzapfens versehen ist. Durch die Befestigungsbohrungen der über den Zapfen und die Bohrung zusammengefügten Endplatteneinheit werden Schrauben in eine der in Bewegungsrichtung liegenden Seiten des bewegbaren Blockes gedreht, um die Endplatteneinheit an diesem zu befestigen.

Patentansprüche

1. Führungsvorrichtung, welche aufweist:
eine Spurschiene (**1**) mit einer in Längsrichtung sich erstreckenden Rollbahn (**11-1**, **11-2**, **12-1**, **12-2**) für Rollelemente,
einen auf der Spurschiene (**1**) bewegbar zu dieser angeordneten Block (**2**), wobei
der Blockkörper (**21**) mit einer Lastaufnahmerollbahn (**22-1**, **22-2**, **23-1**, **23-2**), welche zusammen mit der Rollbahn (**11-1**, **11-2**, **12-1**, **12-2**) an der Spurschiene (**1**) einen Rollkanal (R1, R2, R3, R4) für die Rollelemente bildet, und außerdem mit einer Entlastungsbohrung (**22-3**, **22-4**, **23-3**, **23-4**), welche mit der Lastaufnahmerollbahn (**22-1**, **22-1**, **23-1**, **23-2**) in Verbindung steht, versehen ist,
eine Endplatte (**24**, **25**) an jeder der beiden Stirnseiten des bewegbaren Blocks (**2**), welche mit einem die Entlastungsbohrung (**22-3**, **22-4**, **23-3**, **23-4**) und den Rollkanal (R1, R2, R3, R4) miteinander verbindenden und zusammen mit diesen einen Zirkulationskanal für die Rollelemente bildenden Richtungsumkehrkanal (R5, R6, R7, R8) versehen ist, und
mehrere im Zirkulationskanal angeordnete Rollelemente (**3**), welche bei der Relativbewegung zwischen der Spurschiene (**1**) und dem bewegbaren Block (**2**) im Zirkulationskanal zirkulieren, wobei
der bewegbare Block (**2**) rechtwinklig zur axialen Richtung einen entsprechenden Querschnitt hat und an einem Zwischenstück der Spurschiene (**1**) auf diese montiert ist,
die Endplatte (**24**, **25**) in Breitenrichtung im wesentlichen aus einer linken Hälfte (**24-1**) und einer rechten Hälfte (**24-2**) zusammengesetzt ist,
die paarigen Hälften der Endplatte durch Verbindungselemente (**26**, **27**, **31**, **32**, **33**) exakt zueinander positioniert sind und die zusammengefügte Endplatte (**24**, **25**) in Bewegungsrichtung des Blocks (**2**) mit Befestigungselementen sicher an einem Ende des Blockkörpers (**21**) befestigt ist.

2. Führungsvorrichtung gemäß Anspruch 1, wobei
der Verbindungsmechanismus
einen aus der Verbindungsfläche an einer der beiden Endplattenhälften ragenden Positionierzapfen (**26**) und
eine an der Verbindungsfläche der anderen Endplattenhälfte vorhandene, zum Positionierzapfen passende Positionierbohrung (**27**) aufweist und
bei zusammengefügter Endplatte (**24**, **25**) der Positionierzapfen (**26**) in die Positionierbohrung (**27**) ragt, wobei
der Befestigungsmechanismus
Befestigungsbohrungen (**28-1**, **28-2**) an den beiden Endplattenhälften (**24-1**, **24-2**) und
Befestigungsschrauben aufweist und
wobei von den durch die Befestigungsbohrungen in Richtung der Relativbewegung in ein Ende des Blockkörpers (**21**) gedrehten Befestigungsschrauben die zusammengefügte Endplatte (**24**, **25**) an diesem gehalten wird.

3. Führungsvorrichtung gemäß Anspruch 1, wobei
der Verbindungsmechanismus
Positionierbohrungen (**30-1**, **30-2**), welche in einem bestimmten Abstand von der Verbindungsfläche an jeder der beiden Endplattenhälften (**24-1**, **24-2**) vorhanden sind, und
ein U-förmig gebogenes Positionierelement (**31**), dessen Schenkel in die Positionierbohrungen passen, aufweist,
bei zusammengefügter Endplatte (**24**, **25**) die Endplattenhälften sich an den Verbindungsflächen berühren und die Schenkel des Positionierelements (**31**) in die Positionierbohrungen (**30-1**, **30-2**) ragen, wobei
der Befestigungsmechanismus
Befestigungsbohrungen (**28-1**, **28-2**) an den beiden Endplattenhälften und
Befestigungsschrauben aufweist und
wobei von den durch die Befestigungsbohrungen (**28-1**, **28-2**) in Richtung der Relativbewegung in ein Ende des Blockkörpers (**21**) gedrehten Befestigungsschrauben die zusammengefügte Endplatte (**24**, **25**) an diesem gehalten wird.

4. Führungsvorrichtung gemäß Anspruch 1, wobei
der Verbindungsmechanismus
ein U-förmig gebogenes Halteelement (**32**) aufweist,
bei zusammengefügter Endplatte (**24**, **25**) die beiden Endplattenhälften sich an den Verbindungsflächen berühren und von den Schenkeln des Halteelements (**32**) in diesem Zustand gehalten werden, wobei
der Befestigungsmechanismus
Befestigungsbohrungen (**28-1**, **28-2**) an den beiden Endplattenhälften und
Befestigungsschrauben aufweist und
wobei von den durch die Befestigungsbohrungen (**28-1**, **28-2**) in Richtung der Relativbewegung in ein Ende des Blockkörpers (**21**) gedrehten Befestigungsschrauben die zusammengefügte Endplatte (**24**, **25**) an diesem gehalten wird.

5. Führungsvorrichtung gemäß Anspruch 1, wobei
der Verbindungsmechanismus
einen Vorsprung (g, h) und eine Vertiefung (f, i) an jeder Verbindungsfläche der beiden Endplattenhälften aufweist, welche ineinander passen und relatives Verschieben der beiden Endplattenhälften in Breitenrichtung verhindern,
wobei bei zusammengefügter Endplatte (**24**, **25**) die Endplattenhälften sich an den Verbindungsflächen berühren und die Vorsprünge (g, h) in die entsprechenden Vertiefungen (f, i) ragen, wobei
der Befestigungsmechanismus
Befestigungsbohrungen (**28-1**, **28-2**) an den beiden

Endplattenhälften und
Befestigungsschrauben aufweist und
wobei von den durch die Befestigungsbohrungen (**28-1**, **28-2**) in Richtung der Relativbewegung in ein Ende des Blockkörpers (**21**) gedrehten Befestigungsschrauben die zusammengefügte Endplatte (**24**, **25**) an diesem gehalten wird.

6. Führungsvorrichtung gemäß Anspruch 1, wobei
der Verbindungsmechanismus
einen unbearbeiteten zylindrischen Stopfen (**33**), welcher in einer Aussparung (**29**) in der Verbindungsfläche einer der beiden Endplatten positioniert ist und teilweise aus der Verbindungsfläche ragt, und
eine Aussparung (**29**) in der Verbindungsfläche der anderen Endplattenhälfte aufweist,
bei zusammengesetzter Endplatte (**24**, **25**) der an der Verbindungsfläche der einen Endplattenhälfte vorstehende Teil des unbearbeiteten zylindrischen Stopfens (**33**) in die Aussparung (**29**) an der Verbindungsfläche der anderen Endplattenhälfte ragt, wobei
der Befestigungsmechanismus
Befestigungsbohrungen (**28-1**, **28-2**) an den beiden Endplattenhälften und
Befestigungsschrauben aufweist und
wobei von den durch die Befestigungsbohrungen (**28-1**, **28-2**) in Richtung der Relativbewegung in ein Ende des Blockkörpers (**21**) gedrehten Befestigungsschrauben die zusammengefügte Endplatte (**24**, **25**) an diesem gehalten wird.

7. Führungsvorrichtung gemäß Anspruch 1, wobei
die Endplatte (**24**, **25**) rechtwinklig zur axialen Richtung einen nahezu U-förmigen Querschnitt hat und rittlings auf der Spurschiene (**1**) sitzt, wobei
der Verbindungsmechanismus
einen Steg (**34**) aufweist, über welchen die beiden Endplattenhälften teilweise miteinander verbunden sind und beim Montieren auf die Spurschiene (**1**) auseinander gedrückt werden, um die Öffnung in dieser zu verbreitern, wobei
der Befestigungsmechanismus
Befestigungsbohrungen (**28-1**, **28-2**) an den beiden Endplattenhälften und
Befestigungsschrauben aufweist und
wobei von den durch die Befestigungsbohrungen (**28-1**, **28-2**) in Richtung der Relativbewegung in ein Ende des Blockkörpers (**21**) gedrehten Befestigungsschrauben die zusammengefügte Endplatte (**24**, **25**) an diesem gehalten wird.

8. Führungsvorrichtung gemäß Anspruch 1, wobei die Spurschiene (**1**) als endloser Ring ausgeführt ist.

9. Führungsvorrichtung gemäß Anspruch 2, wobei die Spurschiene (**1**) als endloser Ring ausgeführt ist.

10. Führungsvorrichtung gemäß Anspruch 3, wobei die Spurschiene (**1**) als endloser Ring ausgeführt ist.

11. Führungsvorrichtung gemäß Anspruch 4, wobei die Spurschiene (**1**) als endloser Ring ausgeführt ist.

12. Führungsvorrichtung gemäß Anspruch 5, wobei die Spurschiene (**1**) als endloser Ring ausgeführt ist.

13. Führungsvorrichtung gemäß Anspruch 6, wobei die Spurschiene (**1**) als endloser Ring ausgeführt ist.

14. Führungsvorrichtung gemäß Anspruch 7, wobei die Spurschiene (**1**) als endloser Ring ausgeführt ist.

15. Führungsvorrichtung gemäß Anspruch 1, wobei die Spurschiene (**1**) eine zu deren beiden Enden hin ansteigende Rollbahn (**11-1**, **11-2**, **12-1**, **12-2**) hat.

16. Führungsvorrichtung gemäß Anspruch 2, wobei die Spurschiene (**1**) eine zu deren beiden Enden hin ansteigende Rollbahn (**11-1**, **11-2**, **12-1**, **12-2**) hat.

17. Führungsvorrichtung gemäß Anspruch 3, wobei die Spurschiene (**1**) eine zu deren beiden Enden hin ansteigende Rollbahn (**11-1**, **11-2**, **12-1**, **12-2**) hat.

18. Führungsvorrichtung gemäß Anspruch 4, wobei die Spurschiene (**1**) eine zu deren beiden Enden hin ansteigende Rollbahn (**11-1**, **11-2**, **12-1**, **12-2**) hat.

19. Führungsvorrichtung gemäß Anspruch 5, wobei die Spurschiene (**1**) eine zu deren beiden Enden hin ansteigende Rollbahn (**11-1**, **11-2**, **12-1**, **12-2**) hat.

20. Führungsvorrichtung gemäß Anspruch 6, wobei die Spurschiene (**1**) eine zu deren beiden Enden hin ansteigende Rollbahn (**11-1**, **11-2**, **12-1**, **12-2**) hat.

21. Führungsvorrichtung gemäß Anspruch 7, wobei die Spurschiene (**1**) eine zu deren beiden Enden hin ansteigende Rollbahn (**11-1**, **11-2**, **12-1**, **12-2**) hat.

22. Führungsvorrichtung, welche aufweist:
eine Spurschiene (**4**) mit einer längs sich erstreckenden Rollbahn (**41-1**, **41-2**, **42-1**, **42-2**),
einen auf der Spurschiene (**4**) angeordneten und relativ zu dieser bewegbaren Block (**5**, **6**),
wobei in den Blockkörper (**51**, **61**) eine Lastaufnahmerollbahn (**52-1**, **53-1**, **62-1**, **63-1**) eingearbeitet ist, welche zusammen mit der Rollbahn (**41-1**, **41-2**, **42-1**, **42-2**) an der Spurschiene (**4**) einen Lastaufnahmekanal (R1, R2, R3, R4) bildet, und der Blockkörper (**51**, **61**) außerdem mit einer Entspannungsbohrung (**52-2**, **53-2**, **62-2**, **63-2**) versehen ist, welche zur

Lastaufnahmerollbahn (**52-1**, **53-1**, **62-1**, **63-1**) Verbindung hat,
eine Endplatte (**24**, **25**) an jeder der beiden Stirnseiten des bewegbaren Blockkörpers (**51**, **61**), welche mit einem Richtungsumkehrkanal (R5, R6, R7, R8) versehen ist, der zusammen mit der Lastaufnahmerollbahn (**52-1**, **53-1**, **62-1**, **63-1**) und der Entspannungsbohrung (**52-2**, **53-2**, **62-2**, **63-2**) einen Zirkulationskanal bildet, und
zahlreiche Rollelemente (**3**), welche im Zirkulationskanal untergebracht sind und bei einer Relativbewegung zwischen dem bewegbaren Block (**5**, **6**) und der Spurschiene (**4**) in diesem zirkulieren,
wobei der Blockkörper (**51**, **61**) rechtwinklig zur axialen Richtung eine Geometrie hat, welche die Montage des Blocks (**5**, **6**) an einem Zwischenstück der Spurschiene (**4**) auf diese ermöglicht,
wobei die Endplatte (**24**, **25**) rechtwinklig zur axialen Richtung annähernd U-Form hat, aus einem elastischen Material gefertigt ist und beim Aufsetzen auf die Spurschiene (**4**) so verformt wird, daß die Breite der Öffnung an dieser sich vergrößert, und
wobei die auf die Spurschiene (**4**) gesetzte Endplatte (**24**, **25**) von den durch die Befestigungsbohrungen (**28-1**, **28-2**) in Richtung der Relativbewegung in ein Ende des bewegbaren Blockkörpers (**51**, **61**) gedrehten Befestigungsschrauben an diesem gehalten wird.

Es folgen 18 Blatt Zeichnungen

Anhängende Zeichnungen

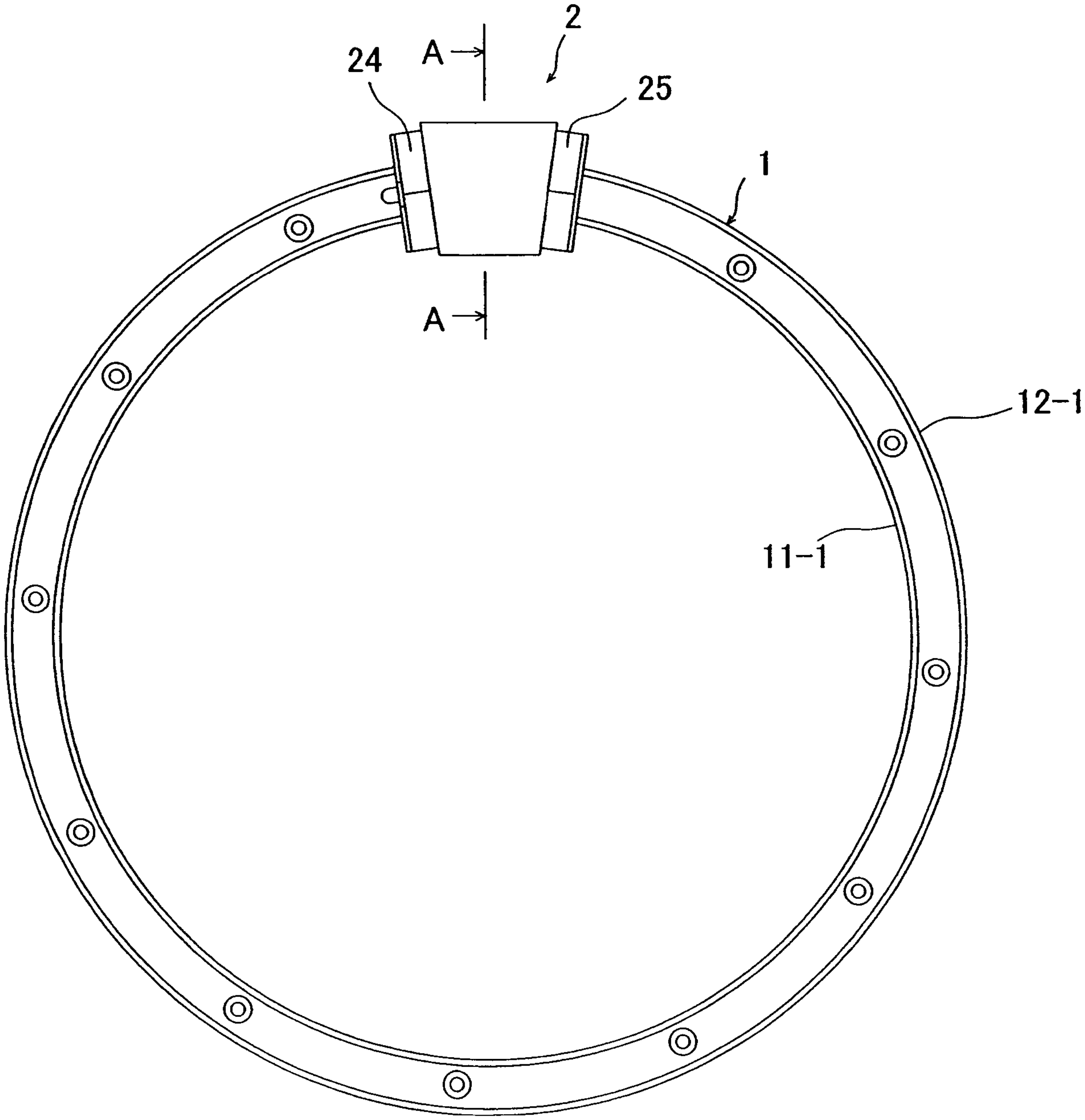


Fig.1

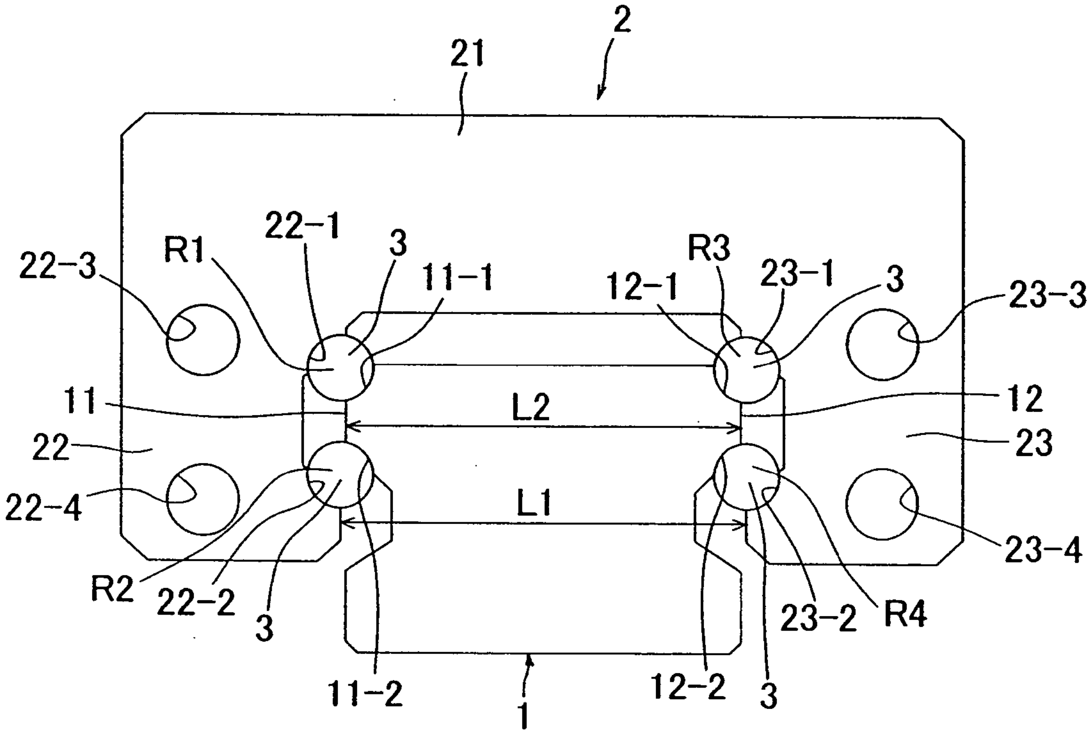

2
21
22-1
R1
3
11-1
R3
23-1
3
22-3
12-1
23-3
11
L2
12
22
23
22-4
L1
23-4
R2
22-2
3
23-2
R4
11-2
12-2
3
1

Fig.2

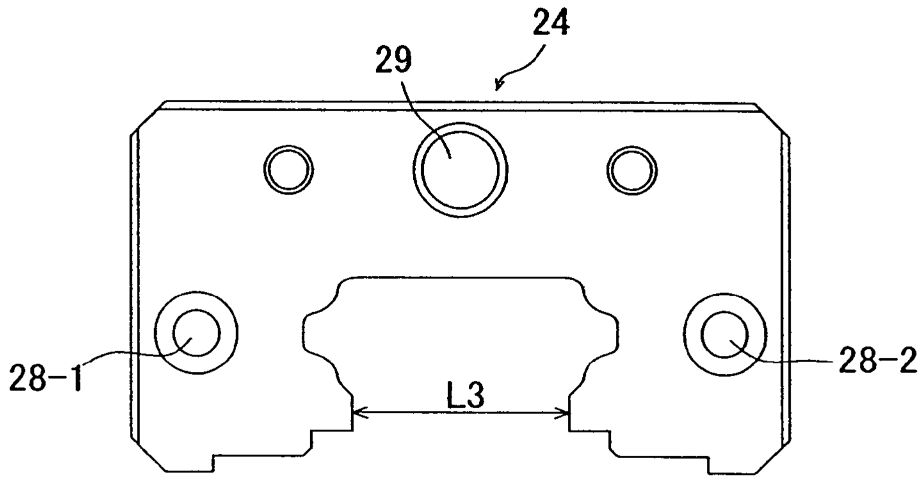


Fig.3

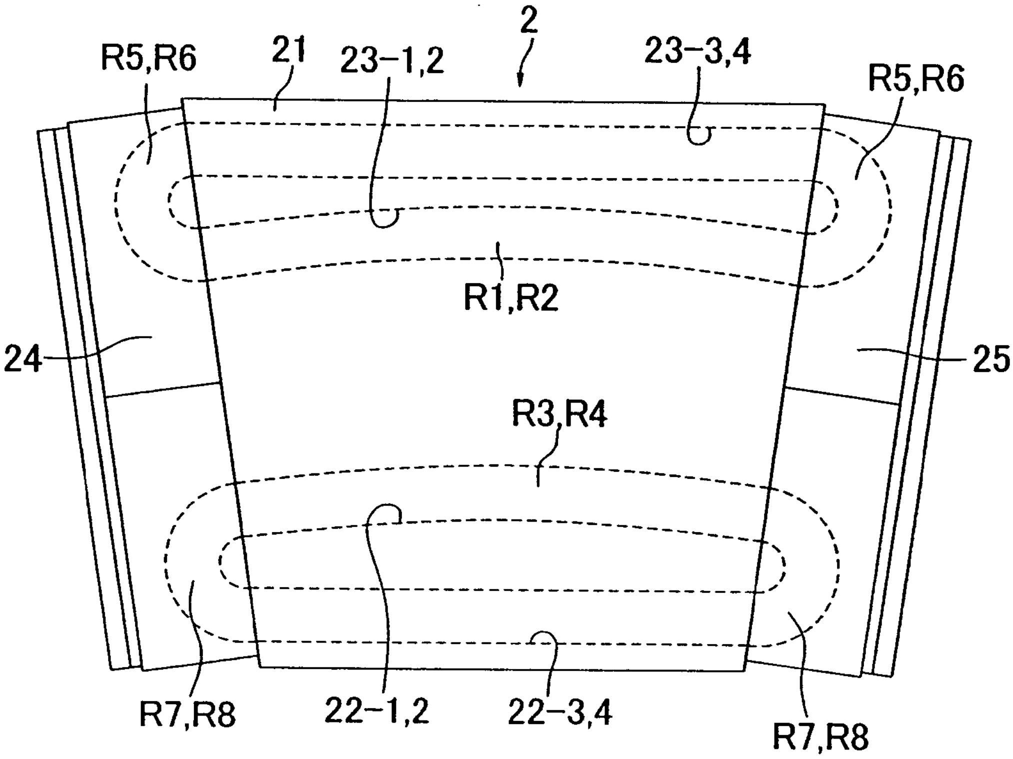


Fig.4

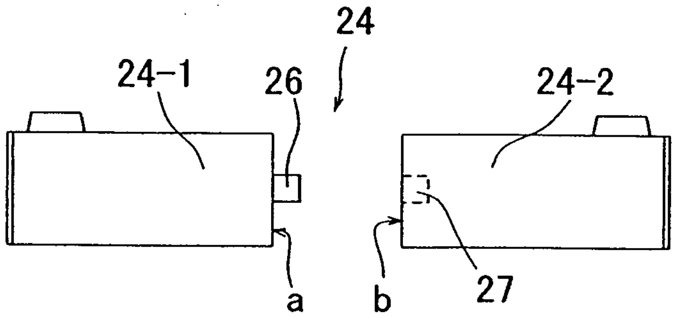


Fig.5A

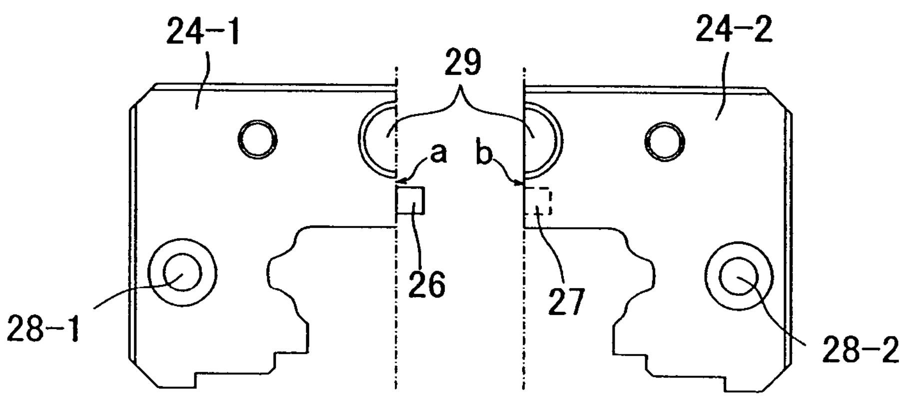


Fig.5B

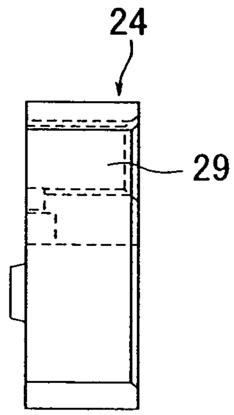


Fig.5C

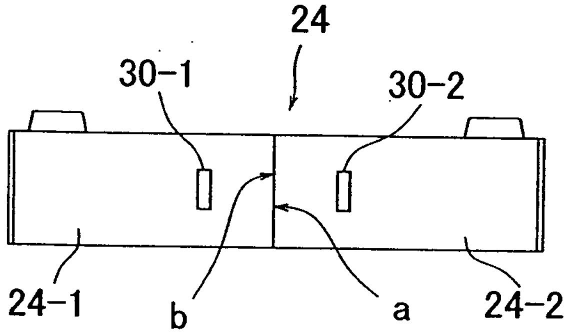


Fig.6A

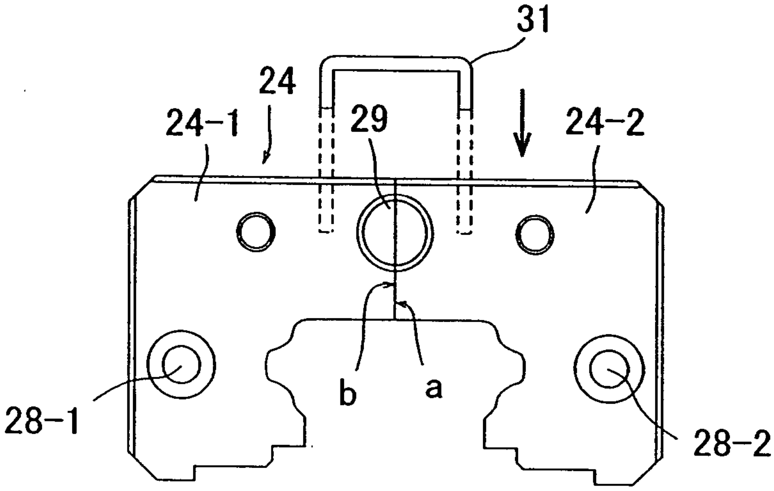


Fig.6B

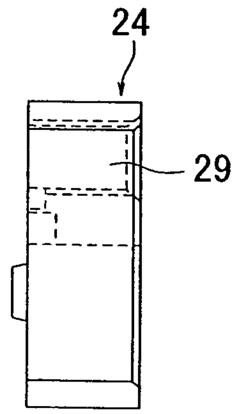


Fig.6C

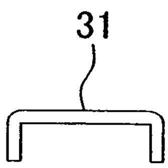


Fig.6D

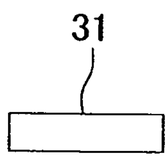


Fig.6E

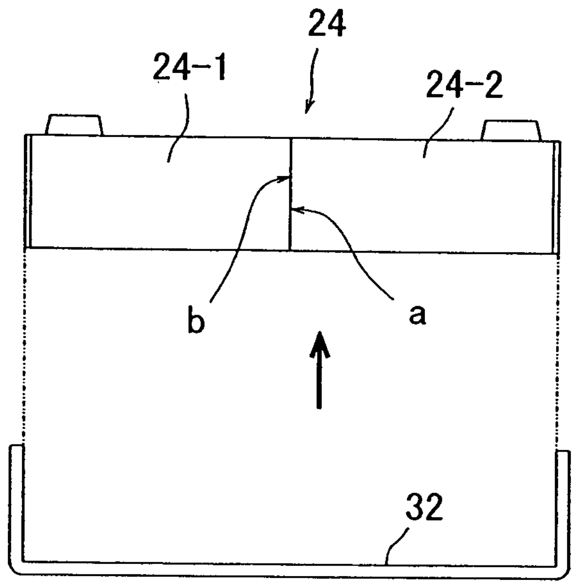


Fig.7A

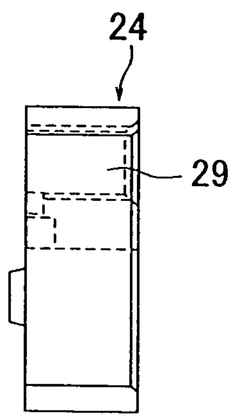


Fig.7B

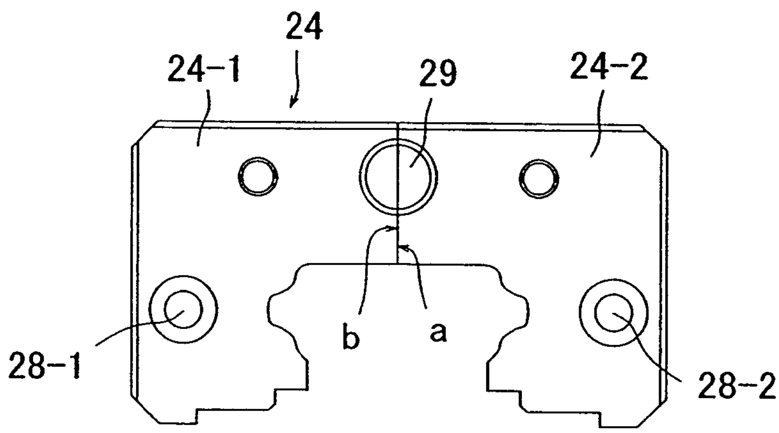


Fig.7C

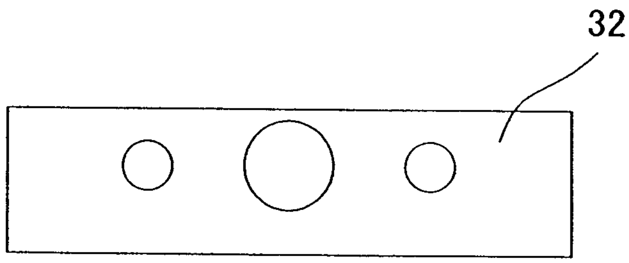


Fig.7D

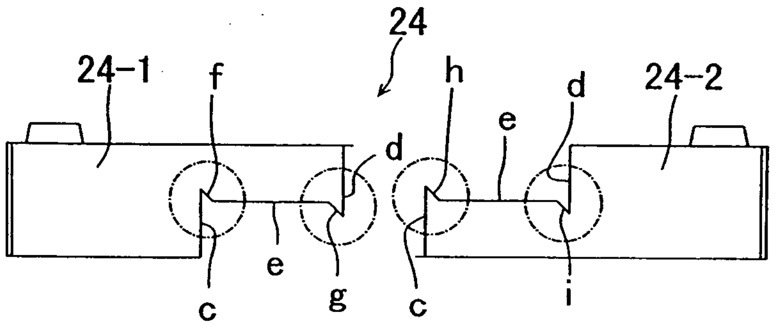


Fig.8A

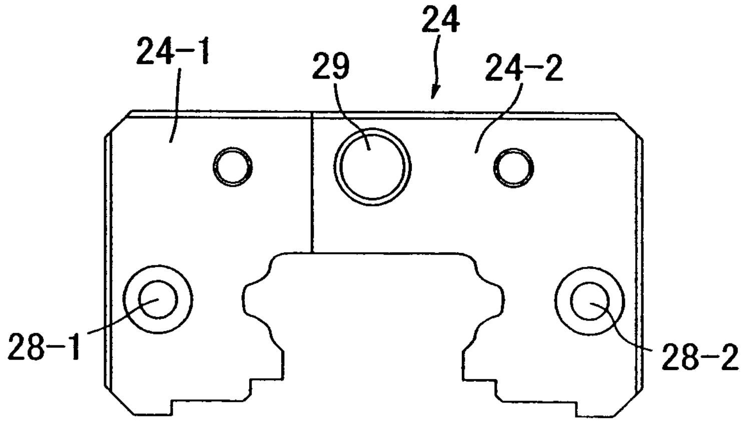


Fig.8B

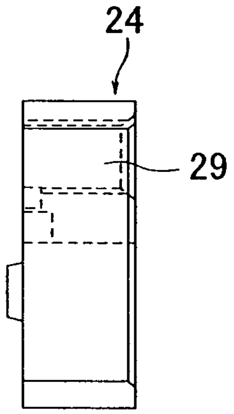


Fig.8C

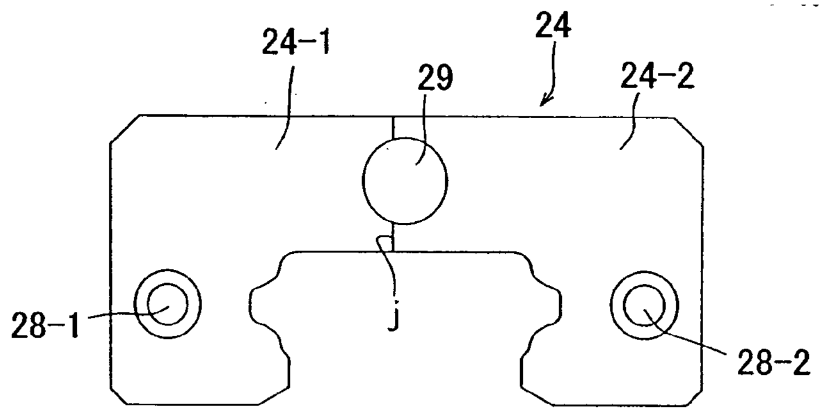


Fig.9A

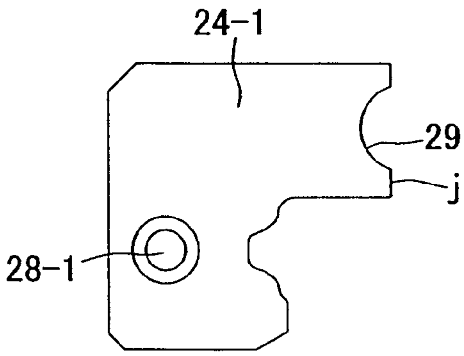


Fig.9B

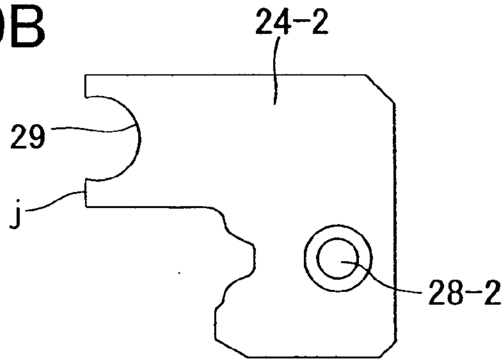


Fig.9C

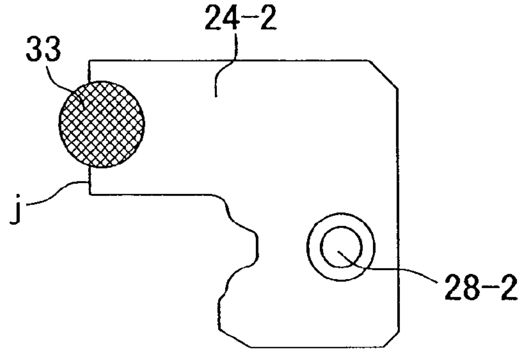


Fig.9D

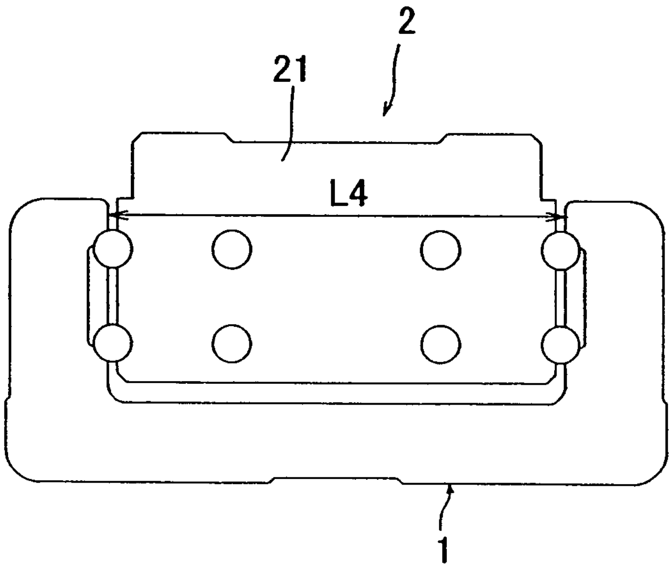


Fig.10

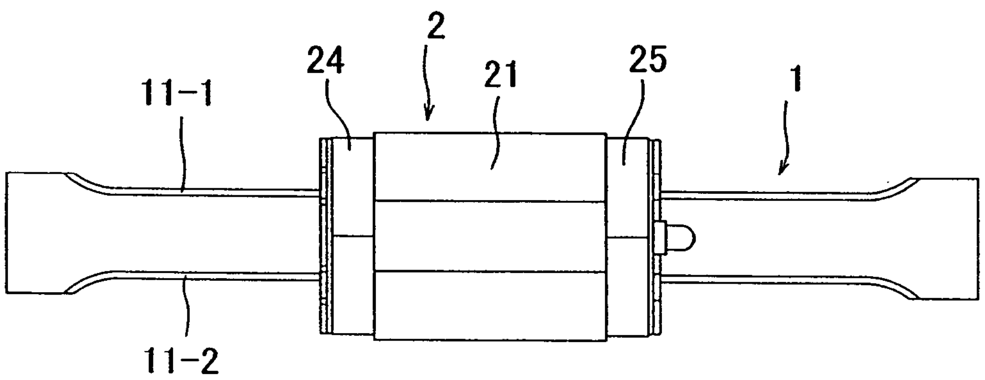


Fig.11

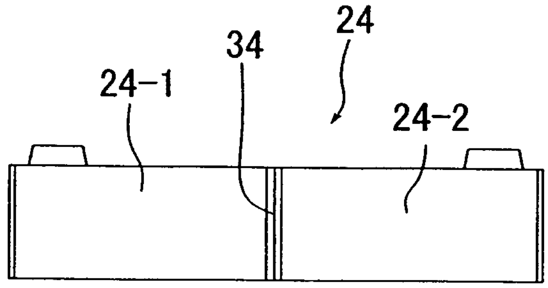


Fig.12A

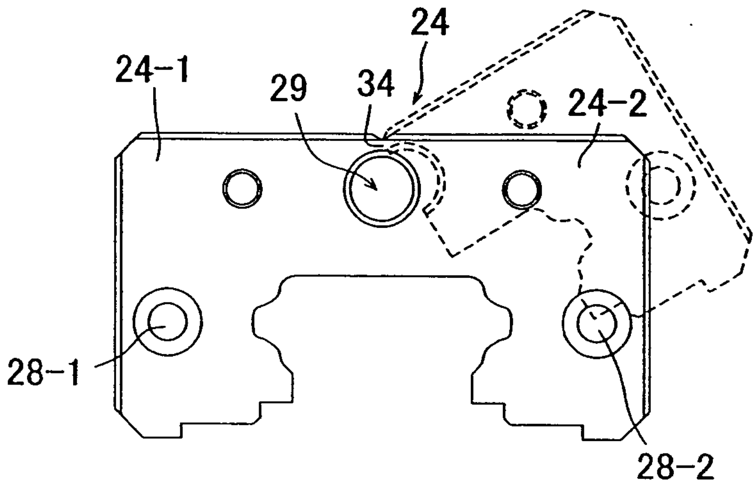


Fig.12B

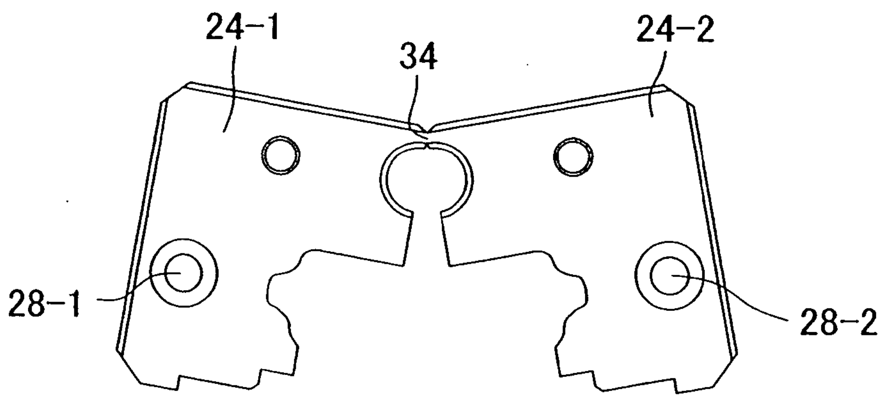


Fig.12C

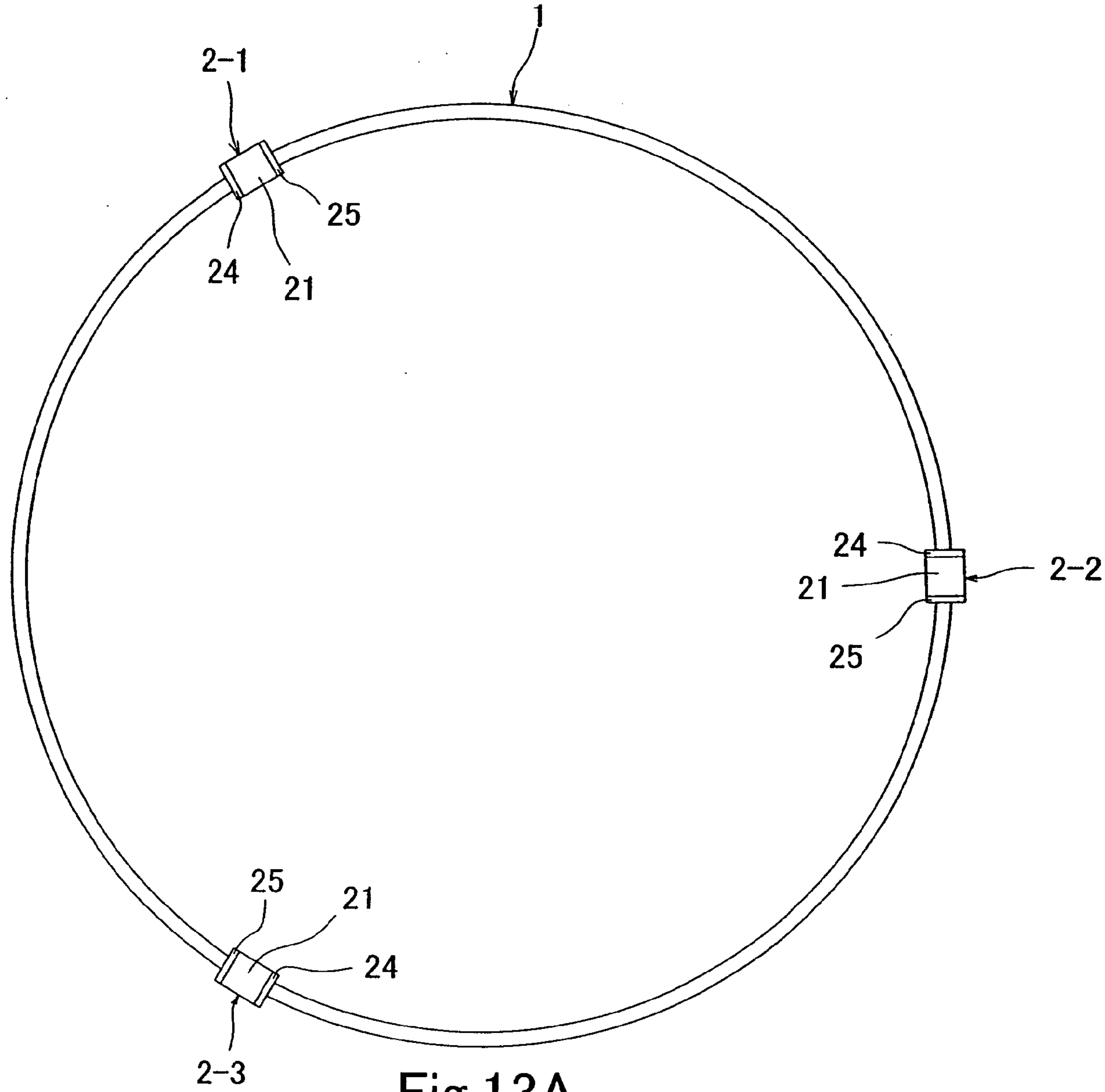


Fig.13A

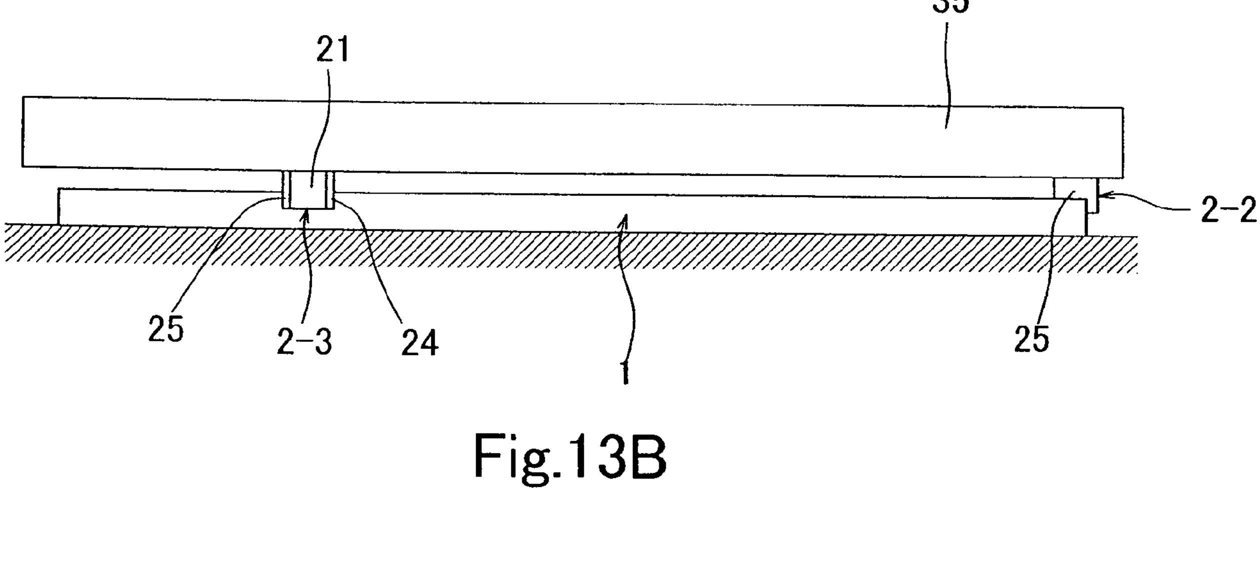


Fig.13B

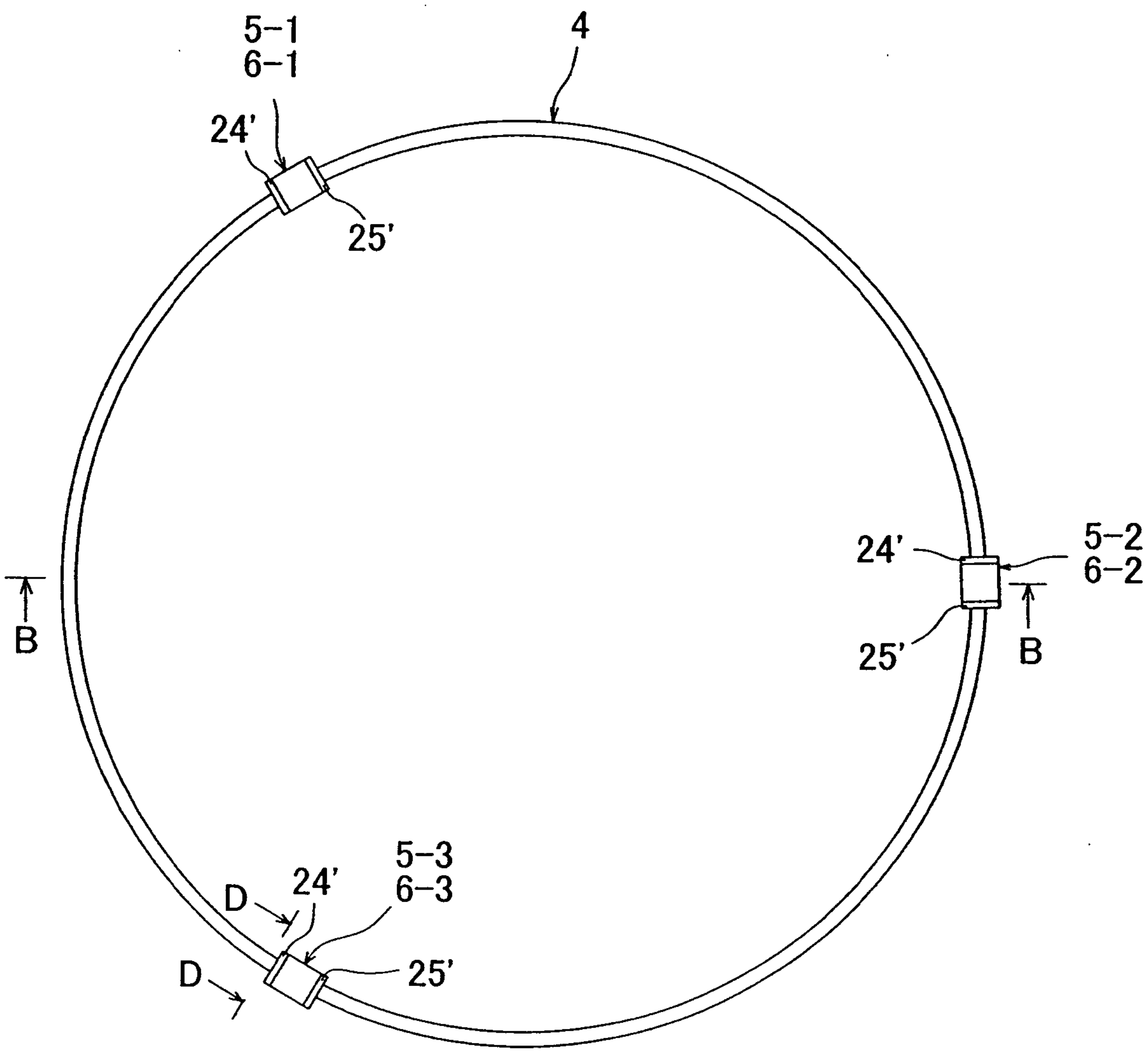


Fig.14A

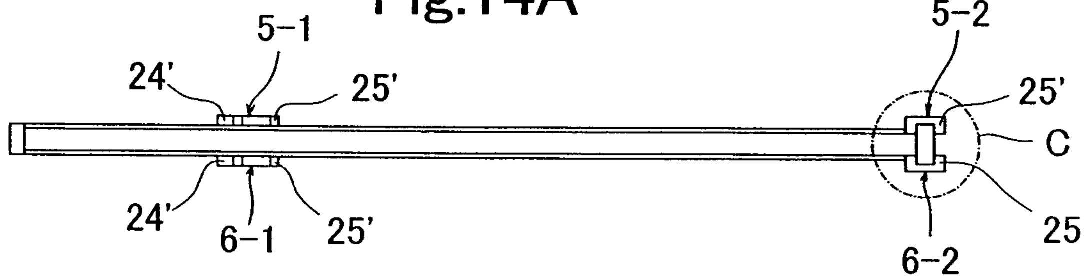


Fig.14B

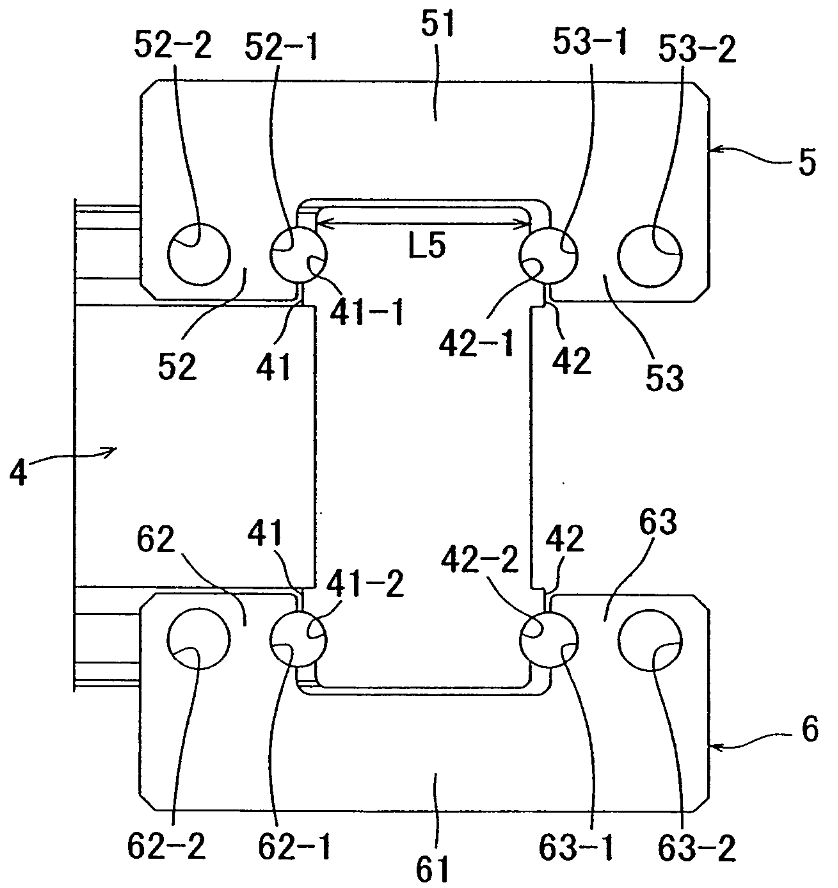

52-2
52-1
51
53-1
53-2
5
L5
41-1
42-1
52
41
42
53
4
62
41
42-2
42
63
41-2
6
62-2
62-1
63-1
63-2
61

Fig.15

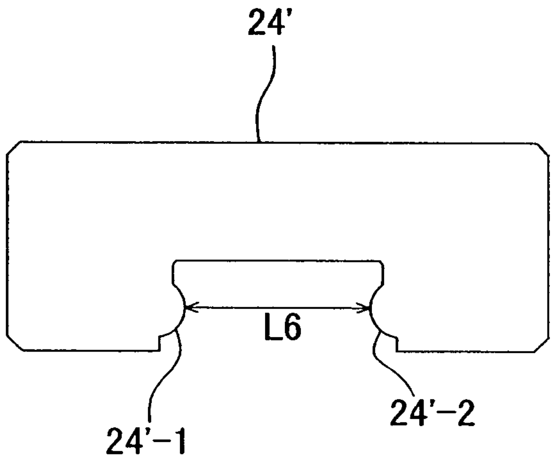


Fig.16

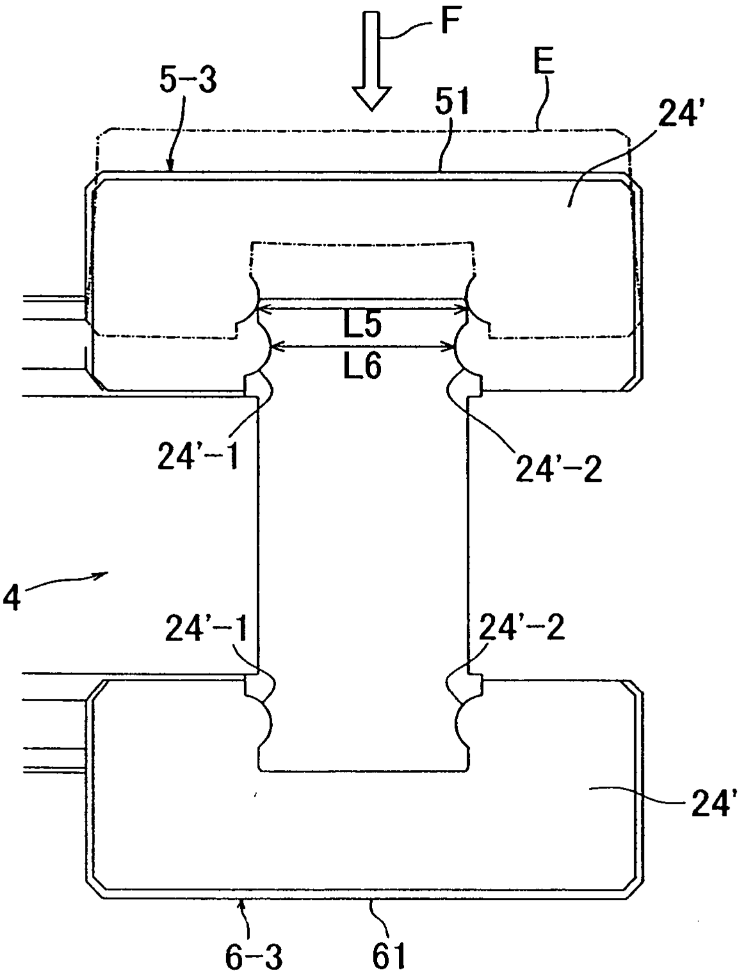


Fig.17

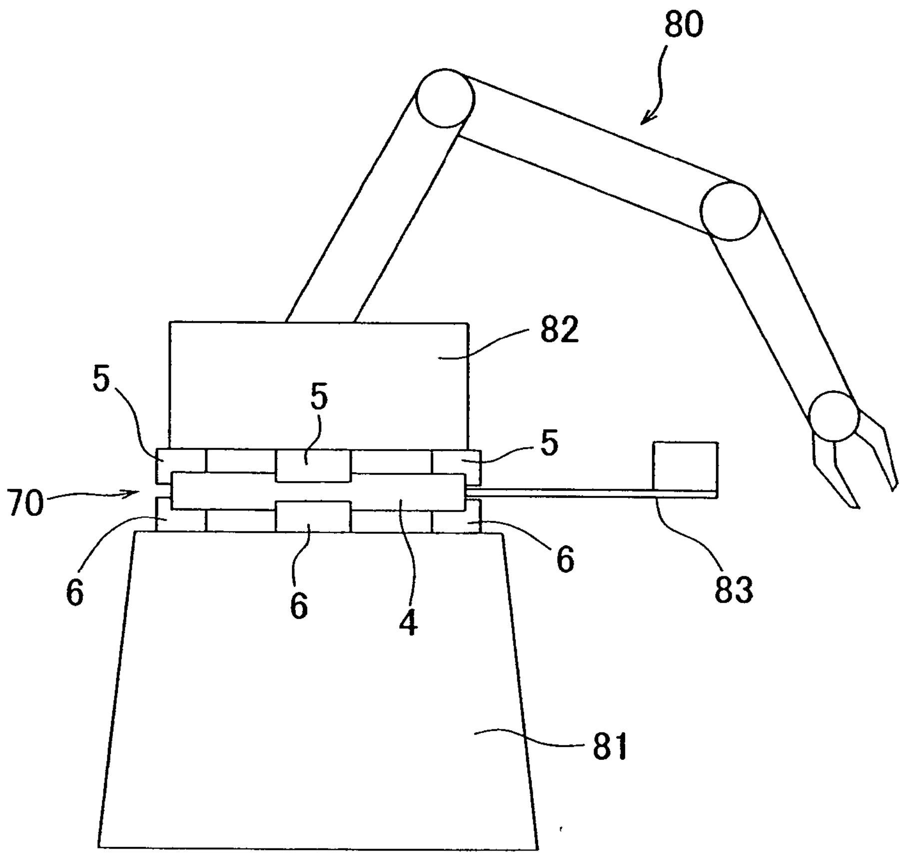


Fig.18

(19) Bundesrepublik Deutschland
Deutsches Patent- und Markenamt

(10) **DE 10 2004 031 122 A1** 2005.02.10

(12) # Offenlegungsschrift

(21) Aktenzeichen: **10 2004 031 122.6**
(22) Anmeldetag: **28.06.2004**
(43) Offenlegungstag: **10.02.2005**

(51) Int Cl.[7]: **F16C 29/02**

(30) Unionspriorität:
2003-197393 15.07.2003 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

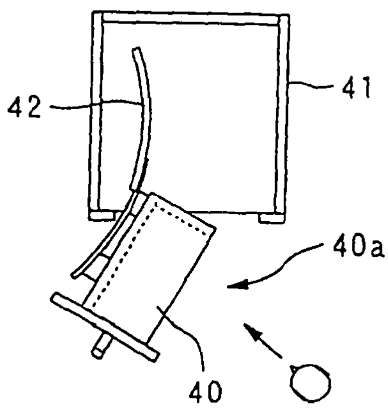
(74) Vertreter:
Viering, Jentschura & Partner, 80538 München

(72) Erfinder:
Hoshide, Kaoru, Tokio/Tokyo, JP; Sato, Akira, Tokio/Tokyo, JP; Kouchi, Minoru, Tokio/Tokyo, JP; Sasaki, Soichi, Tokio/Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Bezeichnung: **Gleitschieneneinheit**

(57) Zusammenfassung: Gleitschieneneinheit zum Führen eines Gegenstandes (40), der aus einem Körper (41) herauszuziehen ist, in welchem der Gegenstand (40) gleitend aufgenommen ist, aufweisend eine körperseitige Schiene, die für den Körper (41) vorgesehen ist, und eine gegenstandseitige Schiene, die für den Gegenstand (40) vorgesehen ist, um relativ zu der körperseitigen Schiene gleitend ausgezogen zu werden, wobei die körperseitige Schiene und die gegenstandseitige Schiene jeweils einen Abschnitt aufweisen, der in Kreisbogenform derart gebogen ist, dass der Gegenstand (40) entlang einer kreisbogenförmigen Ortskurve ausgezogen wird.



Beschreibung

[0001] Die Erfindung betrifft eine Gleitschieneneinheit zum sanften Führen einer Zieh- oder Schiebebewegung eines Gegenstandes, wie einer Schublade, die aus einem Körper, wie einem Möbelstück, einem Schreibtisch oder dergleichen, herauszuziehen ist.

Stand der Technik

[0002] Eine Gleitschieneneinheit ist zum Beispiel an einer Schublade eines Möbelstücks, eines Schreibtisches oder dergleichen angebracht ist, um zu ermöglichen, dass die Schublade leicht und sanft geöffnet oder geschlossen werden kann. Eine derartige Gleitschieneneinheit ist zum Beispiel in dem japanischen Patent mit der Veröffentlichungsnummer (KOKAI) SHO 51-048046 offenbart, das der DE 2540656, GB 1512069 und US 3966273 entspricht.

[0003] Die Gleitschieneneinheit ist insgesamt aus einer Außenschiene und einer Innenschiene zusammengesetzt, die an der Außenschiene angepasst ist. Eine Anzahl von Kugeln sind zwischen der Außenschiene und der Innenschiene angeordnet. Im Allgemeinen ist die Außenschiene an einem Körper beispielsweise eines Möbelstücks angebracht, und die Innenschiene ist an der Schublade angebracht. Bei dieser Struktur rollen bei Ausübung einer äußeren Kraft auf die Innenschiene die Kugeln zwischen der Innenschiene und der Außenschiene, wodurch die Innenschiene in Bezug auf die Außenschiene gleitet. Ferner ist es zum Erreichen eines großen Hubes der Innenschiene notwendig, die Innenschiene derart zu gestalten, dass deren Länge so groß wie die Länge der Außenschiene ist.

[0004] Im Allgemeinen haben bei der oben genannten herkömmlichen Gleitschienenstruktur sowohl die Außenschiene als auch die Innenschiene eine geradlinige Form, und die Schublade wird daher geradlinig herausgezogen. Bei einer derartigen Struktur kann beim geradlinigen Herausziehen der Schublade der Fall eintreten, dass die Schublade mit einem Hindernis kollidiert oder die Schublade nicht leicht herausgezogen werden kann, was unangenehm ist.

Aufgabenstellung

[0005] Mit der Erfindung wird eine Gleitschieneneinheit geschaffen, bei der die Ortskurve einer Schublade von einer geradlinigen Ortskurve abweicht.

[0006] Dies wird gemäß der Erfindung erreicht durch eine Gleitschieneneinheit zum Führen eines Gegenstandes, der aus einem Körper herauszuziehen ist, in welchem der Gegenstand gleitend aufgenommen ist, aufweisend eine körperseitige Schiene, die für den Körper vorgesehen ist, und eine gegenstandseitige Schiene, die für den Gegenstand vorgesehen ist, um relativ zu der körperseitigen Schiene gleitend ausgezogen zu werden, wobei die körperseitige Schiene und die gegenstandseitige Schiene jeweils einen Abschnitt aufweisen, der in Kreisbogenform derart gebogen ist, dass der Gegenstand entlang einer kreisbogenförmigen Ortskurve ausgezogen wird.

[0007] Gemäß der Erfindung kann der herauszuziehende Gegenstand entlang einer kreisbogenförmigen Ortskurve zum Beispiel in einer vertikalen Ebene oder in einer horizontalen Ebene auf der Basis eines Verfahrens, mittels welchem eine Gleitschiene an einem Körper montiert wird, ausgezogen werden.

[0008] Bei einer bevorzugten Ausführungsform der Erfindung weist die Gleitschieneneinheit eine Außenschiene, die eine der körperseitigen Schiene und der gegenstandseitigen Schiene für den herauszuziehenden Gegenstand bildet, wobei die Außenschiene aus einem Bodenwandabschnitt, der sich in dessen Längsrichtung in Kreisbogenform erstreckt, und einem Paar Seitenwandabschnitten zusammengesetzt ist, die in einer gebogenen Form quer zur Längsrichtung an beiden Längsseiten des Bodenwandabschnitts ausgebildet sind und sich in deren Längsrichtung in Kreisbogenform erstrecken, um dadurch einen Wälzkörperrollabschnitt zu bilden, eine Innenschiene, die eine andere der körperseitigen Schiene und der gegenstandseitigen Schiene bildet, um an die Außenschiene angepasst zu werden, wobei die Innenschiene aus einem Bodenwandabschnitt, der sich parallel zu dem Bodenwandabschnitt der Außenschiene erstreckt, und einem Paar Seitenwandabschnitten zusammengesetzt ist, die in einer gebogenen Form quer zur Längsrichtung an beiden Längsseiten des Bodenwandabschnitts ausgebildet sind und sich in deren Längsrichtung in Kreisbogenform erstrecken, um dadurch einen Wälzkörperrollabschnitt zu bilden, und eine Anzahl von Wälzkörpern auf, die zwischen dem Wälzkörperrollabschnitt der Außenschiene und dem Wälzkörperrollabschnitt der Innenschiene angeordnet sind.

[0009] Die Außenschiene kann in einer virtuellen Ebene des Bodenwandabschnitts der Außenschiene in der Kreisbogenform gebogen sein, und die Innenschiene ist in einer virtuellen Ebene des Bodenwandabschnitts der Innenschiene in der Kreisbogenform gebogen.

[0010] Die Außenschiene kann in einer virtuellen Ebene senkrecht zu dem Bodenwandabschnitt der Außenschiene in der Kreisbogenform gebogen sein, und die Innenschiene ist in einer virtuellen Ebene senkrecht zu dem Bodenwandabschnitt der Innenschiene in der Kreisbogenform gebogen.

[0011] Die Innenschiene hat eine Querschnittsform, die einer umgekehrten Querschnittsform der Außenschiene entspricht, und die Innenschiene ist an der Außenschiene angepasst, um dadurch eine Wälzkörperrollbahn dazwischen zu definieren.

[0012] Die Wälzkörper können Kugeln sein.

[0013] Die körperseitige Schiene und die gegenstandseitige Schiene können jeweils einen zu dem kreisbogenförmigen Abschnitt verlaufenden geradlinigen Abschnitt aufweisen.

[0014] Die kreisbogenförmige Ortskurve kann einen vorbestimmten Krümmungsradius haben.

[0015] Ferner wird angemerkt, dass die Gleitschiene auf zweierlei Weise gebogen sein kann, d.h. einerseits in einer so genannten horizontal gebogenen Schwertform und andererseits in einer so genannten vertikal gebogenen Ringform. Bei der horizontal gebogenen Schwertform ist die Außenschiene in einer virtuellen Ebene des Bodenwandabschnitts der Außenschiene in der Kreisbogenform gebogen, und die Innenschiene ist auch in einer virtuellen Ebene des Bodenwandabschnitts der Innenschiene in der Kreisbogenform gebogen. Andererseits ist bei der vertikal gebogenen Ringform die Außenschiene in einer virtuellen Ebene senkrecht zu der Ebene des Bodenwandabschnitts der Außenschiene in der Kreisbogenform gebogen, und die Innenschiene ist auch in einer virtuellen Ebene senkrecht zu der Ebene des Bodenwandabschnitts der Innenwand in der Kreisbogenform gebogen.

[0016] Gemäß der oben genannte Struktur der Gleitschieneneinheit kann der auszuziehende Gegenstand, wie eine Schublade für Möbel, ein Schreibtisch oder dergleichen, anders als entlang einer herkömmlichen geradlinigen Ortskurve entlang der kreisbogenförmigen Ortskurve ausgezogen werden. Daher ist es möglich, die Gleitschiene an dem Körper, in welchem der Gegenstand verschiebbar untergebracht ist, in unterschiedlicher Weise anzubringen, und zum Beispiel kann die Schublade entlang der kreisbogenförmigen Ortskurve in der vertikalen Ebene oder in der horizontalen Ebene ausgezogen werden, was vorteilhaft ist.

Ausführungsbeispiel

[0017] Die Erfindung wird mit Bezug auf die Zeichnung näher erläutert. In der Zeichnung zeigen:

[0018] **Fig.** 1 eine Gleitschieneneinheit nach einer ersten Ausführungsform der Erfindung in einem Zustand, in dem eine Innenschiene in eine Außenschiene eingeschoben ist, wobei **Fig.** 1A eine Draufsicht der Gleitschieneneinheit, **Fig.** 1B eine Seitenansicht der Gleitschieneneinheit, und **Fig.** 1C eine Ansicht in Richtung des Pfeils IC in **Fig.** 1A ist;

[0019] **Fig.** 2 die Gleitschieneneinheit aus **Fig.** 1 in einem Zustand, in dem die Innenschiene aus der Außenschiene herausgezogen ist, wobei **Fig.** 2A eine Draufsicht der Gleitschieneneinheit und **Fig.** 2B eine Seitenansicht der Gleitschieneneinheit ist;

[0020] **Fig.** 3 eine Gleitschieneneinheit nach einer zweiten Ausführungsform der Erfindung in einem Zustand, in dem die Innenschiene in die Außenschiene eingeschoben ist, wobei **Fig.** 3A eine Draufsicht der Gleitschieneneinheit, **Fig.** 3B eine Seitenansicht der Gleitschieneneinheit, und **Fig.** 3C eine Ansicht in Richtung des Pfeils IIIC in **Fig.** 3A ist;

[0021] **Fig.** 4 die Gleitschieneneinheit aus **Fig.** 3 in einem Zustand, in dem die Innenschiene aus der Außenschiene herausgezogen ist, wobei **Fig.** 4A eine Draufsicht der Gleitschieneneinheit und **Fig.** 4B eine Seitenansicht der Gleitschieneneinheit ist;

[0022] **Fig.** 5 eine Ansicht, aus der das Biegen einer Innenschiene und einer Außenschiene der Gleitschieneneinheit mittels einer Rollenbiegemaschine ersichtlich ist;

[0023] **Fig.** 6 eine schematische Ansicht der Abfolge beim Biegen der Außenschiene und der Innenschiene mittels eines Rollenbiegeverfahrens;

[0024] **Fig.** 7 eine Gleitschieneneinheit in einem Zustand, in dem ein Schubfach entlang einer kreisbogenförmigen Ortskurve in einer horizontalen Ebene aus einem Körper herausgezogen ist, wobei **Fig.** 7A eine Draufsicht und **Fig.** 7B eine Vorderansicht ist;

[0025] **Fig.** 8 eine Draufsicht einer anderen Gleitschieneneinheit in einem Zustand, in dem ein Schubfach entlang einer kreisbogenförmigen Ortskurve in einer horizontalen Ebene aus einem Körper herausgezogen ist;

[0026] **Fig.** 9 ein Beispiel, bei dem eine Schublade mit einer üblichen Struktur entlang einer kreisbogenförmigen Ortskurve in einer horizontalen Ebene aus einem Körper herausgezogen wird, wobei **Fig.** 9A eine Gleitschieneneinheit der horizontal gebogenen Ringform und **Fig.** 9B eine Gleitschieneneinheit der horizontal gebogenen Schwertform zeigt;

[0027] **Fig.** 10 ein Beispiel, bei dem die Schublade entlang einer kreisbogenförmigen Ortskurve in einer vertikalen Ebene aus einem Körper herausgezogen wird, wobei **Fig.** 10A eine Seitenansicht im Zustand der eingeschobenen Schublade, **Fig.** 10B eine Seitenansicht im Zustand der herausgezogenen Schublade, und **Fig.** 10C eine Vorderansicht im Zustand der eingeschobenen Schublade zeigt;

[0028] **Fig.** 11 eine Seitenansicht eines Beispiels, bei dem die Schublade entlang der kreisbogenförmigen Ortskurve in der vertikalen Ebene aus einem Körper herausgezogen wird;

[0029] **Fig.** 12 ein Beispiel, bei dem ein Fach entlang einer kreisbogenförmigen Ortskurve in einer vertikalen Ebene aus einem Körper herausgezogen wird, wobei **Fig.** 12A eine Seitenansicht vor dem Herausziehen des Faches, **Fig.** 12B eine Seitenansicht während des Herausziehens des Faches, und **Fig.** 12C eine Seitenansicht nach dem Herausziehen des Faches zeigt;

[0030] **Fig.** 13 ein Beispiel, bei dem eine geradlinige Gleitschiene und eine kreisbogenförmige Gleitschiene miteinander kombiniert sind, wobei **Fig.** 13A eine Seitenansicht vor dem Herausziehen einer Schublade, **Fig.** 13B eine Seitenansicht während des Herausziehens der Schublade, und **Fig.** 13C eine Seitenansicht nach dem Herausziehen der Schublade zeigt; und

[0031] **Fig.** 14 ein anderes Beispiel, bei dem eine geradlinige Gleitschiene und eine kreisbogenförmige Gleitschiene miteinander kombiniert sind, wobei **Fig.** 14A eine Seitenansicht vor dem Herausziehen einer Schublade, **Fig.** 14B eine Seitenansicht während des Herausziehens der Schublade, und **Fig.** 14C eine Seitenansicht nach dem Herausziehen der Schublade zeigt.

[0032] Mit Bezug auf die Zeichnung werden bevorzugte Ausführungsformen einer Gleitschieneneinheit gemäß der Erfindung beschrieben.

[0033] Zuerst ist mit Bezug auf **Fig.** 1 und 2 eine Gleitschieneneinheit nach einer ersten Ausführungsform der Erfindung insgesamt ein Metallgegenstand zum sanften Öffnen oder Schließen eines ausziehbaren Gegenstandes, und beispielsweise ist die Gleitschieneneinheit an einer Schublade einer Systemküche, eines Spülschrankes, eines Möbelstücks, wie eines Fächerschrankes, eines Garderobenschrankes, Systemmöbeln, oder dergleichen angebracht. Die Gleitschieneneinheit weist eine Außenschiene **1**, eine Innenschiene **2** und eine Anzahl von Kugeln (Wälzkörper) **3** auf, die zwischen der Außenschiene und der Innenschiene **1** und **2** angeordnet sind, um an diesen entlang zu rollen. **Fig.** 1 zeigt einen Zustand, in dem die Innenschiene **2** in die Außenschiene **1** eingeschoben ist, und **Fig.** 2 zeigt einen Zustand, in dem die Innenschiene **2** aus der Außenschiene herausgezogen ist.

[0034] Die Außenschiene **1** hat einen kanalförmigen Querschnitt und weist einen Bodenwandabschnitt **1a**, der sich in Längsrichtung erstreckt, und ein Paar Seitenwandabschnitte **1b** auf, die an beiden Längsseiten des Bodenwandabschnitts **1a** quer zur Längsrichtung gebogen sind. Die beiden Seitenwandabschnitte **1b** haben jeweils einen nach außen vorstehenden kreisbogenförmigen Querschnitt. An den einander gegenüberliegenden Innenwandflächen der Seitenwandabschnitte **1b** sind Kugelrollabschnitte (Wälzkörperrollabschnitte) **5** ausgebildet, die sich in Längsrichtung der Außenschiene **1** erstrecken.

[0035] Bei der erläuterten Ausführungsform ist die Außenschiene **1** in einer virtuellen Ebene des Bodenwandabschnitts **1a** (d.h. in der in **Fig.** 1A und 2A gezeigten Ebene) kreisbogenförmig mit einem konstanten Krümmungsradius in eine so genannte horizontal gebogene Schwertform gebogen. In anderen Worten ist die Außenschiene **1** um eine Achse senkrecht zu dem Bodenwandabschnitt **1a** gebogen. Dementsprechend sind die beiden einander gegenüberliegenden Seitenwandabschnitte **1b** und auch die beiden einander gegenüberliegenden nutförmigen Kugelrollabschnitte **5** mit einem durchgängig konstanten Abstand voneinander kreisbogenförmig gekrümmt. In dem Bodenwandabschnitt **1a** der Außenschiene **1** sind eine Mehrzahl von Öffnungen **7** (siehe **Fig.** 4) mit einem in Längsrichtung konstanten Abstand voneinander ausgebildet, in welche Befestigungsmittel, wie Schrauben oder dergleichen, eingesetzt werden, um dadurch die Außenschiene **1** an der Schublade oder dem Körper, wie einem Möbelstück, zu befestigen.

[0036] An dem einen Längsendabschnitt der Außenschiene **1** ist ein Schienenanschlag **8** (siehe **Fig.** 2) ausgebildet, der durch Biegen des Endabschnitts der Außenschiene **1** im rechten Winkel zu dem Bodenwandabschnitt **1a** geformt wird. Der Schienenanschlag **8** stößt gegen die Innenschiene **2**, wenn diese in Einschubrichtung A bewegt wird, um die Innenschiene **2** in deren Einschubzustand zu stoppen, wie in **Fig.** 1 gezeigt ist. Wie in **Fig.** 2A gezeigt ist, ist in der Nähe des Schienenanschlags **8** ein Rückhalteanschlag **9** ausgebildet, der aus flachen vorstehenden oder vertieften Abschnitten zusammengesetzt ist, die zum Beispiel durch einen Prägevorgang geformt werden. Der Rückhalteanschlag **9** stößt gegen einen Rückhalter **10** der Innenschiene **2**, um den Rückhalter **10** in dessen Einschubzustand zu stoppen, wie in **Fig.** 1 gezeigt ist.

[0037] An dem anderen Längsendabschnitt der Außenschiene **1** sind Führungskugeln **11** angeordnet, die aus Kunststoff oder dergleichen sind und die aus der Außenschiene **1** herausgezogene Innenschiene **2** führen. Die Führungskugeln **11** sind in den an der Außenschiene **1** ausgebildeten Kugelrollabschnitten **5** eingepasst und werden von Haltern **12** abgestützt, die an den Innenabschnitten der Außenschiene **1** derart befestigt sind, dass sie in Bezug auf die Außenschiene **1** nicht gleiten.

[0038] Die Innenschiene **2** hat an ihren beiden Längsseiten eine zu dem Nutquerschnitt der Außenschiene **1** umgekehrte Nutquerschnittsform und ist in dem Innenabschnitt der Außenschiene **1** eingepasst, um relativ zu diesem zu gleiten. Die Innenschiene **2** hat in Längsrichtung im Wesentlichen dieselbe Länge wie die Außenschiene **1**.

[0039] Die Innenschiene **2** hat einen kanalförmigen Querschnitt und weist einen Bodenwandabschnitt **2a**, der sich in Längsrichtung erstreckt, und ein Paar Seitenwandabschnitte **2b** auf, die an beiden Längsseiten des Bodenwandabschnitts **2a** quer zur Längsrichtung gebogen sind. Die beiden Seitenwandabschnitte **2b** haben jeweils einen nach innen vorstehenden kreisbogenförmigen Querschnitt. An den einander gegenüberliegenden Außenwandflächen der Seitenwandabschnitte **2b** sind Kugelrollabschnitte (Wälzkörperrollabschnitte) **13** ausgebildet, die sich in Längsrichtung der Innenschiene **2** erstrecken.

[0040] Bei der erläuterten Ausführungsform ist die Innenschiene **2** in einer virtuellen Ebene des Bodenwandabschnitts **2a** kreisbogenförmig mit einem konstanten Krümmungsradius in eine so genannte horizontal gebogene Schwertform gebogen. Dementsprechend sind die beiden einander gegenüberliegenden Seitenwandabschnitte **2b** und auch die beiden einander gegenüberliegenden Kugelrollabschnitte **13** mit einem durchgängig konstanten Abstand voneinander kreisbogenförmig gekrümmt. In dem Bodenwandabschnitt **2a** der Innenschiene **2** sind eine Mehrzahl von Öffnungen **15** (siehe **Fig.** 4) mit einem in Längsrichtung konstanten Abstand voneinander ausgebildet, in welche Befestigungsmittel, wie Schrauben oder dergleichen, eingesetzt werden, um dadurch die Innenschiene **2** an der Schublade oder dem Körper, wie einem Möbelstück, zu befestigen.

[0041] An dem einen Längsendabschnitt der Innenschiene **2**, der dem einen Längsendabschnitt der Außenschiene **1** entspricht, an dem der Schienenanschlag **8** ausgebildet ist, ist eine Klaue **16** ausgebildet, die zu dem Bodenwandabschnitt **1a** der Außenschiene **1** hin vorsteht. Die Klaue **16** ist mit dem Schienenanschlag **8** in Eingriff zu bringen, um die Bewegung der Innenschiene **2** in deren Einschubzustand zu stoppen, wie in **Fig.** 1 gezeigt ist. Wie in **Fig.** 2A gezeigt ist, ist an dem anderen Längsendabschnitt des Bodenwandabschnitts **2a** der Innenschiene **2** ein Schubladenanschlag (nicht gezeigt) vorgesehen, um mit einer Klaue (nicht gezeigt) zu kollidieren, die an dem jeweiligen Halter **12** der Außenschiene **1** ausgebildet ist, um dadurch die Bewegung der Innenschiene **2** in dessen Auszugzustand (**Fig.** 2) zu stoppen.

[0042] Die Kugeln **3** als Wälzkörper sind zwischen den Kugelrollabschnitten **13**, die an den Seitenwandabschnitten **2b** der Innenschiene **2** ausgebildet sind, und den Kugelrollabschnitten **5** angeordnet, die an den Seitenwandabschnitten **1b** der Außenschiene **1** ausgebildet sind. Eine Reihe der Kugeln **3** werden gehalten, um mittels des Rückhalters **10** gerollt zu werden.

[0043] Der Rückhalter **10** hat eine geringe Dicke und weist einen Bodenwandabschnitt **10a**, der sich in dessen Längsrichtung erstreckt, und ein Paar Armabschnitte **10b** auf, die an beiden Längsseiten des Bodenwandabschnitts **10a** quer zur Längsrichtung gebogen sind. Eine Reihe von Kugeln **3** werden zwischen den mit dem Bodenwandabschnitt **10a** verbundenen Armabschnitten **10b** und den Kugelrollabschnitten **5** der Außenschiene **1** gehalten, so dass die Kugeln **3** aus diesen Abschnitten selbst dann nicht herausfallen, wenn die Innenschiene **2** von der Außenschiene **1** demontiert wird. Der Bodenwandabschnitt **10a** des Rückhalters **10** ist mit einem umgekehrten Kanalabschnitt **18**, der sich in Längsrichtung in der Mitte des Rückhalters **10** erstreckt, und Verbindungsabschnitten **20** versehen, die Seitenwandabschnitte **19** des umgekehrten Kanalabschnitts **18** und die jeweiligen Armabschnitte **10b** des Rückhalters **10** miteinander verbinden. Der umgekehrte Kanalabschnitt **18** dient zur Verhinderung der gegenseitigen Beeinflussung des Rückhalters **10** mit einem Schraubenkopf oder dergleichen einer Schraube beim Befestigen der Außenschiene **1** an der Schublade oder dem Körper und zur Erhöhung der Festigkeit des Rückhalters **10**. In dem umgekehrten Kanalabschnitt **18** sind Öffnungen **21** in einem in Längsrichtung konstanten Abstand voneinander ausgebildet, um die Pressbearbeitung des Rückhalters **10** zu erleichtern.

[0044] Wie oben erwähnt, werden eine Anzahl von Kugeln **3** von den seitlichen Armabschnitten **10b** des Rückhalters **10** gehalten, um in dessen Längsrichtung in gleichen Abständen voneinander gerollt zu werden. Die Armabschnitte **10b** sind parallel zueinander und beiderseits und senkrecht zu dem umgekehrten Kanalabschnitt **18** angeordnet. In den Armabschnitten **10b** sind Öffnungen zum Aufnehmen der Kugeln **3** ausgebildet, wobei der Durchmesser der Öffnungen etwas kleiner als der Durchmesser der Kugeln **3** ist.

[0045] Ferner sind in den Armabschnitten **10b** und den Verbindungsabschnitten **20** des Rückhalters **10** Ausschnitte **22** zwischen einander benachbarten Kugeln **3** ausgebildet. In den Ausschnitten **22** sind Schlitze **23** ausgebildet, die sich quer zur Längsrichtung von den Ausschnitten **22** zu einem der Seitenwandabschnitte **19** und dem Bodenabschnitt des umgekehrten Kanalabschnitts **18** durch diese hindurch erstrecken. Die Schlitze **23** sind derart ausgebildet, dass der Rückhalter **10** leicht in Kreisbogenform gebogen werden kann, um mit der Kreisbogenkurve der Außenschiene **1** übereinzustimmen. Das heißt, wenn beabsichtigt ist, den Rückhalter **10** in einer Ebene des Bodenabschnitts des umgekehrten Kanalabschnitts **18** zu biegen, wird ein großes Flächenträgheitsmoment verursacht, wodurch der Rückhalter **10** nicht leicht gebogen werden kann. Jedoch werden bei der Struktur mit den Schlitzen **23** jeweils nur ein Teil der Seitenwandabschnitte **19** des umgekehrten Kanalabschnitts **18** und ein Teil des Verbindungsabschnitts **20** gebogen, so dass der Biegevorgang leicht durchgeführt werden kann.

[0046] Ferner ist es möglich, einen Rückhalter **10** mit einer gekrümmten Struktur in Übereinstimmung mit der Krümmung der Außenschiene **1** mittels eines Pressvorgangs ohne Formung derartiger Schlitze **23** herzustellen. Der Rückhalter **10** kann aus Kunststoff mittels eines Kunststoffformungsvorgangs gebildet werden. Außerdem ist die Form des Rückhalters **10** nicht auf die oben beschriebene Form beschränkt, sondern der Rückhalter **10** kann auch verschiedene andere Formen annehmen, soweit diese mit einer Haltefunktion für die Kugeln **3** versehen ist.

[0047] Wenn eine äußere Kraft in Längsrichtung auf die Innenschiene **2** ausgeübt wird, wenn die Außenschiene **1** befestigt ist, rollen die Kugeln **3** ab, und die Innenschiene **2** gleitet in dessen Längsrichtung in Bezug auf die Außenschiene **1**. In diesem Moment rollen die Kugeln **3** in dem Raum zwischen dem Kugelrollabschnitt **5** der Außenschiene **1** und dem Kugelrollabschnitt **13** der Innenschiene **2**, um sich über eine Strecke zu bewegen, die der Hälfte der Verschiebung der Innenschiene **2** entspricht. Der Rückhalter **10** bewegt sich auch über eine Strecke, die gleich der Verschiebung der jeweiligen Kugel **3** ist. Andererseits behält die Führungskugel **11** ihre konstante Position an der Außenschiene **1**. Daher gleitet die Innenschiene **2** in Bezug auf die Außenschiene **1**, während sie durch die Führungskugel **11** und die von dem Rückhalter **10** gehaltene Kugel **3** gehalten wird.

[0048] Die Innenschiene **2** und die Außenschiene **1** können in deren Längsrichtung relativ zueinander gleiten. Da die Außenschiene **1** und die Innenschiene **2** in einer Kreisbogenform gebogen sind, wird die Innenschiene **2**, und daher die Schublade auch derart bewegt, dass sie eine kreisbogenförmige Ortskurve beschreibt. Daher wird, wenn zum Beispiel die Gleitschieneneinheit mit der Schwertform an einem Abschnitt zwischen der Seitenfläche der Schublade und der Seitenfläche des Körpers montiert ist, die Schublade derart bewegt, dass sie die kreisbogenförmige Ortskurve (Spur oder Bahn) in der vertikalen Ebene beschreibt.

[0049] **Fig.** 3 und 4 zeigen eine Gleitschieneneinheit nach einer zweiten Ausführungsform der Erfindung. **Fig.** 3 zeigt den Zustand, in dem die Innenschiene **2** in die Außenschiene **1** eingeschoben ist, während **Fig.** 4 den Zustand zeigt, in dem die Innenschiene **2** aus der Außenschiene **1** herausgezogen ist.

[0050] Die zweite Ausführungsform unterscheidet sich von der ersten Ausführungsform in der Krümmungsstruktur der Außenschiene **1** und der Innenschiene **2**, während die anderen Strukturen im Wesentlichen dieselben wie die der ersten Ausführungsform sind, so dass gleiche Teile mit denselben Bezugszeichen bezeichnet sind und deren Erläuterung weggelassen wird. Bei dieser Ausführungsform sind die Außenschiene **1** und die Innenschiene **2** jeweils in einer virtuellen Ebene senkrecht zu dem Bodenwandabschnitt **1a** der Außenschiene **1** bzw. zu dem Bodenwandabschnitt **2a** der Innenschiene **2** (d.h. in der in **Fig.** 3B und 4B gezeigten Ebene) kreisbogenförmig mit einem konstanten Krümmungsradius in eine so genannte vertikal gebogene Ringform gebogen. In anderen Worten sind die Außenschiene **1** und die Innenschiene **2** um eine Achse parallel zu den Bodenwandabschnitten **1a** und **2a** der Außenschiene **1** bzw. der Innenschiene **2** gebogen. Ferner sind die beiden einander gegenüberliegenden Seitenwandabschnitte **1b** und **2b** und auch die beiden einander gegenüberliegenden Kugelrollabschnitt **5** und **13** der Außenschiene **1** bzw. der Innenschiene **2** jeweils mit einem durchgängig konstanten Abstand voneinander kreisbogenförmig gekrümmt.

[0051] Der Rückhalter **10** ist in Übereinstimmung mit der Biegung der Außenschiene **1** in einer Ebene senkrecht zu dem Bodenabschnitt des umgekehrten Kanalabschnitts **18** des Rückhalters **10** gebogen. Bei dieser Struktur ist im Vergleich zu dem Rückhalter **10** der ersten Ausführungsform das Flächenträgheitsmoment des Rückhalters **10** gering. In dieser Weise ist es möglich, Schlitze **23** zu bilden, die sich quer zur Längsrichtung von den Ausschnitten **22** in den Verbindungsabschnitten **20** des Rückhalters **10** zu einem der Seitenwandabschnitte **19** des umgekehrten Kanalabschnitts **18** durch diesen hindurch erstrecken. In diesem Falle ist es möglich, das Material, die Form usw. des Rückhalters **10** in derselben Weise wie bei der ersten Ausführungsform zu verändern.

[0052] Bei der zweiten Ausführungsform sind die Innenschiene **2** und die Außenschiene **1** in deren Längsrichtung ebenfalls relativ zueinander verschiebbar. Da die Außenschiene **1** und die Innenschiene **2** in eine Kreisbogenform gebogen sind, hat auch die Ortskurve der Innenschiene **2**, und daher die Ortskurve der Schublade eine Kreisbogenform. Zum Beispiel beschreibt in dem Falle, in dem eine Gleitschieneneinheit mit der vertikal gebogenen Ringform an einem Abschnitt zwischen dem Seitenabschnitt der Schublade und dem Seitenabschnitt des Körpers angebracht ist, die Schublade eine kreisbogenförmige Ortskurve (Spur oder Bahn) in der horizontalen Ebene.

[0053] Im Folgenden wird ein Verfahren zur Herstellung der Außenschiene **1** und der Innenschiene **2** der Gleitschieneneinheit gemäß der oben genannten

Struktur beschrieben. **Fig.** 5 zeigt ein Beispiel der Herstellung der Gleitschieneneinheit unter Verwendung einer Bearbeitungsmaschine, die als Rollenbiegemaschine (Winkelbiegemaschine) bezeichnet wird, zum Biegen der Außenschiene **1** und der Innenschiene **2**.

[0054] Zuerst werden eine Außenschiene **1** und eine Innenschiene **2** angefertigt, die vorläufig mit einer geradlinigen Form ausgebildet sind. In diesem Stadium der Herstellung sind die Außenschiene **1** und die Innenschiene **2** bereits mit einem kanalförmigen Abschnitt geformt. Als nächstes werden eine Mehrzahl von Rollen **31**, **32** und **33** vorbereitet, deren Achsen parallel zueinander angeordnet sind, und die geradlinige Außenschiene **1** wird durch mehrmalige Hin- und Herbewegung durch einen Spalt zwischen der Rolle **33** und der Rolle **32** und dann einen Spalt zwischen der Rolle **33** und der Rolle **31** hindurch mittels Drehung der Rollen **21**, **32** und **33** gerollt, wie in **Fig.** 5 gezeigt ist, um dadurch die Außenschiene **1** in eine Kreisform zu biegen. In derselben Weise wird die geradlinige Innenschiene **2** mehrmals zwischen den Rollen **33** und **32** und den Rollen **33** und **31** mittels Drehung der Rollen **31**, **32** und **33** hin- und hergehend gerollt, um dadurch die Innenschiene **2** in eine Kreisform zu biegen. Es ist natürlich auch möglich, zuerst die Innenschiene **2** und dann die Außenschiene **1** zu biegen.

[0055] Die Außenschiene **1** und die Innenschiene **2** haben jeweils einen kanalförmigen Querschnitt, so dass die Gefahr besteht, dass die Seitenwandabschnitte **1b** und **2b** der Außenschiene **1** bzw. der Innenschiene **2** beim Biegen mittels des Rollenbiegevorgangs nach innen gebogen werden können. Wenn die Seitenwandabschnitte **1b** und **2b** nach innen gebogen werden, besteht auch die Gefahr, dass es schwierig ist, die Kugeln **3** zwischen dem Kugelrollabschnitt **5** des Seitenwandabschnitts **1b** der Außenschiene **1** und dem Kugelrollabschnitt **13** des Seitenwandabschnitts **2b** der Innenschiene **2** anzuordnen. Um einer solchen Gefahr vorzubeugen, wird ein Einschluss- oder Zwischenteil mit einer der Form der Nut des Kanals der Außenschiene **1** entsprechenden Form in die Außenschiene **1** eingepasst, um die Reduzierung des Abstandes zwischen den beiden einander gegenüberliegenden Seitenwandabschnitten **1b** der Außenschiene **1** beim Passieren der Spalte zwischen den Rollen **33** und **32** und den Rollen **33** und **31** zu unterdrücken. In der gleichen Weise wird ein Einschluss- oder Zwischenteil mit einer der Form des Kanals der Innenschiene **2** entsprechenden Form in die Innenschiene **2** eingepasst, um die Reduzierung des Abstandes zwischen den einander gegenüberliegenden Seitenwandabschnitten **2b** der Innenschiene **2** beim Passieren der Spalte zwischen den Rollen **33** und **32** und den Rollen **33** und **31** zu unterdrücken. Die Einschluss- oder Zwischenteile sind aus weichem Kunststoff, wie Polyvinylchlorid, geformt und können auch bei dem Rollenbiegevorgang in derselben Weise wie die Außenschiene **1** und die Innenschiene **2** gebogen werden.

[0056] Wie oben beschrieben, können unter Verwendung der Rollenbiegemaschine die Außenschiene **1** und die Innenschiene **2** mit verschiedenen Größen und Biegekrümmungsradien hergestellt werden.

[0057] **Fig.** 6 zeigt ein Beispiel der Herstellung der Außenschiene und der Innenschiene mittels eines Rollenbiegeverfahrens. In diesem Beispiel wird ein flaches Teil zwischen einer Mehrzahl von Paaren von Profilrollen **34–37** geführt, und entsprechend dem Passieren von der vorderen Rolle zu den nachfolgenden Rollen wird die Außenschiene **1** oder die Innenschiene **2** allmählich geformt, um einen kanalförmigen Querschnitt zu schaffen. Während dieses Rollvorgangs wird die Außenschiene **1** oder die Innenschiene **2** derart gebogen, dass die Innenschiene **2** die kreisbogenförmige Ortskurve in Bezug auf die Außenschiene **1** bildet. Mit der kreisbogenförmigen Anordnung der Mehrzahl von Profilrollen **34–37** in der senkrechten Ebene, wie in **Fig.** 6 gezeigt ist, kann die vertikal gebogene Ringform der Außenschiene **1** oder der Innenschiene **2** unter Bildung der kanalförmigen Struktur geschaffen werden. Ferner kann mit der kreisbogenförmigen Anordnung der Mehrzahl von Profilrollen **34–37** in der horizontalen Ebene die horizontal gebogene Schwertform der Außenschiene **1** oder der Innenschiene **2** geschaffen werden.

[0058] Die Außenschiene **1** und die Innenschiene **2** können mittels eines anderen Verfahrens als dem oben genannten Verfahren hergestellt werden, wie zum Beispiel mittels eines Pressverfahrens, welches für die Herstellung einer Schiene mit einer vorbestimmten Länge und einem vorbestimmten Krümmungsradius geeignet ist.

[0059] Die oben beschriebene Gleitschieneneinheit nach der ersten und der zweiten Ausführungsform kann in der folgenden Weise verwendet werden. **Fig.** 7 zeigt ein Beispiel, bei dem ein Schubfach entlang einer kreisbogenförmigen Ortskurve in einer horizontalen Ebene aus einem Körper herausgezogen wird, wobei **Fig.** 7A eine Draufsicht und **Fig.** 7B eine Vorderansicht ist. Eine Gleitschieneneinheit **42** ist an der Seitenfläche einer Schublade **40**, wie eines Schrankfaches, und an der Seitenfläche eines Körpers **41** montiert, um die Schublade **40** in Bezug auf den Körper **41** gleitend zu bewegen. Wenn eine Bedienperson die Schublade **40** aus dem Körper **41** herauszieht, bewegt sich die Schublade **40** entlang der kreisbogenförmigen Ortskurve in der horizontalen Ebene. In diesem Beispiel ist anzumerken, dass die offene Seite **40a** der herausgezogenen Schublade **40** von der Bedienperson leicht eingesehen werden kann.

[0060] **Fig.** 8 zeigt auch ein Beispiel in Draufsicht, bei dem das Schubfach **40** entlang einer kreisbogenförmigen Ortskurve in einer horizontalen Ebene aus einem Körper herausgezogen wird. In diesem Beispiel ist die Gleitschieneneinheit **42** auch an der Seitenfläche der Schublade **40**, wie eines Schrankfaches, und an der Seitenfläche des Körpers **41** montiert. Wenn eine Bedienperson die Schublade **40** aus dem Körper **41** herauszieht, bewegt sich die Schublade **40** entlang der kreisbogenförmigen Ortskurve in der horizontalen Ebene, um ein in der geradlinigen Bahn vorhandenes Hindernis **50** zu umgehen, wodurch eine Kollision der Schublade **40** mit dem Hindernis **50** verhindert wird.

[0061] **Fig.** 9 zeigt ein Beispiel, bei dem eine Schublade **44** der üblichen Art mit offener Oberseite entlang einer kreisbogenförmigen Ortskurve in einer horizontalen Ebene aus einem Körper herausgezogen wird, wobei in **Fig.** 9A eine Gleitschieneneinheit **42** der horizontal gebogenen Ringform an den Seitenflächen der Schublade **44** und des Körpers **41** montiert ist und in **Fig.** 9B eine Gleitschieneneinheit **43** der horizontal gebogenen Schwertform an den unteren Flächen der Schublade **44** und des Körpers **41** montiert ist.

[0062] In diesem Beispiel kann, wenn die Bedienperson die Schublade **44** aus einer Position von dem vorderen Seitenabschnitt der Schublade **44** weg aus dem Körper **41** herauszieht und die Schublade **44** derart ausgebildet ist, dass sie entlang der kreisbogenförmigen Ortskurve ausziehbar ist, die Bedienperson die Schublade **44** so leicht aus dem Körper **41** herausziehen, wie eine Tür nach vorn zu öffnen ist. Dieses Beispiel kann besonders in dem Falle angewendet werden, wo die Schublade **44** sehr nahe zu einer Wandfläche vorgesehen ist, d.h. die Bedienperson kann, wenn sie von der Wandfläche weg ist, die Schublade **44** aus dem Körper **41** herausziehen. Wie oben erwähnt, kann durch die Gestaltung der Schublade mit einer kreisbogenförmigen Ortskurve im Vergleich zu der üblichen geradlinigen Ortskurve der Freiheitsgrad für die Gestaltung der Schublade und deren nutzbaren Bereichs beträchtlich erweitert werden.

[0063] **Fig.** 10 zeigt ein Beispiel, bei dem die Schublade entlang einer kreisbogenförmigen Ortskurve in einer vertikalen Ebene aus einem Körper herausgezogen werden kann. In diesem Beispiel ist die Gleitschieneneinheit **43** in der vertikal gebogenen Schwertform zwischen der Seitenfläche der Schublade **44** und der Seitenfläche des Körpers **41** montiert. **Fig.** 10A zeigt eine Seitenansicht im Zustand der eingeschobenen Schublade **44**, **Fig.** 10B zeigt eine Seitenansicht im Zustand der herausgezogenen Schublade **44**, und **Fig.** 10C zeigt eine Vorderansicht im Zustand der eingeschobenen Schublade **44**. In diesem Beispiel kann, wenn die Schublade **44** aus dem Körper **41** herausgezogen ist, ein großer Spalt in vertikaler Richtung zwischen der Schublade **44** und dem geöffneten Seitenabschnitt des Körpers **41**, in dem die Schublade **44** aufgenommen wird, vorgesehen sein, so dass die Schublade **44** in eine nach unten geneigte Position herausgezogen werden kann, wodurch Gegenstände und dergleichen leicht in die Schublade **44** gelegt oder aus dieser herausgenommen werden können und die Bedienperson kann die Innenseite des Schubfaches **44** leicht einsehen kann.

[0064] **Fig.** 11 zeigt auch ein Beispiel, bei dem die Schublade **44** entlang der kreisbogenförmigen Ortskurve in der vertikalen Ebene aus einem Körper herausgezogen wird. In diesem Beispiel ist die Gleitschieneneinheit **42** in vertikal gebogener Ringform zwischen der unteren Fläche der Schublade **44** und der unteren Fläche des Körpers **41** montiert. In diesem Beispiel kann, wenn die Schublade **44** aus dem Körper **41** herausgezogen wird, ein großer Spalt in vertikaler Richtung zwischen der Schublade **44** und dem geöffneten Seitenabschnitt des Körpers **41**, in dem die Schublade **44** aufgenommen wird, vorgesehen sein, so dass die Schublade **44** in eine nach unten geneigte Position herausgezogen werden kann, wodurch Gegenstände und dergleichen leicht in die Schublade **44** gelegt oder aus dieser herausgenommen werden können und die Bedienperson die Innenseite des Schubfaches **44** leicht einsehen kann.

[0065] **Fig.** 12 zeigt ein Beispiel, bei dem ein Fach **45** entlang einer kreisbogenförmigen Ortskurve in einer vertikalen Ebene aus einem Körper herausgezogen wird. In diesem Beispiel ist die Gleitschieneneinheit **43** in der vertikal gebogenen Schwertform zwischen der Seitenfläche des Faches **45** und der Seitenfläche des Körpers **41** montiert. **Fig.** 12A zeigt eine Seitenansicht vor dem Herausziehen des Faches **45**, **Fig.** 12B zeigt eine Seitenansicht während des Herausziehens des Faches **45**, und **Fig.** 12C zeigt eine Seitenansicht nach dem Herausziehen des Faches **45**. Das Fach **45** ist in dem Körper **41** in einer vertikalen Ebene positioniert und wird jedoch beim Herausziehen aus dem Körper **41** in eine horizontale Ebene positioniert. Daher kann das ausgezogene Fach **45** zum Beispiel als ein Tisch oder bei der Verwendung als Touch-Paneel zum Beispiel als eine Arbeitsplatte benutzt werden, wobei die Arbeitsplatte leicht überblickt und bedient werden kann.

[0066] **Fig.** 13 zeigt ein Beispiel einer Kombination einer geradlinigen Gleitschiene **46** mit einer kreisbogenförmigen Gleitschiene **43**. **Fig.** 13A zeigt eine Seitenansicht vor dem Herausziehen einer Schublade **44**, **Fig.** 13B zeigt eine Seitenansicht während des Herausziehens der Schublade **44**, und **Fig.** 13C zeigt eine Seitenansicht nach dem Herausziehen der Schublade **44**. In diesem Beispiel ist die kreisbogenförmige Gleitschiene **43** in vertikal gebogener Schwertform als Außenschiene oder Innenschiene mit der herkömmlichen geradlinigen Gleitschiene **46** als zugeordnete Außenschiene bzw. Innenschiene verbunden. Wenn die Schublade **44** aus der in **Fig.** 13A gezeigten Position herausgezogen wird, wird zuerst die kreisbogenförmige Gleitschiene **43** betätigt, und die Schublade **44** wird entlang der kreisbogenförmigen Ortskurve bewegt, wie in **Fig.** 13B gezeigt ist. Bei diesem Vorgang wird der Betrieb der geradlinigen Gleitschiene **46** blockiert. Wenn die Schublade **44** weiter herausgezogen wird, wird die Schublade **44** geradlinig nach unten gezogen, wie in **Fig.** 13C gezeigt ist. Dieses Beispiel kann vorzugsweise zum Beispiel bei einer Schublade einer Systemküche angewendet werden, die in einem oberen Bereich der Küche angeordnet ist, um die Schublade nach unten zu ziehen, wodurch Gegenstände leicht in die Schublade **44** eingelegt und herausgenommen werden können.

[0067] **Fig.** 14 zeigt ein Beispiel einer Kombination einer geradlinigen Gleitschiene **46** mit einer kreisbogenförmigen Gleitschiene **43**, wobei **Fig.** 14A eine Seitenansicht vor dem Herausziehen einer Schublade **44**, **Fig.** 14B eine Seitenansicht während des Herausziehens der Schublade **44**, und **Fig.** 14C eine Seitenansicht nach dem Herausziehen der Schublade **44** zeigt. In diesem Beispiel ist die kreisbogenförmige Gleitschiene **43** in vertikal gebogener Schwertform als Außenschiene oder Innenschiene mit der herkömmlichen geradlinigen Gleitschiene **46** als zugeordnete Außenschiene bzw. Innenschiene verbunden. Wenn die Schublade **44** aus der in **Fig.** 14A gezeigten Position herausgezogen wird, wird zuerst die geradlinige Gleitschiene **46** betätigt, und die Schublade **44** wird geradlinig in horizontaler Richtung bewegt, wie in **Fig.** 14B gezeigt ist. Bei diesem Vorgang wird der Betrieb der kreisbogenförmigen Gleitschiene **43** blockiert. Wenn die Schublade **44** weiter herausgezogen wird, wird die Schublade **44** entlang der kreisbogenförmigen Ortskurve nach unten gezogen, wie in **Fig.** 14C gezeigt ist. Dieses Beispiel kann vorzugsweise zum Beispiel bei einer Schublade einer Systemküche angewendet werden, die in einem oberen Bereich der Küche angeordnet ist, um die Schublade nach unten zu ziehen, wodurch Gegenstände leicht in die Schublade **44** eingelegt und herausgenommen werden können.

[0068] Ferner wird angemerkt, dass die Erfindung nicht auf die beschriebenen Ausführungsformen beschränkt ist und viele verschiedene Änderungen und Modifikationen vorgenommen werden können, ohne vom Schutzbereich der Erfindung abzuweichen. Zum Beispiel kann die Schublade mit der oben beschriebenen Struktur anders als bei Möbeln auch bei einer Tonerwechseleinrichtung einer Kopiermaschine, einer Öffnungs- und Schließeinrichtung einer Nottür oder irgendwelchen anderen Einrichtungen für Gegenstände, die herauszuziehen sind, angewendet werden. Anstelle von Kugeln können Rollen verwendet werden. Ferner kann die Kombinationsstruktur der relativ zueinander bewegbaren Außenschiene und Innenschiene auch ohne Wälzkörper, die zwischen der Außenschiene und der Innenschiene angeordnet sind, angewendet werden.

Patentansprüche

1. Gleitschieneneinheit zum Führen eines Gegenstandes (**40**), der aus einem Körper (**41**) herauszuziehen ist, in welchem der Gegenstand (**40**) gleitend aufgenommen ist, aufweisend:
eine körperseitige Schiene, die für den Körper (**41**) vorgesehen ist; und
eine gegenstandseitige Schiene, die für den Gegenstand (**40**) vorgesehen ist, um relativ zu der körperseitigen Schiene gleitend ausgezogen zu werden,
wobei die körperseitige Schiene und die gegenstandseitige Schiene jeweils einen Abschnitt aufweisen, der in Kreisbogenform derart gebogen ist, dass der Gegenstand (**40**) entlang einer kreisbogenförmigen Ortskurve ausgezogen wird.

2. Gleitschieneneinheit nach Anspruch 1, aufweisend:
eine Außenschiene (**1**), die eine der körperseitigen Schiene und der gegenstandseitigen Schiene für den herauszuziehenden Gegenstand bildet, wobei die Außenschiene (**1**) aus einem Bodenwandabschnitt (**1a**), der sich in dessen Längsrichtung in Kreisbogenform erstreckt, und einem Paar Seitenwandabschnitten (**1b**) zusammengesetzt ist, die in einer gebogenen Form quer zur Längsrichtung an beiden Längsseiten des Bodenwandabschnitts (**1a**) ausgebildet sind und sich in deren Längsrichtung in Kreisbogenform erstrecken, um dadurch einen Wälzkörperrollabschnitt (**5**) zu bilden;
eine Innenschiene (**2**), die eine andere der körperseitigen Schiene und der gegenstandseitigen Schiene bildet, um an die Außenschiene (**1**) angepasst zu werden, wobei die Innenschiene (**2**) aus einem Bodenwandabschnitt (**2a**), der sich parallel zu dem Bodenwandabschnitt (**1a**) der Außenschiene (**1**) erstreckt, und einem Paar Seitenwandabschnitten (**2b**) zusammengesetzt ist, die in einer gebogenen Form quer zur Längsrichtung an beiden Längsseiten des Bodenwandabschnitts (**2a**) ausgebildet sind und sich in deren Längsrichtung in Kreisbogenform erstrecken, um dadurch einen Wälzkörperrollabschnitt (**13**) zu bilden; und
eine Anzahl von Wälzkörpern (**3**), die zwischen dem Wälzkörperrollabschnitt (**5**) der Außenschiene (**1**) und dem Wälzkörperrollabschnitt (**13**) der Innenschiene (**2**) angeordnet sind.

3. Gleitschieneneinheit nach Anspruch 2, wobei die Außenschiene (**1**) in einer virtuellen Ebene des Bodenwandabschnitts (**1a**) der Außenschiene (**1**) in der Kreisbogenform gebogen ist, und die Innenschiene (**2**) in einer virtuellen Ebene des Boden-

wandabschnitts (**2a**) der Innenschiene (**2**) in der Kreisbogenform gebogen ist.

4. Gleitschieneneinheit nach Anspruch 2, wobei die Außenschiene (**1**) in einer virtuellen Ebene senkrecht zu dem Bodenwandabschnitt (**1a**) der Außenschiene (**1**) in der Kreisbogenform gebogen ist, und die Innenschiene (**2**) in einer virtuellen Ebene senkrecht zu dem Bodenwandabschnitt (**2a**) der Innenschiene (**2**) in der Kreisbogenform gebogen ist.

5. Gleitschieneneinheit nach Anspruch 2, wobei die Innenschiene (**2**) eine Querschnittsform hat, die einer umgekehrten Querschnittsform der Außenschiene (**1**) entspricht, und die Innenschiene (**2**) an der Außenschiene (**1**) angepasst ist, um dadurch eine Wälzkörperrollbahn dazwischen zu definieren.

6. Gleitschieneneinheit nach Anspruch 1, wobei die Wälzkörper Kugeln (**3**) sind.

7. Gleitschieneneinheit nach Anspruch 1, wobei die körperseitige Schiene (**1**) und die gegenstandseitige Schiene (**2**) jeweils einen zu dem kreisbogenförmigen Abschnitt verlaufenden geradlinigen Abschnitt aufweisen.

8. Gleitschieneneinheit nach Anspruch 1, wobei die kreisbogenförmige Ortskurve einen vorbestimmten Krümmungsradius hat.

Es folgen 8 Blatt Zeichnungen

Anhängende Zeichnungen

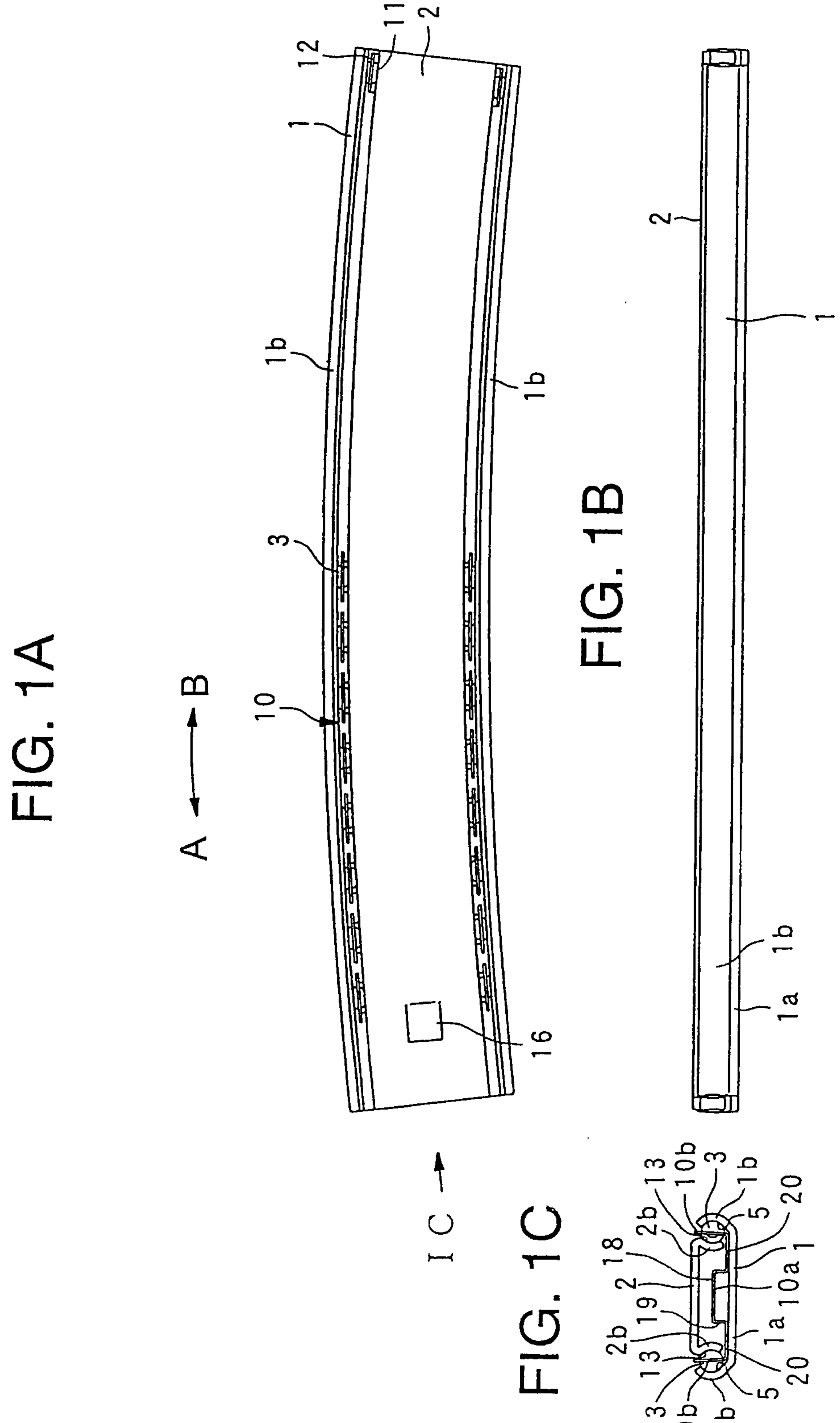


FIG. 1A

FIG. 1B

FIG. 1C

FIG. 2A

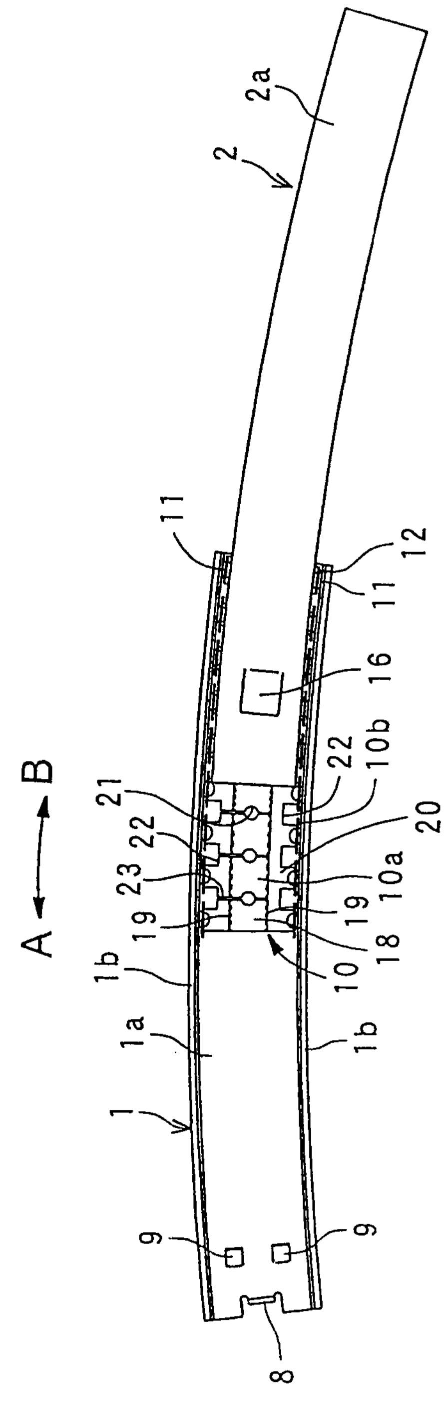
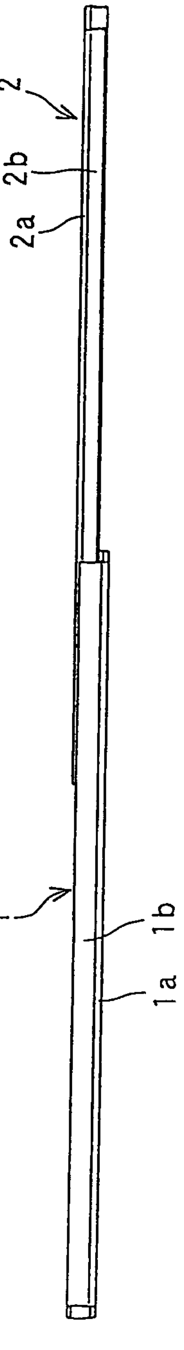

A
B
2a
2
11
12
11
16
22
10b
21
22
20
23
10a
19
19
18
10
1b
1a
1
1b
9
9
8

FIG. 2B


2
2b
2a
1
1b
1a

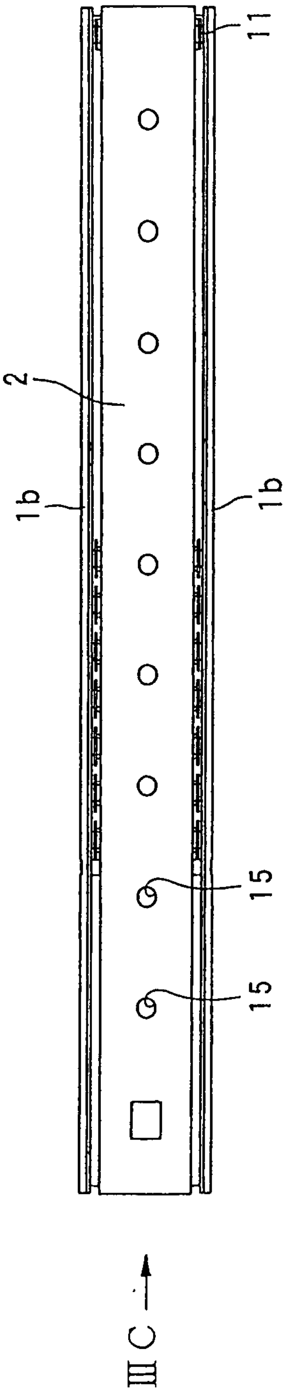


FIG. 3A

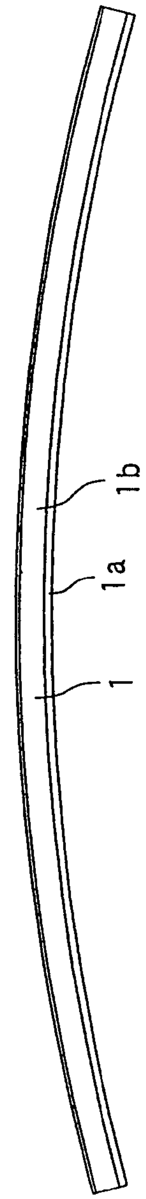


FIG. 3B

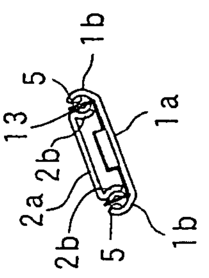


FIG. 3C

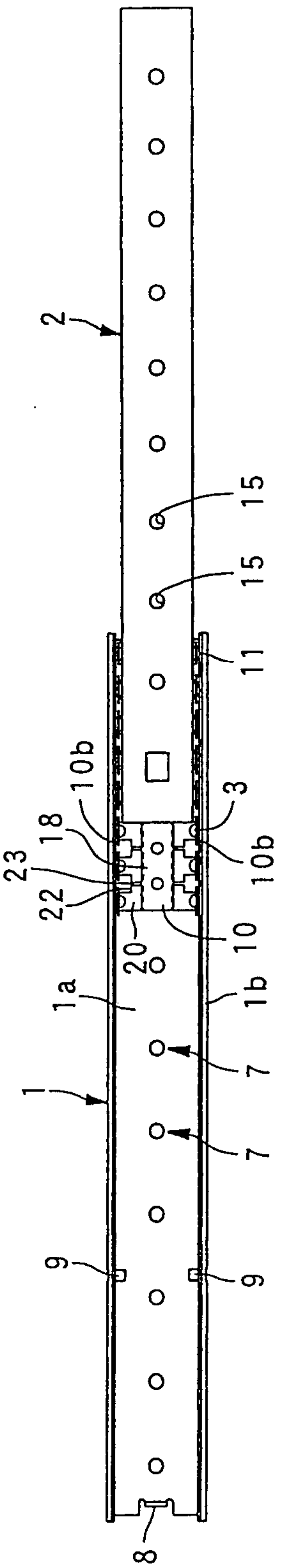


FIG. 4A

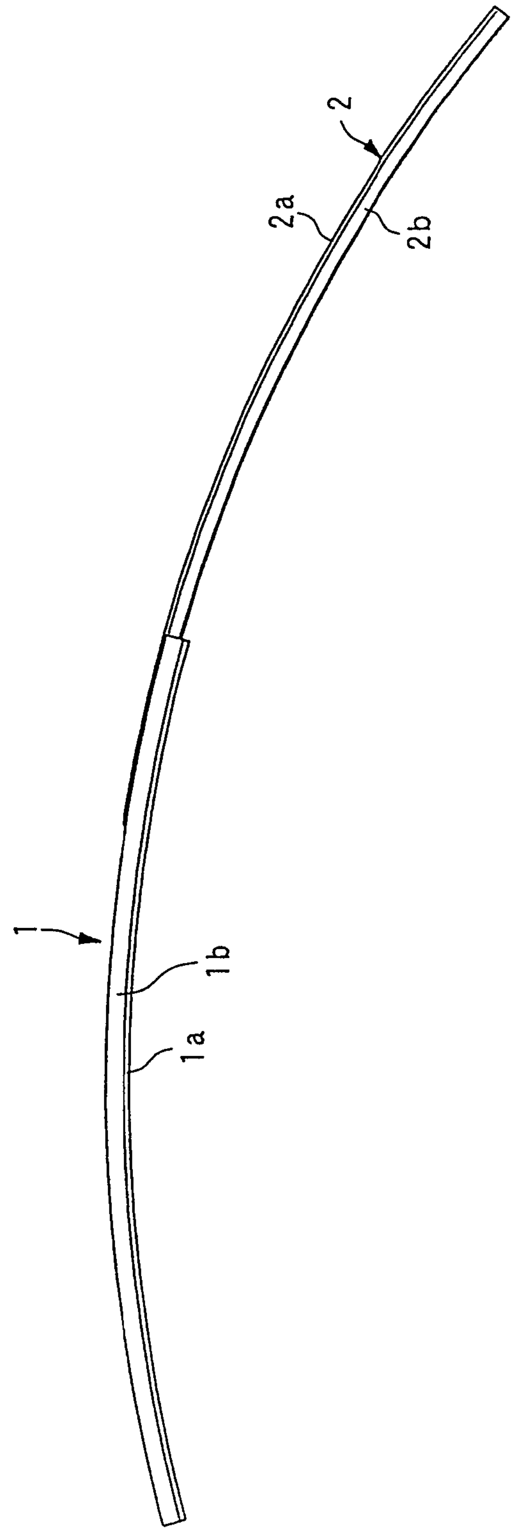


FIG. 4B

FIG. 5

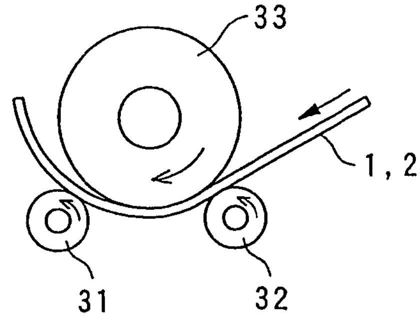


FIG. 6

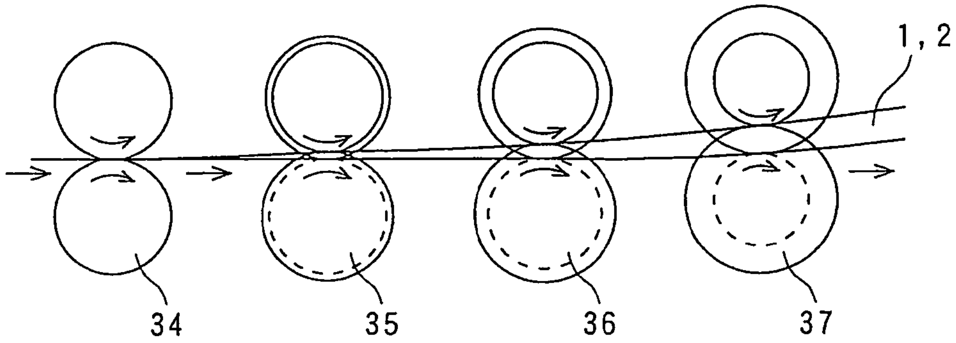


FIG. 7A

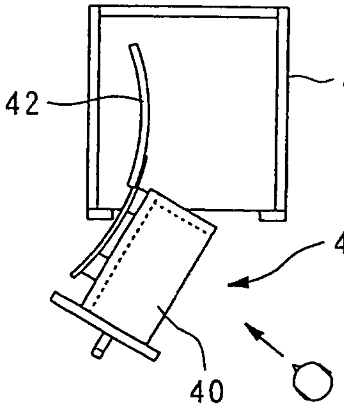


FIG. 7B

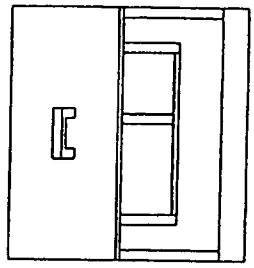


FIG. 8

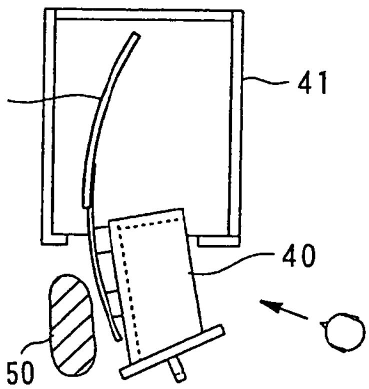


FIG. 9A

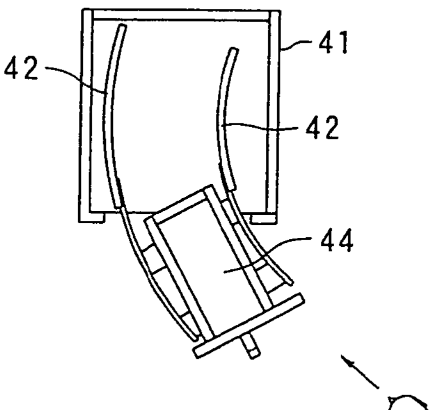


FIG. 9B

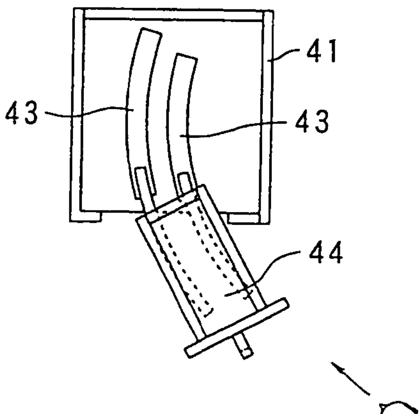


FIG. 10A

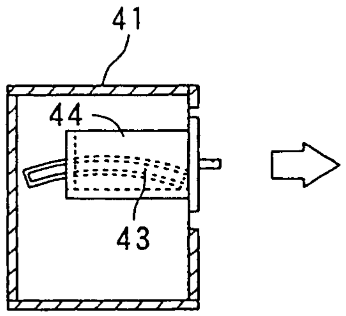


FIG. 10B

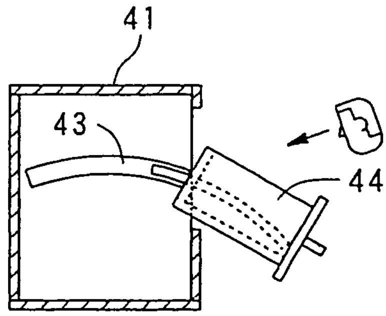


FIG. 10C

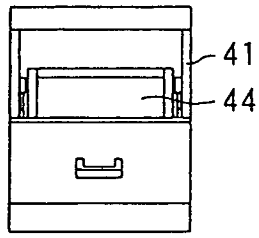


FIG. 11

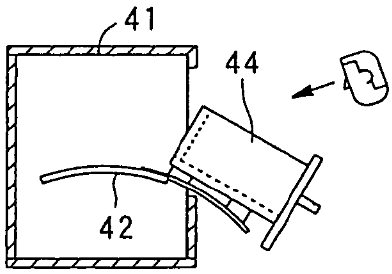


FIG. 12A

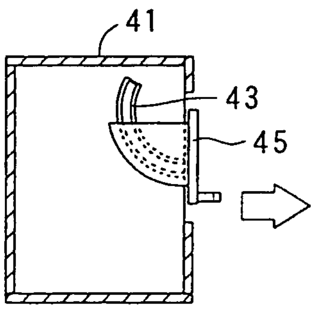


FIG. 12B

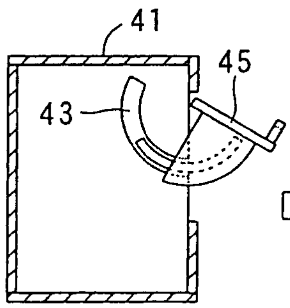


FIG. 12C

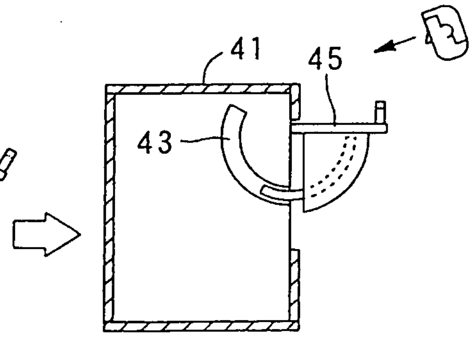


FIG. 13A FIG. 13B FIG. 13C

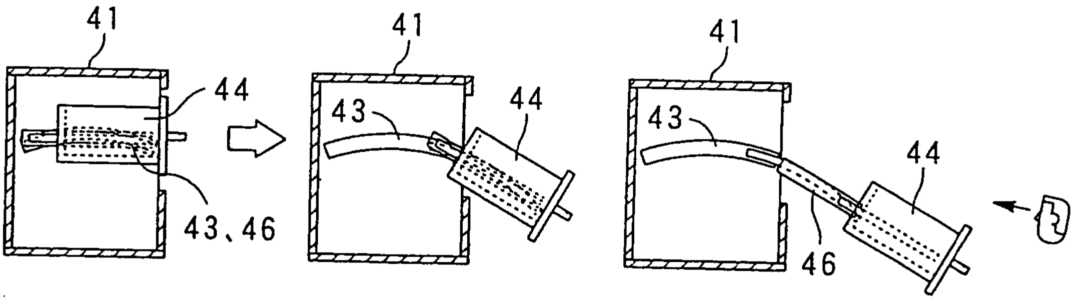
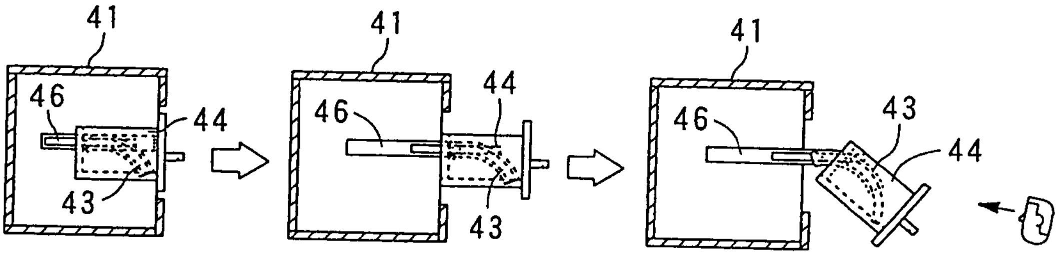


FIG. 14A FIG. 14B FIG. 14C



(19) Bundesrepublik Deutschland
Deutsches Patent- und Markenamt

(10) **DE 699 28 966 T2** 2006.08.17

(12) # Übersetzung der europäischen Patentschrift

(97) **EP 1 150 037 B1**
(21) Deutsches Aktenzeichen: **699 28 966.1**
(86) PCT-Aktenzeichen: **PCT/JP99/06214**
(96) Europäisches Aktenzeichen: **99 954 436.4**
(87) PCT-Veröffentlichungs-Nr.: **WO 2001/035002**
(86) PCT-Anmeldetag: **08.11.1999**
(87) Veröffentlichungstag der PCT-Anmeldung: **17.05.2001**
(97) Erstveröffentlichung durch das EPA: **31.10.2001**
(97) Veröffentlichungstag der Patenterteilung beim EPA: **14.12.2005**
(47) Veröffentlichungstag im Patentblatt: **17.08.2006**

(51) Int Cl.[8]: ***F16H 25/24*** (2006.01)
F16C 29/00 (2006.01)

(73) Patentinhaber:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Kohler Schmid Möbus Patentanwälte, 70565 Stuttgart

(84) Benannte Vertragsstaaten:
DE, FR, GB, IT

(72) Erfinder:
Takeda, Ryuji, Tokyo 141-0031, JP; Nishide, Tetsuhiro, Tokyo 141-0031, JP; Niwa, Hiroshi, Tokyo 141-0031, JP; Honma, Mitsuaki, Tokyo 141-0031, JP

(54) Bezeichnung: **KUGELSPINDEL**

Beschreibung

[0001] Die vorliegende Erfindung bezieht sich auf eine Kugelspindel gemäß der Präambel von Anspruch 1.

[0002] Als ein Dichtungselement einer herkömmlichen Kugelspindel sind Dichtungselemente bekannt, die an beiden Endabschnitten einer Mutter angebracht sind (siehe Japanisches Gebrauchsmuster JP 6006795U). Jedes dieser Dichtungselemente hat eine Ringform und besitzt eine innere Umfangsfläche, an der ein Vorsprung ausgebildet ist, der in eine Kugelrollnut einer Spindelwelle einpassbar ist. Ein Schlitz ist auf dem Dichtungselement so ausgebildet, dass er sich ausgehend von einem Endabschnitt der Mutter nach außen weisend in axialer Richtung der Mutter zu einem Zwischenabschnitt des Dichtungselements hin erstreckt. Indem die Dichtungselemente an beiden Endabschnitten der Mutter angebracht werden, kommen die Dichtungselemente in engen Kontakt mit den äußeren Umfangsflächen der Spindelwelle, wodurch ein Schmiermittel innerhalb der Mutter eingeschlossen wird. Indem der Schlitz auf dem Dichtungselement ausgebildet wird, streift zudem ein Randabschnitt des Schlitzes, der mit der äußeren Umfangsfläche der Spindelwelle in Kontakt ist, Fremdkörper ab, die an der Spindelwelle haften, und führt die Fremdkörper nach außerhalb der Mutter ab, wodurch verhindert wird, dass die Fremdkörper in die Mutter hinein eindringen.

[0003] Jedoch dringt bei der vorstehend beschriebenen herkömmlichen Dichtungsstruktur das Schmiermittel innerhalb der Mutter leicht in einen Spalt zwischen der Spindelwelle und den Dichtungselementen ein, und es ist zu befürchten, dass das Schmiermittel nach außen aus der Mutter ausläuft. Darüberhinaus wird auch das Schmiermittel, ebenso wie die Fremdkörper, von dem Randabschnitt des Schlitzes abgestreift werden, und aus diesem Grund wird das abgestreifte Schmiermittel nach außerhalb der Mutter abgeführt und nicht in das Innere der Mutter zurückgeführt.

[0004] Das am Nächsten kommende Dokument in Bezug auf den bisherigen Stand der Technik, EP-A-0376164, beschreibt eine Kugelspindel, die aufweist: eine Spindelwelle, an der an einer äußeren Umfangsflächen eine Kugelrollnut ausgebildet ist, eine Anzahl von Kugeln, die entlang der Kugelrollnut rollen, eine Mutter, die mit der Spindelwelle über die Kugeln und Dichtungselemente, die an beiden Endabschnitten der Mutter angeordnet sind, verschraubt ist, wobei jedes der Dichtungselemente an einer inneren Umfangsfläche mit einem spiralförmigen Vorsprung ausgebildet ist, der in die Kugelrollnut einpassbar ist, wobei ein Schmiermittel zurückhaltender Abschnitt an dem Dichtungselement ausgehend von einer in axialer Richtung der Mutter nach innen weisenden Endfläche desselben gebildet ist, und wobei der Schmiermittel zurückhaltende Abschnitt einen Schlitz aufweist, und wobei der Schmiermittel zurückhaltende Abschnitt formschlüssig Schmiermittel auffängt, das in den Spalt zwischen dem Dichtungselement und der Spindelwelle durch die Endfläche dringt und das Schmiermittel in das Innere der Mutter zurückführt, und wobei der Schlitz des Schmiermittel zurückhaltenden Abschnitts sich von der Endfläche des Dichtungselements zu einem Zwischenabschnitt desselben erstreckt, und wobei ein Fremdkörper entfernender Abschnitt an dem Dichtungselement gebildet ist, um Fremdkörper, die an einer äußeren Umfangsfläche der Spindelwelle haften, zu entfernen und die Fremdkörper nach außerhalb der Mutter abzuführen.

[0005] Die vorliegende Erfindung beabsichtigt, eine Kugelspindel bereit zu stellen, die ein Dichtungselement aufweist, das in der Lage ist, ein Schmiermittel in effizienter Weise innerhalb einer Mutter einzubehalten und zu verhindern, dass Fremdkörper in das Innere der Mutter eindringen.

[0006] Gemäß der vorliegenden Erfindung ist eine wie vorstehend definierte Kugelspindel dadurch gekennzeichnet, dass der Fremdkörper entfernende Abschnitt ein Schlitz ist, der so auf dem Dichtungselement gebildet ist, dass er sich von einer in axialer Richtung der Mutter nach außen weisenden Endfläche desselben zu einem Zwischenabschnitt desselben erstreckt.

[0007] In einer Kugelspindel der Erfindung ist der Schmiermittel zurückhaltende Abschnitt an dem Dichtungselement von einer in axialer Richtung der Mutter nach innen weisenden Endfläche desselben zu einem Zwischenabschnitt desselben ausgebildet. Daher kann das in den Spalt zwischen dem Dichtungselement und der Kugelspindel durch die Endfläche eindringende Schmiermittel formschlüssig aufgefangen werden und in den inneren Abschnitt der Mutter zurückgeführt werden. Auf diese Weise kann verhindert werden, dass das Schmiermittel innerhalb der Mutter aus der Mutter ausläuft. Da der Schmiermittel zurückhaltende Abschnitt einen Schlitz aufweist, wird das Schmiermittel durch den Randabschnitt einer Seitenfläche des Schlitzes bei Kontakt mit der Spindelwelle abgestreift und in das Innere der Mutter zurückgeführt.

[0008] Weiterhin werden, da ein Fremdkörper entfernender Abschnitt an dem Dichtungselement von einer in axialer Richtung der Mutter nach außen weisenden Endfläche desselben zu einem Zwischenabschnitt desselben gebildet ist, Fremdkörper, die an der äußeren Umfangsfläche der Spindelwelle (einschließlich einer Oberfläche der Kugelrollnut) verbleiben, entfernt und aus der Mutter heraus abgeführt.

[0009] In einer Ausführung sind Pressvorrichtungen vorgesehen, um die Dichtungselemente gegen die Spindelwelle zu pressen. Die Pressvorrichtungen stellen sicher, dass der Schmiermittel zurückhaltende Abschnitt und der Fremdkörper entfernende Abschnitt in engem Kontakt mit der Spindelwelle sind. Daher kann das Schmiermittel sicher aufgefangen werden, und die Fremdkörper können entfernt werden.

[0010] Ausführungen der vorliegenden Erfindung werden nachstehend anhand von Beispielen unter Bezugnahme auf die begleitenden Zeichnungen beschrieben, in welchen;

[0011] Fig. 1 eine Grundrissansicht einer Mutter und von Dichtungselementen einer Kugelspindel einer Ausführung der Erfindung darstellt;

[0012] Fig. 2 eine Endansicht von Fig. 1 darstellt;

[0013] Fig. 3 eine Schnittansicht von Fig. 1 darstellt;

[0014] Fig. 4 eine Endansicht eines Dichtungselements darstellt;

[0015] Fig. 5 eine Schnittansicht des Dichtungselements darstellt;

[0016] Fig. 6 eine Seitenansicht eines Rings, an den eine Feder montiert ist, darstellt; und

[0017] Fig. 7 eine Schnittansicht darstellt, die eine Spindelwelle und das Dichtungselement zeigt.

[0018] Fig. 1 bis Fig. 3 stellen eine Kugelspindel mit einer Kugelspindelmutter **1** und Dichtungselementen **2** dar. Wie bekannt ist, weist die Kugelspindel eine Spindelwelle (nicht abgebildet) auf, die eine äußere Umfangsfläche besitzt, auf der eine spiralförmige Kugelrollnut gebildet ist. Die Mutter **1** hat eine innere Umfangsfläche, an der eine spiralförmige Kugelrollnut **1a**, entgegengesetzt der an der Spindelwelle gebildeten Kugelrollnut, gebildet ist. Eine Anzahl von Kugeln (nicht abgebildet) sind zwischen der Kugelrollnut **1a** der Mutter **1** und der Kugelrollnut der Spindelwelle angeordnet und eingepasst. Wenn die Spindelwelle gedreht wird, rollen die Kugeln in dem Raum zwischen der Kugelrollnut **1a** der Mutter **1** und der Kugelrollnut der Spindelwelle. Wenn eine Kugel einen Endabschnitt der Kugelrollnut **1a** der Mutter **1** erreicht, kehrt diese durch einen an der Mutter **1** befestigte Rückführröhre **3** zu der entgegengesetzten Seite der Kugelrollnut **1a** zurück. Die Mutter **1** führt eine lineare Bewegung entlang der Spindelwelle durch Drehung derselben aus.

[0019] Ein Paar von Montagelöchern für Dichtungselemente **1b** ist an jeweiligen axialen Endabschnitten der Mutter **1** ausgebildet. Ein ringförmiges Dichtungselement **2** ist in jedes der Montagelöcher für Dichtungselemente **1b** montiert und in diesen mittels eines Sprengrings **4** befestigt. Jedes Dichtungselement **2** wird durch eine Einspritzformung eines synthetischen Harzes oder durch eine Schneidebearbeitung hergestellt, und ein spiralförmiger Vorsprung **2a** wird an der inneren Umfangsfläche des Dichtungselements **2**, das in die Kugelrollnut der Spindelwelle einpassbar ist, gebildet (siehe Fig. 3).

[0020] Wie in Fig. 3 dargestellt, sind eine Mehrzahl von Schlitzen **5** zum Zurückhalten von Schmiermittel an dem Dichtungselement **2** so gebildet, dass jeder sich von einer in axialer Richtung der Mutter **1** nach innen weisenden Endfläche **2b** desselben zu einem Zwischenabschnitt des Dichtungselements **2** erstreckt. Eine Mehrzahl von Schlitzen zum Entfernen von Fremdkörpern sind an dem Dichtungselement **2** so ausgebildet, dass jeder sich von einer in axialer Richtung der Mutter **1** nach außen weisenden Endfläche **2c** desselben zu einem Zwischenabschnitt des Dichtungselements **2** erstreckt. Die Schmiermittel zurückhaltenden Schlitze **5** können verhindern, dass Schmiermittel (zum Beispiel Fett), das den inneren Abschnitt der Mutter **1** füllt, nach außen ausläuft. Die Fremdkörper entfernenden Schlitze **6** können verhindern, dass Fremdkörper von außen in die Mutter **1** eindringen.

[0021] Fig. 4 stellt eine Endansicht der Dichtung dar und veranschaulicht die Anordnung der Schmiermittel zurückhaltenden Schlitze **5**. Jeder der Schmiermittel zurückhaltenden Schlitze **5** erstreckt sich im Wesentlichen in radialer Richtung der Spindelwelle, so dass diese als Löcher das Dichtungselement **2** von dessen innerem Umfang zu dessen äußerem Umfang hin durchdringen. Zudem stellen in Fig. 4 schräge Linienabschnitte die nachstehend beschriebenen Federn **12a** und **12b** dar. Wie dargestellt, sind die Schmiermittel zurückhaltenden Schlitze **5** an acht Abschnitten des Dichtungselements **2** mit gleicher Distanz zwischen solchen, die benachbart sind, in Umfangsrichtung angeordnet. Die acht Schmiermittel zurückhaltenden Schlitze **5** sind so gebildet, dass jeder eine Neigung (θ1) in der Drehrichtung F der Spindelwelle aufweist, und sich nach und nach in die Richtung von Pfeil F von der inneren Umfangsfläche der Spindelwelle zu der äußeren Umfangsfläche derselben hin verschiebt.

[0022] Die geneigte Ausbildung der Schmiermittel zurückhaltenden Schlitze **5** ermöglicht es, dass eine der einander gegenüber liegenden Seitenflächen **8a** und **8b** jedes Schlitzes **5** als eine Schmiermittel zurückhaltende Abstreiffläche mit einem Randabschnitt zum Abstreifen des Schmiermittels fungiert. Die Anzahl der Schmiermittel zurückhaltenden Schlitze **5** kann je nach Bedarf gewählt werden.

[0023] Fig. 5 stellt eine Schnittansicht des Dichtungselements **2** dar. Die Schmiermittel zurückhaltenden Schlitze **5** sind so gebildet, dass jeder eine Neigung (θ2) in Bezug auf die Richtung einer Achse X der Mutter **1** aufweist. Das heißt, dass in einem Fall, in dem die Mittellinie E der Kugelrollnut **9** in einem Steigungswinkel α geneigt ist, in einer vorbestimmten abgelenkten Richtung D in Bezug auf die Richtung (Richtung der Hilfslinie C), die normal in Bezug auf die Richtung der Achse X der Mutter **1** ist, die Mittellinie des Schmiermittel zurückhaltenden Schlitzes **5** von dem vorbestimmten Winkel (θ2) umfasst ist, in einer in Bezug auf die Achse X der Mutter **1** der Richtung D entgegengesetzten Richtung. Die Schmiermittel zurückhaltende Abstreiffläche **8b** ist in einem Winkel β von einer Fläche aus geneigt, die lotrecht zu der Mittellinie E der Kugelrollnut **9** ist, so dass sie das Schmiermittel in die axiale Richtung X der Mutter verschiebt und das Schmiermittel in die Mutter **1** zurückführt. Die acht Schmiermittel zurückhaltenden Schlitze sind alle mit einer Neigung (θ2) in Bezug auf die Achse X der Mutter **1** ausgebildet.

[0024] Die Fremdkörper entfernenden Schlitze **6** erstrecken sich im Wesentlichen in radialer Richtung der Spindelwelle, so dass diese als Löcher das Dichtungselement **2** von dessen innerem Umfang zu dessen äußerem Umfang hin durchdringen (siehe Fig. 2). In der veranschaulichten Ausführung sind diese Fremdkörper entfernenden Schlitze **6** ebenfalls an acht Abschnitten des Dichtungselements **2** mit gleicher Distanz zwischen solchen, die benachbart sind, in Umfangsrichtung ausgebildet. Jeder der Fremdkörper entfernenden Schlitze **6** hat eine Neigung (θ1) in der Drehrichtung F der Spindelwelle in Bezug auf die radiale Richtung der Spindelwelle. Eine der einander gegenüber liegenden Oberflächen **10a** und **10b** jedes der Schlitze **6** fungiert als eine Fremdkörper entfernende Oberfläche mit einem Randabschnitt zum Abstreifen der Fremdkörper.

[0025] Wie in Fig. 5 dargestellt, sind die Fremdkörper entfernenden Schlitze **6** so gebildet, dass jeder eine Neigung (θ2) in Bezug auf die Richtung derr Achse X der Mutter **1** aufweist. Das heißt, dass in einem Fall, in dem die Mittellinie E der Kugelrollnut **9** in einem Steigungswinkel α geneigt ist, in einer vorbestimmten abgelenkten Richtung D in Bezug auf die Richtung (Richtung der Hilfslinie C), die lotrecht zu der Richtung der Achse X der Mutter **1** ist, die Mittellinie des Fremdkörper entfernenden Schlitzes **6** in dem vorbestimmten Winkel (θ2) in der in Bezug auf die Achse X der Mutter **1** der Richtung D entgegengesetzten Richtung geneigt ist. Die Fremdkörper entfernende Abstreiffläche **10b** ist in einem Winkel β von einer Oberfläche aus geneigt, die lotrecht zu der Mittellinie E der Kugelrollnut **9** ist, so dass sie die abgestreiften Fremdkörper in die axiale Richtung X der Mutter verschiebt und diese nach außerhalb der Mutter **1** abführt.

[0026] Wie in Fig. 6 und Fig. 7 dargestellt, ist jedes Dichtungselement **2** mit zwei Nuten **11a** und **11b** an seiner äußeren Umfangsfläche gebildet, die sich beide in der Umfangsrichtung desselben erstrecken. Eine Feder **12a** bzw. **12b** ist um jede der Nuten **11a**, **11b** gewunden. Indem Federn **12a** und **12b** um die äußeren Umfänge der Dichtungselemente **2** herum gewunden werden, wird jedem Dichtungselement **2** eine elastische Eigenschaft verliehen. Das flexible elastische Dichtungselement **2** kann eng an die Spindelwelle angepasst werden, um hierdurch die Dichtungsleistung zu verbessern. Zusätzlich können die Randabschnitte der Schmiermittel zurückhaltenden Abstreiffläche **8b** und der Fremdkörper entfernenden Abstreiffläche **10b** in sicheren Kontakt mit der Spindelwelle gedrängt werden, um hierdurch in verlässlicher Weise das Schmiermittel und die Fremdkörper abzustreifen. Die Anzahl von Nuten, wie **11a** und **11b**, die sich in der Umfangsrichtung jedes Dichtungselements **2** erstrecken, ist nicht auf zwei begrenzt und kann je nach Bedarf gewählt werden. In einem Beispiel ist nur eine einzige Nut an jedem Dichtungselement vorgesehen.

[0027] Die Schmiermittel abstreifende Funktion und die Fremdkörper entfernende Funktion der Dichtungselemente **2** wird nun für den Fall beschrieben, in dem die Spindelwelle in der Richtung F gedreht wird, dargestellt in Fig. 2 und Fig. 4.

[0028] Wenn die Kugelspindel in die Richtung F in Fig. 2 oder Fig. 4 gedreht wird, wird der Randabschnitt der Abstreiffläche **8b** jedes Schmiermittel zurückhaltenden Schlitzes **5** des Dichtungselements **2** in Kontakt mit der äußeren Umfangsfläche der Spindelwelle gleiten. Aus diesem Grund wird das an der äußeren Umfangsfläche der Spindelwelle haftende Schmiermittel von dem Randabschnitt der Abstreiffläche **8b** des Schmiermittel zurückhaltenden Schlitzes **5** abgestreift werden und auf die Abstreiffläche **8b** desselben abgestreift werden. Da diese Abstreiffläche **8b** des Schmiermittel zurückhaltenden Schlitzes in einem Winkel β in Bezug auf die zu der Mittellinie E lotrechten Richtung der Kugelrollnut **9** geneigt ist, wird das Schmiermittel in das Innere der Mutter **1** zurückgeführt. Dementsprechend kann Schmiermittel, das von der Endfläche **2b** des Dichtungselements **2** in den Spalt zwischen der Mutter **1** und der Spindelwelle eindringt, formschlüssig aufgefangen werden und wieder in das Innere der Mutter **1** zurück geführt werden. Zudem kann in dem Fall, in dem die Kugelspindel in die der Richtung F in Fig. 2 oder Fig. 4 entgegengesetzte Richtung gedreht wird, das Schmiermittel an der Endfläche **2b** des Dichtungselements **2** ebenso einbehalten werden wie in dem Fall, in dem ein Schmiermittel entfernender Schlitz nicht ausgebildet ist (siehe Fig. 3).

[0029] In ähnlicher Weise gleitet, wenn die Spindelwelle in die Richtung F in Fig. 2 oder Fig. 4 gedreht wird, der Randabschnitt der Abstreiffläche **10b** des Fremdkörper entfernenden Schlitzes **6** auf der äußeren Umfangsfläche der Spindelwelle in Kontakt mit dieser. Dementsprechend können Fremdkörper, die an der äußeren Umfangsfläche der Spindelwelle haften, abgestreift werden, und die abgestreiften Fremdkörper werden dann zum Entfernen der Fremdkörper auf die Abstreiffläche **10b** gestreift. Zudem werden, da diese Abstreiffläche **10b** eine Neigung β zu einer Richtung hat, die lotrecht zu der Mittellinie E der Kugelrollnut **9** ist, die abgestreiften Fremdkörper aus der Mutter **1** heraus abgeführt.

[0030] Wie vorstehend erläutert wurde, ist in Ausführungen der Erfindung jeder der Schmiermittel zurückhaltenden Abschnitte an dem Dichtungselement von einer in der axialen Richtung der Mutter nach innen weisenden Endfläche des Dichtungselements zu einem Zwischenabschnitt desselben hin ausgebildet. In ähnlicher Weise ist jeder der Fremdkörper entfernenden Abschnitte an dem Dichtungselement von einer in der axialen Richtung der Mutter nach außen weisenden Endfläche des Dichtungselements zu dem Zwischenabschnitt desselben hin ausgebildet. Auf diese Weise kann Schmiermittel, das in den Spalt zwischen dem Dichtungselement und der Spindelwelle durch die Endfläche dringt, formschlüssig aufgefangen werden und in das Innere der Mutter zurück geführt werden, und Fremdkörper, die auf der äußeren Umfangsfläche der Spindelwelle verbleiben, können entfernt und nach außen abgeführt werden. Daher kann das Schmiermittel in dem inneren Abschnitt der Mutter zurückgehalten werden, und es kann verhindert werden, dass die Fremdkörper in das Innere der Mutter eindringen.

Patentansprüche

1. Kugelspindel mit einer Spindelwelle, an der an einer äußeren Umfangsfläche eine Kugelrollnut ausgebildet ist, einer Anzahl von Kugeln, die entlang der Kugelrollnut rollen, einer Mutter (**1**), die mit der Spindelwelle über die Kugeln und Dichtungselemente (**2**), die an beiden Endabschnitten der Mutter angeordnet sind, verschraubt ist, wobei jedes der Dichtungselemente an einer inneren Umfangsfläche mit einem spiralförmigen Vorsprung (**2a**) ausgebildet ist, der in die Kugelrollnut einpassbar ist,
wobei ein Schmiermittel zurückhaltender Abschnitt (**5**) an dem Dichtungselement (**2**) ausgehend von einer in axialer Richtung der Mutter nach innen weisenden Endfläche desselben (**2b**) gebildet ist, und der Schmiermittel zurückhaltende Abschnitt einen Schlitz (**5**) aufweist, und wobei der Schmiermittel zurückhaltende Abschnitt formschlüssig Schmiermittel auffängt, das in den Spalt zwischen dem Dichtungselement und der Spindelwelle durch die Endfläche dringt und das Schmiermittel in das Innere der Mutter (**1**) zurückführt,
und dass der Schlitz (**5**) des Schmiermittel zurückhaltenden Abschnitts sich von der Endfläche (**2b**) des Dichtungselements (**2**) zu einem Zwischenabschnitt desselben erstreckt,
und wobei ein Fremdkörper entfernender Abschnitt (**6**) an dem Dichtungselement gebildet ist, um Fremdkörper, die an einer äußeren Umfangsfläche der Spindelwelle haften, zu entfernen und die Fremdkörper nach außerhalb der Mutter abzuführen,
dadurch gekennzeichnet, dass der die Fremdkörper entfernende Abschnitt ein Schlitz (**6**) ist, der an dem Dichtungselement (**2**) gebildet ist, so dass er sich von einer in axialer Richtung der Mutter nach außen weisenden Endfläche (**2c**) desselben zu einem Zwischenabschnitt desselben erstreckt.

2. Kugelspindel nach Anspruch 1, wobei Presseinrichtungen (**12a**, **12b**) zum Anpressen des Dichtungselements an die Spindelwelle vorgesehen sind.

3. Kugelspindel nach Anspruch 1 oder 2, wobei der Schlitz (**5**) des Schmiermittel zurückhaltenden Abschnitts das Dichtungselement (**2**) von einem inneren Umfangsabschnitt zu einem äußeren Umfangsabschnitt durchdringt.

4. Kugelspindel nach einem der vorhergehenden Ansprüche, wobei der Schlitz (**6**) des Fremdkörper entfernenden Abschnitts das Dichtungselement (**2**) von einem inneren Umfangsabschnitt zu einem äußeren Umfangsabschnitt durchdringt.

5. Kugelspindel nach einem der vorhergehenden Ansprüche, wobei eine Schmiermittel zurückhaltende Abstreiffläche (**8b**) mit einem Randabschnitt zum Abstreifen von Schmiermittel an einer von einander gegenüberliegenden Seitenflächen des Schlitzes (**5**) des Schmiermittel zurückhaltenden Abschnitts gebildet ist und die Schmiermittel zurückhaltende Abstreiffläche (**8b**) so gebildet ist, dass sie eine Neigung (θ1) in eine Drehrichtung der Spindelwelle aufweist und eine Neigung (θ2) in Bezug auf eine Richtung einer Achse der Mutter aufweist, so dass sie das abgestreifte Schmiermittel in axialer Richtung der Mutter verschiebt und das Schmiermittel in die Mutter zurückführt.

6. Kugelspindel nach einem der vorhergehenden Ansprüche, wobei der Schmiermittel zurückhaltende Abschnitt eine Mehrzahl von Schlitzen (**5**) hat und eine der gegenüberliegenden Seitenflächen (**8a**, **8b**) jedes Schlitzes (**5**) als eine Schmiermittel zurückhaltende Abstreiffläche wirkt, die einen Randabschnitt hat, um das Schmiermittel abzustreifen.

7. Kugelspindel nach Anspruch 6, wobei die Schmiermittel zurückhaltenden Schlitze (**5**) so gebildet sind, dass sie jeweils eine Neigung (θ2) relativ zur axialen Richtung der Mutter (**1**) haben.

8. Kugelspindel nach einem der vorhergehenden

Ansprüche, wobei der Fremdkörper entfernende Abschnitt (**6**) eine Mehrzahl von Schlitzen (**6**) hat und eine der einander gegenüberliegenden Oberflächen (**10a**, **10b**) jedes Schlitzes (**6**) als Fremdkörper entfernende Oberfläche wirkt, die einen Randabschnitt hat, um die Fremdkörper abzustreifen.

9. Kugelspindel nach Anspruch 8, wobei die Fremdkörper entfernenden Schlitze (**6**) so gebildet sind, dass sie jeweils eine Neigung (θ2) in Bezug auf die axiale Richtung der Mutter haben.

Es folgen 5 Blatt Zeichnungen

Anhängende Zeichnungen

FIG. 1

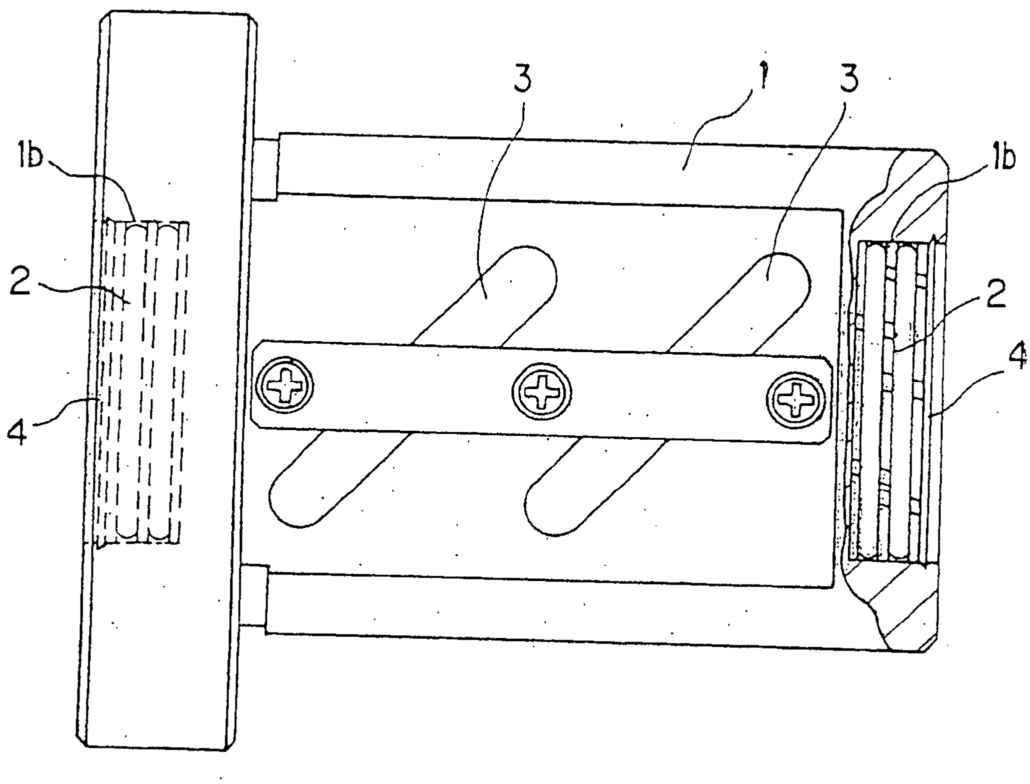


FIG. 2

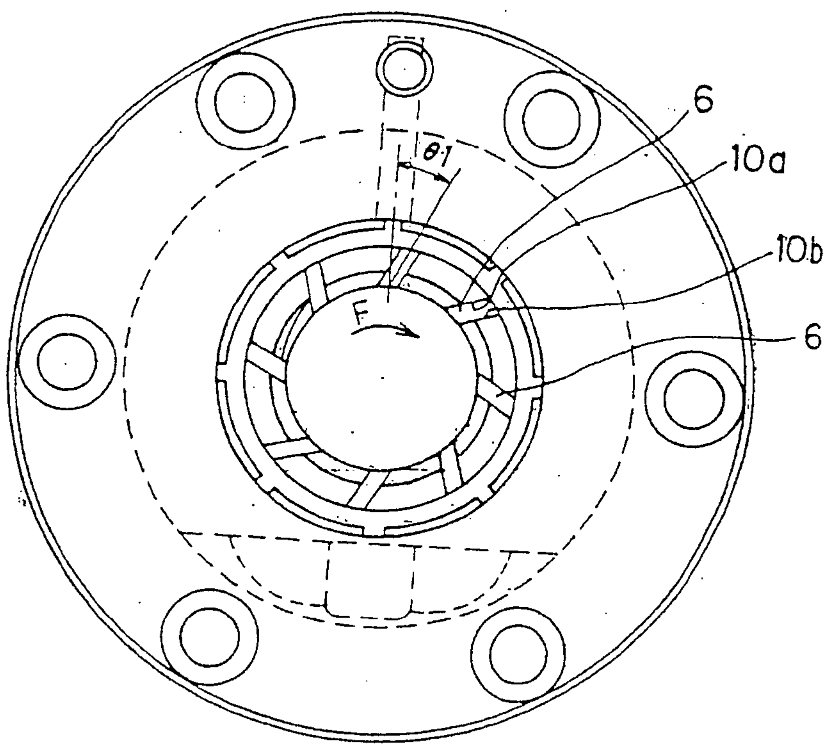


FIG. 3

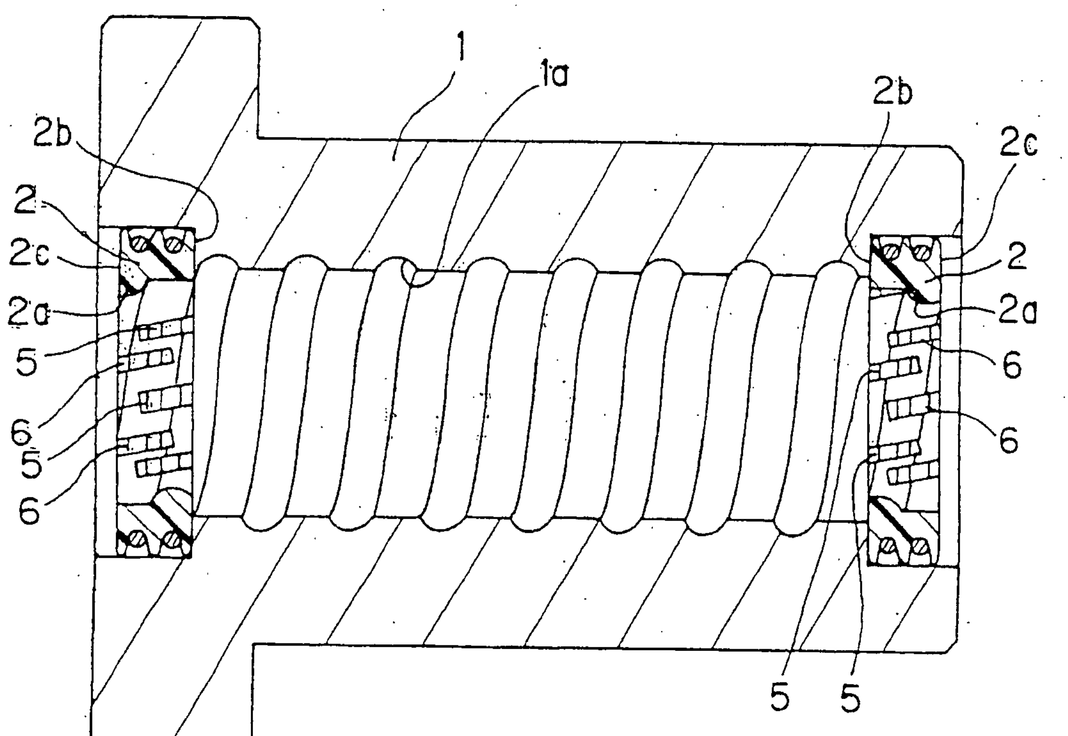


FIG. 4

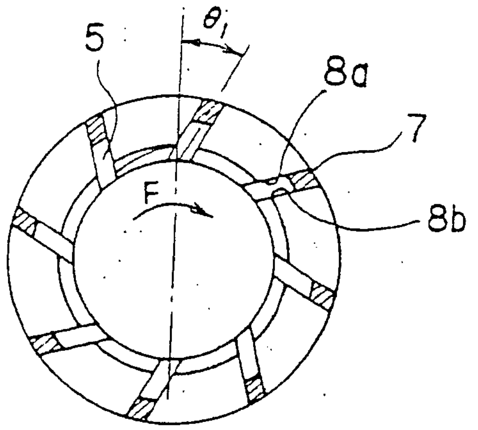


FIG. 5

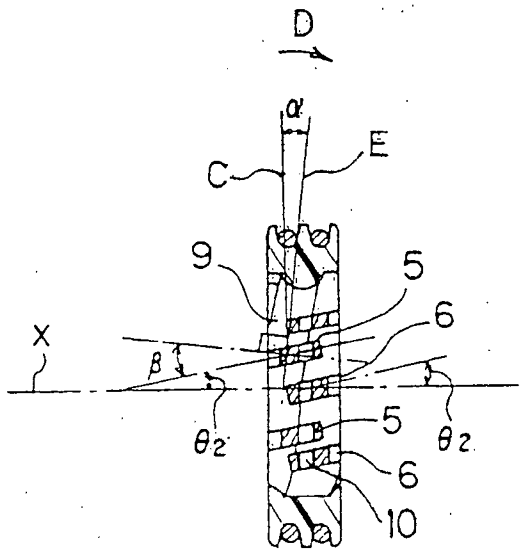


FIG. 6

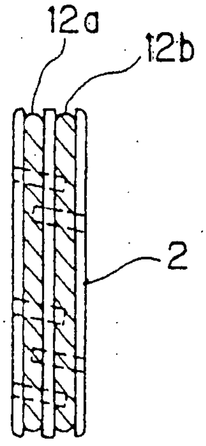
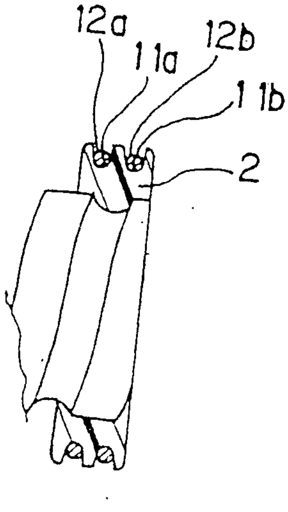


FIG. 7



(19) Bundesrepublik Deutschland
Deutsches Patent- und Markenamt

(10) **DE 698 30 142 T2** 2006.01.19

(12) # Übersetzung der europäischen Patentschrift

(97) **EP 0 936 365 B1**
(21) Deutsches Aktenzeichen: **698 30 142.0**
(86) PCT-Aktenzeichen: **PCT/JP98/03949**
(96) Europäisches Aktenzeichen: **98 941 698.7**
(87) PCT-Veröffentlichungs-Nr.: **WO 99/011942**
(86) PCT-Anmeldetag: **03.09.1998**
(87) Veröffentlichungstag der PCT-Anmeldung: **11.03.1999**
(97) Erstveröffentlichung durch das EPA: **18.08.1999**
(97) Veröffentlichungstag der Patenterteilung beim EPA: **11.05.2005**
(47) Veröffentlichungstag im Patentblatt: **19.01.2006**

(51) Int Cl.[8]: ***F16C 29/06*** (2006.01)
F16F 15/02 (2006.01)
F16F 15/04 (2006.01)

(30) Unionspriorität:
25601697 **04.09.1997** **JP**

(84) Benannte Vertragsstaaten:
DE, IT

(73) Patentinhaber:
THK Co., Ltd., Tokio/Tokyo, JP

(72) Erfinder:
ISHIKAWA, Hirokazu, Tokyo 141-8503, JP; KONOMOTO, Masashi, Tokyo 141-8503, JP; SUGA, Yoshikazu, Tokyo 141-8503, JP

(74) Vertreter:
WAGNER & GEYER Partnerschaft Patent- und Rechtsanwälte, 80538 München

(54) Bezeichnung: **DREIDIMENSIONALE FÜHRUNG**

Beschreibung

Technisches Gebiet

[0001] Die vorliegende Erfindung bezieht sich auf eine schwingungsisolierende dreidimensionale Führungsvorrichtung und insbesondere auf eine schwingungsisolierende dreidimensionale Führungsvorrichtung zur Anordnung zwischen dem Erdboden und einer Struktur um so weit wie möglich zu verhindern, dass die Schwingungen vom Erdboden auf die Struktur (Gebäude) übertragen werden.

Technischer Hintergrund

[0002] Bis jetzt sind einige Strukturen bei einer schwingungsisolierenden Konstruktion eingesetzt worden, die insbesondere dafür ausgelegt wurden, den Effekt von seismischen Schwingungen in Hinsicht der Eigenschaften der seismischen Schwingungen zu minimieren. Eine solche schwingungsisolierte Struktur weist einen Schwingungsisolator auf, der zwischen dem Erdboden und der Struktur angeordnet ist, um soweit wie möglich zu verhindern, dass Schwingungen vom Erdboden aufgrund von Erdbeben auf die Struktur (Gebäude) übertragen werden.

[0003] Gemäß einem solchen Schwingungsisolator, wie er in den Fig. 15A und Fig. 15B der beigefügten Zeichnungen gezeigt ist (Fig. 15A ist eine Ansicht und Fig. 15B ist eine Draufsicht), ist ein Gebäude **301** nicht an einem Fundament **302** befestigt, sondern eine Vielzahl von Führungsvorrichtungen **303**, um zu gestatten, dass das Gebäude **301** sich auf dem Fundament **302** bewegt, ist zwischen dem Fundament **302** und dem Gebäude **301** angeordnet. Wenn höhere seismische Kräfte als ein gewisses Niveau aufgebracht werden, gleitet das Gebäude **301** auf den Führungsvorrichtungen **303**, um zu verhindern, dass die seismischen Kräfte auf das Gebäude **301** wirken.

[0004] Die Anmelderin der vorliegenden Erfindung hat zuvor dreidimensionale Führungsvorrichtungen zur Anwendung als die obige Führungsvorrichtung in der japanischen Patentanmeldung Nr. 9-37072 vorgeschlagen, die als JP-A-09-324 555 nach dem Prioritätsdatum der vorliegenden Anmeldung veröffentlicht wurde. Die vorgeschlagenen dreidimensionalen Führungsvorrichtungen sind grob in zwei Bauarten gruppiert. Fig. 12 der beigefügten Zeichnungen zeigt die Perspektive von einer der Bauarten der vorgeschlagenen dreidimensionalen Führungsvorrichtung. Wie in Fig. 12 gezeigt, hat die dreidimensionale Führungsvorrichtung eine Basis **140**, eine erste gekrümmte Führungsvorrichtung **150**, die an der Basis **140** montiert ist und eine bogenförmige Spur bzw. Schiene besitzt, eine zweite gekrümmte Führungsvorrichtung **116**, die über der ersten gekrümmten Führungsvorrichtung **150** angeordnet ist und eine Bewegungsebene entlang einer bogenförmigen Spur bzw. Schiene besitzt, die die Bewegungsebene der ersten gekrümmten Führungsvorrichtung **150** kreuzt, und ein Zwischenglied **170**, welches zwischen der ersten gekrümmten Führungsvorrichtung **150** und der zweiten gekrümmten Führungsvorrichtung **160** positioniert ist und die erste gekrümmte Führungsvorrichtung **150** und die zweite gekrümmte Führungsvorrichtung **160** verbindet.

[0005] Die ersten und zweiten gekrümmten Führungsvorrichtungen **150**, **160** weisen Führungsschienen **151**, **161** auf, die vertikal mit einer vorbestimmten Krümmung gekrümmt sind und Kugellaufnuten **153**, **163** besitzen, die entlang einer Bogenform von vorbestimmter Krümmung in gegenseitig gegenüberstehenden Oberflächen definiert sind, weiter Lagerblöcke **152**, **162**, die einen U-förmigen Querschnitt über die Führungsschienen **151**, **161** aufweisen, und die Kugellaufnuten besitzen, die in Ausrichtung mit den Kugellaufnuten in den Raupenschienen **151**, **161** definiert sind, und zwar entlang einer Bogenform von vorbestimmter Krümmung, und eine Vielzahl von (nicht gezeigten) Kugeln, die zum Tragen von Lasten zwischen den Kugellaufnuten in den Führungsschienen **151**, **161** und den Kugellaufnuten in den Tragblöcken bzw. Lagerblöcken **152**, **162** angeordnet sind. Das Zwischenglied **170**, wel ches die erste gekrümmte Führungsvorrichtung **150** und die zweite gekrümmte Führungsvorrichtung **160** verbindet, ist in Form eines starren Blockes.

[0006] Fig. 13 der beigefügten Zeichnungen ist eine Ansicht, die die Weise zeigt, in der die dreidimensionale Führungsvorrichtung verwendet wird, die in Fig. 12 gezeigt ist.

[0007] Wie in Fig. 13 gezeigt, haben dreidimensionale Führungsvorrichtungen **303** jeweilige sphärische bzw. kugelförmige Führungsschienen, deren Krümmungsmittelpunkte getrennt an einem Gebäude **301** eingerichtet sind und nicht als eine gemeinsame Mitte. Zwischen dem Gebäude **301** und den dreidimensionalen Führungsvorrichtungen sind Kippaufnahmemechanismen **304** vorgesehen, um zu gestatten, dass die Kippbewegungen absorbiert werden, die zwischen dem Gebäude **301** und den dreidimensionalen Führungsvorrichtungen **303** erzeugt werden, wenn Schwingungen auftreten. Jeder der Kippaufnahmemechanismen **304** kann eine Universalverwendung aufweisen, ein Kugellager oder ein elastisches Glied aus Gummi oder ähnlichem.

[0008] Fig. 14 der beigefügten Zeichnungen ist eine Frontansicht, die eine andere Bauart einer zuvor vorgeschlagenen dreidimensionalen Führungsvorrichtung zeigt.

[0009] Wie in Fig. 14 gezeigt, weist die dreidimensionale Führungsvorrichtung eine Basis **140** auf, weiter eine erste gekrümmte Führungsvorrichtung **150**, die an der Basis **140** montiert ist und eine bogenförmige Spur bzw. Führung besitzt, eine zweite gekrümmte Führungsvorrichtung **160**, die um die erste gekrümmte Führungsvorrichtung **150** herum angeordnet ist und eine Bewegungsebene entlang einer bogenförmigen Führung besitzt, die die Bewegungsebene der ersten gekrümmten Führungsvorrichtung **150** kreuzt, und ein Zwischenglied **170**, welches zwischen der ersten gekrümmten Führungsvorrichtung **150** und der zweiten gekrümmten Führungsvorrichtung **160** positioniert ist und die erste gekrümmte Führungsvorrichtung **150** und die zweite gekrümmte Führungsvorrichtung **160** miteinander verbindet. Eine sich bewegende Basis **180**, auf der ein Gebäude getragen wird, ist fest an der zweiten gekrümmten Führungsvorrichtung **160** montiert. In diesem Beispiel weist das Zwischenglied **170** eine Universalverbindung auf, um Kippvorgänge zwischen der ersten gekrümmten Führungsvorrichtung **150** und der zweiten gekrümmten Führungsvorrichtung **160** aufzunehmen. Das Zwischenglied kann anstelle der Universalverbindung ein Kugellager oder ein elastisches Glied aufweisen, wie beispielsweise eine Feder oder ein Gummiglied.

[0010] Die ersten und zweiten gekrümmten Führungsvorrichtungen **150**, **160** weisen Führungsschienen bzw. Spurschienen **151**, **161** auf, die vertikal mit einer vorbestimmten Krümmung gekrümmt sind und Kugellaufnuten **153**, **163** besitzen, die entlang einer Bogenform von vorbestimmter Krümmung in gegenseitig gegenüberstehenden Oberflächen definiert sind, weiter Lagerblöcke **152**, **162**, die einen U-förmigen Querschnitt über den Spurschienen **151**, **161** besitzen, und die Kugellaufnuten besitzen, die in Ausrichtung mit den Kugellaufnuten in den Spurschienen **151**, **161** entlang einer Bogenform von vorbestimmter Krümmung definiert sind, und eine Vielzahl von (nicht gezeigten) Kugeln, die zum Tragen von Lasten zwischen den Kugellaufnuten in den Führungsschienen bzw. Spurschienen **151**, **161** und den Kugellaufnuten in den Lagerblöcken **152**, **162** angeordnet sind.

[0011] In Abwesenheit von seismischen Schwingungen gestattet die schwingungsisolierende Konstruktion mit der obigen dreidimensionalen Führungsvorrichtung, dass das Gebäude stabil in einer stetigen Position auf der dreidimensionalen Führungsvorrichtung positioniert ist. Auch wenn ein Erdbeben auftritt und bewirkt, dass der Erdboden schwingt, sind der Boden und das Gebäude gegen die Übertragung von Schwingungen durch die dreidimensionale Führungsvorrichtung isoliert, so dass große Schwingungen nicht auf das Gebäude übertragen werden. Nachdem seismische Schwingungen abgeklungen sind, werden irgendwelche Schwingungen des Gebäudes mit Bezug zum Erdboden gedämpft, und das Gebäude wird in der stetigen Position auf der dreidimensionalen Führungsvorrichtung stabilisiert.

[0012] Damit die dreidimensionale Führungsvorrichtung, die in der japanischen Patentanmeldung Nr. 9-37072 vorgeschlagen wird, das Gebäude in einem horizontalen Zustand hält, wenn das Gebäude unter Schwingungen leidet, die durch Erdbeben oder ähnliches verursacht werden, ist es nötig, einen Kippabsorptionsmechanismus zwischen der ersten gekrümmten Führungsvorrichtung und der zweiten gekrümmten Führungsvorrichtung vorzusehen. Der Kippabsorptionsmechanismus weist eine Universalverbindung, ein Kugellager oder ein elastisches Glied auf, wie beispielsweise eine Feder oder ein Gummiglied.

[0013] Wenn der Kippabsorptionsmechanismus eine Universalverbindung bzw. Kreuzgelenk oder ein Kugellager aufweist, werden Spannungen, die auf dem gleitenden Teil entwickelt werden, übermäßig größer als jene, die in anderen Gliedern entwickelt werden, da das Gesamtgewicht des Gebäudes auf einem gleitenden Teil getragen werden muß, wie beispielsweise auf einer Kreuzgelenkwelle (Universalverbindung) oder einem Kugelsitz mit einer kleinen Fläche, und diese tendieren dazu, in kurzer Zeit zu zerbrechen oder abgenutzt zu werden.

[0014] Wenn der Kippabsorptionsmechanismus ein elastisches Glied aufweist, wie beispielsweise ein Gummiglied, siehe JP-A-09-72333, dann kann er nur Lasten innerhalb eines elastisch verformbaren Bereiches tragen und kann nicht höhere Lasten tragen. Ein weiteres Problem ist, dass das elastische Glied eine schlechte Haltbarkeit hat, da es aufgrund von Alterung wahrscheinlich an Setzung leidet. Das heißt, die in der japanischen Patentanmeldung Nr. 9-37072 oder in JP-A-09-72333 vorgeschlagene Vorrichtung kann wegen dem Kippabsorptionsmechanismus keine schweren Lasten tragen.

[0015] Es ist ein Ziel der vorliegenden Erfindung, eine dreidimensionale Führungsvorrichtung vorzusehen, die eine Kippabsorptionsfunktion hat, die schwere Lasten tragen kann, und die eine hervorragende Haltbarkeit hat.

Offenbarung der Erfindung

[0016] Um das obige Ziel zu erreichen, ist gemäß der vorliegenden Erfindung eine dreidimensionale Führungsvorrichtung mit einer Basis vorgesehen, weiter mit einer ersten gekrümmten Führungsvorrichtung, die an der Basis montiert ist und eine bogenförmige Spur bzw. Führung besitzt, weiter eine zweite gekrümmte Führungsvorrichtung, die um die erste gekrümmte Führungsvorrichtung herum angeordnet ist und eine Bewegungsebene entlang einer bogenförmigen Spur besitzt, die die Bewegungsebene der ersten gekrümmten Führungsvorrichtung überkreuzt, und ein Zwischenglied, welches zwischen der ersten gekrümmten Führungsvorrichtung und der zweiten gekrümmten Führungsvorrichtung positioniert ist und die erste gekrümmte Führungsvorrichtung und die zweite gekrümmte Führungsvorrichtung verbindet, wobei jede der ersten und zweiten gekrümmten Führungsvorrichtungen folgendes aufweist: eine Führungsschiene bzw. Spurschiene, die vertikal mit einer vorbestimmten Krümmung gekrümmt ist und eine Vielzahl von Wälzelementlaufnuten besitzt, die in den Außenflächen davon definiert sind; weiter einen Lagerblock, der einen im Wesentlichen zylindrischen starren Körper besitzt und in den Innenflächen davon eine Vielzahl von Wälzelementlaufnuten in Ausrichtung mit den Wälzelementlaufnuten in der Spurschiene besitzt, und nicht belastete Wälzelementrolldurchlässe benachbart zu den Wälzelementlaufnuten; weiter ein Paar von Deckeln, die jeweils auf den vorderen und hinteren Enden der Lagerblöcke montiert sind und jeweilige Wälzelementrichtungsänderungsdurchlässe besitzen, die in jeweiligen Innenflächen davon definiert sind, wobei die Wälzelementrichtungsänderungsdurchlässe Enden der Wälzelementlaufnuten und der nicht belastenden Wälzelementdurchlässe verbinden, und einen endlosen Zirkulationspfad für Wälzelemente vorsehen; und eine Vielzahl von Wälzelementen, die angeordnet sind, um in dem endlosen Wälzelementzirkulationspfad zu zirkulieren, um Lasten zwischen den Wälzelementlaufnuten in der Spurschiene und den Wälzelementlaufnuten in dem Lagerblock zu tragen; wobei das Zwischenglied einen starren Körper in Form eines Blocks besitzt, und offene zylindrische Ausnehmungen besitzt, die jeweils in zwei Oberflächen davon definiert sind, wobei die Lagerblöcke drehbar in die offenen zylindrischen Ausnehmungen gepaßt sind.

[0017] Das Zwischenglied weist einen starren Körper in Form eines Blocks und des Lagerblocks auf; wobei jeder einen starren Körper aufweist, und wobei die ersten und zweiten gekrümmten Führungsvorrichtungen drehbar jeweils in den zylindrischen Ausnehmungen eingepasst sind, die jeweils in den zwei Oberflächen des Zwischengliedes definiert sind, was somit eine Kippabsorptionsfähigkeit zwischen den ersten und zweiten Führungsvorrichtungen vorsieht. Da die Kippabsorptionsmöglichkeit ausgeführt wird und das Gebäude durch gleitende Oberflächen getragen wird, die eine große Kontaktfläche haben, und die durch die berührenden starren Körper vorgesehen werden, kann die dreidimensionale Führungsvorrichtung schwerere Lasten tragen und eine hervorragende Haltbarkeit aufweisen.

Kurze Beschreibung der Zeichnungen

[0018] Fig. 1 ist eine Perspektivansicht einer dreidimensionalen Führungsvorrichtung gemäß einem ersten Ausführungsbeispiel der vorliegenden Erfindung;

[0019] Fig. 2A und Fig. 2B sind Perspektivansichten der ersten und zweiten Führungsvorrichtung in dem in Fig. 1 gezeigten Ausführungsbeispiel;

[0020] Fig. 3 ist eine Perspektivansicht, die die Kugellaufnuten zeigt, die in einem Lagerblock in dem in Fig. 1 gezeigten Ausführungsbeispiel definiert sind;

[0021] Fig. 4 ist eine Perspektivansicht, die ein Zwischenglied in Form eines Blockes in dem in Fig. 1 gezeigten Ausführungsbeispiel zeigt;

[0022] Fig. 5 ist eine Seitenansicht einer dreidimensionalen Führungsvorrichtung gemäß einem zweiten Ausführungsbeispiel der vorliegenden Erfindung;

[0023] Fig. 6 ist eine Querschnittsansicht, aufgenommen entlang der Linie VI-VI in Fig. 5;

[0024] Fig. 7 ist eine vergrößerte bruchstückhafte Ansicht eines Teils der Fig. 5;

[0025] Fig. 8 ist eine Seitenansicht einer dreidimensionalen Führungsvorrichtung gemäß einem dritten Ausführungsbeispiel der vorliegenden Erfindung;

[0026] Fig. 9 ist eine Querschnittsansicht, die entlang der Linie IX-IX der Fig. 8 aufgenommen wurde;

[0027] Fig. 10 ist eine vergrößerte bruchstückhafte Ansicht eines Teils der Fig. 9;

[0028] Fig. 11 ist eine Perspektivansicht einer dreidimensionalen Führungsvorrichtung gemäß einem vierten Ausführungsbeispiel der vorliegenden Erfindung;

[0029] Fig. 12 ist eine Perspektivansicht eines Beispiels der dreidimensionalen Führungsvorrichtung, die zuvor von der Anmelderin der vorliegenden Erfindung vorgeschlagen wurde;

[0030] Fig. 13 ist eine Ansicht, die die Art und Weise zeigt, in der die dreidimensionale Führungsvorrichtung verwendet wird, die in Fig. 12 gezeigt ist;

[0031] Fig. 14 ist eine Perspektivansicht eines weiteren Beispiels der dreidimensionalen Führungsvorrichtung, die zuvor von der Anmelderin der vorliegenden Erfindung vorgeschlagen wurde; und

[0032] Fig. 15A und Fig. 15B sind Diagramme, die die Beziehung zwischen einem Gebäude und einer schwingungsisolierenden Konstruktion zeigt.

Bester Weg zur Ausführung der Erfindung

[0033] Ausführungsbeispiele der dreidimensionalen Führungsvorrichtung gemäß der vorliegenden Erfindung werden im Detail unten mit Bezug auf die Fig. 1

bis Fig. 13 beschrieben.

[Erstes Ausführungsbeispiel]

[0034] Die Fig. 1 bis Fig. 4 zeigen eine dreidimensionale Führungsvorrichtung gemäß einem ersten Ausführungsbeispiel der vorliegenden Erfindung. Fig. 1 ist eine Perspektivansicht der dreidimensionalen Führungsvorrichtung, **Fig.** 2 ist eine Perspektivansicht der ersten und zweiten gekrümmten Führungsvorrichtung, Fig. 3 ist eine Perspektivansicht, die einen Lagerblock zeigt, und Fig. 4 ist eine Perspektivansicht, die ein Zwischenglied zeigt.

[0035] Wie in Fig. 1 gezeigt, weist die dreidimensionale Führungsanordnung gemäß dem ersten Ausführungsbeispiel eine Basis **23** auf, die an einem Fundament befestigt ist, weiter eine erste gekrümmte Führungsvorrichtung **21**, die an der Basis **23** montiert ist und eine bogenförmige Spur bzw. Schiene besitzt, weiter eine zweite gekrümmte Führungsvorrichtung **22**, die über der ersten gekrümmten Führungsvorrichtung **21** angeordnet ist und eine Bewegungsebene entlang einer bogenförmigen Spur besitzt, die die Bewegungsebene der ersten gekrümmten Führungsvorrichtung **21** kreuzt, und ein Zwischenglied **24**, welches zwischen der ersten gekrümmten Führungsvorrichtung **21** und der zweiten gekrümmten Führungsvorrichtung **22** positioniert ist und die erste gekrümmte Führungsvorrichtung **21** und die zweite gekrümmte Führungsvorrichtung **22** verbindet. Eine sich bewegende Basis **25**, auf der ein Gebäude getragen wird, ist fest an der zweiten gekrümmten Führungsvorrichtung **22** montiert.

[0036] Die erste gekrümmte Führungsvorrichtung **21** und die zweite gekrümmte Führungsvorrichtung **22** sind strukturell miteinander identisch. Wie in den Fig. 2A und Fig. 2B gezeigt (Fig. 2A ist eine bruchstückhafte Perspektivansicht, die teilweise aufgebrochen ist, und Fig. 2B ist eine querverlaufende Querschnittsansicht) weisen sowohl die erste gekrümmte Führungsvorrichtung **21** als auch die zweite gekrümmte Führungsvorrichtung **22** eine gekrümmte Spurschiene **1** auf, die vertikal mit einer vorbestimmten Krümmung gekrümmt ist, und einen Tragblock bzw. Lagerblock **10**, der verschiebbar auf der gekrümmten Spurschiene **1** durch eine Anzahl von Kugeln **9** getragen wird, und der einen endlosen Kugelzirkulationsdurchlaß besitzt. Wie in Fig. 1 gezeigt, hat die gekrümmte Spurschiene **1** eine im Wesentlichen rechteckige Querschnittsform und ist bogenförmig mit einer vorbestimmten vertikalen Krümmung gekrümmt. Die gekrümmte Spurschiene **1** hat einen Krümmungsmittelpunkt O, der vertikal oben positioniert ist, und einen Krümmungsradius R. Die gekrümmte Spurschiene **1** hat eine konvexe Befestigungsoberfläche (Unterseite) **1a** und eine konkave Oberfläche (Oberseite) **1b** gegenüberliegend zur Befestigungsoberfläche **1a**.

[0037] Die Befestigungsfläche (Unterseite) der Spurschiene **1** wird als eine erste Oberfläche **1** bezeichnet, die Oberfläche (Oberseite) gegenüberliegend zur Befestigungsfläche als eine zweite Oberfläche **1b**, und beide Seitenflächen, die sich von beiden Oberflächen der ersten Oberfläche **1a** erstrecken, werden als dritte und vierte Oberflächen **1c**, **1d** bezeichnet.

[0038] Wie in den Fig. 2A und Fig. 2B gezeigt, haben die dritten und vierten Oberflächen **1c**, **1d** der gekrümmten Spurschiene **1** Kugellaufnuten **111**, die dadurch entlang einer Bogenform von vorbestimmter Krümmung definiert sind, und die zweite Oberfläche **1b** hat parallele Kugellaufnuten **112** entlang der Spurschiene **1**.

[0039] Der Tragblock bzw. Lagerblock **10** weist einen im wesentlichen zylindrischen starren Körper auf und hat einen nach unten weisenden offenen Hohlraum **101** darin definiert. Der Lagerblock **10** hat auch Kugellaufnuten **221**, die in beiden Innenseitenflächen **10c**, **10d** davon in Ausrichtung mit den Kugellaufnuten **111** in der gekrümmten Spurschiene **1** entlang einer Bogenform von vorbestimmter Krümmung definiert sind (mit dem Krümmungsradius R). Der Lagerblock **10** hat auch parallele Kugellaufnuten **222**, die in einer unteren Innenseite **10a** davon in Ausrichtung mit den Kugellaufnuten **112** definiert sind.

[0040] Der Lagerblock **10** hat auch nicht belastete Kugeldurchlässe **223**, **224** benachbart darin zu den Kugellaufnuten **221**, **222** definiert, und zwar in Assoziation mit den Kugellaufnuten **221**, **222**. Wie in den Fig. 2A und Fig. 2B gezeigt, sind Deckel **13**, **13** jeweils an vorderen und hinteren Enden des Lagerblockes **10** montiert und haben jeweilige Kugelrichtungsumlenkdurchlässe bzw. Kugelrücklaufdurchlässe **15**, die in jeweiligen Innenflächen davon definiert sind, und die Enden der Kugellaufnuten **221**, **222** und der nicht belasteten Kugeldurchlässe **223**, **224** verbinden, was somit einen endlosen Kugelzirkulationspfad vorsieht. Die Kugeln **9** sind angeordnet, um in dem endlosen Kugelumlaufpfad zu zirkulieren, um Lasten zwischen den Kugellaufnuten **111**, **112** in der Spurschiene **1** und den Kugellaufnuten **221**, **222** in dem Lagerblock **10** zu tragen.

[0041] Kontaktwinkellinien, die Kontaktpunkte zwischen den Kugeln **9** und den gegenüberstehenden unteren Kugellaufnuten **111**, **221** verbinden, sind in horizontaler Richtung um 45 Grad geneigt. Kontaktlinien, die Kontaktpunkte zwischen den Kugeln **9** und den gegenüberstehenden oberen Kugellaufnuten **112**, **222** verbinden, erstrecken sich in vertikaler Richtung (der Richtung, in welcher Lasten aufgebracht sind).

[0042] Fig. 3 ist eine Perspektivansicht, die die oberen und unteren Kugellaufnuten **221**, **222** zeigt, die in dem inneren Hohlraum in dem Lagerblock **10** definiert sind. Die oberen und unteren Kugellaufnuten **221**, **222** haben eine Bogenform mit einer vorbestimmten vertikalen Krümmung (Krümmungsradius R) und sind nach unten konvex.

[0043] Fig. 4 ist eine Perspektivansicht des Zwischengliedes **24** in Form eines Blockes. Wie in Fig. 4 gezeigt, weist das Zwischenglied **24** einen starren Körper auf, im Wesentlichen in Form eines rechteckigen Parallelepipedes, und es hat eine obere zylindrische Ausnehmung **241**, **242**, die jeweils in der Ober- und Unterseite **24a**, **24b** definiert sind. Die Lagerblöcke **10** sind drehbar jeweils in den zylindrischen Ausnehmungen **241**, **242** eingepaßt. Die Lagerblöcke **10**, die jeweils in die zylindrischen Ausnehmungen **241**, **242** eingepasst sind, sind durch Befestigungsmittel festgelegt, so dass die Lagerblöcke **10** um die Längsachsen davon mit Bezug auf das Zwischenglied **24** drehbar sind, jedoch entlang der Längsachsen davon unbeweglich sind.

[0044] Gemäß dem ersten Ausführungsbeispiel weist das Zwischenglied **24** einen starren Körper in Form eines Blockes auf, und die Lagerblöcke **10**, **10** der ersten und zweiten Führungsvorrichtung **21**, **22**, die jeweils einen starren Körper aufweisen, sind drehbar jeweils in die zylindrischen Ausnehmungen **241**, **242** eingepasst, die jeweils in den Ober- und Unterseiten des Zwischengliedes **24** definiert sind, was somit eine Möglichkeit zur Aufnahme einer Verkippung zwischen den ersten und zweiten gekrümmten Führungsvorrichtungen **21**, **22** vorsieht. Da die Möglichkeit zur Aufnahme einer Verkippung ausgeführt ist und das Gebäude durch gleitende Oberflächen getragen wird, die eine große Kontaktfläche haben, und die in den sich berührenden starren Körpern vorgesehen sind (die Innenumfangsflächen der Ausnehmungen **241**, **242** des Zwischengliedes **24** und der Außenumfangsflächen der Lagerblöcke **10**), kann die dreidimensionale Führungsvorrichtung schwere Lasten tragen und eine hervorragende Haltbarkeit aufweisen.

[0045] Wenn das Fundament des Gebäudes auf der sich bewegenden Basis **25** aufgrund eines Erdbebens schwingt, welches durch Erdkrustenbewegungen verursacht wird, bewegt sich in dem ersten Ausführungsbeispiel das Gebäude entlang der oberen und unteren gekrümmten Spurschienen **1** aufgrund der Beschleunigung. Dies kommt daher, dass die Beschleunigung in Komponenten entlang der X-und Y-Richtungen der Spurschienen **1** durch die seismische Schwenkbewegung in irgendeiner willkürlichen Richtung aufgeteilt ist. Auch wenn das Gebäude schwingt, wird die Aufnahmefähigkeit für Verkippungen durch die Winkelbewegung zwischen dem Zwischenglied **24** und den Lagerblöcken **10** ausgeführt, um somit das Gebäude horizontal zu halten. Da die oberen und unteren gekrümmten Spurschienen **1** in gegenseitig senkrechten Richtungen zu jedem Zeitpunkt gehalten werden, kann eine Vielzahl von dreidimensionalen Führungsvorrichtungen leicht richtungsmäßig ausgerichtet werden, wenn das Gebäude aufgebaut wird. Insbesondere sobald die gekrümmten Spurschienen **1** der Fundamentseite richtungsmäßig ausgerichtet sind, sind die gekrümmten Spurschienen **1** der Gebäudeseite notwendigerweise festgelegt und müssen nicht richtungsmäßig ausgerichtet werden.

[0046] In dem ersten Ausführungsbeispiel ist weiterhin eine Vielzahl von dreidimensionalen Führungsvorrichtungen zwischen dem Erdboden und dem Gebäude angeordnet. Insofern als die oberen und unteren Lagerblöcke **10** mit Bezug auf das Zwischenglied **24** drehbar sind, können irgendwelche Fehlausrichtungen (Zentrierungsfehler) und Niveaufehler leicht aufgenommen werden. Das Zwischenglied **24** in Form eines einfachen Blockes mit niedrigem Profil gestattet, dass die dreidimensionale Führungsvorrichtung in vertikaler Höhe kleiner ist als sie es sein würde, wenn eine Universalverbindung bzw. ein Kreuzgelenk als das Zwischenglied verwendet werden würde.

[Zweites Ausführungsbeispiel]

[0047] Die Fig. 5 bis Fig. 7 zeigen eine dreidimensionale Führungsvorrichtung gemäß einem zweiten Ausführungsbeispiel der vorliegenden Erfindung. Fig. 5 ist eine Seitenansicht der dreidimensionalen Führungsvorrichtung, Fig. 6 ist eine Querschnittsansicht, die entlang der Linie VI-VI der Fig. 5 aufgenommen ist, und Fig. 7 ist eine vergrößerte bruchstückhafte Ansicht eines Teils der Fig. 5. Jene Teile des in den Fig. 5 bis Fig. 7 gezeigten Ausführungsbeispiels, die in derselben Weise arbeiten, wie jene des in den Fig. 1 bis Fig. 4 gezeigten Ausführungsbeispiels, werden mit identischen Bezugszeichen beschrieben.

[0048] Die Hauptanordnung des zweiten Ausführungsbeispiels ist identisch mit der Anordnung des ersten Ausführungsbeispiels. Jedoch sind eine zweite gekrümmte Führungsvorrichtung **22** und ein Zwischenglied **24** gemäß dem zweiten Ausführungsbeispiel anders als jene des ersten Ausführungsbeispiels. Insbesondere wie in den Fig. 5 und Fig. 6 gezeigt, hat die gekrümmte Spurschiene **1** der zweiten gekrümmten Führungsvorrichtung **22** der dreidimensionalen Führungsvorrichtung gemäß dem zweiten Ausführungsbeispiel eine im Wesentlichen rechteckige Querschnittsform und ist bogenförmig mit einer vorbestimmten vertikalen Krümmung gekrümmt, wie bei dem ersten Ausführungsbeispiel, ist jedoch um 90 Grad gegenüber der gekrümmten Spurschiene **1** gemäß dem ersten Ausführungsbeispiel versetzt. Die gekrümmte Spurschiene **1** der zweiten gekrümmten Führungsvorrichtung **22** hat eine konkave dritte

Oberfläche **1c** und eine konvexe vierte Oberfläche **1d**. Wie in Fig. 7 gezeigt, haben die dritten und vierten Oberflächen **1c**, **1d** der Spurschiene **1** jeweilige Kugellaufnuten **111** darin entlang der Spurschiene **1** definiert. Die zweite Oberfläche **1b** gegenüberliegend zur ersten Oberfläche **1a** hat parallele Kugellaufnuten **112**, die darin entlang einer Bogenform von vorbestimmter Krümmung definiert sind.

[0049] Der Lagerblock **10** der zweiten gekrümmten Führungsvorrichtung **22** weist einen im Wesentlichen zylindrischen starren Körper auf und hat Innenseitenflächen **10c**, **10d**, die gekrümmte Oberflächen entlang der dritten und vierten Oberflächen **1c**, **1d** der Spurschiene **1** aufweisen. Die dritten und vierten Oberflächen **10c** und **10d** des Lagerblockes **10** haben darin definierte Kugellaufnuten **221** in Ausrichtung mit den Kugellaufnuten **111** der gekrümmten Spurschiene **1**. Der Lagerblock **10** hat auch parallele Kugellaufnuten **222**, die in seiner unteren Innenfläche **10a** definiert sind, und zwar in Ausrichtung mit den Kugellaufnuten **112** entlang einer Bogenform von vorbestimmter Krümmung.

[0050] Das Zwischenglied **24** hat eine offene zylindrische Ausnehmung **242**, die in einer Unterseite **24b** davon definiert ist, und eine offene zylindrische Ausnehmung **241**, die in einer Seitenfläche **24c** davon definiert ist. Lagerblöcke **10** sind drehbar jeweils in die zylindrischen Ausnehmungen **241**, **242** eingepasst. Eine sich bewegende Basis **25** ist fest an der ersten Oberfläche **1a** (Befestigungsfläche) der Spurschiene **1** befestigt und erstreckt sich nach oben. Die Oberseite der sich bewegenden Basis **25** bildet eine Einbau- bzw. Befestigungsfläche für das Gebäude. Die Teile der anderen Komponenten, wie beispielsweise die erste gekrümmte Führungsvorrichtung **21**, sind identisch mit jenen des ersten Ausführungsbeispiels.

[Drittes Ausführungsbeispiel]

[0051] Die Fig. 8 bis Fig. 10 zeigen eine dreidimensionale Führungsvorrichtung gemäß einem dritten Ausführungsbeispiel der vorliegenden Erfindung. Fig. 8 ist eine Seitenansicht der dreidimensionalen Führungsvorrichtung, und Fig. 9 ist eine Querschnittsansicht, die entlang der Linie IX-IX der Fig. 8 aufgenommen ist. Jene Teile des in den Fig. 8 bis Fig. 10 gezeigten Ausführungsbeispiels, die in der gleichen Weise arbeiten, wie jene des in den Fig. 1 bis Fig. 4 gezeigten Ausführungsbeispiels, werden mit identischen Bezugszeichen beschrieben.

[0052] Die Hauptanordnung des dritten Ausführungsbeispiels ist identisch mit der Anordnung des zweiten Ausführungsbeispiels. Jedoch sind eine erste gekrümmte Führungsvorrichtung **21** und ein Zwischenglied **24** gemäß dem dritten Ausführungsbeispiel anders als jene des zweiten Ausführungsbeispiels. Insbesondere wie in den Fig. 8 und Fig. 9 gezeigt, hat die gekrümmte Spurschiene **1** der ersten gekrümmten Führungsvorrichtung **21** der dreidimensionalen Führungsvorrichtung gemäß dem dritten Ausführungsbeispiel eine im wesentlichen rechteckige Querschnittsform und ist bogenförmig mit einer vorbestimmten vertikalen Krümmung gekrümmt, wie bei dem zweiten Ausführungsbeispiel, ist jedoch in Winkelrichtung um 90 Grad gegenüber der gekrümmten Spurschiene **1** gemäß dem zweiten Ausführungsbeispiel verschoben. Die gekrümmte Spurschiene **1** der zweiten gekrümmten Führungsvorrichtung **22** hat eine konkave dritte Oberfläche **1c** und eine konvexe vierte Oberfläche **1d**. Wie in Fig. 10 gezeigt, haben die dritten und vierten Oberflächen **1c**, **1d** der Spurschiene **1** jeweilige Kugellaufnuten **111**, die darin entlang der Spurschiene **1** definiert sind. Die zweite Oberfläche **1b** hat parallele Kugellaufnuten **112**, die darin entlang einer Bogenform von vorbestimmter Krümmung definiert sind.

[0053] Der Lagerblock **10** der ersten gekrümmten Führungsvorrichtung **21** weist einen im Wesentlichen zylindrischen starren Körper auf und hat Innenseitenflächen **10c**, **10d**, die gekrümmte Oberflächen entlang der dritten und vierten Oberflächen **1c**, **1d** der Spurschiene **1** aufweisen. Die dritten und vierten Oberflächen **10c**, **10d** des Lagerblockes **10** haben Kugellaufnuten **221**, die darin in Ausrichtung mit den Kugellaufnuten **111** der gekrümmten Spurschiene **1** definiert sind. Der Lagerblock **10** hat auch parallele Kugellaufnuten **222**, die in einer unteren Innenseite **10a** davon in Ausrichtung mit den Kugellaufnuten **112** entlang einer Bogenform von vorbestimmter Krümmung definiert sind.

[0054] Das Zwischenglied **24** hat eine offene zylindrische Ausnehmung **241**, die in einer Seitenfläche **24c** davon definiert ist, und eine offene zylindrische Ausnehmung **242**, die in einer anderen Seitenfläche **24d** davon definiert ist. Die Lagerblöcke **10** sind drehbar jeweils in die zylindrischen Ausnehmungen **241**, **242** eingepasst. Eine Basis **23** ist fest an der ersten Oberfläche (Befestigungsfläche) **1a** der Spurschiene **1** befestigt und erstreckt sich nach unten. Die Teile von anderen Komponenten, wie beispielsweise die zweite gekrümmte Führungsvorrichtung **22**, sind identisch mit jenen des zweiten Ausführungsbeispiels. Gemäß den zweiten und dritten Ausführungsbeispielen sind die Lagerblöcke **10**, die in die Seiten des Zwischenblockes **24** eingepasst sind, dahingehend wirksam, dass sie die gesamte vertikale Höhe der dreidimensionalen Führungsvorrichtung verringern.

[Viertes Ausführungsbeispiel]

[0055] Fig. 11 zeigt eine dreidimensionale Führungsvorrichtung gemäß einem vierten Ausführungsbeispiel der vorliegenden Erfindung. Gemäß dem vierten Ausführungsbeispiel sind der Mittelteil des Lagerblockes **10** der ersten gekrümmten Führungsvorrichtung **21** und der Mittelteil des Lagerblockes **10** der zweiten gekrümmten Führungsvorrichtung **22** in einer Ebene angeordnet, um die zwei senkrechten Spurschienen **1** nahe zusammen zu einer Position gerade kurz vor einer physischen Gegenwirkung miteinander zu bringen.

[0056] Die Anordnung der ersten und zweiten gekrümmten Führungsvorrichtung **21**, **22** in dem in Fig. 11 gezeigten Ausführungsbeispiel ist identisch mit der Anordnung von jenen gemäß dem zweiten Ausführungsbeispiel, welches in den Fig. 5 bis Fig. 7 gezeigt ist. Ein Zwischenglied **24** weist zwei Blöcke **24A**, **24B** auf, jeweils in Form eines rechteckigen Parallelepipedes, die miteinander durch einen L-förmigen Verbinder **24C** verbunden sind. Das Zwischenglied **24** hat zylindrische Ausnehmungen **241**, **242**, die jeweils in einer Seitenfläche **24c** und einer Unterseite **24b** definiert sind, wobei die Lagerblöcke **10** in die zylindrischen Ausnehmungen **241**, **242** eingepasst sind. Das Zwischenglied **24** insgesamt hat ein niedrigeres Profil als das Zwischenglied gemäß dem zweiten Ausführungsbeispiel. Das Zwischenglied **24** ist nicht in einem Bereich vorhanden, wo die zwei Spurschienen **1** einander überkreuzen. Daher können zwei Spurschienen **1** nahe zusammen zu einer Position gerade kurz vor einer physischen Gegenwirkung miteinander gebracht werden.

[0057] Gemäß dem vierten Ausführungsbeispiel wird die gesamte vertikale Höhe der dreidimensionalen Führungsvorrichtung verringert, weil das Zwischenglied **24** so geformt ist, dass es die zwei Spurschienen **1** zusammen zu einer Position gerade kurz vor einer physischen Gegenwirkung miteinander bringt.

[0058] Bei den obigen Ausführungsbeispielen sind Kugeln als Wälzelemente beschrieben worden, jedoch können Rollen als Wälzelemente eingesetzt werden.

[0059] Gemäß der vorliegenden Erfindung, wie sie oben beschrieben wurde, weist das Zwischenglied einen starren Körper in Form eines Blockes auf, und die Lagerblöcke, jeweils in Form eines starren Körpers, der ersten und zweiten gekrümmten Führungsvorrichtung sind drehbar in die jeweiligen zwei Oberflächen des Zwischengliedes eingepasst, um dadurch eine Aufnahmefähigkeit für eine Verkippung zwischen den ersten und zweiten gekrümmten Führungsvorrichtungen vorzusehen. Da die Aufnahmefähigkeit für Verkippungen ausgeführt ist und das Gebäude durch gleitende Flächen getragen wird, die eine große Kontaktfläche haben, und die in den sich berührenden starren Körpern vorgesehen sind, kann daher die dreidimensionale Führungsvorrichtung schwere Lasten tragen und eine hervorragende Haltbarkeit aufweisen.

[0060] Gemäß der vorliegenden Erfindung sind weiterhin eine Vielzahl von dreidimensionalen Führungsvorrichtungen zwischen dem Erdboden und dem Gebäude angeordnet. Insofern als die zwei Lagerblöcke mit Bezug zu dem Zwischenglied drehbar sind, können irgendwelche Fehlausrichtungen (Zentrierungsfehler) und Niveaufehler leicht aufgenommen werden. Das Zwischenglied in Form eines einfachen Blockes mit niedrigem Profil gestattet, dass die dreidimensionale Führungsvorrichtung in vertikaler Höhe kleiner ist als sie es wäre, wenn eine Universalverbindung bzw. ein Kreuzgelenk als das Zwischenglied verwendet worden wäre.

Industrielle Anwendbarkeit

[0061] Die vorliegende Erfindung bezieht sich auf eine dreidimensionale Führungsvorrichtung und kann vorzugsweise bei einer Schwingungsisolationsvorrichtung zur Isolation von Gebäuden von Schwingungen verwendet werden.

Patentansprüche

1. Dreidimensionale Führungsvorrichtung mit einer Basis, mit einer ersten gekrümmten Führungsvorrichtung, die an der Basis befestigt ist und eine bogenförmige Spur besitzt, weiter mit einer zweiten gekrümmten Führungsvorrichtung, die über der ersten gekrümmten Führungsvorrichtung angeordnet ist und eine Bewegungsebene entlang einer bogenförmigen Spur hat, die die Bewegungsebene der ersten gekrümmten Führungsvorrichtung kreuzt, und mit einem Zwischenglied, welches zwischen der ersten gekrümmten Führungsvorrichtung und der zweiten gekrümmten Führungsvorrichtung positioniert ist und die erste gekrümmte Führungsvorrichtung und die zweite gekrümmte Führungsvorrichtung verbindet,
wobei jede der ersten und zweiten gekrümmten Führungsvorrichtungen Folgendes aufweist:
eine Spurschiene, die vertikal mit einer vorbestimmten Krümmung gekrümmtist und eine Vielzahl von Roll- bzw. Wälzelementlaufnuten besitzt, die in Außenflächen davon definiert sind;
einen Lagerblock, der einen im Wesentlichen zylindrischen starren Körper aufweist und in Innenflächen davon eine Vielzahl von Wälzelementlaufnuten in Ausrichtung mit den Wälzelementlaufnuten in der Spurschiene aufweist, und nicht belastete Wälzelementrolldurchlässe benachbart zu den Wälzelementlaufnuten;
ein Paar von Deckeln, die jeweils an den vorderen und hinteren Enden des Lagerblockes montiert sind und jeweilige Wälzelementrichtungsumlenkdurchlässe besitzen, die in jeweiligen Innenflächen davon definiert sind, wobei die Wälzelementrichtungsumlenkdurchlässe die Enden der Wälzelementlaufnuten und der nicht belasteten Wälzelementdurchlässe verbin-

den und einen endlosen Wälzelementumlaufpfad vorsehen; und
eine Vielzahl von Wälzelementen, die angeordnet sind, um in dem endlosen Wälzelementumlaufpfad zu zirkulieren, um Lasten zwischen den Wälzelementlaufnuten in der Spurschiene und den Wälzelementlaufnuten in dem Lagerblock zu tragen;
wobei das Zwischenglied einen starren Körper in Form eines Blockes aufweist und offene zylindrische Ausnehmungen besitzt, die jeweils in den zwei Oberflächen davon definiert sind, wobei die Lagerblöcke drehbar in die offenen zylindrischen Ausnehmungen eingepasst sind.

2. Dreidimensionale Führungsvorrichtung nach Anspruch 1, wobei die zylindrischen Ausnehmungen jeweils in oberen und unteren Oberflächen des Zwischengliedes definiert sind.

3. Dreidimensionale Führungsvorrichtung nach Anspruch 1, wobei das Zwischenglied die zylindrischen Ausnehmungen besitzt, die jeweils in den unteren und seitlichen Oberflächen davon definiert sind.

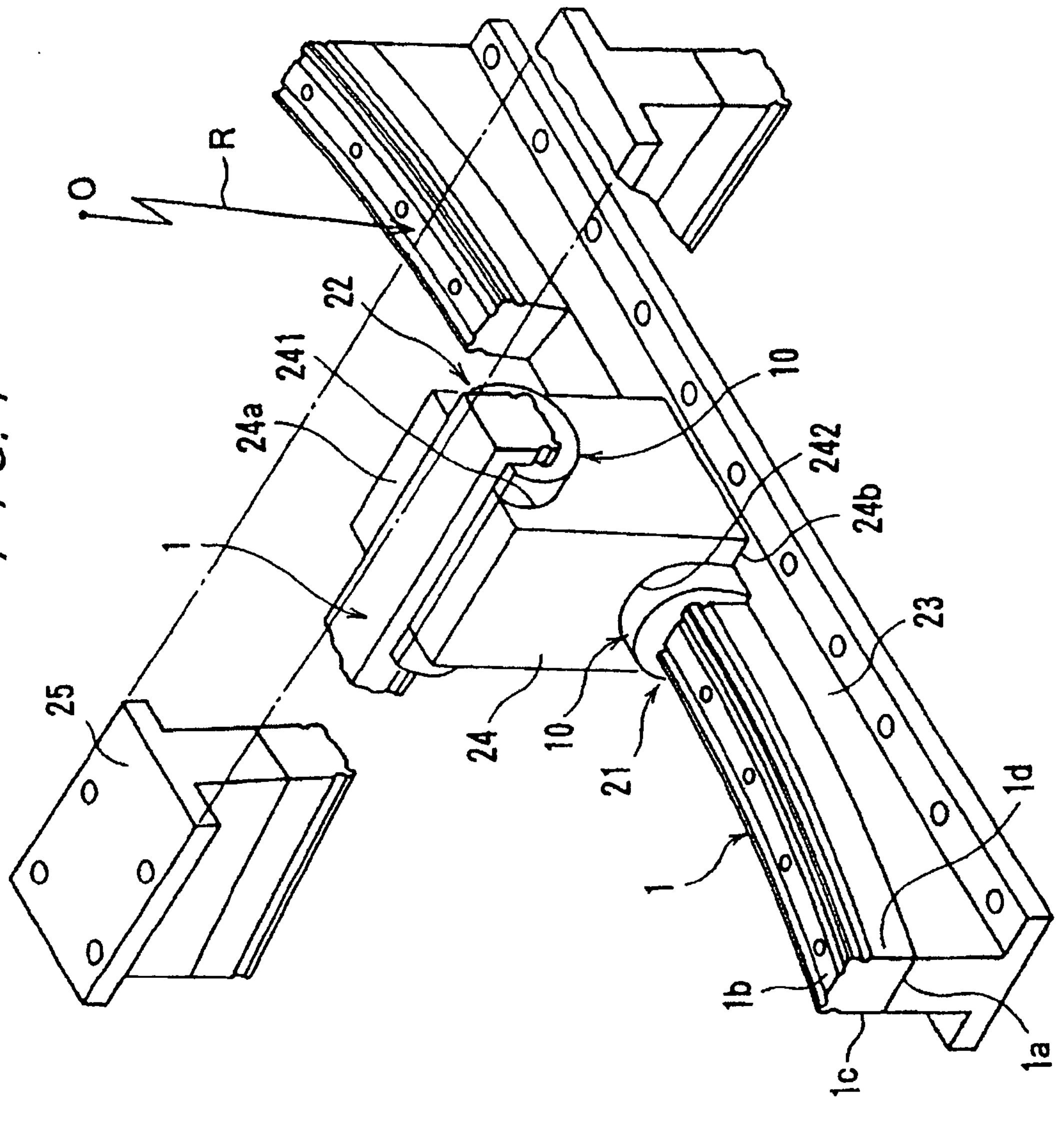
4. Dreidimensionale Führungsvorrichtung nach Anspruch 1, wobei das Zwischenglied die zylindrischen Ausnehmungen jeweils in beiden Seitenflächen davon definiert hat.

5. Dreidimensionale Führungsvorrichtung nach einem der Ansprüche 1 bis 4, wobei das Zwischenglied die zylindrischen Ausnehmungen besitzt, die in jeweiligen Positionen definiert sind, so dass der mittlere Teil von einem der Lagerblöcke und die mittlere Position des anderen Lagerblockes in einer Ebene verschoben sind, um die zwei senkrechten Spurschienen nahe aneinander zu bringen.

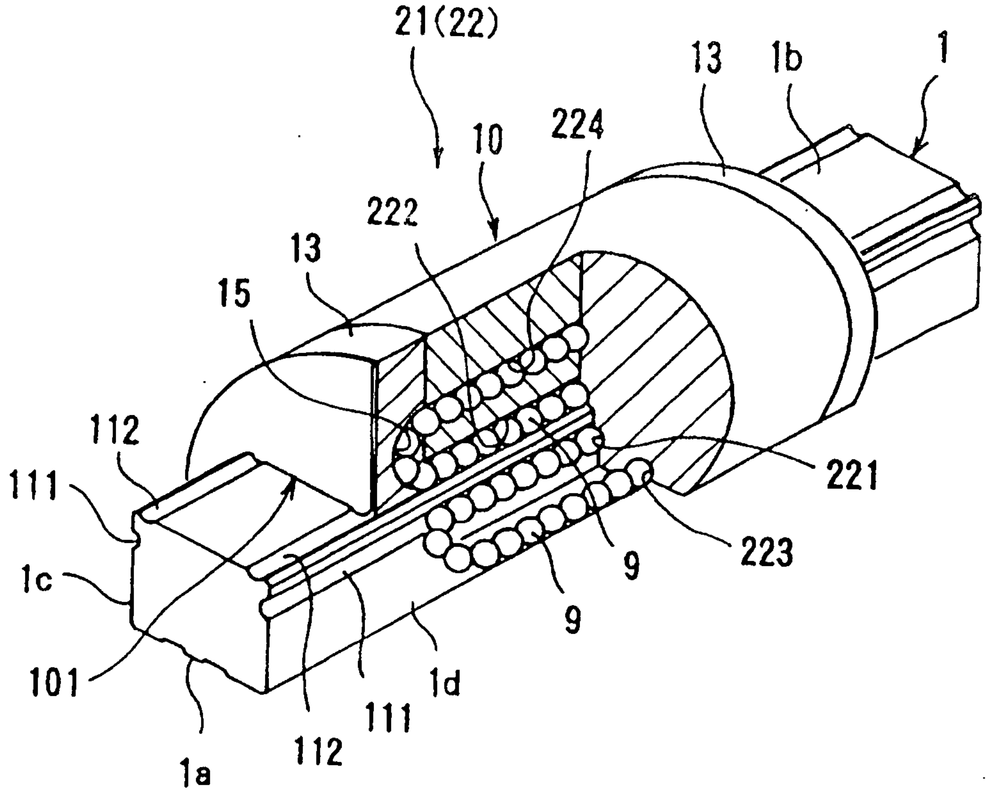
Es folgen 13 Blatt Zeichnungen

Anhängende Zeichnungen

F I G. 1



F I G. 2A


21(22)
10
224
13
1b
1
222
13
15
112
111
1c
101
1a
112
111
1d
9
9
221
223

F I G. 2B

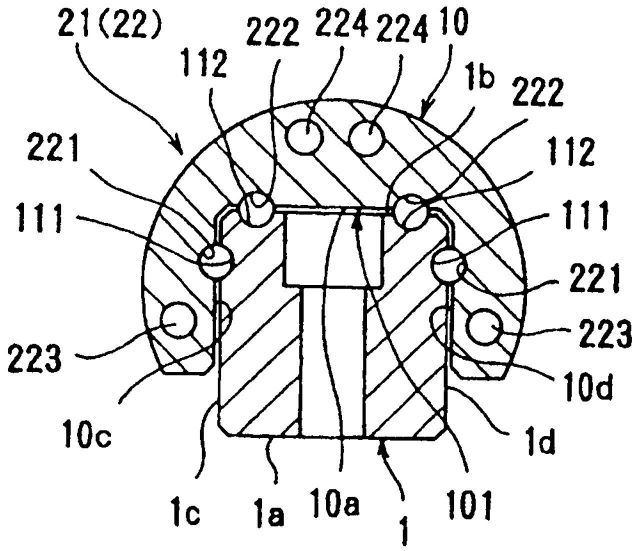

21(22)
222
224
224
10
1b
222
112
221
112
111
111
221
223
223
10d
10c
1d
1c
1a
10a
1
101

FIG. 3

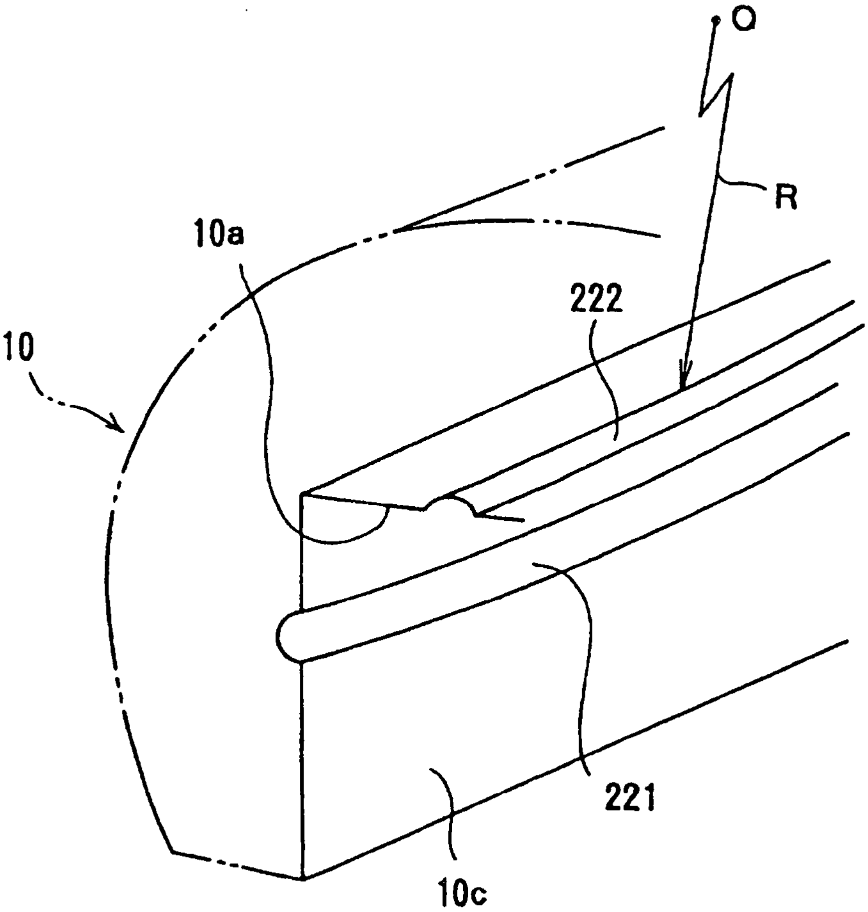
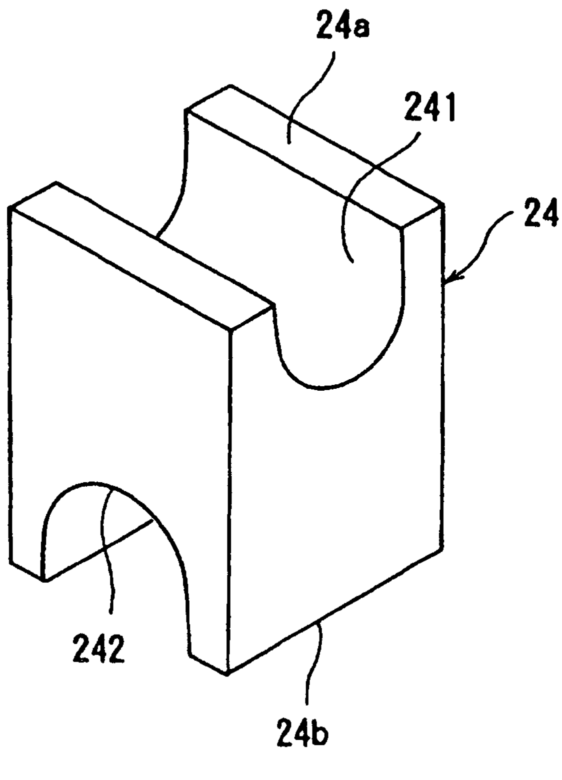
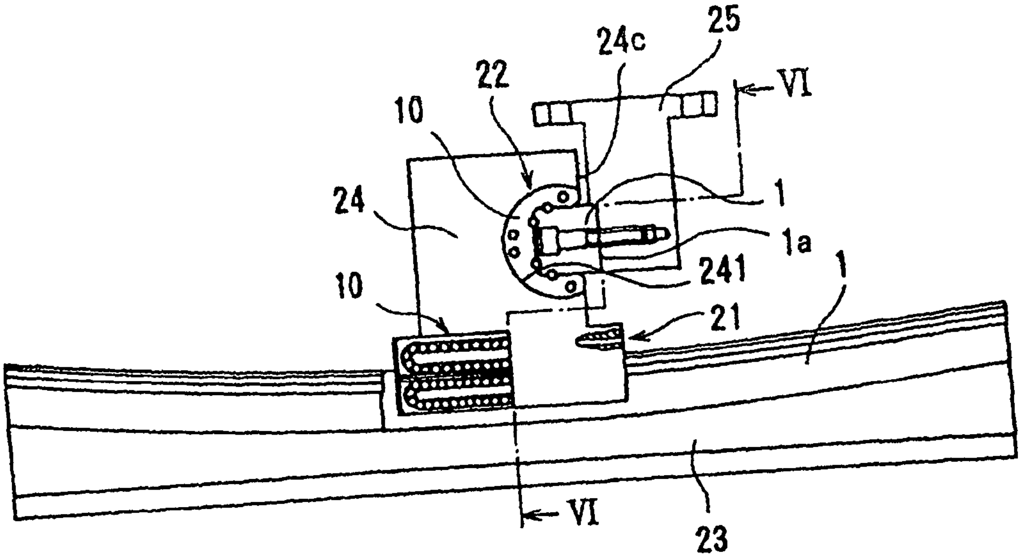


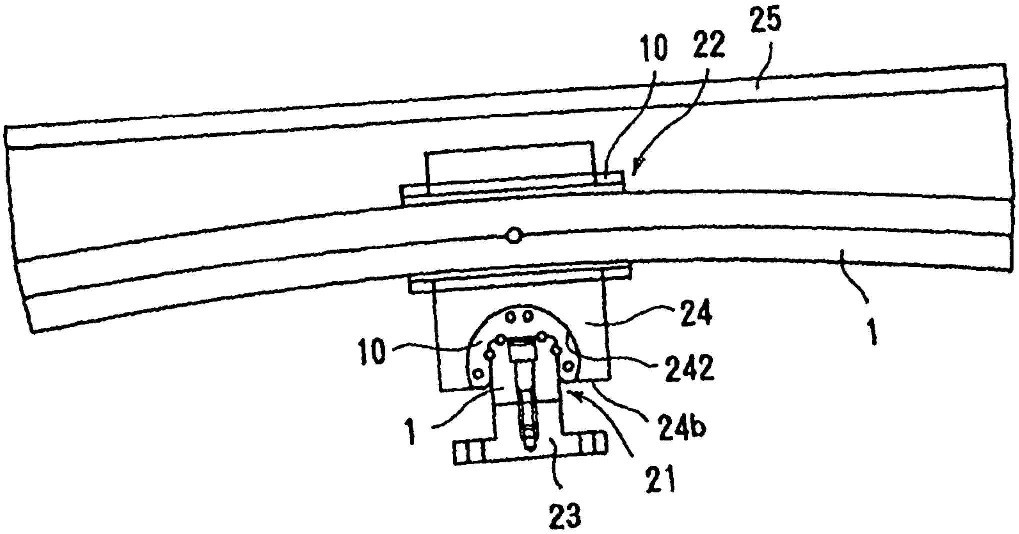
FIG. 4



F I G. 5


25
24c
VI
22
10
24
1
1a
241
1
10
21
VI
23

F I G. 6


25
10
22
24
1
10
242
1
24b
21
23

F I G. 7

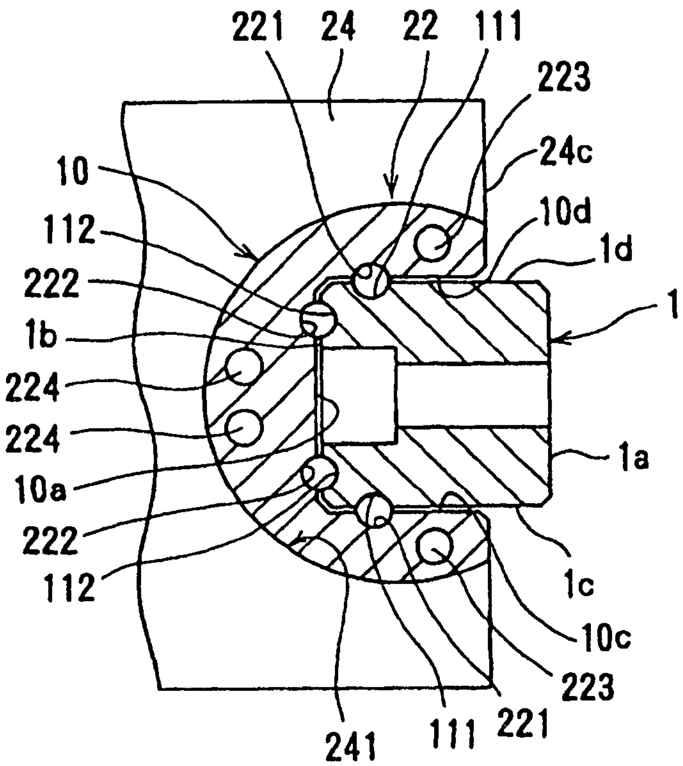

221
24
22
111
223
24c
10
10d
1d
112
222
1
1b
224
224
1a
10a
222
112
1c
10c
223
241
111
221

FIG. 8

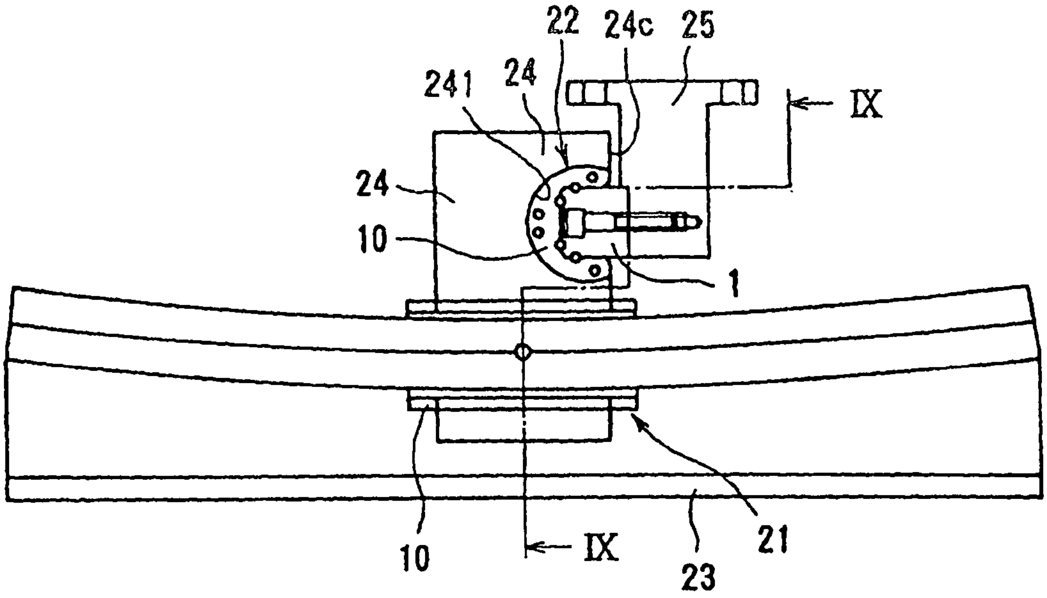
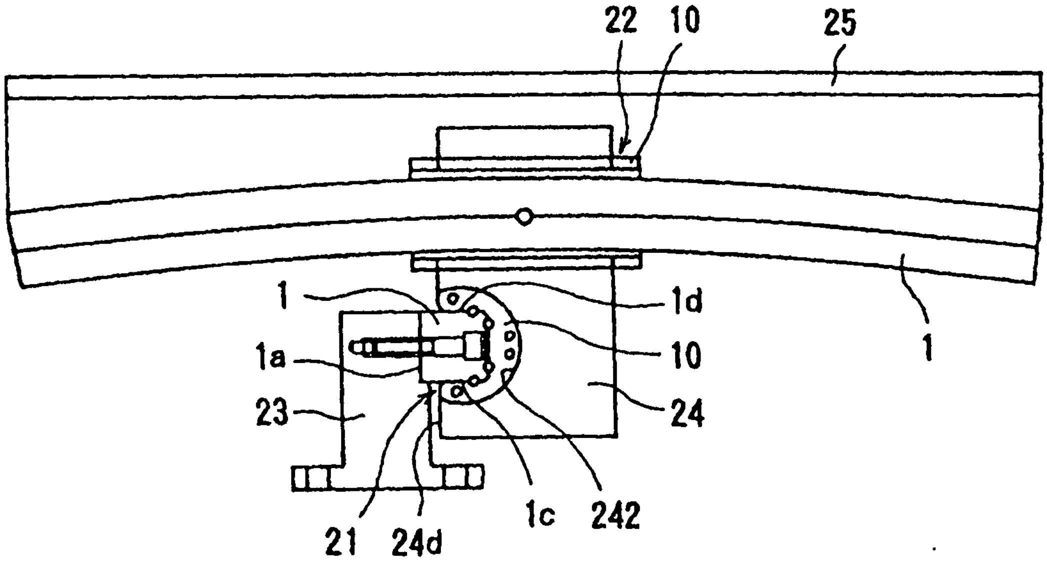
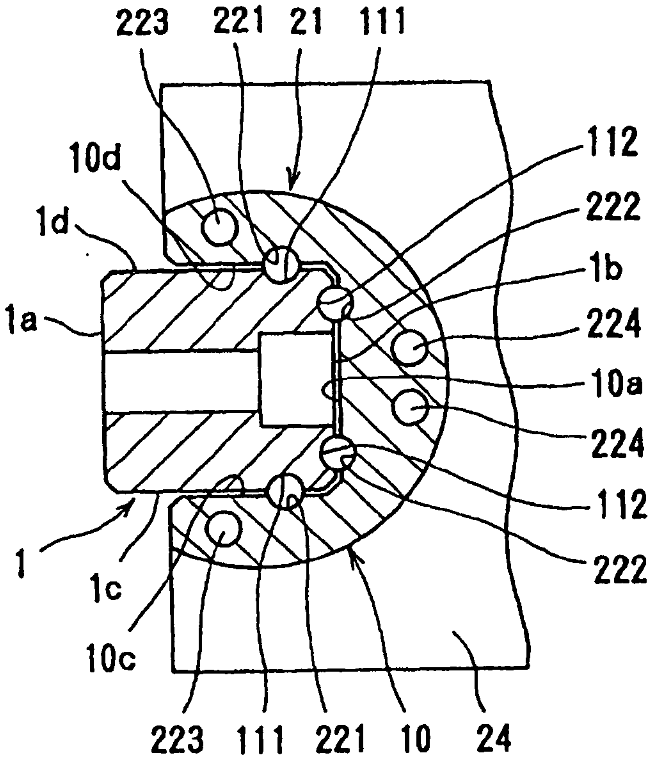

22
24c
25
241
24
IX
24
10
1
10
IX
21
23

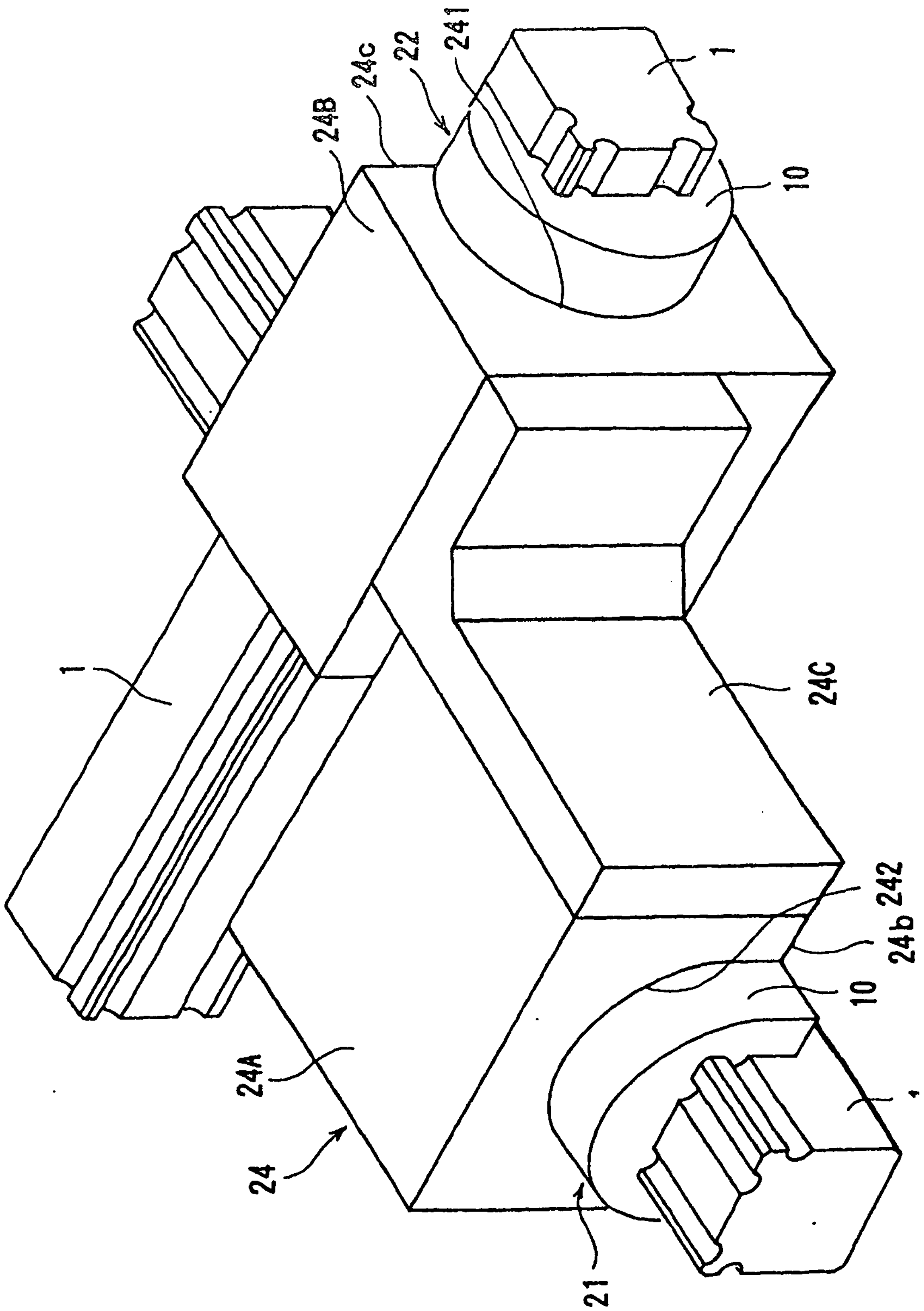
FIG. 9


22
10
25
1
1d
1a
10
23
24
1
21
24d
1c
242

F I G. 1 0


223
221
21
111
10d
1d
1a
1
1c
10c
223
111
221
10
24
112
222
1b
224
10a
224
112
222

F I G. 1 1



F I G. 1 2

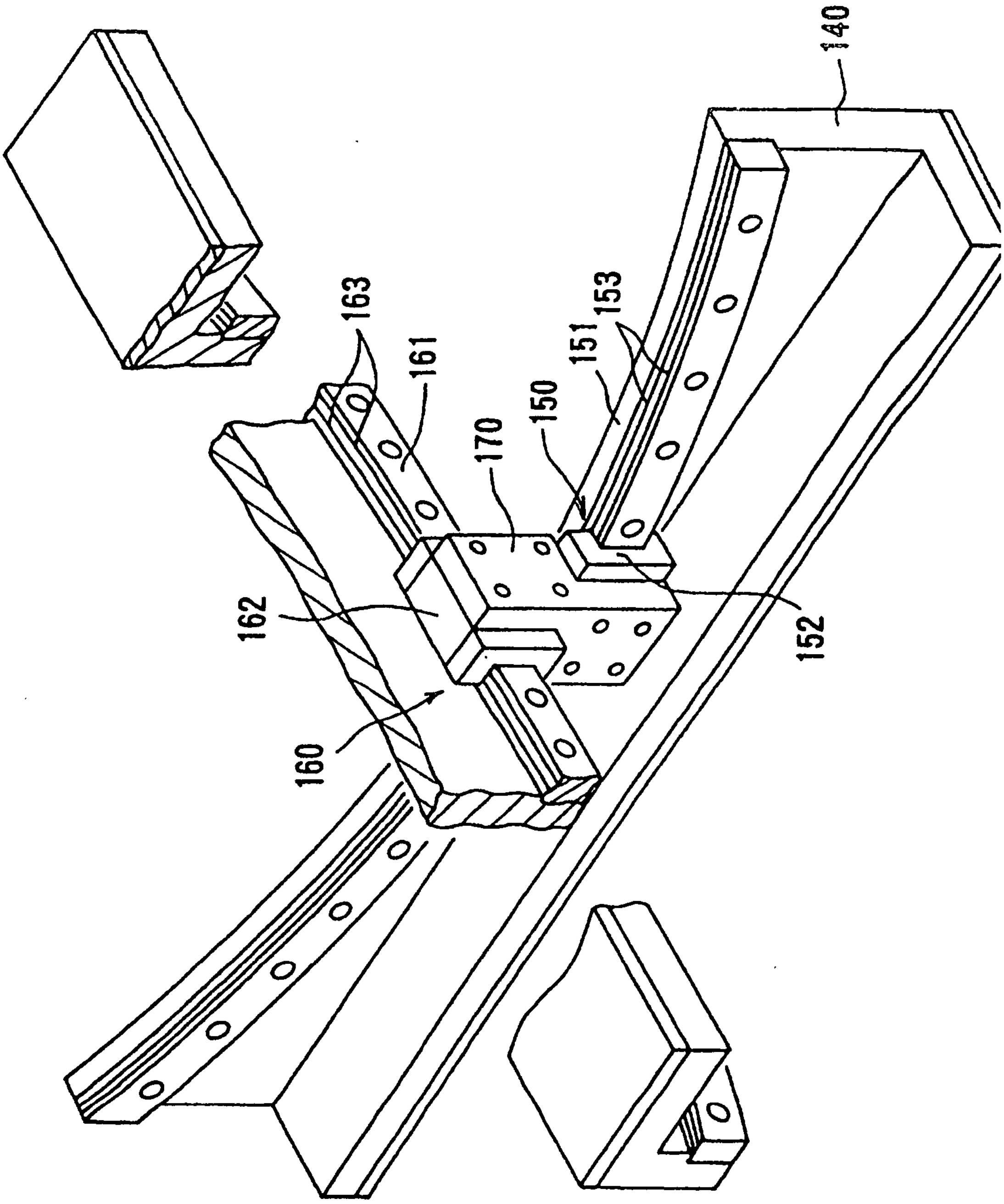
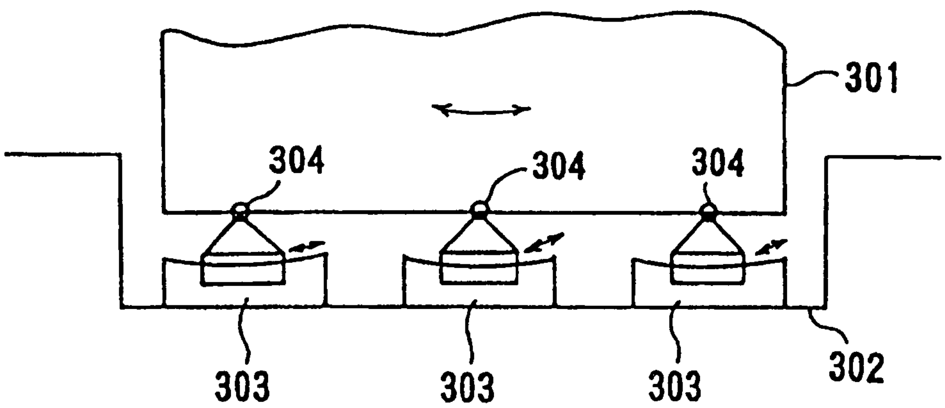


FIG. 13



F I G. 1 4

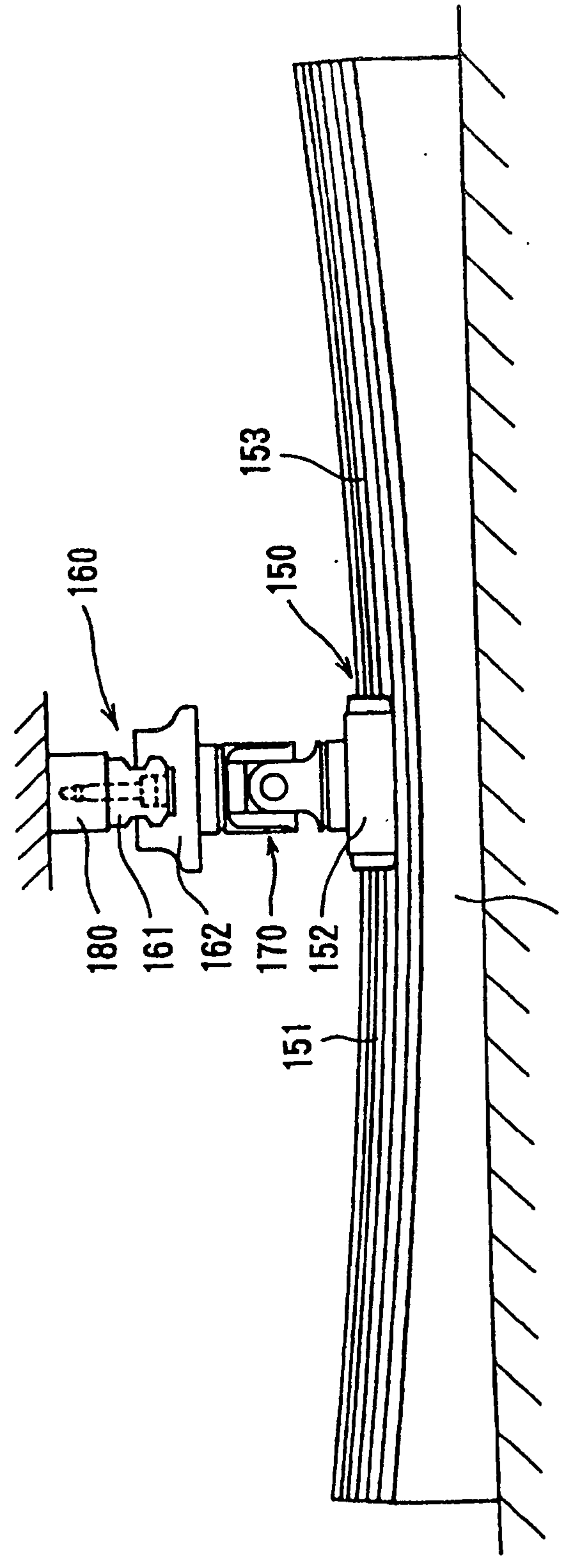


FIG. 15A

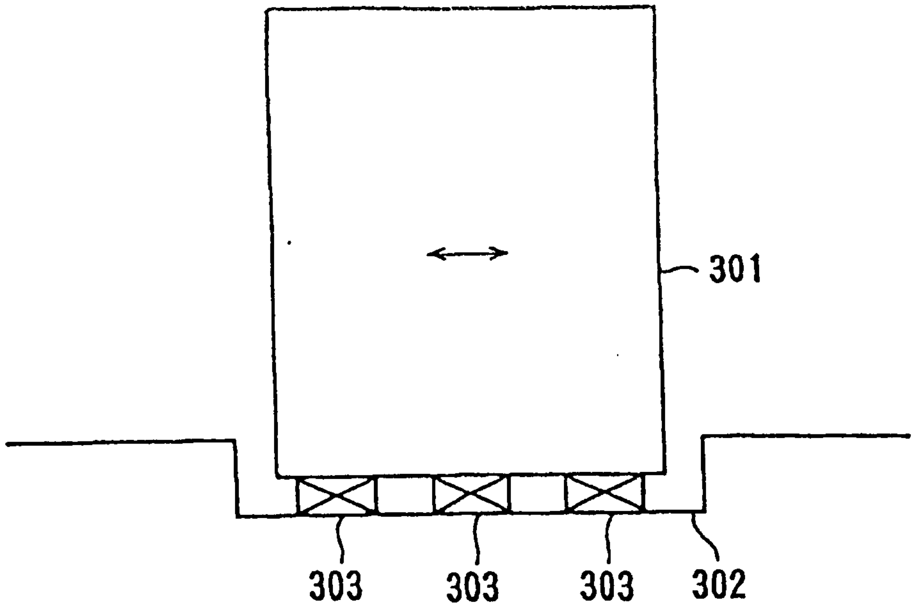
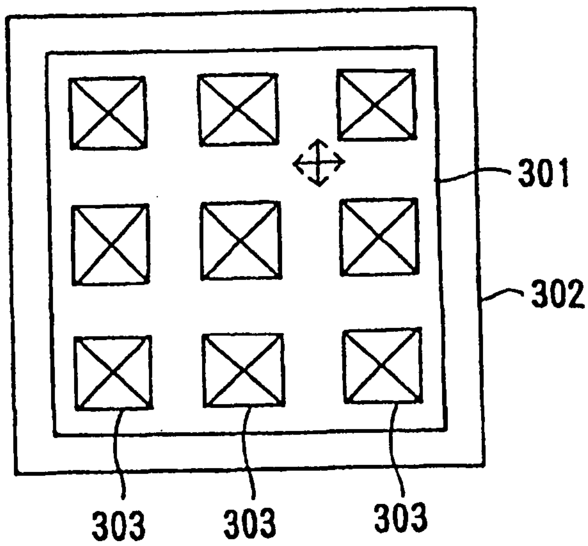


FIG. 15B



(19) Bundesrepublik Deutschland
Deutsches Patent- und Markenamt

(10) DE 698 24 914 T2 2004.11.04

(12) # Übersetzung der europäischen Patentschrift

(97) EP 0 875 684 B1
(21) Deutsches Aktenzeichen: 698 24 914.3
(96) Europäisches Aktenzeichen: 98 107 831.4
(96) Europäischer Anmeldetag: 29.04.1998
(97) Erstveröffentlichung durch das EPA: 04.11.1998
(97) Veröffentlichungstag der Patenterteilung beim EPA: 07.07.2004
(47) Veröffentlichungstag im Patentblatt: 04.11.2004

(51) Int Cl.[7]: F16C 29/06

(30) Unionspriorität:
11289597 30.04.1997 JP

(84) Benannte Vertragsstaaten:
DE, FR, GB, IT

(73) Patentinhaber:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Vossius & Partner, 81675 München

(72) Erfinder:
Michioka, Hidekazu, Shinagawa-ku, Tokyo 141-0031, JP; Takamatsu, Hiroshi, Shinagawa-ku, Tokyo 141-0031, JP; Honma, Mitsuaki, Shinagawa-ku, Tokyo 141-0031, JP

(54) Bezeichnung: **Apparat mit Endlos-Gleitführung**

Beschreibung

[0001] Die Erfindung betrifft eine endlose Gleitführungsvorrichtung, z. B. eine geradlinige Führungsvorrichtung, eine krummlinige Führungsvorrichtung, ein Drehlager o. ä., und insbesondere eine solche Art von endloser Gleitführungsvorrichtung, die aufweist: eine Spurschiene, einen entlang der Spurschiene beweglichen Gleittisch und Wälz- bzw. Rollkörper, die zwischen der Spurschiene und dem Gleittisch rollen, während sie eine Last tragen, wobei ein Leerlaufrollweg, ein Innenumfangsabschnitt eines Richtungsänderungswegs und/oder ein Rollkörperhalteabschnitt eines Lastrollwegs des Gleittisches durch Kunstharz-Rollkörperführungsteile gebildet ist, die durch Einsatzformen unter Verwendung eines Lauf- bzw. Lagerrings als Kern hergestellt sind.

[0002] Bei verschiedenen Arten endloser Gleitführungsvorrichtungen, die jeweils mit einem Lager versehen sind, ist die Linearbewegung oder Drehbewegung von Rollkörpern, z. B. Kugeln oder Rollen, zwischen einer Spurschiene und einem Gleittisch ermöglicht, indem die Rollbewegung der Rollkörper genutzt wird, um (1) das Herausfallen der Rollkörper zu verhindern, wenn der Gleittisch von der Spurschiene getrennt wird, (2) den Reibungswiderstand zu reduzieren, indem verhindert wird, daß die Rollkörper miteinander in Kontakt kommen, und (3) zu veranlassen, daß sich die Rollkörper gleichmäßig bewegen, indem sie in einer Linie an einer vorbestimmten Position gebildet werden, wobei in der Praxis eine Anzahl solcher Rollkörper zwischen der Spurschiene und dem Gleittisch durch Verwendung eines Korbs oder Käfigs aus metallischem Dünnblech oder Kunstharz eingebaut sind.

[0003] In einem den Korb nutzenden Verfahren ist es aber nötig, eine Endlosspur für die Rollkörper zu bilden, indem der Korb im Gleittisch so montiert wird, daß die Rollkörper in der Endlosspur eingebaut sind, wobei aber solche Probleme vorliegen, daß Fertigkeiten zum Montieren des Korbs erforderlich sind und es schwierig ist, die Montage zu automatisieren. Da ferner in einem Verfahren unter Verwendung des Käfigs der Käfig im Gleittisch montiert wird, während eine Anzahl von Rollkörpern drehbar im Käfig festgehalten werden, kommt es trotz der Tatsache, daß die Rollkörper leicht in den Gleittisch eingebaut werden können, zu einem weiteren Problem, daß es nötig wird, die Anzahl von Rollkörpern in jeweiligen Taschen des Käfigs vorab einzubauen, so daß ein hoher Arbeits- und Kostenaufwand erforderlich ist, um den Käfig mit einer Anzahl darin eingebauter Rollkörper herzustellen.

[0004] In der EP-A-743456, die alle Merkmale des Oberbegriffs von Anspruch 1 zeigt, sind diese Probleme gelöst, indem sie eine endlose Gleitführungsvorrichtung bereitstellt, in der ein Gleittisch mit einer Endlosspur für Rollkörper mit einem Lastrollweg, einem Leerlaufrollweg und einem Richtungsänderungsweg durch einen Lagerring gebildet ist, der mindestens folgendes hat: einen Lastrollweg, Kunstharz-Rollkörperführungsteile, die durch Einsatzformen unter Verwendung des Lagerrings als Kern hergestellt sind und jeweils einen Leerlaufrollweg, einen Innenumfangsabschnitt eines Richtungsänderungswegs und/oder einen Rollkörperhalteabschnitt eines Lastrollwegs haben, und ein Paar Kunstharzdeckel, die jeweils sowohl an einem vorderen als auch an einem hinteren Ende des Lagerrings mit den Rollkörperführungsteilen befestigt sind und jeweils einen Außenumfangsabschnitt auf ihrer Innenfläche haben, der einen Richtungsänderungsweg neben der o. g. Innenumfangsfläche bildet.

[0005] Da bei dieser endlosen Gleitführungsvorrichtung ein Teil oder der Großteil der Endlosspur des Gleittischs durch die Kunstharz-Rollkörperführungsteile gebildet ist, die durch Einsatzformen unter Verwendung eines Lagerrings als Kern hergestellt sind, hat die Vorrichtung die Vorteile, daß die Endlosspur genau gebildet sein kann, das Rollen der Rollkörper in der Endlosspur extrem gleichmäßig wird, das Gleiten des Gleittischs entlang der Spurschiene gleichmäßig wird, der Geräuschpegel minimiert sein kann und die Herstellung des Gleittischs mit den darin eingebauten Rollkörpern zur Automatisierung erleichtert ist.

[0006] Wird aber ein Gleittisch einer endlosen Gleitführungsvorrichtung durch dieses Verfahren hergestellt, liegt mitunter ein Fall vor, in dem Rollkörperführungsteile, hergestellt durch Einsatzformen unter Verwendung eines Lagerrings als Kern, insbesondere ein ihre Ecken abdeckender Abschnitt, zum Reißen neigen (im folgenden als "Eckenreißen" bezeichnet), was manchmal zur Produktion eines fehlerhaften Erzeugnisses oder zur Verkürzung der Lebensdauer des Produkts führt.

[0007] Daher wurde als Ergebnis von Untersuchungen zur Ursache einer solchen Eckenrißbildung im Rahmen der Erfindung festgestellt, daß sich bei Herstellung der Rollkörperführungsteile durch Einsatzformen unter Verwendung eines Lagerrings als Kern zwangsläufig eine Spannung an dem jede der Ecken des Lagerrings abdeckenden Abschnitt im Verlauf der Abkühlung des Harzmaterials konzentriert, so daß während dieses Abkühlungsverfahrens oder danach dieser Abschnitt reißanfällig ist.

[0008] Das heißt, ist bei Anordnung des Lagerrings als Kern in einer Form und Einspritzen eines geschmolzenen Harzmaterials in die Form, um so Rollkörperführungsteile durch Einsatzformen zu bilden, ein dicker Abschnitt des Harzmaterials nahe jeder der Ecken des Lagerrings vorhanden, wird dieses Reißproblem auffällig. Grund dafür ist, daß das geschmolzene Harzmaterial am Abschnitt, der jede der Ecken des Lagerrings abdeckt, zuerst erstarrt, und wird dann der dicke Abschnitt des Harzmaterials nahe jeder der Ecken abgekühlt, um zu erstarren, erstarrt das geschmolzene Harz von seiner Oberfläche in Kontakt mit der metallischen Oberfläche des Lagerrings oder der Form zu seinem Inneren unter Bildung einer sogenannten "Einfallstelle", so daß der anfangs erstarrte Abschnitt des Harzes, der jede der Ecken des Lagerrings bedeckt, gedehnt wird, wodurch eine übermäßige Spannung auf diesen Abschnitt ausgeübt wird, die zur Bildung eines Risses an der Ecke führt.

[0009] Als Wege zur Lösung eines solchen Problems betrachtet man mehrere Verfahren, in denen die Dicke des Harzes vergleichmäßigt wird, damit das gesamte Harz mit einer konstanten Geschwindigkeit abgekühlt werden kann, das Harz in der Form langsam abgekühlt wird, während man eine Verweilzeit einhält (d. h. Einhaltung einer langen Abkühlungszeit in der Form), oder die Abkühlungsgeschwindigkeit verlangsamt wird. Aber auch wenn die Dicke des Harzes vergleichmäßigt wird, kann das Eckenreißproblem nicht vollständig überwunden werden, wozu kommt, daß die Verlängerung der Abkühlungszeit in der Form oder die Verlangsamung der Abkühlungsgeschwindigkeit zu einem starken Produktivitätsrückgang führt, so daß man von keinem dieser Verfahren behaupten kann, es sei eine befriedigende Lösung für das Problem.

[0010] Als Ergebnis beharrlicher Untersuchungen zu Wegen zur Lösung dieses Problems wurde daher im Rahmen der Erfindung festgestellt, daß dieses Eckenreißproblem gelöst werden kann, indem die Rollkörperführungsteile mit einer spezifischen Formmasse geformt werden, insbesondere wenn die Rollkörperführungsteile durch Einsatzformen unter Verwendung eines Lagerrings als Kern geformt werden.

[0011] Somit besteht eine Aufgabe der Erfindung darin, eine endlose Gleitführungsvorrichtung bereitzustellen, die frei vom "Eckenreiß"-Problem ist und die eine lange Nutzungsdauer hat. Dieses Problem wird durch Anspruch 1 gelöst.

[0012] Die erfindungsgemäße Führungsvorrichtung hat verschiedene Vorteile wie folgt: Da die Vorrichtung mit den Kunstharz-Rollkörperführungsteilen versehen ist, die durch Einsatzformen unter Verwendung eines Lagerrings als Kern hergestellt sind und die einen Teil oder den Großteil der Endlosspur des Gleittischs bilden, ist die Endlosspur genau gebildet, damit die Rollkörper recht gleichmäßig rollen können, der Geräuschpegel reduziert ist, und die Verarbeitbarkeit bei der Herstellung des Gleittischs mit den darin eingebauten Rollkörpern verbessert ist, um zu ermöglichen, die Herstellung des Gleittischs zu automatisieren.

[0013] Das heißt, die erfindungsgemäße endlose Gleitführungsvorrichtung weist auf: eine Spurschiene, einen entlang der Spurschiene beweglichen Gleittisch und mehrere Rollkörper, die zwischen der Spurschiene und dem Gleittisch rollen, während sie eine Last tragen, wobei der Gleittisch aufweist: einen Lagerring mit einer Endlosspur mit einem Lastrollweg, einem Leerlaufrollweg und einem Richtungsänderungsweg und mindestens eine Lastrollfläche, Kunstharz-Rollkörperführungsteile, die durch Einsatzformen unter Verwendung des Lagerrings als Kern hergestellt sind und einen Leerlaufrollweg, einen Innenumfangsabschnitt eines Richtungsänderungswegs und/oder einen Rollkörperhalteabschnitt eines Lastrollwegs haben, und ein Paar Kunstharzdeckel, die am vorderen bzw. hinteren Ende des Lagerrings befestigt sind und jeweils auf ihrer Innenfläche einen Außenumfangsabschnitt zum Bilden eines Richtungsänderungswegs neben dem o. g. Innenumfangsabschnitt haben, wobei die Rollkörperführungsteile durch Verwendung eines Materials geformt sind, das den Relationsausdruck $(a \times b) \div c \geq 700$ MPa erfüllt.

[0014] In der Erfindung muß das Material zum Formen der Rollkörperführungsteile den Relationsausdruck $(a \times b) \div c \geq 700$ MPa oder vorzugsweise $(a \times b) \div c \geq 800$ MPa im Hinblick auf die Zugfestigkeit a (MPa), die Verlängerung bei Zug b (%) und das Formschrumpfmaß c (%) erfüllen, was man durch Verwendung eines Prüfkörpers von 120 mm × 120 mm × 2 mm erhält, der unter den Standardformbedingungen geformt wird (Spritzgießdruck: 500 kp/cm^2, Zylindertemperatur: 240°C, Formtemperatur: 70°C, Einspritzgeschwindigkeit: 3,5 m/min, Zyklus: Verweilen 25 s und Abkühlen 10 s sowie Anguß 4 W 2t). Liegt der Wert $(a \times b) \div c$ unter 700 MPa, wird bei Herstellung der Rollkörperführungsteile durch Einsatzformen unter Verwendung des Lagerrings als Kern oder nach deren Herstellung leicht ein Eckenriß erzeugt, so daß es unmöglich ist, die Nutzungsdauer des Erzeugnisses zu verlängern.

[0015] Als Formmassen, die die o. g. Anforderungen erfüllen, lassen sich grundsätzlich verschiedene Arten thermoplastischer Harzzusammensetzungen aufzählen, die aus thermoplastischen Harzen, z. B. Polyolefin, ABS, Nylon, Polybutylenterephthalat, Polyacetal, denaturiertes Polyphenylenoxid, Polyphenylensulfid u. ä., in Mischung in verschiedenen Verhältnisses mit vielfältigen Arten von Mineralfasern (als Füllmittel), z. B. Glasfaser, Mineralwollefasern, Kohlenstoffasern, Kaliumtitanatwhisker u. ä., bestehen. Ferner können zu diesen Harzzusammensetzungen Zusatzstoffe zugegeben sein, z. B. Färbemittel wie Pigmente, Wärmestabilisatoren, Flammenhemmstoffe, Antistatikmittel u. ä.

[0016] Da die Rollkörperführungsteile eine vergleichsweise komplizierte Form haben und vergleichsweise harten Bedingungen ausgesetzt sind und unter Berücksichtigung der Formbarkeit, Wärmefestigkeit, Gleitfähigkeit und des Elastizitätsmoduls der Formmassen, ist bevorzugt, von diesen thermoplastischen Harzzusammensetzungen Nylon, Polybutylenterephthalat und Polypropylen als thermoplastische Harze zu verwenden und Kaliumtitanatwhisker, Kohlenstoffaser und Glasfaser als Füllmittel zu nutzen, und besonders unter dem Gesichtspunkt der Formbarkeit ist die Verwendung solcher Materialien mit einem Schmelzindex über 15, vorzugsweise über 25, stärker bevorzugt. Ferner ist die am stärksten erwünschte der thermoplastischen Harzzusammensetzungen eine Zusammensetzung mit einem Schmelzindex von 15 bis 35, die man durch Mischen von 2 bis 5 Gew.-% Kaliumtitanatwhiskern in Polybutylenterephthalat erhält. Durch Einsatz dieser thermoplastischen Harzzusammensetzung als Formmasse für die Rollkörperführungsteile ist es nicht nur möglich, die Bildung von Rissen an jeder der Ecken der so hergestellten Rollkörperführungsteile des Gleittischs der endlosen Gleitführungsvorrichtung zu verhindern, sondern auch die Nutzungsdauer des Erzeugnisses stark zu verbessern.

[0017] Zudem verfügt in der Erfindung jedes der Rollkörperführungsteile, die über einem Lagerring unter Verwendung einer Formmasse in einem Stück gebildet sind, über einen Leerlaufrollweg, eine Innenumfangsfläche eines Richtungsänderungswegs und/oder einen Rollkörperhalteabschnitt eines Lastrollwegs, wodurch die gesamte Endlosspur für die Rollkörper genau gebildet sein kann.

[0018] Eine erfindungsgemäße endlose Gleitführungsvorrichtung kann sein: eine geradlinige Gleitführungsvorrichtung mit einem Gleittisch, der lineare Hin- und Herbewegungen auf einer Spurschiene vollführen kann, während er eine Last trägt, eine endlose krummlinige Führungsvorrichtung mit einem Gleittisch, der krummlinige Hin- und Herbewegungen auf einer krummlinigen Spurschiene mit einem vorbestimmten Krümmungsradius vollführen kann, und ein Kipplager mit einem block- oder kreisförmigen Gleittisch, der entlang einer kreisförmigen Spurschiene kippen kann, und als Rollkörper, die zwischen der Spurschiene und dem Gleittisch rollen, können Kugeln oder Walzen verwendet werden.

[0019] Da wie zuvor beschrieben in einer erfindungsgemäßen endlosen Gleitführungsvorrichtung die Rollkörperführungsteile, die durch Einsatzformen unter Verwendung eines Lagerrings gebildet sind, aus einer Formmasse hergestellt sind, die den Relationsausdruck $(a \times b) \div c \geq 700$ MPa erfüllt, ist ein Teil oder der Großteil der Endlosspur des Gleittischs genau gebildet, so daß das Rollen der Rollkörper recht gleichmäßig wird, der Geräuschpegel gesenkt ist und die Verarbeitungsfähigkeit bei Herstellung des Gleittischs mit den darin eingebauten Rollkörpern verbessert ist, damit die Herstellung automatisiert sein kann. Ferner läßt sich das Problem von "Eckenrissen" an den Rollkörperführungsteilen beseitigen, während die zuvor beschriebenen Vorteile unverändert gewahrt bleiben, so daß die Anzahl fehlerhafter Produkte minimiert und die Nutzungsdauer des Produkts stark verbessert sein kann.

[0020] Im folgenden wird die beste Durchführungsweise der Erfindung anhand von bevorzugten Ausführungsformen der Erfindung beschrieben, die in den beigefügten Zeichnungen gezeigt sind. Es zeigen:

[0021] **Fig.** 1 eine (teilweise im Schnitt gezeigte) Vorderansicht einer endlosen geradlinigen Gleitführungvorrichtung gemäß einer Ausführungsform der Erfindung;

[0022] **Fig.** 2 eine (teilweise im Schnitt gezeigte) Seitenansicht der geradlinigen Führungsvorrichtung von **Fig.** 1;

[0023] **Fig.** 3 eine Perspektivansicht eines Lagerrings, von Rollkörperführungsteilen und eines von Deckeln, die zusammen einen Gleittisch der endlosen geradlinigen Gleitführungsvorrichtung von **Fig.** 1 bilden;

[0024] **Fig.** 4 eine Schnittansicht eines Lagerrings von **Fig.** 2;

[0025] **Fig.** 5 eine Schnittansicht des Lagerrings von **Fig.** 4, insbesondere wenn er in einer Form angeordnet ist; und

[0026] **Fig.** 6 eine Schnittansicht von Kugelhalteteilen, die im Lagerring durch die Form von **Fig.** 5 vorgesehen sind.

Ausführungsform 1

[0027] In **Fig.** 1 und 2 ist eine endlose geradlinige Gleitführungsvorrichtung gemäß einer ersten Ausführungsform der Erfindung gezeigt. Diese geradlinige Führungsvorrichtung verfügt grundsätzlich über eine Spurschiene **1**, einen entlang der Spurschiene **1** beweglichen Gleittisch **2** und Kugeln **3a**, die zwischen der Spurschiene **1** und dem Gleittisch **2** rollen, während sie eine Last tragen.

[0028] Die Spurschiene **1** ist mit einer kreisbogenförmigen Kugelrollrille **1a** versehen, in der eine Kugel **3a** zwischen der Spurschiene **1** und dem Gleittisch **2** rollt, während sie eine Last trägt. Ferner verfügt der Gleittisch **2** über einen Lagerring **4** mit einer kreisbogenförmigen Lastkugelrille (Lastrollfläche) **4a**, die gegenüber der Kugelrollrille **1a** der Spurschiene **1** liegt und in der die Lastkugel **3a** rollt, Kunstharz-Kugelführungsteile (Rollkörperführungsteile) **5**, die durch Einsatzformen gebildet sind, wobei der Lagerring **4** als Kern dient, und ein Paar Kunstharzdeckel **6**, die am vorderen bzw. hinteren Ende des Lagerrings **4** befestigt sind.

[0029] Ferner verfügt jedes der Kugelführungsteile **5** über ein Kugelaustrittsloch (Leerlaufrollweg) **5a**, das entlang der Innenumfangswand eines Durchgangslochs **4b** für eine Leerlaufkugel **3b** gebildet ist, die im Lagerring **4** beim Formen vorgesehen ist, einen im wesentlichen halbkreisförmigen Innenumfangsabschnitt **5b**, der einen Richtungsänderungsweg zum Ändern der Rollrichtung der Leerlaufkugel **3b** von einem Lastbereich zu einem Leerlaufbereich oder umgekehrt bildet, und Kugelhalteabschnitte **5c**, die auf beiden Seiten der Lastkugelrille **4a** des Lagerrings **4** gebildet und geeignet sind, die in der Lastkugelrille **4a** rollende Lastkugel **3a** am Hergleiten zu hindern, wenn die Spurschiene **1** aus dem Gleittisch **2** gezogen wird. Ferner hat jeder der Deckel **6** auf der Seite seiner Innenfläche einen im wesentlichen halbkreisförmigen Außenumfangsabschnitt **6a** zum Bilden eines Richtungsänderungswegs für die Leerlaufkugel **3b** zusammen mit dem Innenumfangsabschnitt **5b** des Kugelführungsteils **5**, was eine Endlosspur für die Kugeln **3** durch die durch das Kugelaustrittsloch **5a** gebildeten Leerlaufrollwege, die durch die Innenumfangsabschnitte **5b** der Kugelführungsteile **5** und die Außenumfangsabschnitte **6a** der Deckel **6** gebildeten Richtungsänderungswege und die durch die Kugelhalteabschnitte **5c** der Kugelführungsteile **5** gebildeten Lastrollwege bildet.

[0030] In dieser Ausführungsform 1 erhält man jedes der Kugelführungsteile **5** durch Formen einer thermoplastischen Harzzusammensetzung, die aus Polybutylenterephthalat (PBT) besteht, das mit 3,5 Gew.-% Kaliumtitanatwhiskern gemischt ist (Produktbezeichnung TISMO von Otsuka Chemical Co., Ltd.) und die in Tabelle 1 in der folgenden Ausführungsform angegebenen physikalischen Eigenschaften hat.

[0031] Zunächst wurde gemäß **Fig.** 4 ein Lagerring **4** mit vier Reihen Lastkugelrillen **4a** und zwei Reihen Durchgangslöchern **4b** für eine Leerlaufkugel **3b** aus einem Stahlmaterial hergestellt. Als nächstes wurde gemäß **Fig.** 5 der Lagerring **4** durch eine Abstützung **8** in einem durch ein Paar Formteile **7a** und **7b** gebildeten Hohlraum abgestützt, vier stabförmige Teile **9** zum Bilden von Kugelaustrittslöchern **5a** wurden jeweils an vorbestimmten Positionen angeordnet, wodurch Spalte **10a**, **10b**, **10c** und **10d** gebildet wurden, und eine Schmelze der o. g. thermoplastischen Harzzusammensetzung wurde unter vorbestimmten Bedingungen eingespritzt, so daß gemäß **Fig.** 6 die Kunstharz-Kugelführungsteile **5** in einem Stück mit den vorbestimmten Abschnitten des Lagerrings **4** hergestellt wurden.

[0032] Das Spritzgießen der Kugelführungsteile **5** erfolgte mit Hilfe einer Inline-Schneckenspritzgießmaschine unter folgenden Bedingungen: Temperatur der Harzschmelze 240°C, Einspritzdruck 400 bis 700 kp/cm^2, Formtemperatur 40 bis 80°C und Einspritzgeschwindigkeit 2,5 bis 6,0 m/min.

[0033] Ferner wurde eine Wärmeschockprüfung an den in der Ausführungsform 1 gebildeten Kugelführungsteilen **5** mit Hilfe einer von Satake Chemical Machine Industry Co., Ltd. hergestellten Wärmeschock-Prüfmaschine durchgeführt, in der die Probe niedrigen/hohen Temperaturen von –20°C bis +60°C eine Stunde ausgesetzt wurde, wozu eine 10-minütige Temperaturanstiegszeit und eine 10-minütige Temperaturabfallzeit gehörten. Zusätzlich erfolgte ein Durchwärmversuch bei hoher Temperatur an der Probe unter Verwendung einer mit Heißluftumlauf und konstanter Temperatur arbeitenden Trocknungsmaschine von Satake Chemical Machine Industry Co., Ltd. bei einer gesteuerten Temperatur von 100 ± 2°C. Die Ergebnisse dieser Versuche wurden nach den folgenden vier Kriterien gemäß Tabelle 1 bewertet:

⊙: Keine Eckenrisse und andere Haarrisse beobachtet.
O: Kein Eckenriß und kein Haarriß beobachtet, aber kleine Größenänderung festgestellt.
Δ: Weiße Flecken auf der Oberfläche der Probe beobachtet, aber kein Bruch oder Riß festgestellt.

X: Fehler wie Eckenrisse und Haarrisse beobachtet.

Ausführungsform 2

[0034] Eine thermoplastische Harzzusammensetzung, die mit 3,0 Gew.-% Kaliumtitanatwhiskern gemischt war und die physikalischen Eigenschaften gemäß Tabelle 1 hatte, wurde geformt, um Kugelführungsteile eines Gleittischs wie in der Ausführungsform 1 bereitzustellen, und das geformte Erzeugnis wurde bewertet, indem es einer Wärmeschockprüfung und einem Dauerwärmversuch bei hoher Temperatur unterzogen wurde, wobei die Ergebnisse in Tabelle 1 dargestellt sind.

Tabelle 1

		Ausführungsformen	
		1	2
Physikalische Eigenschaften der Harzzusammensetzung	Zugfestigkeit (MPa)	63	60
	Verlängerung bei Zug b (%)	49	16
	Formschrumpfmaß c (%)	1,5	1,3
	(a x b) ÷ c	2058	738
	Schmelzindex	18	30
Bewertung der Wärmeschockprüfung		⊙	O
Durchwärmversuch bei hoher Temperatur		⊙	O

[0035] Anhand der Ergebnisse von Tabelle 1 wurde festgestellt, daß bei Herstellung der Kugelführungsteile durch Verwendung einer Harzzusammensetzung mit einem Wert des Relationsausdrucks (a × b) ÷ c über 700 MPa, der auf der Grundlage der Zugfestigkeit a, der Verlängerung bei Zug b und des Formschrumpfmaßes c erhalten wurde, ein Produkt erhalten werden konnte, das praktisch keine Problem im Hinblick auf seine Leistung und Nutzungsdauer im Zusammenhang mit der Bildung von Eckenrissen und anderen Haarrissen hatte.

Patentansprüche

1. Endlose Gleitführungsvorrichtung mit einer Spurschiene (**1**), einem entlang der Spurschiene beweglichen Gleittisch (**2**) und mehreren Rollkörpern (**3a**), die zwischen der Spurschiene und dem Gleittisch rollen, während sie eine Last tragen, wobei der Gleittisch mit einer Endlosspur versehen ist, die aufweist: einen Lastrollweg (**4a**), einen Leerlaufrollweg (**5a**) und einen Richtungsänderungsweg (**5b**), einen Lagerring (**4**) mit mindestens einem Lastrollweg, Kunstharz-Rollkörperführungsteile (**5**), die durch Einsatzformen unter Verwendung des Lagerrings (**4**) als Kern gebildet sind und jeweils einen Leerlaufrollweg (**5a**), einen Innenumfangsabschnitt eines Richtungsänderungswegs (**5b**) und/oder einen Rollkörperhalteabschnitt (**5c**) eines Lastrollwegs haben, und ein Paar Kunstharzdeckel (**6**), die sowohl am vorderen als auch am hinteren Ende des Lagerrings (**4**) befestigt sind und jeweils einen Außenumfangsabschnitt auf einer Innenfläche von ihnen haben, um den Richtungsänderungsweg neben dem Innenumfangsabschnitt jedes der Rollkörperführungsteile (**5**) zu bilden, **dadurch gekennzeichnet**, daß die Rollkörperführungsteile (**5**) durch Verwendung eines Materials geformt sind, das den Relationsausdruck (a × b) ÷ c ≥ 700 MPa im Hinblick auf die Zugfestigkeit a (MPa), die Verlängerung bei Zug b (%) und das Formschrumpfmaß c (%) erfüllt.

2. Endlose Gleitführungsvorrichtung nach Anspruch 1, wobei jedes der Rollkörperführungsteile (**5**) den Leerlaufrollweg (**5a**), den Innenumfangsabschnitt des Richtungsänderungswegs (**5b**) und den Rollkörperhalteabschnitt (**5c**) des Lastrollwegs aufweist.

3. Endlose Gleitführungsvorrichtung nach Anspruch 1 oder 2, wobei das Material zum Formen der Rallkörperführungsteile (**5**) eine thermoplastische Harzzusammensetzung ist, die einen Schmelzindex über 15 hat und aus einer oder mehreren Arten thermoplastischer Harze besteht, die aus Polybutylenterephthalat, Polyacrylnitril, Polybutadienstyrol und Polycarbonat unter Zugabe eines anorganischen Faserfüllmaterials ausgewählt sind.

4. Endlose Gleitführungsvorrichtung nach Anspruch 3, wobei das Material zum Bilden der Rollkörperführungsteile (**5**) aus einer thermoplastischen Harzzusammensetzung mit einem Schmelzindex von 15 bis 35 besteht, die durch Zugabe von 2 bis 5 Gew.-% Kaliumtitanatwhiskern zu Polybutylenterephthalat erhalten wird.

Es folgen 6 Blatt Zeichnungen

Anhängende Zeichnungen

F I G. 1

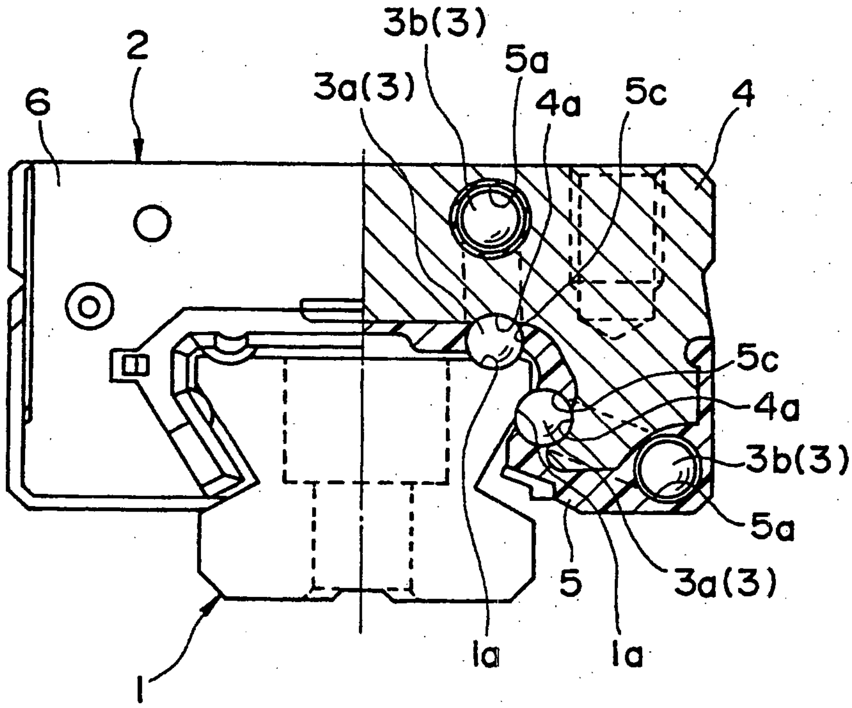


FIG. 2

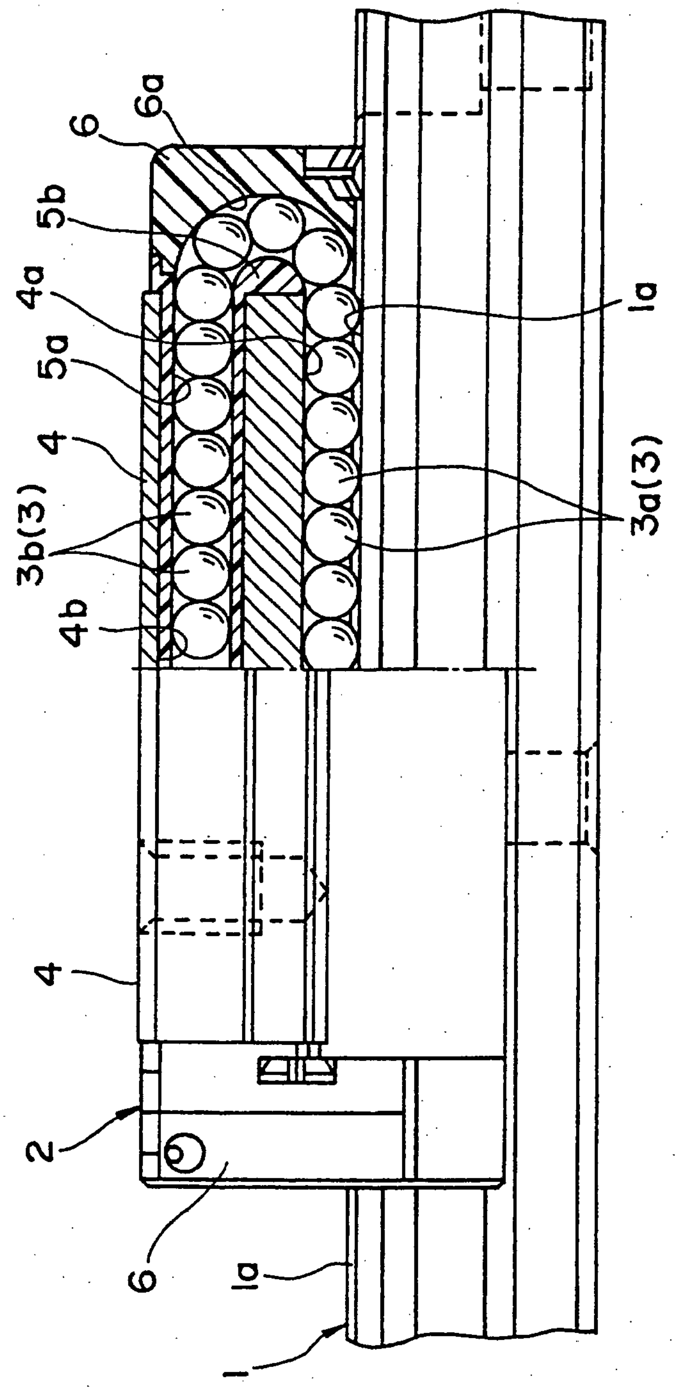


FIG. 3

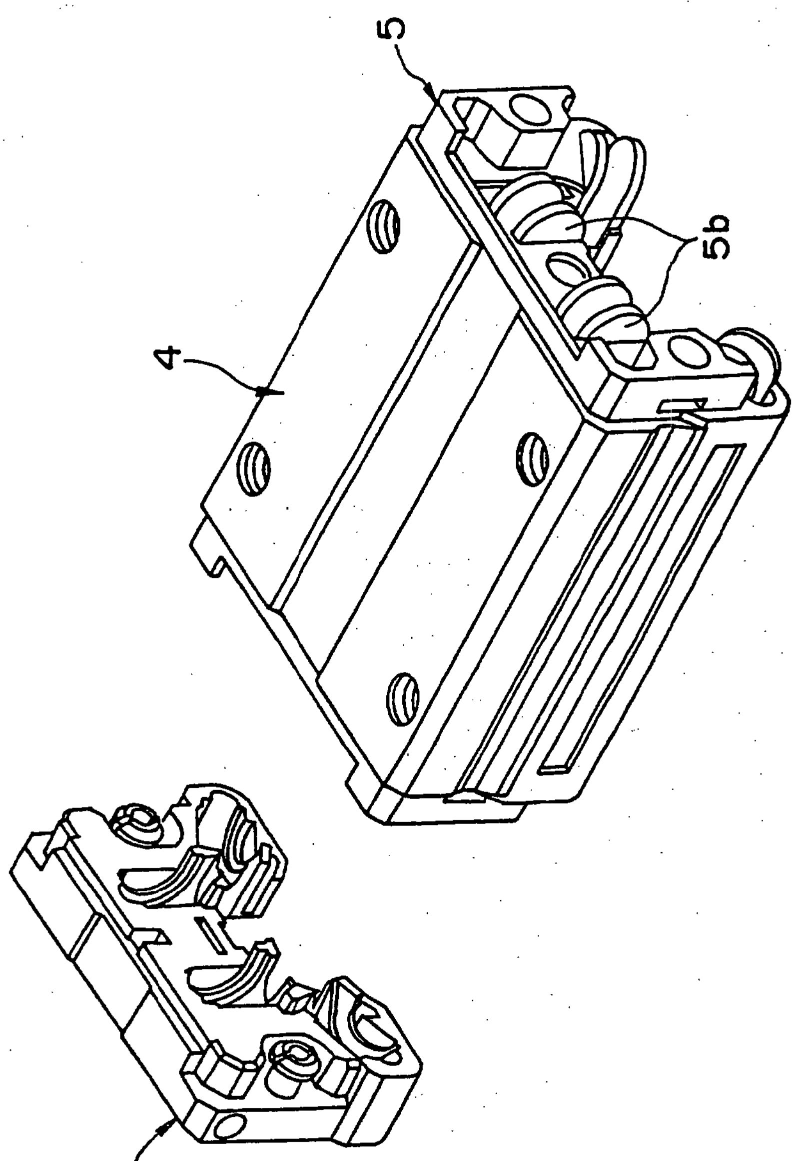


FIG. 4

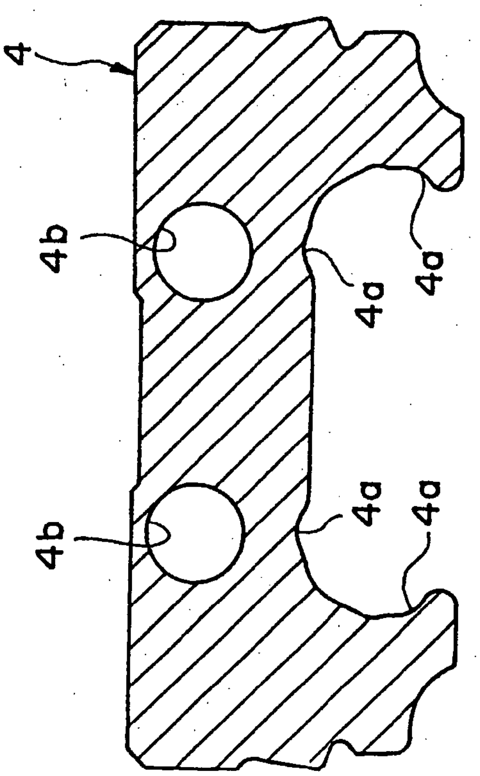


FIG. 5

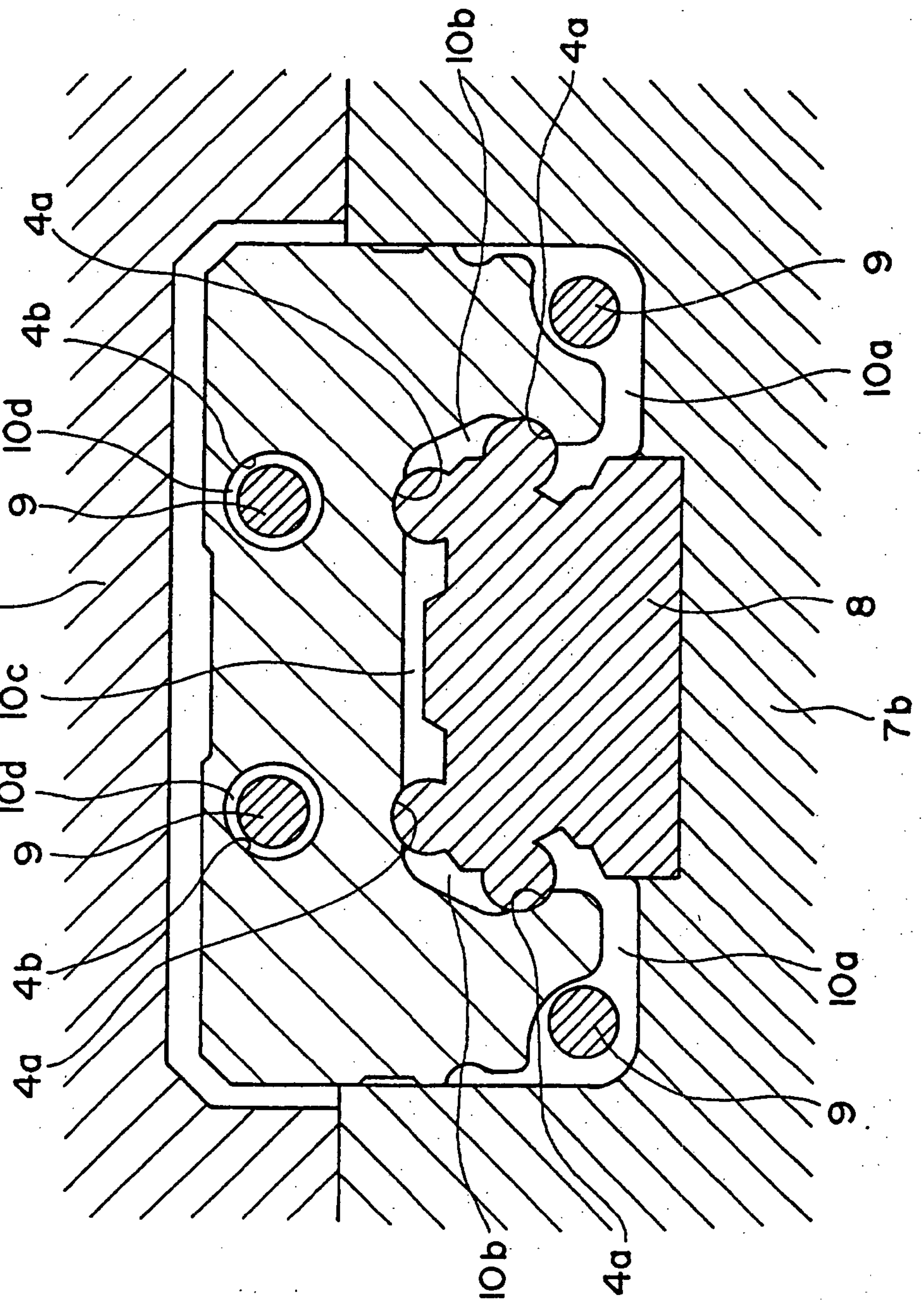
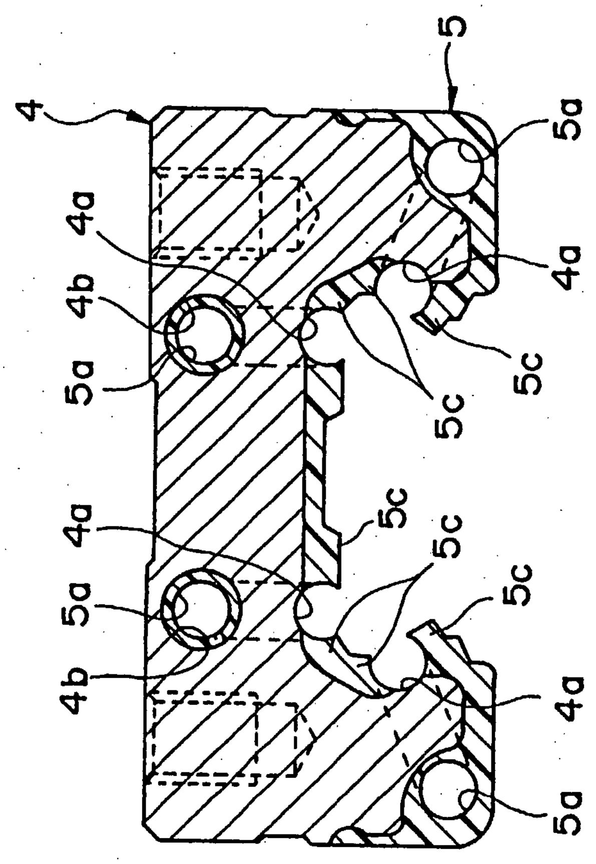


FIG. 6



(19) **Bundesrepublik Deutschland**
Deutsches Patent- und Markenamt

(10) **DE 697 35 548 T2** 2006.08.24

(12) # Übersetzung der europäischen Patentschrift

(97) **EP 0 857 883 B1**
(21) Deutsches Aktenzeichen: **697 35 548.9**
(86) PCT-Aktenzeichen: **PCT/JP97/03246**
(96) Europäisches Aktenzeichen: **97 940 381.3**
(87) PCT-Veröffentlichungs-Nr.: **WO 1998/012442**
(86) PCT-Anmeldetag: **12.09.1997**
(87) Veröffentlichungstag der PCT-Anmeldung: **26.03.1998**
(97) Erstveröffentlichung durch das EPA: **12.08.1998**
(97) Veröffentlichungstag der Patenterteilung beim EPA: **22.03.2006**
(47) Veröffentlichungstag im Patentblatt: **24.08.2006**

(51) Int Cl.[8]: ***F16C 29/06*** (2006.01)
F16C 31/06 (2006.01)
F16H 25/22 (2006.01)
F16C 33/38 (2006.01)

(30) Unionspriorität:

24531496	**17.09.1996**	**JP**
33095696	**11.12.1996**	**JP**
35073796	**27.12.1996**	**JP**

(73) Patentinhaber:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Vossius & Partner, 81675 München

(84) Benannte Vertragsstaaten:
DE, FR, GB, IT

(72) Erfinder:
TERAMACHI, Hiroshi, Shinagawa-ku Tokyo 141, JP; SUGA, Kaichi, Shinagawa-ku Tokyo 141, JP

(54) Bezeichnung: **VORRICHTUNG ZUM VERBINDEN VON KUGELN UND DIESE VORRICHTUNG VERWENDENDE LINEARFÜHRUNG UND KUGELGEWINDESPINDEL**

Beschreibung

Technisches Gebiet

[0001] Die Erfindung betrifft einen Kugelverbinder, in dem eine Anzahl von Kugeln in einer Reihe angeordnet ist und rollfähig gehalten wird und der verwendet wird, indem er z. B. in eine Linearführungsvorrichtung zum Endlosgleiten und eine Kugelendloslaufbahn einer Kugelspindelvorrichtung integriert ist, und insbesondere einen Kugelverbinder, der bei seiner Verwendung frei verbogen oder verdreht werden kann.

Hintergrund der Technik

[0002] Herkömmlich bekannt als Linearführungsvorrichtung zum Führen eines beweglichen Körpers, z. B. eines Tischs o. ä., entlang einer feststehenden Einheit, z. B. einem Bett o. ä., ist ein Lineargleitlager, in dem ein Gleitsockel, der einen beweglichen Körper, z. B. einen Tisch o. ä., trägt, entlang einer Laufschiene bewegt wird, die an einer feststehenden Einheit, z. B. einem Bett, einem Sattel o. ä., angeordnet ist, oder eine Kugelkeilvorrichtung, in der ein zylindrisches Mutternteil, das auf eine Keilwelle aufgepaßt ist, entlang der Keilwelle über Kugeln bewegt wird.

[0003] Von diesen ist als erstgenanntes Lineargleitlager ein Aufbau bekannt, der aufweist: eine Laufschiene mit einer Kugelrollrille, einen Gleitsockel mit einer der Kugelrollrille gegenüberliegenden Lastrollrille sowie einem Kugelrücklaufloch parallel dazu, mit einem Richtungsänderungsweg zum Führen von Kugeln von der Lastrollrille zum Kugelrücklaufloch, die entlang der Laufschiene bewegt werden, und mit einer Anzahl von Kugeln, die zwischen dem Gleitsockel und der Laufschiene rollen, während sie belastet sind, und in einer Endloslaufbahn umlaufen, die durch die Lastrollrille, das Kugelrücklaufloch und den Richtungsänderungsweg des Gleitsockels gebildet ist.

[0004] Zudem ist als letztgenannte Kugelkeilvorrichtung ein Aufbau bekannt, der aufweist: eine Keilwelle mit einer Kugelrollrille entlang der Axialrichtung und ein Mutternteil, das eine der Kugelrollrille gegenüberliegende Lastrollrille hat und auf den Außenumfang der Keilwelle über Kugeln aufgepaßt ist, wobei das Mutternteil entlang der Keilwelle ähnlich wie in einem Endlosumlauf der Kugeln bewegt wird. Diese Vorrichtung wird verwendet, indem das Drehmoment zwischen dem Mutternteil und der Keilwelle gegenseitig übertragen wird.

[0005] Gemäß der herkömmlichen Linearführungsvorrichtung mit dem zuvor beschriebenen Aufbau ist die Endloslaufbahn eines Gleitteils, z. B. des Gleitsockels oder des Mutternteils, mit den Kugeln gefüllt, weshalb bei Bewegung des Gleitteils entlang der Laufschiene oder einem Führungsschaft, z. B. der Keilwelle, die einander benachbarten Kugeln in der Endloslaufbahn im Umlauf geführt werden, wobei sie miteinander kollidieren oder aneinander reiben, was das Problem aufwirft, daß die Kugeln frühzeitig verschleißen und die Lebensdauer der Vorrichtung verkürzt ist.

[0006] Zur Lösung dieses Problems wurde daher ein Lineargleitlager vorgeschlagen, bei dem ein Kugelverbinder, in dem eine Anzahl von Kugeln ausgerichtet ist und gehalten wird, in die Endloslaufbahn integriert ist (JP-A-5-52217). Wie Fig. 25 und Fig. 26 zeigen, sind gemäß einem solchen Kugelverbinder **200** Abstandshalter **202** zwischen jeweiligen einander benachbarten Kugeln **201** eingefügt, die Abstandshalter **202** sind durch ein Paar streifenartige Verbindungsteile **203** in Anordnungsrichtung der Kugeln verbunden, wodurch die Kugeln **201** rosenkranzförmig verbunden sind, und der Kugelverbinder wird dadurch hergestellt, daß flexibles Harz durch Spritzgießen geformt wird, wobei die Kugeln **201** in einem Werkzeug als Kerne angeordnet sind.

[0007] Gemäß dem herkömmlichen Lineargleitlager mit dem zuvor beschriebenen Aufbau ist der o. g. Kugelverbinder **200** gemäß Fig. 27 in ein Kugelrücklaufloch **205** und in Richtungsänderungswege **206** eines Gleitsockels **204** integriert und wird in der Endloslaufbahn im Umlauf geführt, und in diesem Fall sind die Abstandshalter **202** zwischen den einander benachbarten Kugeln **201** eingefügt, weshalb gegenseitige Reibung oder Kollision zwischen den Kugeln vermieden ist und Verschleiß der Kugeln **201** weitgehend verhindert werden kann.

[0008] Beim Umlaufen der Kugeln in der Endloslaufbahn muß die entlastete Kugel von der Kugelrollrille der Laufschiene zum Richtungsänderungsweg des Gleitsockels angehoben werden, und bei einem solchen Anhebevorgang gemäß Fig. 28 ist bevorzugt, die Kugel **201** in einer Richtung zu führen, in der eine Kugelrollrille **208** der Laufschiene **207** und eine Lastrollrille **209** des Gleitsockels **204** einander gegenüber liegen (im folgenden als Kugelkontaktrichtung bezeichnet). Grund dafür ist, daß bei Führung der Kugel **201** in einer solchen Richtung verhindert wird, daß die Kugel **201** im Richtungsänderungsweg **206** schlangenförmig läuft, und der Umlauf der Kugel **201** in der Endloslaufbahn des Gleitsockels **204** glatt erfolgt.

[0009] Aus Sicht der Vermeidung einer Vergrößerung des Gleitsockels **204** tritt der Fall auf, daß die Bildung des Kugelrücklauflochs **205** in Kugelkontaktrichtung nicht unbedingt ordnungsgemäß ist, und es tritt der Fall auf, daß das Kugelrücklaufloch **205** nicht in Kugelkontaktrichtung gebildet werden kann, weil es einem im Gleitsockel **204** zur Befestigung eines beweglichen Körpers, z.B. eines Tisches und der gleichen, gebildeten Gewindeloch im Wege wäre.

[0010] Um den Freiheitsgrad der Position für die Bildung des Kugelrücklauflochs **205** im Hinblick auf den Gleitsockel **204** zu erhöhen, während ein glatter Umlauf der Kugeln **201** in der Endloslaufbahn erreicht wird, muß sich also gemäß Fig. 29 der Richtungsänderungsweg **206** zum Führen der Kugeln von der Lastrollrille **209** zum Kugelrücklaufloch **205** gegenüber der Kugelkontaktrichtung biegen.

[0011] Berücksichtigt man ferner die dem Richtungsänderungsweg innewohnende Rolle bei der Rollrichtungsumkehr der Kugeln, ist bevorzugt, daß der Wenderadius der Kugeln in einem solchen Richtungsänderungsweg groß ist, wozu die Länge des Richtungsänderungswegs lang sein muß. Ist aber das Kugelrücklaufloch von der Lastrollrille aus gesehen in Kugelkontaktrichtung positioniert, kommt es bei großer Länge des Richtungsänderungswegs dazu, daß der Abstand zwischen der Lastrollrille und dem Kugelrücklaufloch natürlich verbreitert ist, und eine Vergrößerung des Gleitsockels läßt sich nicht vermeiden.

[0012] Auch angesichts dessen muß das Kugelrücklaufloch an einer beliebigen Position des Gleitsockels gebildet sein, und der Richtungsänderungsweg zum Verbinden des Kugelrücklauflochs mit der Lastrollrille muß eine Biegung bilden.

[0013] Da aber gemäß einem solchen herkömmlichen Kugelverbinder **200** Seitenkanten der streifenartigen Verbindungsteile **203** zum Verbinden der jeweiligen Abstandshalter **202** geradlinig sind, kommt es zu dem Problem, daß trotz der Tatsache, daß der Kugelverbinder **200** leicht in einer Richtung zu biegen ist, die die Stirnflächen der Verbindungsteile **203** schneidet (Pfeillinienrichtung A in Fig. 26), der Kugelverbinder **200** in einer Richtung parallel zu den Stirnflächen der Verbindungsteile **203** schwer zu biegen ist (Pfeillinienrichtung B in Fig. 25), wenn der Richtungsänderungsweg **206** so gebogen ist, daß er von der o. g. Kugelkontaktrichtung abweicht, weshalb sich der Kugelverbinder **200** in die Endloslaufbahn durch zwangsweises Biegen integrieren muß, so daß kein glatter Umlauf des Kugelverbinders **200** erwartet werden kann.

[0014] Betrachtet man daher gemäß der herkömmlichen Linearführungsvorrichtung unter Verwendung des Kugelverbinders den glatten Umlauf des Kugelverbinders in der Endloslaufbahn, muß von der Lastrollrille aus gesehen das Kugelrücklaufloch in Kugelkontaktrichtung gebildet sein, was ein Faktor für die Vergrößerung des Gleitsockels ist.

[0015] Gemäß der zuvor beschriebenen herkömmlichen Kugelkeilvorrichtung muß ferner aus Sicht der Verkleinerung des Mutternteils das Kugelrücklaufloch möglichst nahe am Innendurchmesser des Mutternteils eingebaut sein, und ähnlich wie beim zuvor erwähnten Lineargleitlager ist es schwierig, das Kugelrücklaufloch in Kugelkontaktrichtung von der Lastrollrille aus gesehen zu bilden.

[0016] Wird daher der herkömmliche Kugelverbinder gemäß Fig. 25 in die Endloslaufbahn der Kugelkeilvorrichtung integriert, läßt sich kein glatter Umlauf des Kugelverbinders erwarten.

[0017] Gemäß einer Kugelspindelvorrichtung, die zur Umwandlung von Drehbewegung eines Motors in Linearbewegung verwendet wird und die eine Linearführungseinheit einer Werkzeugmaschine o. ä. bildet, indem sie zusammen mit der o. g. Linearführungsvorrichtung zum Einsatz kommt, greifen eine Gewindespindel und ein Mutternteil über Kugeln ineinander ein, und das Mutternteil ist ähnlich mit einer Endloslaufbahn für die Kugeln versehen. Aus Sicht von Verschleißverhinderung der im Mutternteil umlaufenden Kugeln ist daher bevorzugt, daß auch in der Kugelspindelvorrichtung ein Kugelverbinder in die Endloslaufbahn integriert ist. Wie aber bereits erläutert, hat der herkömmliche Kugelverbinder einen Aufbau, der nur in spezifischen Richtungen leicht zu verbiegen ist, weshalb es schwierig ist, den Kugelverbinder in die Kugelendloslaufbahn der Kugelspindelvorrichtung zu integrieren.

[0018] Das heißt, beim Integrieren des Kugelverbinders in die Kugelendloslaufbahn der Kugelspindelvorrichtung muß sich der Kugelverbinder bezüglich des Spindelschafts spiralförmig wikkeln. Somit darf der Kugelverbinder nicht eben, sondern muß räumlich umlaufen, und beim. herkömmlichen Kugelverbinder mit kleinem Freiheitsgrad bezüglich der Biegerichtung läßt sich kein glatter Umlauf des Kugelverbinders in der Endloslaufbahn erwarten. Ist der Kugelverbinder in die Kugelspindelvorrichtung integriert, muß der Kugelverbinder in der Endloslaufbahn ferner in einem Zustand umlaufen, der mehr oder weniger mit Verdrehungen einhergeht, und bei Gebrauch des herkömmlichen Kugelverbinders mit einem geringen Freiheitsgrad bezüglich der Biegeleistung ist durch sein zwangsweises Verdrehen zu befürchten, daß sich die Kugeln aus dem Kugelverbinder lösen.

Offenbarung der Erfindung

[0019] Die Erfindung kam angesichts dieser Probleme zustande, und eine Aufgabe der Erfindung besteht darin, einen Kugelverbinder bereitzustellen, der sich in jeder Richtung nachgiebig verbiegen und in einer Kugelendloslaufbahn in einem Zustand umlaufen kann, in dem Kugeln auch dann festgehalten werden, wenn er verbogen, verdreht o. ä. ist.

[0020] Zudem besteht eine weitere Aufgabe der Erfindung darin, eine Linearführungsvorrichtung und eine Kugelspindelvorrichtung bereitzustellen, die einen solchen Kugelverbinder nutzen.

[0021] Ein erfindungsgemäßer Kugelverbinder ist ein Kugelverbinder, der aufgebaut ist aus einer Anzahl von Kugeln, die in einer Reihe mit vorbestimmten Abständen angeordnet sind, und einem flexiblen Verbindergurt (Band, Gürtel) zum drehbaren Halten der Kugeln und gegenseitigen Verbinden der einander benachbarten Kugeln, wobei der Verbindergurt vier Gurtteile aufweist, die in streifenartiger Form entlang von Umfangsflächen der Kugeln gebildet und mit den mehreren Kugeln in Kontakt gebracht sind, wobei die Gurtteile mit anderen Gurtteilen an Zwischenstellen der einander benachbarten Kugeln gegenseitig verbunden sind und der Verbindergurt in einer Form ausgebildet ist, die im Vergleich zu dem Außendurchmesser der Kugeln an Positionen der die Kugeln verbindenden Zwischenstellen eingeschnürt ist.

[0022] Gemäß einer Linearführungsvorrichtung der Erfindung unter Nutzung des Kugelverbinders ist ferner die Linearführungsvorrichtung aufgebaut aus einem Führungsschaft mit Kugelrollrillen zum Abrollen von Kugeln in Längsrichtung und einem Gleitteil mit Lastrollrillen zum Abrollen der lasttragenden Kugeln zwischen dem Führungsschaft und den Lastrollrillen, das Endloslaufbahnen zum Umlauf der Kugeln hat und entlang dem Führungsschaft entsprechend dem Umlauf der Kugeln bewegt wird, wobei der Kugelverbinder in eine der Endloslaufbahnen integriert ist und der Kugelverbinder entsprechend einer Relativbewegung zwischen dem Führungsschaft und dem Gleitteil in der Endloslaufbahn im Umlauf geführt wird.

[0023] Ferner ist gemäß einer Kugelspindelvorrichtung der Erfindung unter Verwendung des Kugelverbinders die Kugelspindelvorrichtung aufgebaut aus einem Spindelschaft mit Kugelrollrillen in Spiralform zum Abrollen von Kugeln an Außenumfangsflächen davon und einem Mutternteil mit Lastrollrillen in Spiralform zum Abrollen der lasttragenden Kugeln zwischen dem Spindelschaft und den Lastrollrillen, das Endloslaufbahnen zum Umlauf der Kugeln hat und auf den Spindelschaft über die Kugeln aufgeschraubt ist, wobei der Kugelverbinder in eine der Endloslaufbahnen integriert ist und der Kugelverbinder gemäß einer Relativbewegung zwischen dem Spindelschaft und dem Mutternteil in der Endloslaufbahn im Umlauf geführt wird.

[0024] Gemäß dem Kugelverbinder der Erfindung ist der Verbindergurt mit vier Gurtteilen versehen, die in streifenartiger Form entlang den Kugelflächen der Kugeln gebildet und mit den mehreren Kugeln in Kontakt gebracht sind, die Gurtteile sind mit anderen Gurtteilen an den Zwischenstellen der einander benachbarten Kugeln gegenseitig verbunden, weshalb die einzelnen Kugeln in einen Zustand gebracht sind, in dem sie durch die Gurtteile aus vier Richtungen umfaßt sind, und die Kugeln lösen sich auch dann nicht vom Verbindergurt, wenn der Kugelverbinder stark verbogen oder verdreht wird.

[0025] Auch wenn das Gleitteil der Linearführungsvorrichtung von der Laufschiene abgezogen oder wenn das Mutternteil der Kugelspindelvorrichtung vom Spindelschaft entfernt wird, läßt sich somit ohne Verwendung eines Kugelkäfigs verhindern, daß sich die Kugeln vom Gleitteil oder Mutternteil lösen.

[0026] Ferner ist der Verbindergurt in einer Form ausgebildet, die im Vergleich zum Außendurchmesser der Kugeln an Positionen eingeschnürt ist, an denen die vier Gurtteile miteinander gekoppelt sind, d. h. an Zwischenstellen der einander benachbarten Kugeln, weshalb der Kugelverbinder so einen Aufbau hat, daß er in jeder Richtung an diesen Positionen nachgiebig leicht verbogen werden und auf den Kugelverbinder ausgeübte Verdrehungen leicht aufnehmen kann. Bei seiner Verwendung läßt sich der Kugelverbinder daher in freier Richtung hinsichtlich der Kugelreihe verbiegen oder verdrehen, unabhängig von den Positionen, an denen die Gurtteile gebildet werden, und auch in einer solchen Situation kann der Kugelverbinder in der Endloslaufbahn glatt im Umlauf geführt werden.

Kurze Beschreibung der Zeichnungen

[0027] Fig. 1 ist eine Vorderansicht einer Ausführungsform eines erfindungsgemäßen Kugelverbinders.

[0028] Fig. 2 ist eine Schnittansicht des Kugelverbinders an einer Linie II-II in Fig. 1.

[0029] Fig. 3 ist eine Schnittansicht einer ersten Ausführungsform eines Lineargleitlagers, auf das erfindungsgemäße Kugelverbinder angewendet sind.

[0030] Fig. 4 ist eine Schnittansicht einer Kugelendloslaufbahn des Lineargleitlagers von Fig. 3.

[0031] Fig. 5 ist eine Schnittansicht eines Rollzustands von Kugeln in der Kugelendloslaufbahn von Fig. 4.

[0032] Fig. 6 ist eine Schnittansicht einer zweiten Ausführungsform eines Lineargleitlagers, auf das erfindungsgemäße Kugelverbinder angewendet sind.

[0033] Fig. 7 ist eine Schnittansicht einer dritten Ausführungsform eines Lineargleitlagers, auf das erfindungsgemäße Kugelverbinder angewendet sind.

[0034] Fig. 8 ist eine Schnittansicht einer vierten Ausführungsform eines Lineargleitlagers, auf das erfindungsgemäße Kugelverbinder angewendet sind.

[0035] Fig. 9 ist eine Schnittansicht einer fünften Ausführungsform einer Kugelkeilvorrichtung, auf die erfindungsgemäße Kugelverbinder angewendet sind.

[0036] Fig. 10 ist eine Seitenansicht der fünften Ausführungsform der Kugelkeilvorrichtung, auf die die erfindungsgemäßen Kugelverbinder angewendet sind.

[0037] Fig. 11 ist eine Schnittansicht einer sechsten Ausführungsform einer Kugelspindelvorrichtung, auf die erfindungsgemäße Kugelverbinder angewendet sind.

[0038] Fig. 12 ist eine Vorderansicht eines Mutternhauptkörpers gemäß der sechsten Ausführungsform.

[0039] Fig. 13 ist eine Schnittansicht an einer Linie XIII-XIII von Fig. 12.

[0040] Fig. 14 ist eine Rückansicht eines Abdeckteils gemäß der sechsten Ausführungsform.

[0041] Fig. 15 ist eine Schnittansicht an einer Linie XV-XV von Fig. 14.

[0042] Fig. 16 ist eine Vorderansicht eines Einzelteils und zeigt ein Rücklaufstück gemäß der sechsten Ausführungsform.

[0043] Fig. 17 ist eine Seitenansicht eines Einzelteils und zeigt das Rücklaufstück gemäß der sechsten Ausführungsform.

[0044] Fig. 18 ist eine Perspektivansicht eines Deckels und zeigt Richtungsänderungswege von Kugeln, die im Deckel gemäß der sechsten Ausführungsform gebildet sind.

[0045] Fig. 19 ist eine Perspektivansicht einer siebenten Ausführungsform einer Kugelspindelvorrichtung, auf die ein erfindungsgemäßer Kugelverbinder angewendet ist.

[0046] **Fig.** 20(a) und 20(b) zeigen eine Perspektivansicht eines Rücklaufrohrs gemäß der siebenten Ausführungsform bzw. eine Perspektivansicht einer Rohrhälfte des das Rücklaufrohr bildenden Rohrs.

[0047] Fig. 21 ist eine Perspektivansicht einer achten Ausführungsform einer Kugelspindelvorrichtung, auf die ein erfindungsgemäßer Kugelverbinder angewendet ist.

[0048] Fig. 22 ist eine Vorderansicht eines Ablenkers gemäß der achten Ausführungsform.

[0049] Fig. 23 ist eine Draufsicht auf den Ablenker gemäß der achten Ausführungsform.

[0050] Fig. 24 ist eine Schnittansicht an einer Linie XXIV-XXIV von Fig. 23.

[0051] Fig. 25 ist eine Draufsicht auf einen herkömmlichen Kugelverbinder.

[0052] Fig. 26 ist eine Seitenansicht des herkömmlichen Kugelverbinders.

[0053] Fig. 27 ist eine Schnittansicht eines Zustands, in dem der herkömmliche Kugelverbinder in eine Endloslaufbahn einer Linearführungsvorrichtung integriert ist.

[0054] Fig. 28 ist eine Umrißansicht zur Darstellung eines Kugelumlaufverhaltens in dem Fall, in dem ein Kugelrücklaufloch in Kugelkontaktrichtung bezogen auf eine Lastrollrille vorhanden ist.

[0055] Fig. 29 ist eine Umrißansicht zur Darstellung eines Kugelumlaufverhaltens in dem Fall, in dem das Kugelrücklaufloch an einer von der Kugelkontaktrichtung abweichenden Position bezogen auf die Lastrollrille vorhanden ist.

Bezugszeichenliste

1 Kugelverbinder,
2 Verbindergurt,
3 Kugel,
4 Verbindungsabschnitt,
5 Gurtteil

[0056] Bevorzugte Ausführungsformen der Erfindung Anhand der beigefügten Zeichnungen werden im folgenden ein Kugelverbinder sowie eine einen erfindungsgemäßen Kugelverbinder nutzende Linearführungsvorrichtung und Kugelspindelvorrichtung näher beschrieben.

[0057] Fig. 1 zeigt eine Ausführungsform eines erfindungsgemäßen Kugelverbinders **1**. Gemäß dem Kugelverbinder **1** sind mehrere Kugeln **3** an einem aus Kunstharz hergestellten Verbindergurt **2** in einer Reihe in vorbestimmten Abständen angeordnet, und die Kugeln **3** sind in einem Zustand frei drehbar, in dem sie durch den Verbindergurt **2** gehalten werden.

[0058] Der Verbindergurt **2** ist mit vier Gurtteilen **5** versehen, die in streifenartiger Form entlang von Kugelflächen der Kugeln **3** und in Anordnungsrichtung der Kugeln **3** gebildet sind, und die Gurtteile **5** sind mit anderen Gurtteilen **5** zwischen den einander benachbarten Kugeln **3** gegenseitig verbunden. Ferner sind Verbindungsabschnitte **4** in scheibenartiger Form zwischen den einander benachbarten Kugeln **3** gebildet, die jeweiligen Gurtteile **5** sind mit anderen Gurtteilen **5** über die Verbindungsabschnitte **4** gegenseitig verbunden, und zudem dienen die Verbindungsabschnitte **4** als Abstandshalter zum Verhindern, daß die einander benachbarten Kugeln **3** miteinander in Kontakt kommen.

[0059] Gemäß Fig. 2 sind die Gurtteile **5** bezüglich der Kugelreihe nach oben, unten, links und rechts angeordnet, um die Kugelfläche der Kugel **3** in vier gleiche Teile aufzuteilen und die Bewegung der Kugel **3** in vier Richtungen so zu beschränken, daß sich die Kugel nicht aus einem Paar der angrenzenden Verbindungsabschnitte **4** löst. Weiterhin ist das Gurtteil **5** entlang der Kugelfläche der Kugel **3** gebildet, und betrachtet man den Kugelverbinder **1** insgesamt, bildet der Verbindergurt **2** die am stärksten eingeschnürte Form an der Position, an der der Verbinderabschnitt **4** gebildet ist.

[0060] Der Kugelverbinder **1** ist durch Spritzgießen von Kunstharz geformt, wobei die Kugeln **3** in einem Werkzeug als Kerne angeordnet sind, und wird gefertigt, indem der Verbindergurt **2** zusammen mit den Kugeln **3** nach Formgebungsabschluß aus dem Werkzeug entnommen wird. Wird der Verbindergurt **2** einfach durch Spritzgießen geformt, werden die Verbindungsabschnitte **4** und Gurtteile **5** des Gurts **2** in engen Kontakt mit den Kugeln **3** gebracht, und die Kugeln **3** können im Hinblick auf den Verbindergurt nicht frei drehen, weshalb gemäß dieser Ausführungsform der Kugelverbinder **1** nach Formgebungsabschluß in ein Gleitmittel aus der Gruppe der Mineralöle getaucht wird und sich Spielräume zwischen den Kugeln **3** und den Verbindungsabschnitten **4** oder Gurtteilen **5** bilden, nachdem man das allmähliche Quellen des Verbindergurts **2** abwartet, wodurch die Kugeln **3** frei drehen können.

[0061] Gemäß dem Kugelverbinder **1** dieser Ausführungsform mit dem zuvor beschriebenen Aufbau bildet der Verbindergurt **2** die am stärksten eingeschnürte Form zwischen den Kugeln **3**, d. h. die Position, an der der Verbindungsabschnitt **4** gebildet ist, weshalb der Kugelverbinder **1** an dieser Position in jeder Richtung frei verbogen werden kann, z. B. kann gemäß Fig. 2 der Kugelverbinder **1** nicht nur in Pfeillinienrichtung "a" frei verbogen werden, wo das Gurtteil **5** vorhanden ist, sondern auch in Pfeillinienrichtung "b", die zwischen den einander benachbarten Gurtteilen **5** angeordnet ist.

[0062] Wie zuvor erwähnt, ist der Kugelverbinder **1** an den Positionen, an denen die jeweiligen Verbindungsabschnitte **4** gebildet sind, eingeschnürt, weshalb auch bei Verdrehung des Kugelverbinders **1** in Pfeillinienrichtung "c" in Fig. 2 der Verbindergurt **2** der Verdrehung folgt und problemlos verformt werden kann. Auch bei Verformung des Verbindergurtes **2** durch Folgen der Verdrehung besteht keine Gefahr, daß sich die Kugeln **3** vom Verbindergurt **2** lösen, da die Bewegung der Kugeln **3** aus vier Richtungen durch die vier Abschnitte der streifenartigen Gurtteile **5** eingeschränkt ist.

Erste Ausführungsform

[0063] Fig. 3 zeigt eine erste Ausführungsform, in der der Kugelverbinder auf ein Lineargleitlager angewendet ist.

[0064] In Fig. 3 bezeichnet die Bezugszahl **10** eine Laufschiene, die an einer feststehenden Einheit, z. B. einem Bett einer Werkzeugmaschine o. ä., angeordnet ist, die Bezugszahl **20** bezeichnet einen Gleitsockel mit Kugelendloslaufbahnen, in die die Kugelverbinder **1** integriert sind und die einen beweglichen Körper, z. B. einen Tisch o. ä., entlang der Laufschiene **10** führen, und die Bezugszahl **3** bezeichnet Kugeln, die zwischen der Laufschiene **10** und dem Gleitsockel **20** rollen, während sie Last tragen und im Gleitsockel **20** endlos im Umlauf geführt werden.

[0065] Zunächst ist der Schnitt der Laufschiene **10** im wesentlichen quadratförmig, und insgesamt zwei Trassen von Kugelrollrillen **11** in Spitzbogenform sind auf ihren beiden Seitenflächen in Längsrichtung (senkrechte Richtung zur Fläche von Fig. 2) gebildet. Bolzenbefestigungslöcher **12** sind in der Laufschiene **10** in Längsrichtung mit passenden Abständen gebildet, und die Laufschiene **10** ist an der feststehenden Einheit durch nicht gezeigte Befestigungsbolzen befestigt, die in die Bolzenbefestigungslöcher **12** eingesetzt sind.

[0066] Ferner ist der Gleitsockel **20** mit einem waagerechten Abschnitt **20a**, an dem Befestigungsflächen **21** des beweglichen Körpers gebildet sind, und einem Paar Schürzenabschnitten **20b** versehen, die vom waagerechten Abschnitt **20a** herabhängen, wodurch der Schnitt im wesentlichen eine sattelartige Form hat, und den Kugelrollrillen **11** der Laufschiene **10** gegenüberliegende spitzbogenförmige Lastrollrillen **23** sind auf der Innenflächenseite der jeweiligen Schürzenabschnitte **20b** gebildet. Außerdem sind Kugelrücklauflöcher **24** entsprechend den jeweiligen Lastrollrillen **23** an den jeweiligen Schürzenabschnitten **20b** gebildet, und die Kugel **3**, die den Rollvorgang in der Lastrollrille **23** beendet hat und entlastet ist, rollt in Gegenrichtung zur Rollrichtung in der Lastrollrille **23**.

[0067] Gefertigt ist der Gleitsockel **20** durch Spritzgießen von Kunstharz. Das heißt, der Gleitsockel **20** ist gebildet, indem Harzabschnitte **22** durch Spritzgießen auf den Blockhauptkörper **25** aufgebracht werden, der aus Metall hergestellt und spanend bearbeitet ist, während mechanische Festigkeit erfordernde Abschnitte, z. B. die Befestigungsflächen **21** für den beweglichen Körper, die Lastrollrillen für die Kugeln **3** usw., am Blockhauptkörper **25** gebildet sind, und Abschnitte, in denen mechanische Festigkeit unwichtig ist, z. B. die Kugelrücklauflöcher **24** u. ä., aus Kunstharz gebildet sind, wodurch eine leichtgewichtige Struktur des Gleitsockels **20** mit möglichst geringem Gewicht erreicht ist.

[0068] Fig. 4 ist eine Schnittansicht der Kugelendloslaufbahn des Gleitsockels **20**, in die der Kugelverbinder **1** integriert ist, und die Endloslaufbahn wird fertiggestellt, indem aus Kunstharz hergestellte Deckel **30** sowohl an der Vorder- als auch an der Rückfläche des Gleitsockels **20** befestigt werden. Das heißt, bei Befestigung der Deckel **30** am Gleitteil **20** sind U-förmige Richtungsänderungswege **32** fertiggestellt, indem Kugelführungsabschnitte **26** auf der Seite des Gleitsockels **20** in U-förmige Rillen **31** auf der Seite der Deckel **30** eingefügt und die Lastrollrille **23** sowie das Kugelrücklaufloch **24** des Gleitsockels **20** durch die Richtungsänderungswege **32** verbunden sind.

[0069] Fig. 5 ist eine vergrößerte Ansicht eines Rollzustands der Kugeln in der Endloslaufbahn.

[0070] Austrittsrillen **27** sind an den tiefsten Abschnitten der Kugelrollrille **11** bzw. Lastrollrille **23** spitzbogenförmig ausgebildet, und beim Rollen der Kugeln **3** in den Rollrillen **23** und **11** sind die Gurtteile **5** des Kugelverbinders **1** in den Austrittsrillen **27** aufgenommen. Zudem sind vier Trassen von Führungsrillen **28** im Kugelrücklaufloch **24** des Gleitsockels **20** in Längsrichtung gebildet, die Gurtteile **5** des Kugelverbinders **1** in unbelastetem Zustand werden durch die Führungsrillen **28** geführt, und schlangenförmiges Bewegen des Kugelverbinders **1** im Kugelrücklaufloch **24** ist verhindert.

[0071] Wird ferner gemäß dem Lineargleitlager der Ausführungsform mit dem zuvor beschriebenen Aufbau der Gleitsockel **20** auf der Laufschiene **10** bewegt, rollen die Kugeln **3** auf den Lastrollrillen **23** des Gleitsockels **20** und auf den Kugelrollrillen **11** der Laufschiene **10**, und die Kugelverbinder **1** werden in den Endloslaufbahnen im Umlauf geführt, die im Gleitsockel **20** gebildet sind.

[0072] Gemäß dem Lineargleitlager der Ausführungsform weicht in diesem Fall gemäß Fig. 5 die Position, an der das Kugelrücklaufloch **24** im Gleitsockel **20** gebildet ist, nach oben gegenüber einer Richtung ab, in der die Kugelrollrille **11** der Laufschiene **10** und die Lastrollrille **23** des Gleitsockels **20** einander gegenüber liegen, d. h. gegenüber der Kugelkontaktrichtung, und die Richtungsänderungswege **32** zum Verbinden der Lastrollrille **23** mit dem Kugelrücklaufloch **24** sind so gebogen, daß sie von der Kugelkontaktrichtung abweichen.

[0073] Wie aber zuvor erwähnt, hat der Kugelverbinder **1** den Aufbau, durch den er sich in jeder Richtung nachgiebig leicht verbiegt, weshalb gemäß dem Lineargleitlager dieser Ausführungsform auch bei gebogenen Richtungsänderungswegen **32** gemäß Fig. 5 die Kugelverbinder **1** die Richtungsänderungswege **32** problemlos durchlaufen können und sich ein glatter Umlauf des Kugelverbinders **1** in der Endloslaufbahn erreichen läßt.

Zweite Ausführungsform

[0074] Fig. 6 zeigt eine zweite Ausführungsform, in der ein erfindungsgemäßer Kugelverbinder auf ein Lineargleitlager angewendet ist.

[0075] Während gemäß der o. g. ersten Ausführungsform eine Trasse der Kugelrollrille **11** auf jeder der beiden Seitenflächen der Laufschiene **10** gebildet ist, sind gemäß der Linearführungsvorrichtung dieser Ausführungsform zwei Trassen der Kugelrollrillen **11** auf jeder der beiden Seitenflächen der Laufschiene **10** gebildet, und der Gleitsockel **20** kann auf der Laufschiene **10** unter größerer Last als in der ersten Ausführungsform bewegt werden.

[0076] Ferner sind zwei Trassen der Lastrollrillen **23** auf der Seite jeder der Innenflächen der Schürzenabschnitte des Gleitsockels **20** gebildet, und die Kugeln **3** rollen zwischen den Lastrollrillen **23** und den Kugelrollrillen **11** der Laufschiene **10**. Alle entsprechenden Kugelrollrillen **11** und entsprechenden Lastrollrillen **23** sind spitzbogenförmig und die o. g. Austrittsrillen zur Aufnahme der Gurtteile **5** des Kugelverbinders **1** sind an den tiefsten Abschnitten der Rillen **11** und **23** ähnlich ausgebildet.

[0077] Ferner sind aus Kunstharz hergestellte Führungsabschnitte **29** auf den Seiten der Innenfläche der Schürzenabschnitte des Gleitsockels **20** angrenzend an die Lastrollrillen **23** aufgebracht, und die Führungsabschnitte **29** führen die Teile **5** der Kugelverbinder **1**, wodurch schlangenförmiges Bewegen und Verdrehen der Kugelverbinder **1** in belastetem Zustand verhindert sind. Ansonsten ähnelt der weitere Aufbau dem der o. g. ersten Ausführungsform, weshalb die gleichen Bezugszahlen in Fig. 6 vergeben sind und auf eine nähere Erläuterung verzichtet wird.

[0078] Auch in dieser Ausführungsform sind die Richtungsänderungswege zum Verbinden der Lastrollrillen **23** mit den Kugelrücklauflöchern **24** so gebogen, daß sie von den Kugelkontaktrichtungen abweichen, und als Ergebnis der Integration der Kugelverbinder **1** mit ausgezeichneter Flexibilität gemäß Fig. 1 in die Endloslaufbahnen können ähnlich wie in der o. g. ersten Ausführungsform die Kugelverbinder **1** die Richtungsänderungswege problemlos durchlaufen, und es läßt sich ein glatter Umlauf der Kugelverbinder **1** in den Endloslaufbahnen erreichen.

Dritte Ausführungsform

[0079] In Fig. 7 ist außerdem eine dritte Ausführungsform gezeigt, in der ein erfindungsgemäßer Kugelverbinder auf ein Lineargleitlager angewendet ist.

[0080] Gemäß dieser Ausführungsform sind ähnlich wie in der o. g. zweiten Ausführungsform zwei Trassen der Kugelrollrillen **11** auf jeder der beiden Seitenflächen der Laufschiene **10** gebildet, aber keine der jeweiligen Kugelrollrillen **11** ist dort spitzbogenförmig, wo sich ein Paar Kugelrollflächen schneidet, sondern kreisbogenförmig mit einer einzelnen Kugelrollfläche. Ferner ist jede der Kugelrollrillen **11** nach oben oder unten so gebildet, daß ein Winkel von 45° bezogen auf die waagerechte Richtung vorliegt.

[0081] Außerdem sind zwei Trassen der Lastrollrillen **23** in Kreisbogenform gegenüber den Kugelrollrillen der Laufschiene auf der Seite jeder der Innenflächen der Schürzenabschnitte des Gleitsockels **20** gebildet, und die Kugeln **3** rollen zwischen den Lastrollrillen **23** und den Kugelrollrillen **11** der Laufschiene **10**. Weiterhin sind im Gleitsockel **20** auch die aus Kunstharz hergestellten Führungsabschnitte **29** auf beiden Seiten der jeweiligen Lastrollrillen **23** aufgebracht, die Führungsabschnitte **29** führen die Gurtteile **5** der Kugelverbinder **1**, und schlangenförmiges Bewegen und Verdrehen der Kugelverbinder **1** in belastetem Zustand sind verhindert.

[0082] In dieser Ausführungsform ist aber zu befürchten, daß beim Rollen der Kugeln in den Lastrollrillen **23** des Gleitsokkels **20** und in den Kugelrollrillen **11** der Laufschiene **10** die Gurtteile **5** der Kugelverbinder **1** mit den Lastrollrillen **23** und den Kugelrollrillen **11** in Kontakt kommen können, weshalb die vier Gurtteile **5** zum Umfassen der Kugel **3** nicht so angeordnet sind, daß sie die Kugelfläche der Kugel **3** gleichmäßig vierteilen, sondern die vier Gurtteile **5** so abweichend angeordnet sind, daß der Abstand zwischen zwei Gurtteilen **5**, die auf beiden Seiten jeder der Lastrollrillen **23** und Kugelrollrillen **11** angeordnet sind, verbreitert ist. Im übrigen ähnelt der Aufbau dem der o. g. ersten Ausführungsform, weshalb die gleichen Bezugszahlen in Fig. 7 verwendet werden und auf eine nähere Beschreibung verzichtet wird.

[0083] Die Lastrollrillen **23** sind nach unten oder oben in einem Winkel von 45° bezogen auf die waagerechte Richtung gebildet, weshalb im Hinblick auf den glatten Umlauf der Kugeln **3** die Kugelrücklauflöcher **24** einen Winkel von 45° nach oben oder 45° nach unten zur jeweiligen Lastrollrille **23** aufweisen müssen. Sind aber die Kugelrücklauflöcher **24** an solchen Positionen gebildet, ist zu befürchten, daß der Abstand zwischen den Kugelrücklauflöchern **24**, die in Auf- und Abwärtsrichtung aneinandergrenzen, steigt und daß der Gleitsockel vergrößert ist, weshalb gemäß dieser Ausführungsform die jeweiligen Kugelrücklauflöcher **24** in waagerechter Richtung der jeweiligen Lastrollrillen **23** aneinandergrenzend gebildet sind, indem die Richtungsänderungswege **32** gebogen sind.

[0084] Auch bei Bildung der Kugelrücklauflöcher **24** an diesen Positionen können gemäß der Linearführungsvorrichtung dieser Ausführungsform als Ergebnis der Integration der Kugelverbinder gemäß Fig. 1 in die Endloslaufbahnen die Kugelverbinder **1** die Richtungsänderungswege **32** problemlos durchlaufen, und es läßt sich ein glatter Umlauf der Kugelverbinder **1** in den Endloslaufbahnen erreichen.

Vierte Ausführungsform

[0085] Fig. 8 zeigt eine vierte Ausführungsform, in der ein erfindungsgemäßer Kugelverbinder auf ein Lineargleitlager angewendet ist.

[0086] Die Ausführungsform zeigt eine Linearführungsvorrichtung, in der die Positionen, an denen die Kugelrollrillen **11** gebildet sind, bezüglich der Führungsschiene **10** gegenüber denen in der dritten Ausführungsform geändert sind und zwei Trassen der Kugelrollrillen **11** auf der Oberseite der Laufschiene **10** gebildet sind, während eine Trasse der Kugelrollrille **11** auf jeder der beiden in einem Winkel von 30° nach unten weisenden Seitenflächen gebildet ist.

[0087] Ferner sind die Lastrollrillen **23** im Gleitsockel **20** an Positionen gegenüber den Kugelrollrillen **11** der Laufschiene **10** gebildet, und die an den Kugelverbindern **1** angeordneten Kugeln **3** rollen zwischen den Kugelrollrillen **11** und Lastrollrillen **23**, während sie Last tragen. Ansonsten ähnelt der übrige Aufbau dem der dritten Ausführungsform, weshalb in Fig. 8 die gleichen Bezugszahlen vergeben sind und auf eine nähere Beschreibung verzichtet wird.

[0088] Gemäß der Linearführungsvorrichtung der vierten Ausführungsform sind die nach unten gerichteten Lastrollrillen **23** am waagerechten Abschnitt **20a** des Gleitsockels **20** gebildet, weshalb unter der Annahme, daß die Kugelrücklauflöcher **24** entsprechend den Lastrollrillen **23** in Kugelkontaktrichtung gebildet sind, der waagerechte Abschnitt **20a** des Gleitsockels **20** verdickt sein muß, um der Länge der Richtungsänderungswege Rechnung zu tragen, wobei aber gemäß dieser Ausführungsform in Fig. 8 die Positionen, an denen die Kugelrücklauflöcher **24** gebildet sind, gegenüber den Kugelkontaktrichtungen verschoben sind und die Richtungsänderungswege **32** von den Lastrollrillen **23** zu den Kugelrücklauflöchern **24** gebogen sind, weshalb auch bei dünner Bildung des waagerechten Abschnitts **20a** des Gleitsockels **20** die Längen der Richtungsänderungswege **32** erreicht werden können, und die Wenderadien der Kugeln **3** können aufgrund dieser Beträge groß sein.

[0089] Auch bei gebogenen Richtungsänderungswegen **32** können gemäß der Linearführungsvorrichtung dieser Ausführungsform als Ergebnis der Integration der Kugelverbinder **1** gemäß Fig. 1 in die Endloslaufbahnen die Kugelverbinder **1** die Richtungsänderungswege **32** problemlos durchlaufen, und ein glatter Umlauf der Kugelverbinder **1** in den Endloslaufbahnen läßt sich erreichen.

Fünfte Ausführungsform

[0090] Als nächstes zeigen Fig. 9 und Fig. 10 eine fünfte Ausführungsform, in der ein erfindungsgemäßer Kugelverbinder auf eine Kugelkeilvorrichtung angewendet ist.

[0091] In den Zeichnungen bezeichnet die Bezugszahl **50** eine Keilwelle, in der Kugelrollrillen gebildet sind, die Bezugszahl **60** bezeichnet ein Mutternteil, das Kugelendloslaufbahnen aufweist, in die die Kugelverbinder **1** integriert sind und das auf den Außenumfang der Keilwelle **50** aufgepaßt ist, und die Bezugszahl **3** bezeichnet Kugeln, die zwischen der Keilwelle **50** und dem Mutternteil **60** rollen, während sie Last tragen und im Inneren des Mutternteils **60** endlos im Umlauf geführt werden.

[0092] Zunächst ist die Keilwelle **50** im wesentlichen zylinderförmig, und vorstehende Trassen **51** in Axialrichtung (senkrechte Richtung zur Fläche von Fig. 9) sind auf ihrer Außenumfangsfläche gebildet. Die vorstehenden Trassen **51** sind an drei Stellen in Umfangsrichtung der Keilwelle **50** in gleichmäßigen Abständen angeordnet, und Kugelrollrillen **52** in Kreisbogenform sind jeweils auf beiden Seitenflächen jedes der vorstehenden Trassen **51** gebildet.

[0093] Ferner ist das Mutternteil **60** zylinderförmig und auf seiner Außenumfangsfläche mit einer Keilnut **61** zum Befestigen des Mutternteils **60** an einem beweglichen Körper versehen, und außerdem sind Lastrollrillen **62** auf seiner Innenumfangsfläche in Kreisbogenform gegenüber den Kugelrollrillen **52** der Keilwelle **50** gebildet. Insgesamt drei Sätze der Lastrollrillen **62** sind gebildet, wobei ein Paar aneinandergrenzender Lastrollrillen **62** einen Satz darstellt, und die vorstehende Trasse **51** der Keilwelle **50** ist zwischen dem Paar Lastrollrillen **62** angeordnet, die für jeden Satz vorgesehen sind.

[0094] Zudem ist ein Kugelrücklaufloch **63** entsprechend jeder der Lastrollrillen **62** in der Umgebung der Innenumfangsfläche des Mutternteils **60** gebildet, und die Kugel **3**, die das Rollen auf der Lastrollrille **62** beendet hat und entlastet ist, rollt in Gegenrichtung zu der Richtung, in der sie in der Lastrollrille **62** gerollt ist. Vier Trassen von Führungsrillen **64** sind im Kugelrücklaufloch **63** in Längsrichtung gebildet, die Gurtteile **5** des Kugelverbinders **1** in unbelastetem Zustand werden durch die Führungsrillen **64** geführt, und schlangenförmiges Bewegen des Kugelverbinders **1** im Inneren des Kugelrücklauflochs **63** ist verhindert.

[0095] Weiterhin sind Kugelführungsabschnitte **65** auf der Innenumfangsfläche des Mutternteils **60** angrenzend an die Lastrollrillen **62** gebildet, und die Gurtteile **5** des Kugelverbinders **1** werden in belastetem Zustand zwischen dem Mutternteil **60** und der Keilwelle **50** so geführt, daß sie in Gleitkontakt mit den Kugelführungsabschnitten **65** gebracht sind.

[0096] Das Mutternteil **60** ist durch Spritzgießen von Kunstharz hergestellt. Das heißt, das Mutternteil **60** wird gebildet, indem ein Harzabschnitt **67** durch Spritzgießen auf die Innenumfangsfläche eines Mutternhauptkörper **66** aufgebracht wird, der aus Metall hergestellt und spanend bearbeitet ist, während mechanische Festigkeit erfordernde Abschnitte, z. B. die o. g. Keilnut **61**, die Lastrollrillen **62** u. ä., am Mutternhauptkörper **66** gebildet sind, und Abschnitte, an denen mechanische Festigkeit unwichtig ist, z. B. die Kugelrücklauflöcher **63**, die Kugelführungsabschnitte **65** usw., durch Kunstharz gebildet sind, wodurch ein leichtgewichtiger Aufbau des Mutternteils **60** mit möglichst geringem Gewicht erreicht wird.

[0097] Die Kugelverbinder **1** sind in die Kugelendloslaufbahnen des Mutternteils **60** integriert, und die Kugelendlosbahnen werden fertiggestellt, indem aus Kunstharz hergestellte Dekkel **80** sowohl auf die vordere als auch hintere Endfläche des Mutternteils aufgepaßt werden. Sind also gemäß Fig. 10 die Deckel **80** am Mutternteil **60** befestigt, so sind die Lastrollrillen **62** und die Kugelrücklauflöcher **63** durch Richtungsänderungswege **81** in U-Form verbunden, die an den Deckeln **80** gebildet sind, wodurch die Kugelendloslaufbahn fertiggestellt ist, die die Kugeln durch die Lastrollrille **62**, den Kugelrichtungsänderungsweg **81**, das Kugelrücklaufloch **63**, den Kugelrichtungsänderungsweg **81** und die Lastrollrille **62** im Umlauf führt.

[0098] Wird gemäß der Kugelkeilvorrichtung dieser Ausführungsform mit dem o. g. Aufbau das Mutternteil **60** auf der Keilwelle **50** bewegt, rollen die Kugeln **3** auf den Lastrollrillen **62** des Mutternteils und den Kugelrollrillen **52** der Keilwelle **50**, und die Kugelverbinder **1** werden in den im Mutternteil **60** gebildeten Endloslaufbahnen im Umlauf geführt.

[0099] Um in diesem Fall gemäß der Kugelkeilvorrichtung dieser Ausführungsform eine Vergrößerung des Mutternteils zu verhindern, ist die Position, an der das Kugelrücklaufloch **63** gebildet wird, als Teil der Kugelendloslaufbahn in der Umgebung der Innenumfangsfläche des Mutternteils angeordnet und nicht in einer Richtung angeordnet, in der die Kugelrollrille **52** der Keilwelle **50** und die Lastrollrille **62** des Mutternteils **60** einander gegenüber liegen, d. h. in Kugelkontaktrichtung. Das heißt, auch in dieser Ausführungsform sind die Richtungsänderungswege **81** der Deckel **80** zum Verbinden der Lastrollrillen **62** mit den Kugelrücklauflöchern **63** so gebildet, daß sie von den Kugelkontaktrichtungen abweichen.

[0100] Gleichwohl hat der Kugelverbinder **1** einen solchen Aufbau, daß er beschreibungsgemäß in jeder Richtung nachgiebig leicht zu verbiegen ist, weshalb er gemäß der Kugelkeilvorrichtung dieser Ausführungsform auch bei Biegung der Richtungsänderungswege **81** die Richtungsänderungswege **81** problemlos durchlaufen kann und sich ein glatter Umlauf des Kugelverbinders **1** in der Endloslaufbahn erreichen läßt.

Sechste Ausführungsform

[0101] Fig. 11 zeigt eine sechste Ausführungsform einer Kugelspindelvorrichtung, auf die der Kugelverbinder angewendet ist.

[0102] In der Zeichnung bezeichnet die Bezugszahl **110** einen Spindelschaft, in dem eine Kugelrollrille **111** in Spiralform mit vorbestimmter Steigung gebildet ist, die Bezugszahl **120** bezeichnet ein Mutternteil mit einer Endloslaufbahn, in die der Kugelverbinder **1** integriert ist und das im Eingriff mit dem Spindelschaft **110** steht, und das Mutternteil **120** wird in Axialrichtung des Spindelschafts **110** durch Relativdrehung zwischen dem Spindelschaft **110** und Mutternteil **120** bewegt. Ferner sind gemäß der Kugelspindelvorrichtung zwei Trassen von Kugelrollrillen **111** am Spindelschaft **110** gebildet, und das Mutternteil **120** ist auch mit zwei Endloslaufbahnen versehen, in die die Kugelverbinder **1** integriert sind.

[0103] In diesem Fall ist das Mutternteil **120** durch einen aus Stahl hergestellten Mutternhauptkörper **121** und ein Paar aus Kunstharz hergestellte Deckel **130** gebildet, die sowohl an der vorderen als auch hinteren Endfläche des Mutternhauptkörpers **121** befestigt sind, und die Endloslaufbahnen der Kugeln **3** sind durch Befestigen der Deckel **130** am Mutternhauptkörper **121** komplettiert.

[0104] Gemäß Fig. 12 und Fig. 13 ist der Mutternhauptkörper **121** zylinderförmig mit einem Durchgangsloch **122** des Spindelschafts **110** in seiner Mitte, und ein Flanschabschnitt **123** zum Befestigen des Mutternhauptkörpers **121** an einem beweglichen Körper, z. B. einem Tisch o. ä., steht von seiner Außenumfangsfläche vor. Ferner sind Lastrollrillen **124**, die den Kugelrollrillen **111** des Spindelschafts **110** gegenüber liegen, in der Innenumfangsfläche des Durchgangslochs **122** spiralförmig gebildet und die lasttragenden Kugeln **3** rollen zwischen den Kugelrollrillen **111** und Lastrollrillen **124**. Die Lastrollrille **124** weist eine sogenannte Spitzbogenform dort auf, wo sich zwei Kugelrollflächen schneiden, und eine Austrittsrille **125** zum Aufnehmen der Gurtteile **5** des Kugelver-binders **1** ist am tiefsten Abschnitt der Rille gebildet.

[0105] Ferner sind zwei Kugelrücklauflöcher **126** im Mutternhauptkörper **121** in Axialrichtung vorgesehen. Vier Trassen von Führungsnuten **126a** zum Führen der Gurtteile **5** des Kugelversbinders **1** sind am Innendurchmesser des Kugelrücklauflochs **126** in Längsrichtung gebildet, und zudem sind Aussparungsabschnitte **126b** an seinen beiden Endöffnungsabschnitten zum Einpassen von Positioniervorsprüngen später erwähnter Rücklaufstücke **131** gebildet. Im übrigen bezeichnet in Fig. 12 die Bezugszahl **127** Bolzenbefestigungslöcher, die sich am Flanschabschnitt **123** öffnen, und die Bezugszahl **128** bezeichnet Gewindelöcher, in die Schrauben zum Befestigen der Deckel **130** eingeschraubt werden.

[0106] Die an den beiden Enden des Mutternhauptkörpers **121** befestigten jeweiligen Deckel **130** sind durch ein Paar der Rücklaufstücke **131** mit Richtungsänderungswegen **140** zum Verbinden der Lastrollrillen **124** des Mutternhauptkörpers **121** mit den Kugelrücklauflöchern **126** sowie durch Abdeckteile **132** gebildet, die an Endabschnitten des Mutternhauptkörpers **121** in einem Zustand befestigt sind, in dem die Rücklaufstücke **131** gehalten werden.

[0107] Gemäß Fig. 14 und Fig. 15 ist im Abdeckteil **132** ein Durchgangsloch **133** entsprechend dem Durchgangsloch **122** des Mutternhauptkörpers gebildet, und im wesentlichen fächerförmige Aussparungsabschnitte **134** zum Aufnehmen der Rücklaufstücke sind an zwei Stellen gebildet, zwischen denen das Durchgangsloch **133** eingefügt ist. Ferner sind auf der Innenumfangsfläche des Durchgangslochs **133** Eintrittswege **135** zum Führen der Kugeln **3** gebildet, die aus den Lastrollrillen **124** des Mutternhauptkörpers **121** in die Richtungsänderungswege **140** des Rücklaufstücks **131** rollen, und Führungsrillen **136** zum Führen der Gurtteile **5** der Kugelverbinder **1** sind auch in den Eintrittswegen **135** gebildet. Im übrigen bezeichnet die Bezugszahl **137** in Fig. 14 Befestigungslöcher zum Befestigen von Schrauben, die mit dem Mutternhauptkörper **121** verschraubt sind.

[0108] Ferner ist gemäß Fig. 16 und Fig. 17 das auf den Aussparungsabschnitt **134** des Abdeckteils **132** aufgepaßte Rücklaufstück **131** durch ein Paar aus einem ersten Stück **131a** und einem zweiten Stück **131b** gebildet, die auf den Aussparungsabschnitt **134** in gegenseitiger Überdeckung aufgepaßt sind, und der Richtungsänderungsweg **140** ist durch Überdecken der Stücke **131a** und **131b** fertiggestellt. Die jeweiligen Stücke **131a** und **131b** sind durch Spritzgießen von Kunstharz hergestellt, ausgesparte Trassenrillen **140a** und **140b** mit einem im wesentlichen halbkreisförmigen Schnitt, die durch Zweiteilen des Richtungsänderungswegs **140** in Längsrichtung erzeugt sind, sind auf der Oberfläche des ersten Stücks **131a** bzw. der Rückfläche des zweiten Stücks **131b** gebildet, und ferner sind Führungsnuten **141a** und **141b** zum Führen der Gurtteile **5** des Kugelverbinders **1** an den ausgesparten Trassenrillen **140a** bzw. **140b** ähnlich gebildet.

[0109] Gemäß Fig. 16 erstreckt sich auf der Innendurchmesserseite des Rücklaufstücks **131** der Richtungsänderungsweg **140** in Tangentialrichtung des Durchgangslochs **133** des Abdeckteils **132**, während gemäß Fig. 17 auf der Außendurchmesserseite der Richtungsänderungsweg **140** zur Oberflächenseite des zweiten Stücks **131b** ansteigt. Dadurch wird die Kugel **3**, die die Rollbewegung in der Lastrollrille **124** des Mutternhauptkörpers **121** beendet hat, in den Richtungsänderungsweg **140** über den Eintrittsweg **135** des Abdeckteils **132** glatt eingeführt, während sich die Rollrichtung von der Radialrichtung zur Axialrichtung des Mutternteils **120** ändert, und die Kugel **3** wird störungsfrei zum Kugelrücklaufloch **126** des Mutternhauptkörpers **121** transportiert.

[0110] Ferner stehen Vorsprungstücke **142a** und **142b** in Halbkreisform auf Oberflächen der jeweiligen Stücke **131a** und **131b** entsprechend dem Richtungsänderungsweg **140** vor, und bei Überdeckung des ersten Stücks **131a** und zweiten Stücks **131b** kombinieren sich die Vorsprungstücke **142a** und **142b**, wodurch der Positioniervorsprung **142** des Rücklaufstücks **131** an einem Endabschnitt des Richtungsänderungswegs **140** gebildet ist.

[0111] Weiterhin sind die Stücke **131a** und **131b** am Aussparungsabschnitt **134** des Abdeckteils **132** in einer Reihenfolge vom ersten Stück **130a** aufgepaßt, und das Abdeckteil **132** ist am Mutternhauptkörper **121** so befestigt, daß das zweite Stück **131b** mit dem Mutternhauptkörper **121** in Kontakt steht, wodurch die Befestigung des Deckels **130** am Mutternhauptkörper **121** abgeschlossen ist. Dadurch sind gemäß Fig. 18 die Lastrollrille **124** des Mutternhauptkörpers **121** und das Kugelrücklaufloch **126** durch den Richtungsänderungsweg **140** verbunden, und die Endloslaufbahn der Kugeln **3** ist im Mutternteil **120** gebildet. In diesem Fall ist durch Aufpassen des am Rücklaufstück **131** gebildeten Positioniervorsprungs **142** auf den am Endabschnitt des Kugelrücklauflochs **126** des Mutternhauptkörpers **121** gebildeten Aussparungsabschnitt **126b** die Positionsbeziehung zwischen dem Mutternhauptkörper **121** und dem Deckel **130** ordnungsgemäß hergestellt, und ein glattes Rollen der Kugeln **3** zwischen dem Kugelrücklaufloch **126** und dem Richtungsänderungsweg **140** ist gewährleistet. Im übrigen zeigt Fig. 18 in Perspektive den am Mutternhauptkörper **121** angeordneten Deckel **130** aus der Axialrichtung des Spindelschafts **110**.

[0112] Dreht gemäß der Kugelspindelvorrichtung der Ausführungsform mit dem zuvor beschriebenen Aufbau der Spindelschaft **110** relativ zum Mutternteil **120**, rollen die in den Kugelverbinder **1** integrierten Kugeln **3** in der Lastrollrille **124** des Mutternteils **120** und Kugelrollrille **111** des Spindelschafts **110**, und der Kugelverbinder **1** wird in der im Mutternteil **120** gebildeten Endloslaufbahn im Umlauf geführt.

[0113] Gemäß der Kugelspindelvorrichtung dieser Ausführungsform ist in diesem Fall der Kugelverbinder **1** spiralförmig um den Außenumfang des Spindelschafts **110** gewickelt, weshalb der Kugelverbinder **1** in der Endlosbahn begleitet von Verdrehung im Umlauf geführt wird. Da aber der Kugelverbinder **1** dieser Ausführungsform den Aufbau hat, bei dem er sich beschreibungsgemäß in jeder Richtung nachgiebig leicht verbiegen und leicht verdrehen läßt, kann der Kugelverbinder **1** in der Endloslaufbahn des Mutternteils **120** problemlos im Umlauf geführt werden, und eine glatte Umlaufführung des Kugelverbinders **1** in der Endlosbahn läßt sich erreichen.

[0114] Auch bei häufigem Verbiegen oder Verdrehen des Kugelverbinders **1** sind gemäß dem Kugelverbinder **1** dieser Ausführungsform die Kugeln **3** durch den Verbindergurt **2** vollständig umschlossen, weshalb sich die Kugeln **3** nicht vom Kugelverbinder **1** lösen und unbeabsichtigtes Trennen der Kugeln **3** von der Endloslaufbahn von vornherein verhindert werden kann.

Siebente Ausführungsform

[0115] Fig. 19 zeigt eine siebente Ausführungsform, in der ein erfindungsgemäßer Kugelverbinder auf eine Kugelspindelvorrichtung angewendet ist.

[0116] Während gemäß der o. g. sechsten Ausführungsform die Endloslaufbahnen der Kugeln mit Hilfe der Deckel gebildet sind, die sowohl an der vorderen als auch hinteren Endfläche des Mutternhauptkörpers befestigt sind, und die Kugelverbinder gemäß Fig. 1 in die Endloslaufbahnen integriert sind, ist gemäß dieser Ausführungsform eine Kugelendloslaufbahn durch ein Rücklaufrohr gebildet, das an einem Mutternteil befestigt ist, und der gleiche Kugelverbinder **1** wie in der sechsten Ausführungsform ist in die Endloslaufbahn integriert.

[0117] In der Zeichnung bezeichnet die Bezugszahl **150** einen Spindelschaft, in dem eine Kugelrollrille **151** in Spiralform gebildet ist, die Bezugszahl **152** bezeichnet ein Mutternteil, in dem eine Lastrollrille **153** gegenüber der o. g. Kugelrollrille **151** gebildet ist, und die Bezugszahl **154** bezeichnet ein Rücklaufrohr, das am Mutternteil **152** befestigt ist. Das Rücklaufrohr ist am Mutternteil **152** so befestigt, daß mehrere Windungen der Kugelrollrille **151** des Spindelschafts übersprungen werden, und die Kugeln **3** werden durch einen Endabschnitt des Rücklaufrohrs **154** aus der Kugelrollrille **151** des Spindelschafts **150** nach oben geführt, rollen im Rücklaufrohr **154** und werden in die Kugelrollrille **151** unter Überspringen mehrerer Windungen in Vorwärtsrichtung übergeben, wodurch die Kugeln **3** im Mutternteil **152** endlos umlaufen.

[0118] Gemäß **Fig.** 20(a) und 20(b) ist das Rücklaufrohr **154** durch Kombinieren eines Paars Rohrhälften **155** gebildet, deren Schnitt jeweils im wesentlichen halbkreisförmig ist, und die jeweiligen Rohrhälften **155** sind durch Spritzgießen von Kunstharz hergestellt. Ferner ist eine ausgesparte Trassenrille **156**, die einen Kugelrücklaufweg bildet, an jeder der Rohrhälften **155** gebildet, während Führungsrillen **157** zum Führen der Gurtteile **5** des Kugelverbinders **1** an der ausgesparten Trassenrille **156** gebildet sind.

[0119] Auch bei der Kugelspindelvorrichtung gemäß der Ausführungsform mit dem zuvor beschriebenen Aufbau hat der in die Endloslaufbahn des Mutternteils **152** integrierte Kugelverbinder **1** einen Aufbau, bei dem er in jeder Richtung nachgiebig leicht zu verbiegen und leicht zu verdrehen ist, weshalb er in der Endloslaufbahn des Mutternteils **152** problemlos im Umlauf geführt werden kann und sich eine glatte Umlaufführung des Kugelverbinders **1** in der Endloslaufbahn erreichen läßt.

[0120] Ferner wird der Kugelverbinder **1** in der Endloslaufbahn in einem Zustand im Kreislauf geführt, in dem die Gurtteile **5** in die Führungsrillen **157** des Rücklaufrohrs **154** eingepaßt sind, weshalb bei Annäherung der Kugeln **3** an das Rücklaufrohr **154** diese in das Rücklaufrohr **154** gezogen werden, indem sie durch den Verbindergurt **2** gezogen werden, der den Kugelverbinder **1** bildet, so daß die Kugeln **3** glatt in das Rücklaufrohr **154** ein- und aus ihm austreten können und der Umlauf der Kugeln **3** in der Endloslaufbahn dadurch auch glatt durchgeführt werden kann.

Achte Ausführungsform

[0121] Als nächstes zeigt Fig. 21 eine achte Ausführungsform, in der der erfindungsgemäße Kugelverbinder auf eine Kugelspindelvorrichtung angewendet ist.

[0122] Gemäß der achten Ausführungsform ist anstelle des Rücklaufrohrs **154**, das in der o. g. siebenten Ausführungsform zum Einsatz kommt, ein Ablenker **160** am Mutternteil **152** befestigt, die Endloslaufbahn der Kugeln **3** ist mit Hilfe des Ablenkers **160** gebildet, und der zuvor beschriebene Kugelverbinder **1** ist in die Endloslaufbahn integriert. Ansonsten ähnelt der Aufbau dem in der zuvor beschriebenen siebenten Ausführungsform, weshalb in Fig. 21 die gleichen Bezugszahlen verwendet werden und auf eine nähere Beschreibung verzichtet wird.

[0123] Gemäß Fig. 21 ist der Ablenker **160** am Mutternteil **152** so befestigt, daß eine Windung der Kugelrollrille **151** des Spindelschafts **150** übersprungen wird, der Laufweg der aus der Kugelrollrille **151** rollenden Kugeln **3** wird durch den Ablenker **160** geändert, und die Kugeln **3** werden zu den Kugelrollrillen **151** unter Überspringen einer Windung in Vorwärtsrichtung zurückgeführt, indem sie über den Außendurchmesser des Spindelschafts **150** laufen, wodurch die Kugeln **3** im Mutternteil **152** endlos umlaufen. Ferner sind drei Ablenker **160** am Mutternteil **152** in dieser Ausführungsform befestigt, um den Umfang des Mutternteils **152** dreizuteilen, und insgesamt drei Endloslaufbahnen der Kugeln **3** sind gebildet. Somit sind drei Kugelverbinder **1** in das Mutternteil **152** integriert.

[0124] Fig. 22 bis Fig. 24 zeigen einen näheren Aufbau des Ablenkers **160**.

[0125] Eine im wesentlichen S-trassenförmige Kugelrücklaufrille **161** ist im Ablenker **160** gebildet, und Führungsrillen **162** zum Führen der Gurtteile **5** des Kugelverbinders **1** sind in der Mitte und an beiden Seiten der Kugelrücklaufrille **161** gebildet. Ferner hat die Kugelrücklaufrille **161** eine Form, bei der sie am Mittelabschnitt des Ablenkers **160** am stärksten vertieft ist, so daß die in die Kugelrücklaufrille **161** rollenden Kugeln **3** über den Außendurchmesser des Spindelschafts **150** laufen können.

[0126] Auch in der Kugelspindelvorrichtung gemäß der Ausführungsform mit dem zuvor beschriebenen Aufbau hat der Kugelverbinder **1** so einen Aufbau, daß der in die Endloslaufbahn des Mutternteils **152** integrierte Kugelverbinder **1** in jeder Richtung nachgiebig leicht zu verbiegen und leicht zu verdrehen ist, weshalb der Kugelverbinder **1** in der Endloslaufbahn des Mutternteils **152** problemlos im Umlauf geführt werden kann und sich ein glatter Umlauf des Kugelverbinders **1** in der Endloslaufbahn erreichen läßt.

[0127] Ferner läuft der Kugelverbinder **1** auch in dieser Ausführungsform in der Endloslaufbahn in einem Zustand um, in dem die Gurtteile **5** in die Führungsrillen **161** des Ablenkers **160** eingepaßt sind, weshalb bei Annäherung der Kugeln **3** an den Ablenker **160** diese in den Ablenker **160** aus der Kugelrollrille **151** des Spindelschafts **150** gezogen werden, indem sie durch den Verbindergurt **2** gezogen werden, weshalb die Bewegung der Kugeln **3** bei ihrem Lauf über den Außendurchmesser des Spindelschafts **150** glatt erfolgt und der Umlauf der Kugeln **3** in der Endloslaufbahn dadurch auch glatt durchgeführt werden kann.

Gewerbliche Anwendbarkeit

[0128] Wie zuvor erläutert, hat der erfindungsgemäße Kugelverbinder so einen Aufbau, daß der Verbindergurt so geformt ist, daß er zwischen den einander benachbarten Kugeln eingeschnürt ist, in jeder Richtung nachgiebig leicht zu verbiegen ist und die auf den Kugelverbinder wirkende Verdrehungen leicht aufnehmen kann, weshalb er bei Integration des Kugelverbinders in eine Kugelendloslaufbahn einer Linearführungsvorrichtung, einer Kugelspindelvorrichtung o. ä. frei verbogen oder verdreht werden kann und er sich auch in einem solchen Verwendungszustand in der Endloslaufbahn glatt im Umlauf führen läßt.

[0129] Gemäß dem Kugelverbinder der Erfindung befinden sich ferner die in ihn integrierten Kugeln in einem Zustand, in dem sie durch den Verbindergurt vollständig umfaßt sind, und auch bei erheblicher Verbiegung oder Verdrehung des Kugelverbinders lösen sich die Kugeln nicht vom Verbindergurt, weshalb durch Integrieren des Kugelverbinders in die Kugelendloslaufbahn einer Linearführungsvorrichtung, einer Kugelspindelvorrichtung o. ä., ohne Verwendung eines Kugelkäfigs verhindert werden kann, daß sich die Kugeln aus der Endloslaufbahn lösen.

Patentansprüche

1. Kugelverbinder (**1**) mit mehreren Kugeln (**3**), die in einer Reihe mit vorbestimmten Abständen angeordnet sind, und einem flexiblen Verbindergurt (**2**) zum drehbaren Halten der Kugeln und gegenseitigen Verbinden der einander benachbarten Kugeln, wobei der Verbindergurt aufweist:
vier Gurtteile (**5**), die in streifenartiger Form entlang von Umfangsflächen der Kugeln gebildet und mit den mehreren Kugeln in Kontakt gebracht sind; und
wobei die Gurtteile mit anderen Gurtteilen an Zwischenstellen der einander benachbarten Kugeln miteinander verbunden sind und der Verbindergurt in einer Form ausgebildet ist, die im Vergleich zum Außendurchmesser der Kugeln an Positionen der die Kugeln verbindenden Zwischenstellen eingeschnürt ist.

2. Kugelverbinder (**1**) nach Anspruch 1, wobei der Verbindergurt (**2**) mit den Gurtteilen (**5**) so angeordnet ist, daß die Kugelfläche jeder Kugel viergeteilt ist.

3. Linearführungsvorrichtung mit dem Kugelverbinder (**1**) nach Anspruch 1, wobei die Linearführungsvorrichtung aufweist:
einen Führungsschaft (**10**) mit Kugelrollrillen (**11**) zum Abrollen von Kugeln (**3**) in Längsrichtung;
ein Gleitteil (**20**) mit Lastrollrillen (**23**) zum Abrollen der lasttragenden Kugeln zwischen dem Führungsschaft und den Lastrollrillen, das Endloslaufbahnen zum Umlauf der Kugeln hat und entlang dem Führungsschaft entsprechend dem Umlauf der Kugeln bewegt wird; und
wobei der Kugelverbinder (**1**) nach Anspruch 1 in eine der Endloslaufbahnen integriert ist und der Kugelverbinder entsprechend einer Relativbewegung zwischen dem Führungsschaft und dem Gleitteil in der Endloslaufbahn im Umlauf geführt wird.

4. Linearführungsvorrichtung nach Anspruch 3, wobei jede der Kugelrollrillen (**11**) des Führungsschafts (**10**) und der Lastrollrillen (**23**) des Gleitteils (**20**) mit einem spitzbogenförmigen Abschnitt versehen ist, wo sich ein Paar Kugelrollflächen schneidet, und Austrittsrillen zum Aufnehmen und Führen von Verbindungsabschnitten (**4**) des Kugelverbinders an einem tiefsten Abschnitt jeder Kugelrollrille (**11**) und Lastrollrille (**23**) spitzbogenförmig ausgebildet sind.

5. Linearführungsvorrichtung nach Anspruch 3, wobei jede der Kugelrollrillen (**11**) des Führungsschafts (**10**) und der Lastrollrillen (**23**) des Gleitteils (**20**) mit einem kreisbogenförmigen Abschnitt versehen ist und eine einzige Kugelrollfläche aufweist.

6. Kugelspindelvorrichtung mit dem Kugelverbinder (**1**) nach Anspruch 1, wobei die Kugelspindelvorrichtung aufweist:
einen Spindelschaft (**50**) mit Kugelrollrillen in Spiralform zum Abrollen von Kugeln (**3**) an einer Außenumfangsfläche davon;
ein Mutternteil (**60**) mit Lastrollrillen (**62**) in Spiralform zum Abrollen der lasttragenden Kugeln zwischen dem Spindelschaft und den Lastrollrillen (**62**), das Endloslaufbahnen zum Umlauf der Kugeln hat und auf den Spindelschaft über die Kugeln aufgeschraubt ist; und
wobei der Kugelverbinder (**1**) nach Anspruch 1 in eine der Endloslaufbahnen integriert ist und der Kugelverbinder (**1**) entsprechend einer Relativbewegung zwischen dem Spindelschaft und dem Mutternteil in der Endloslaufbahn im Umlauf geführt wird.

Es folgen 22 Blatt Zeichnungen

Anhängende Zeichnungen

Fig. 1

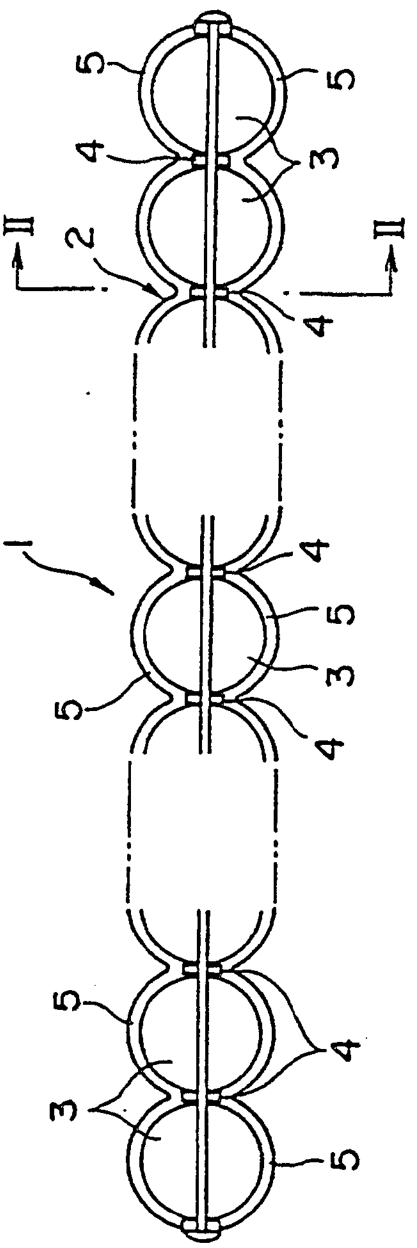


Fig. 2

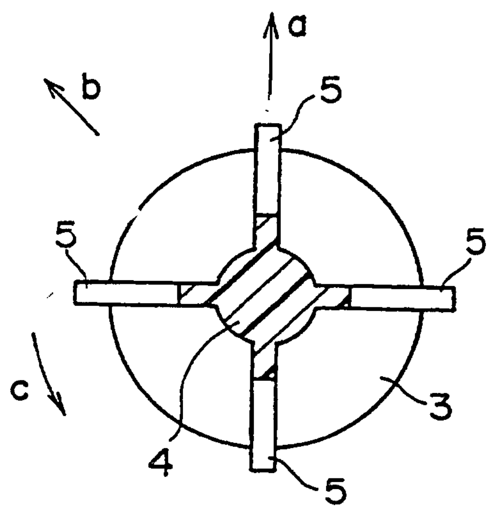


Fig. 3

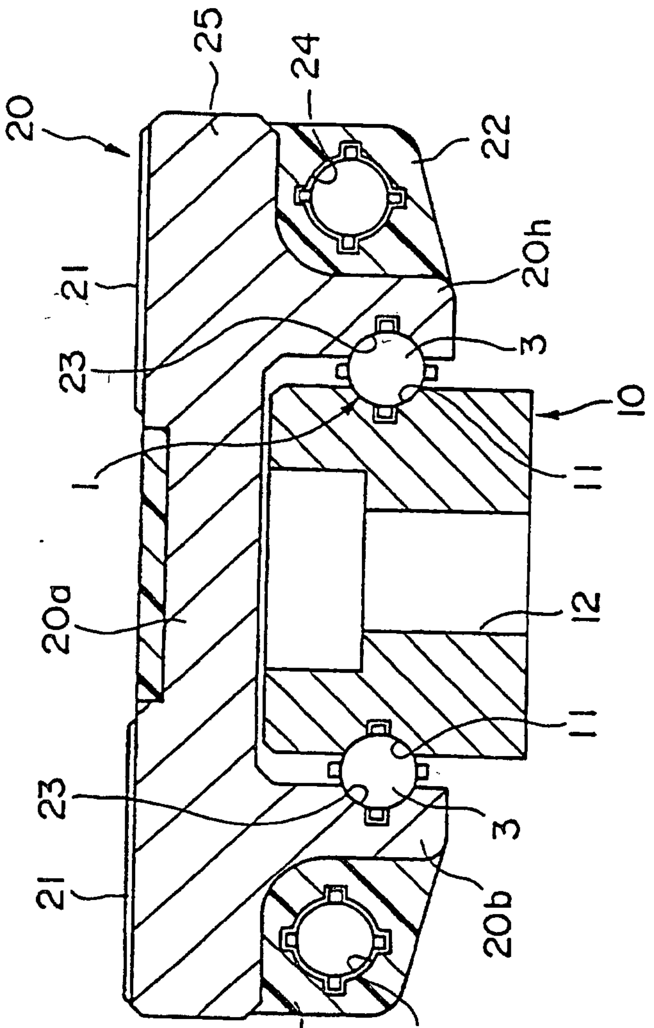


Fig. 4

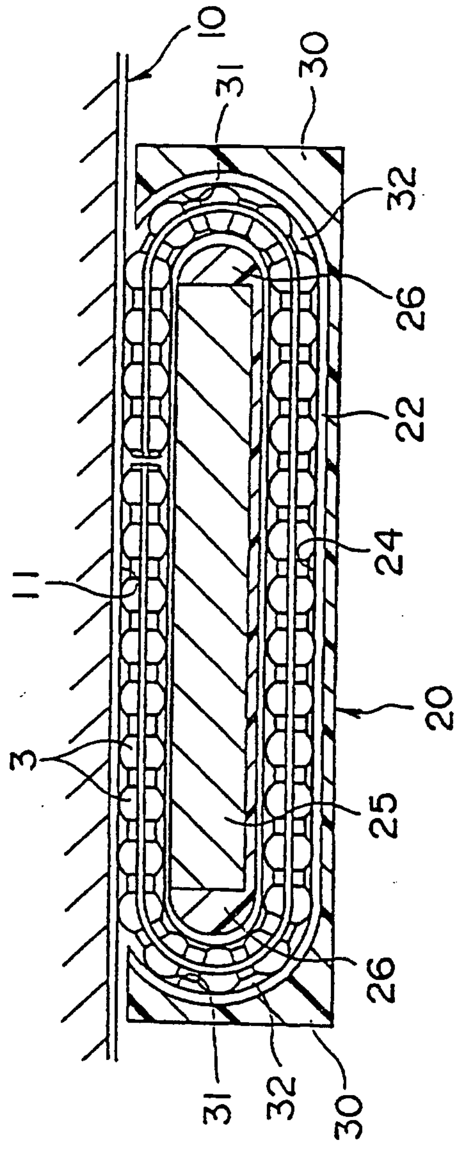


Fig. 5

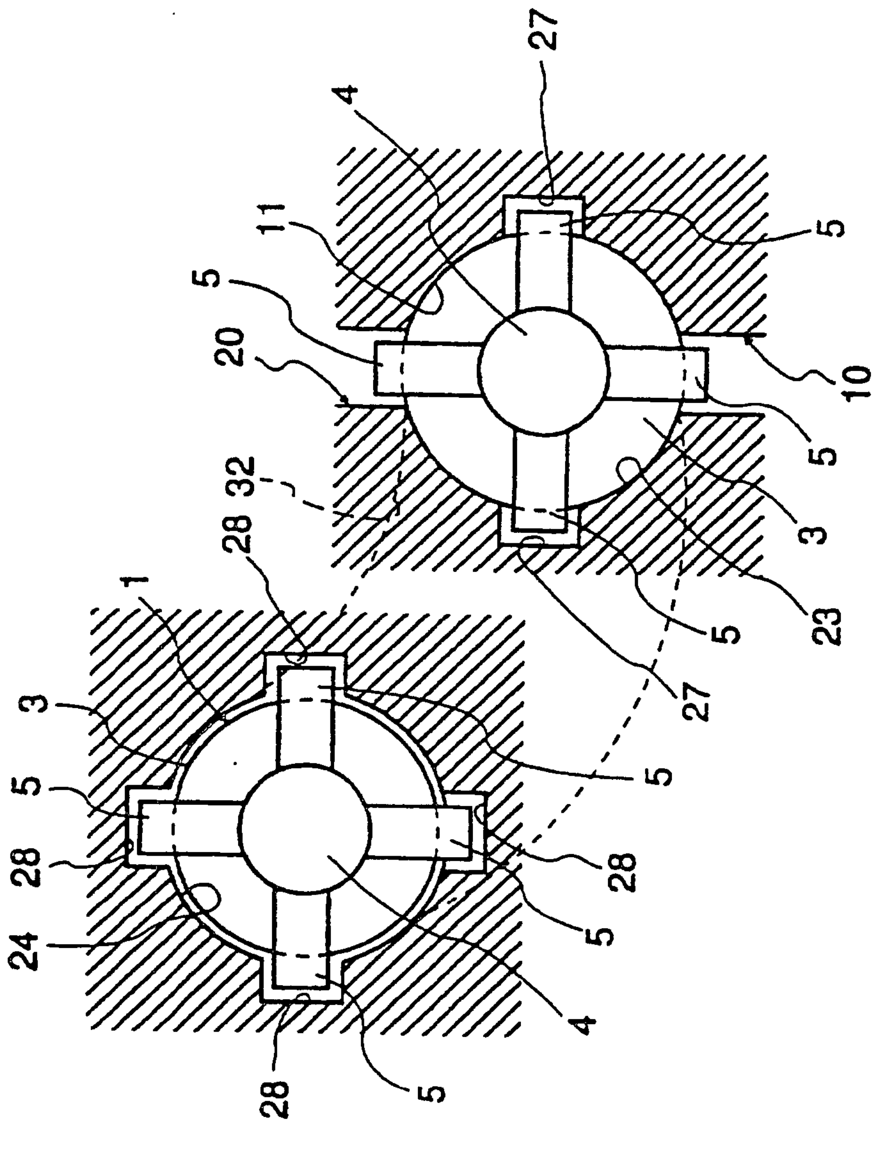


Fig. 6

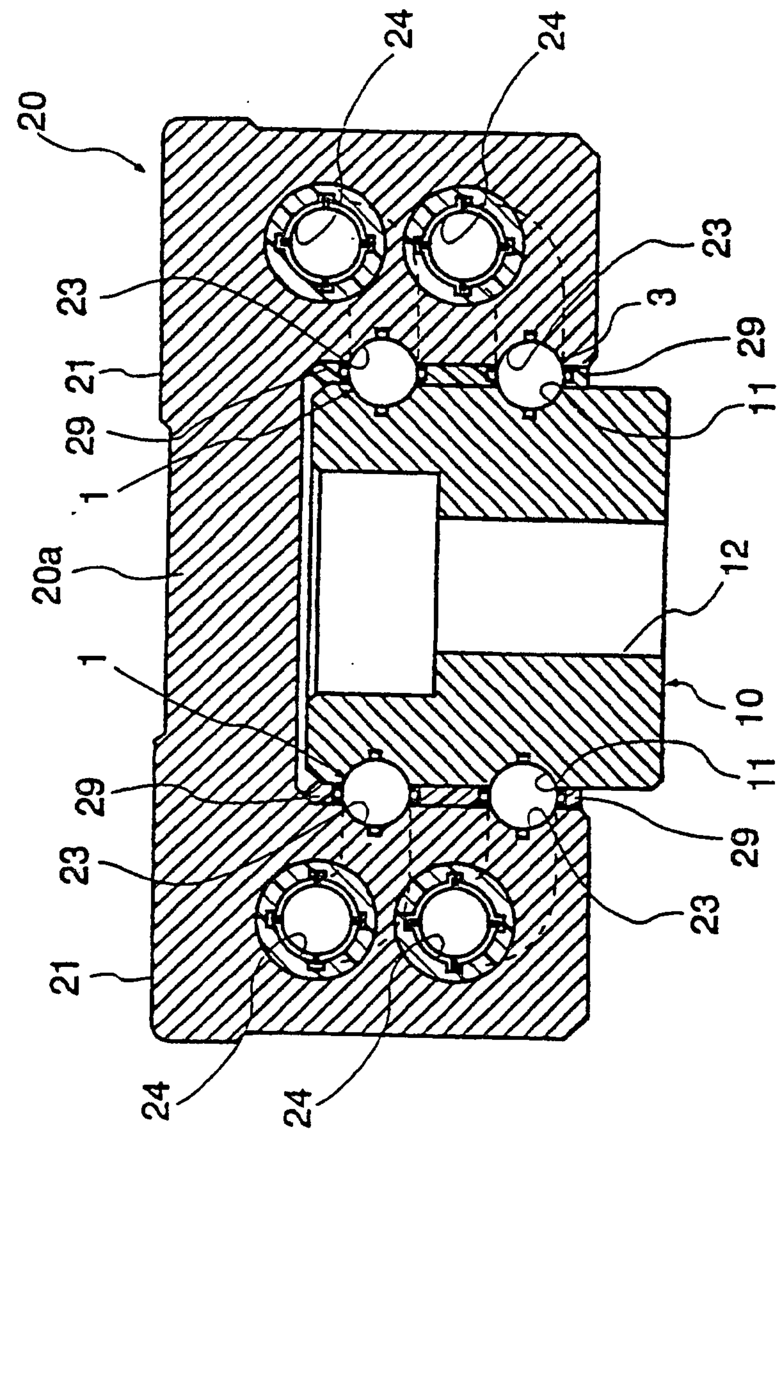


Fig. 7

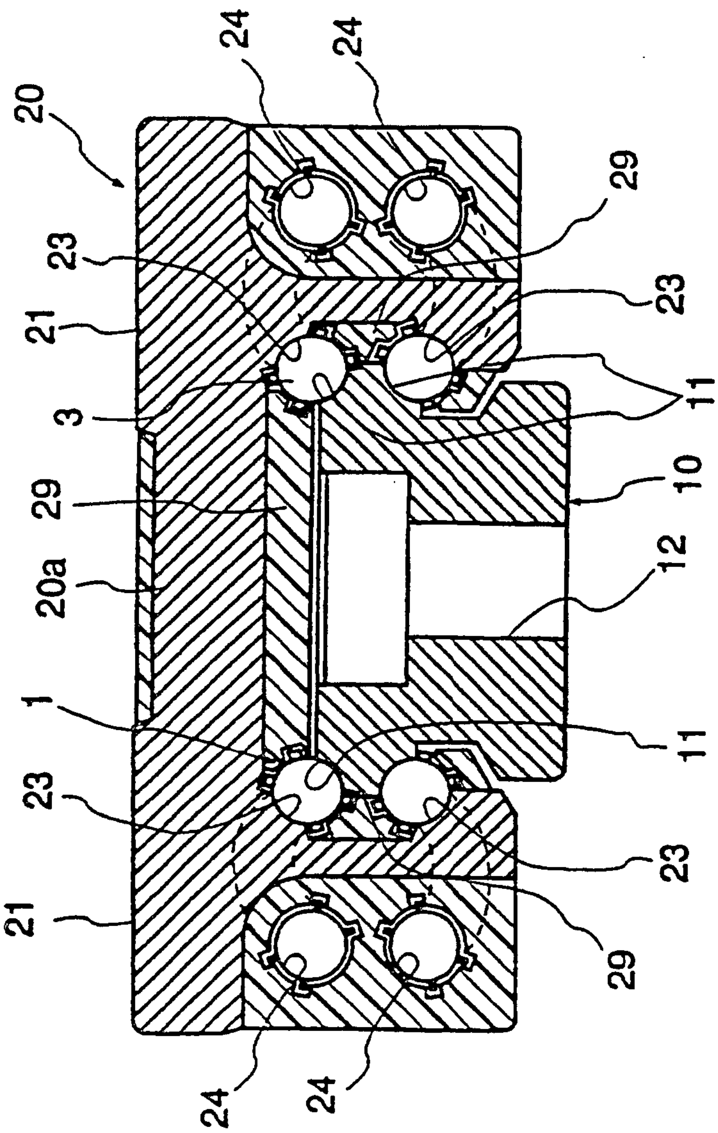


Fig. 8

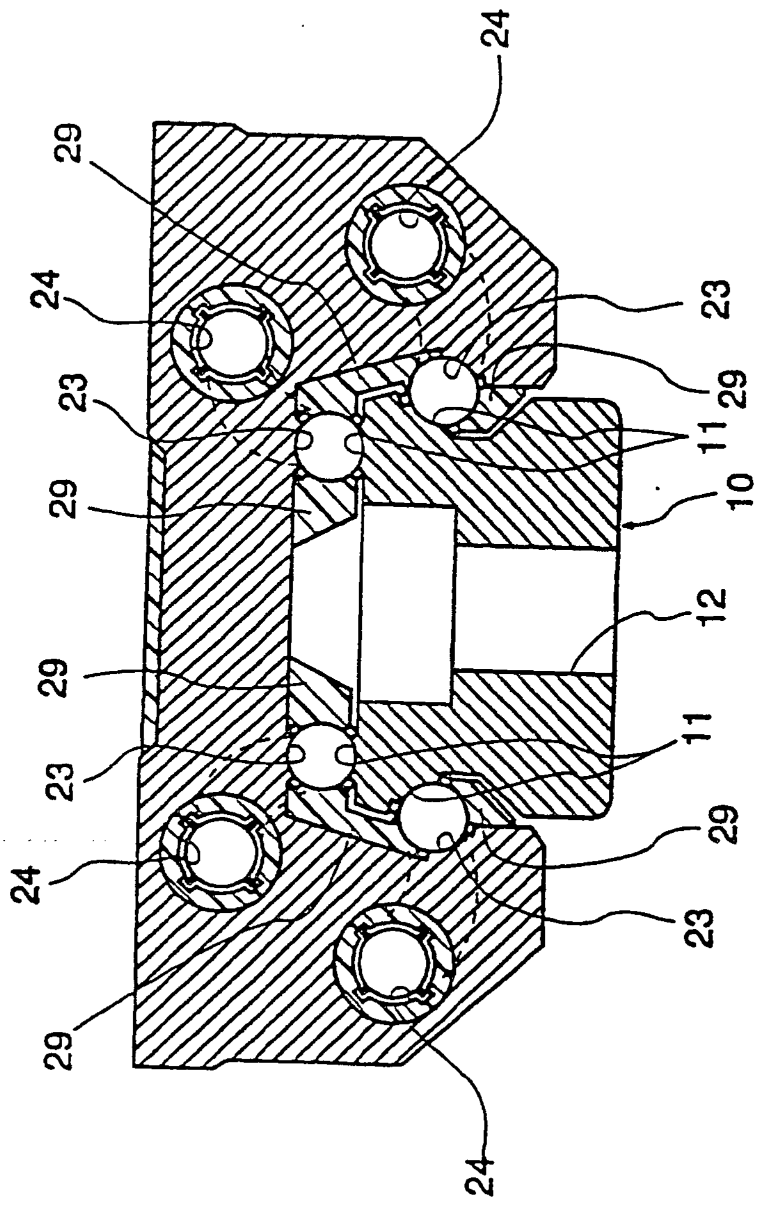


Fig. 9

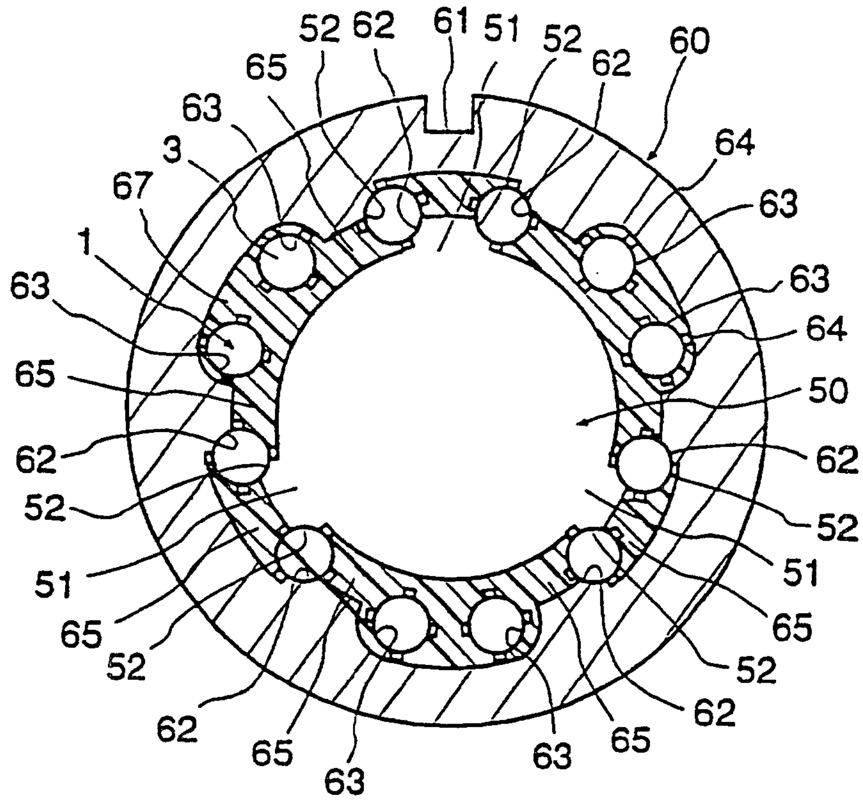
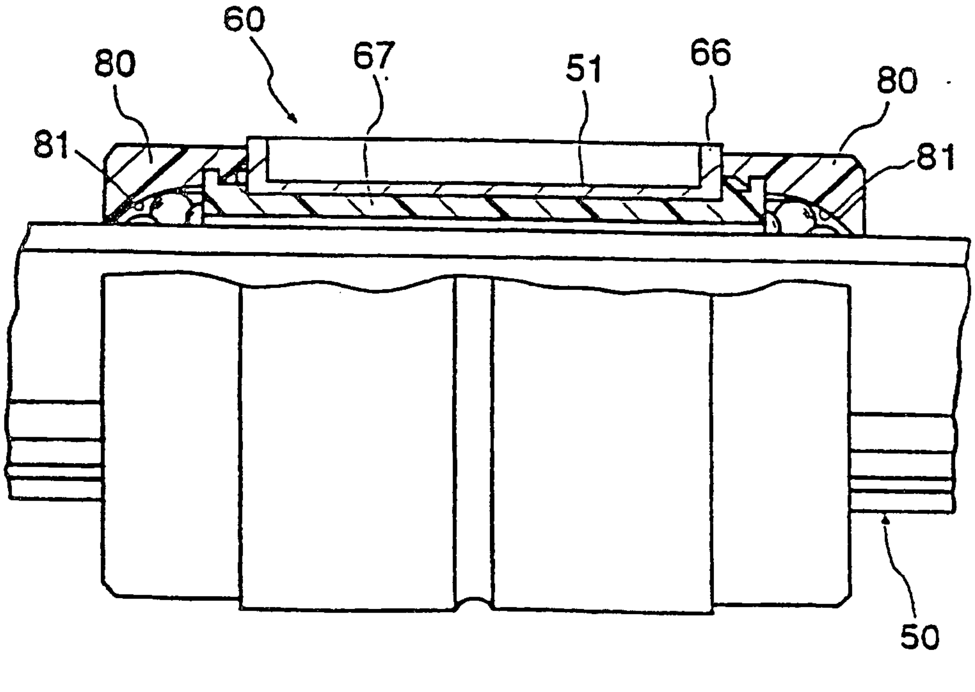

52
62
61
51
52
62
60
65
63
64
3
63
67
63
1
64
63
65
50
62
62
52
52
51
51
65
65
52
52
62
62
65
63
63
65

Fig. 10


60
80
67
51
66
80
81
81
50

F i g.11

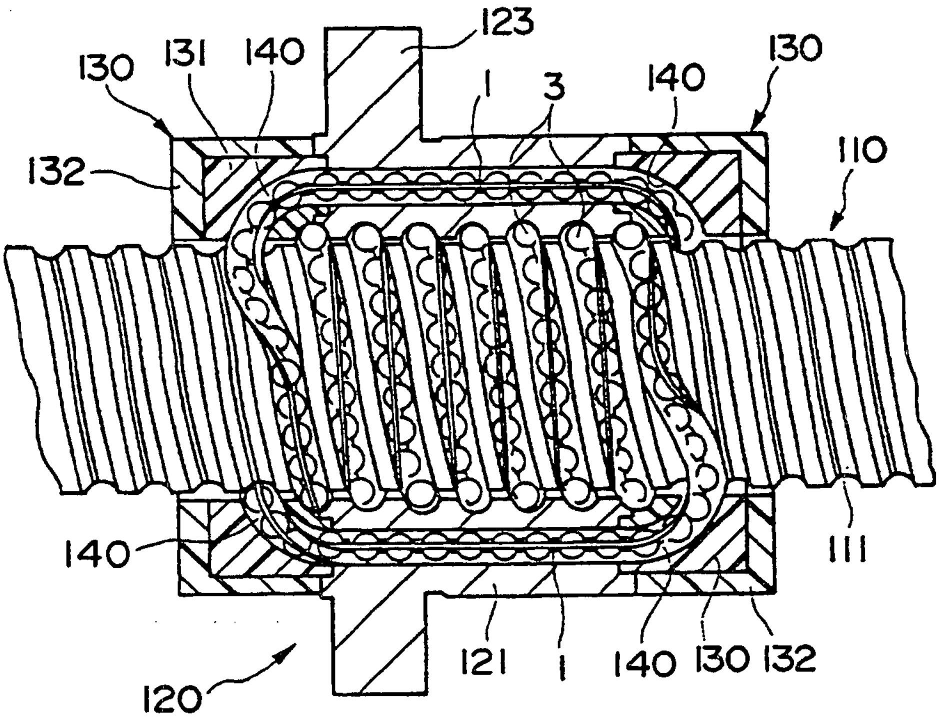


Fig.12

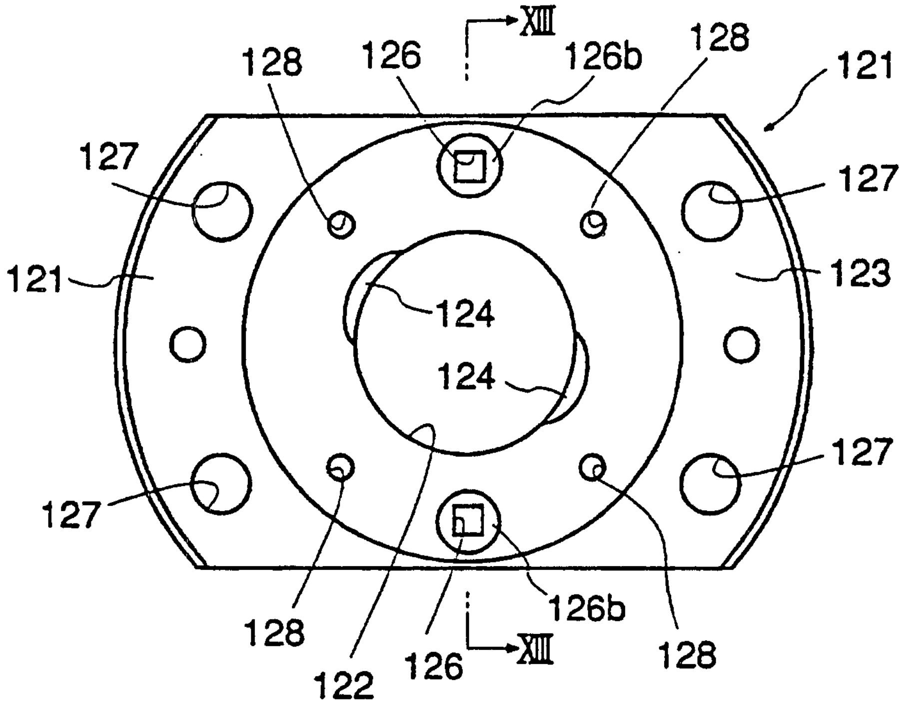
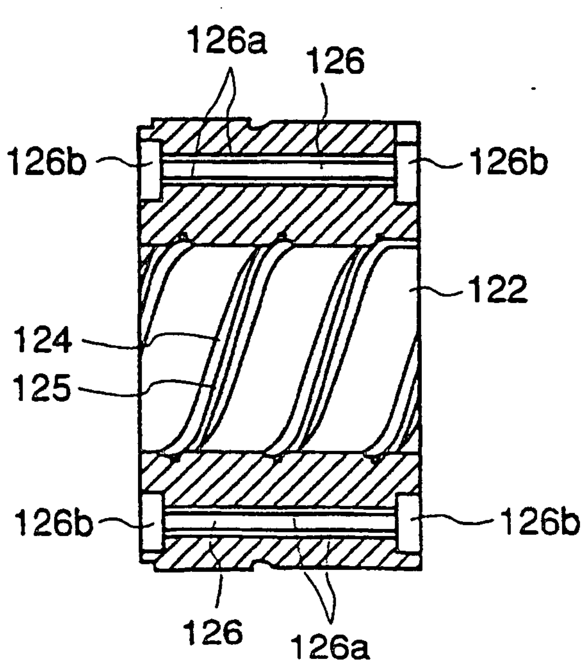
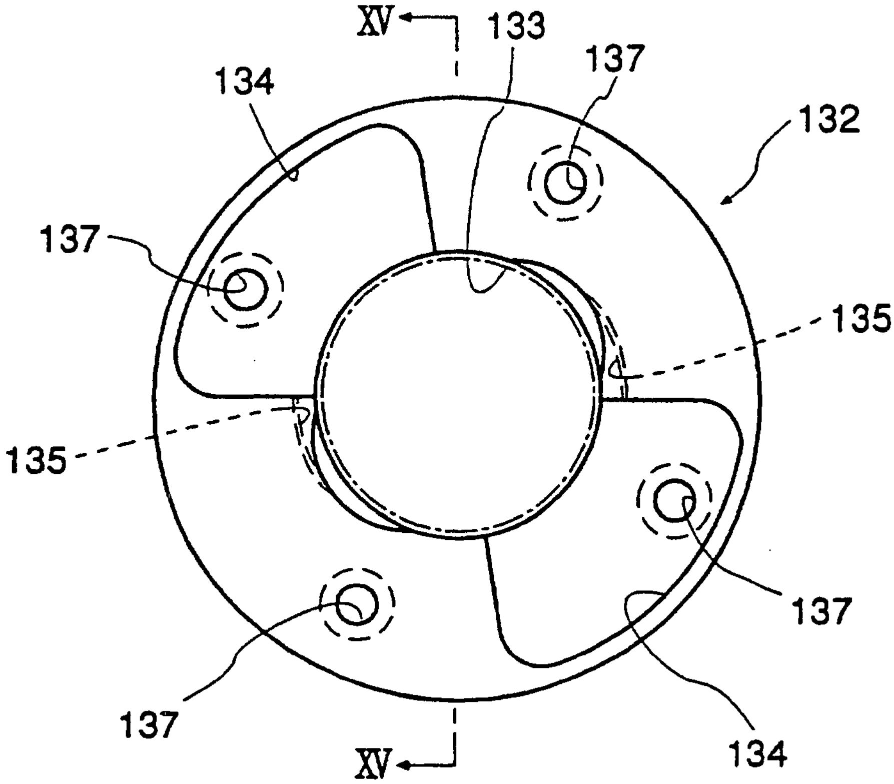

XIII
128
126
126b
128
121
127
127
121
123
124
124
127
127
128
126b
128
126
XIII
122

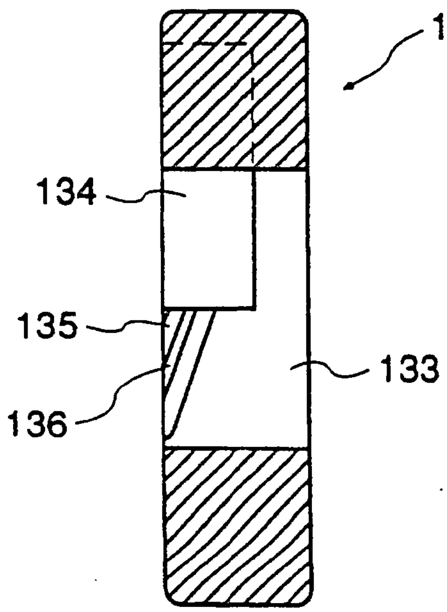
Fig.13


126a
126
126b
126b
122
124
125
126b
126b
126
126a

F i g.14



F i g.15



F i g.16

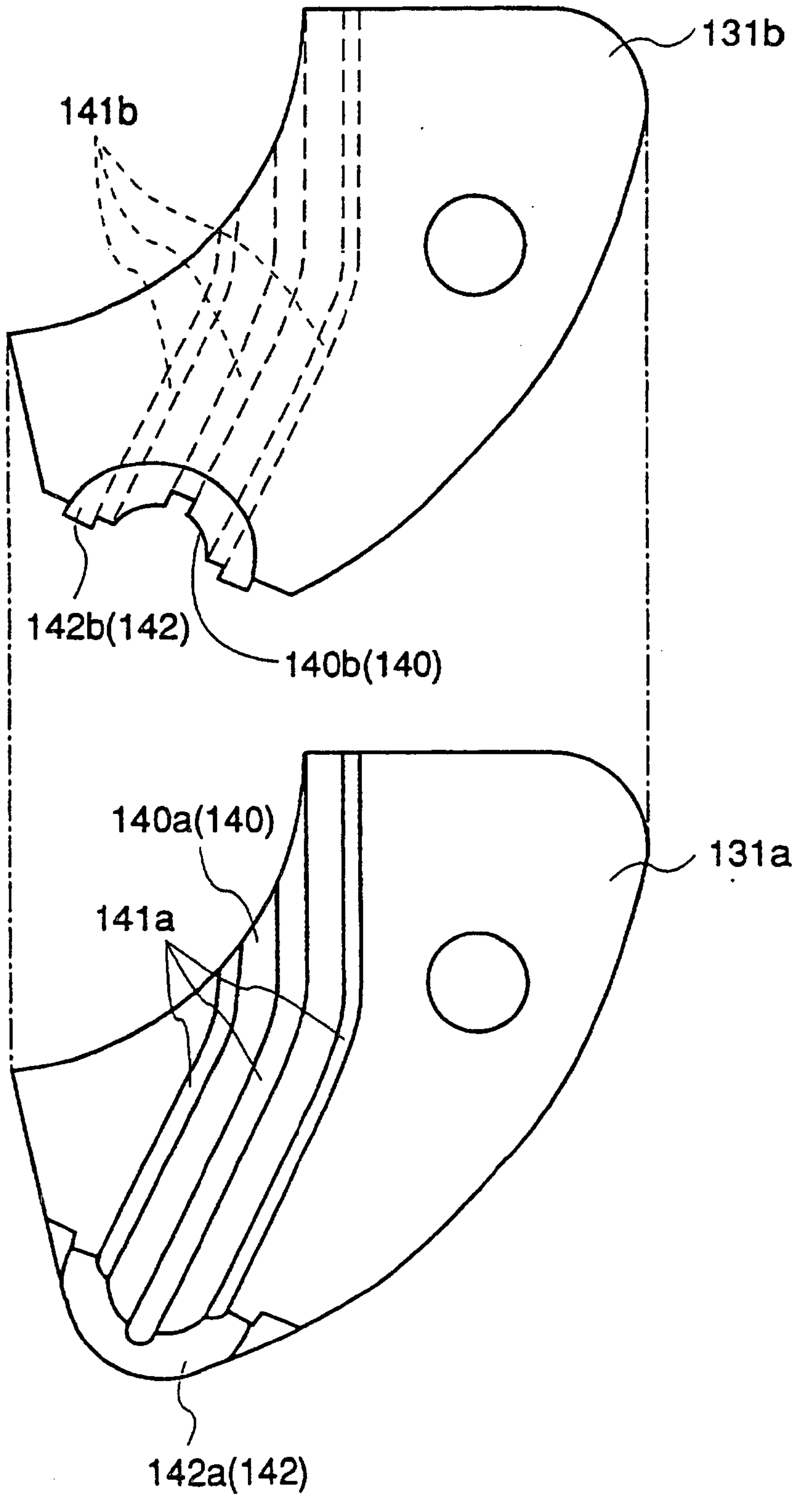
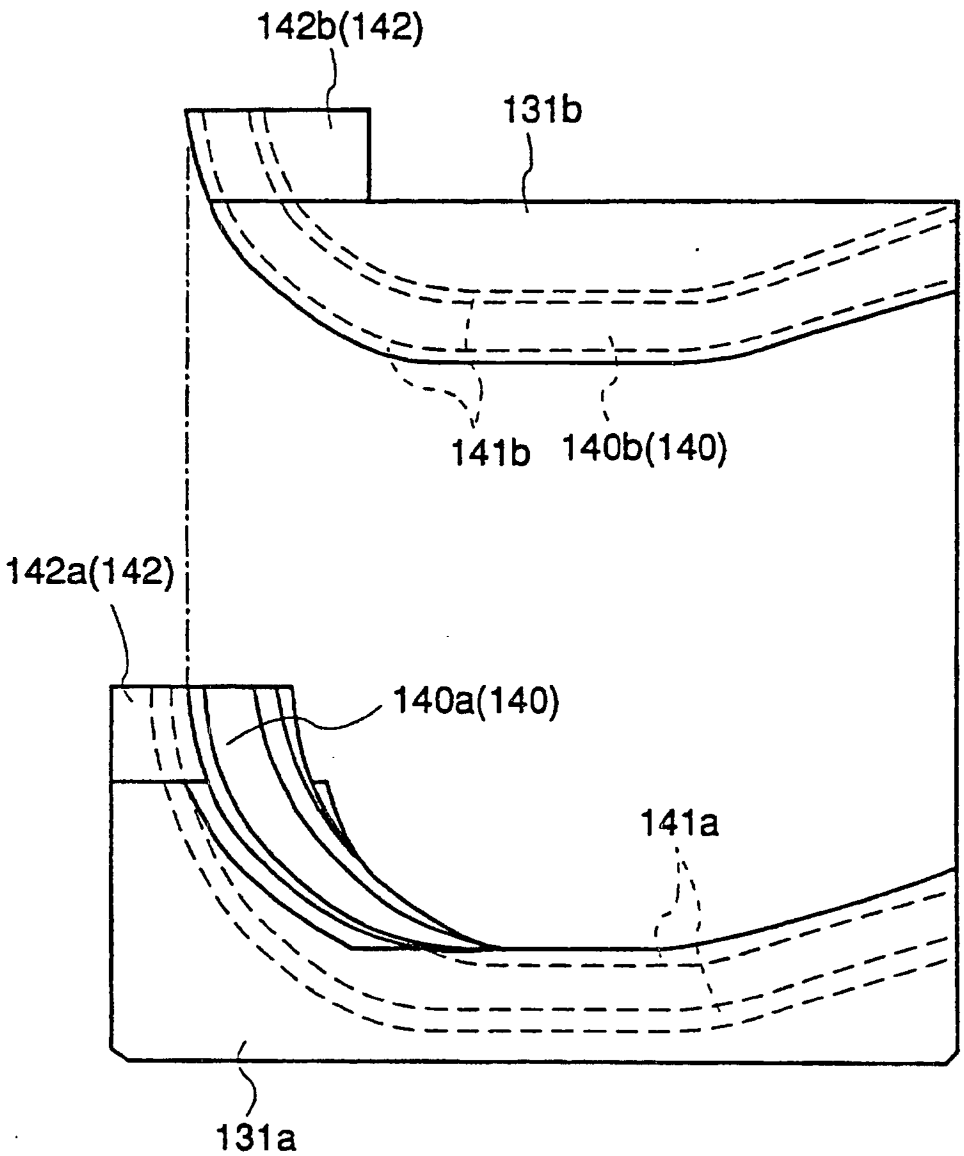


Fig.17



F i g.18

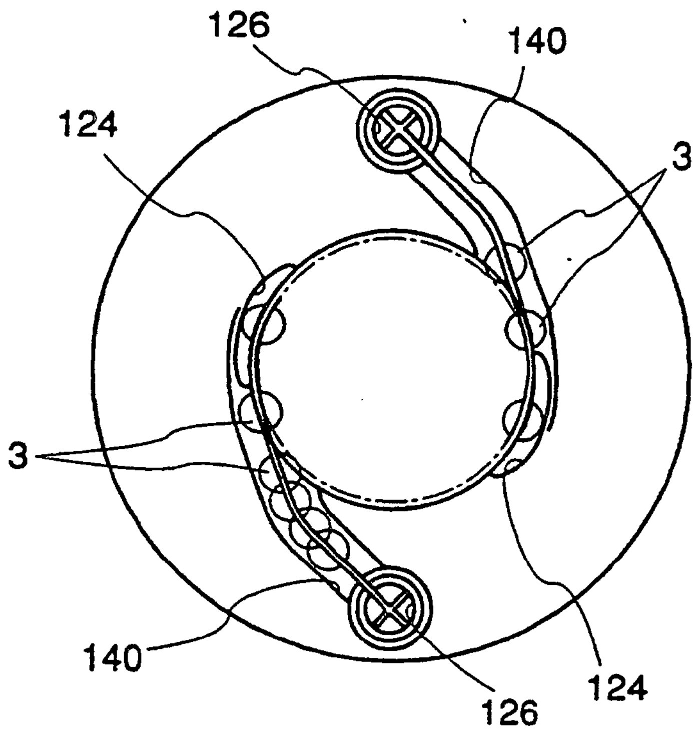
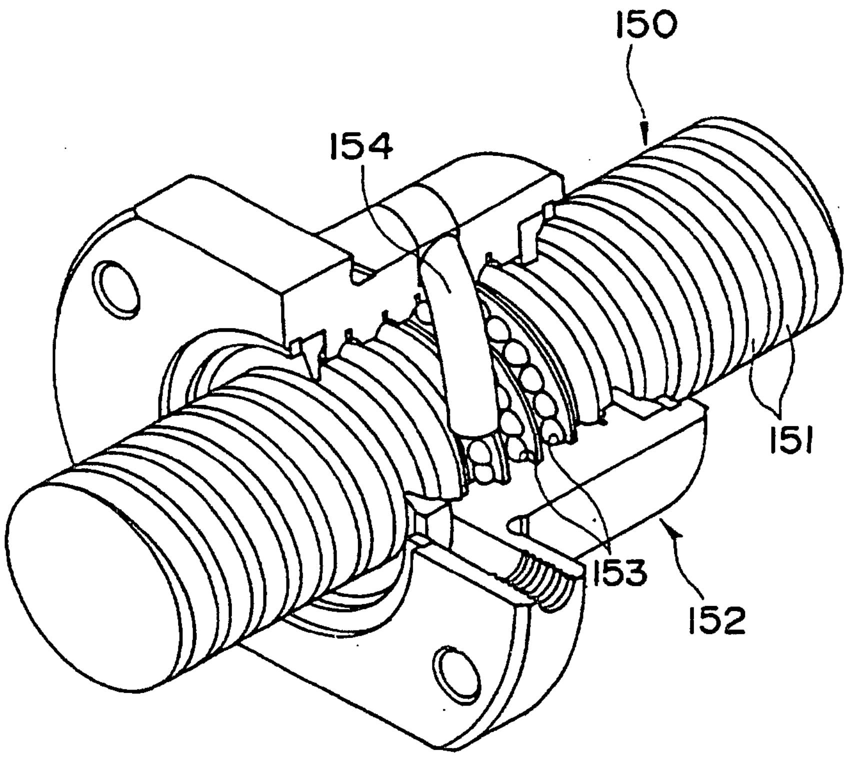
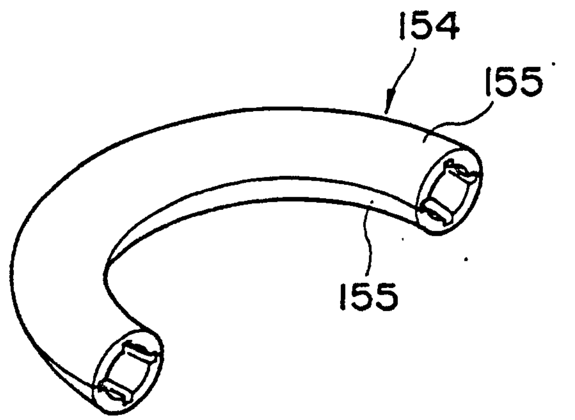


Fig.19



(a)



(b)

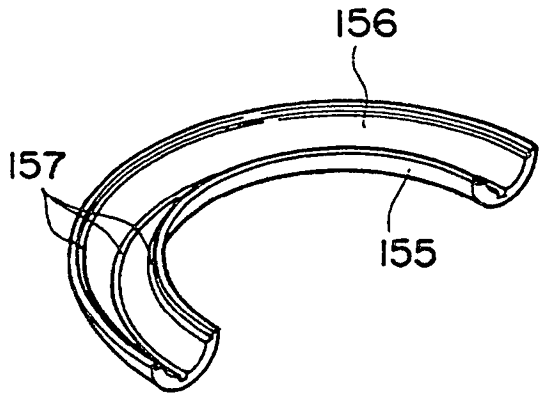


Fig.21

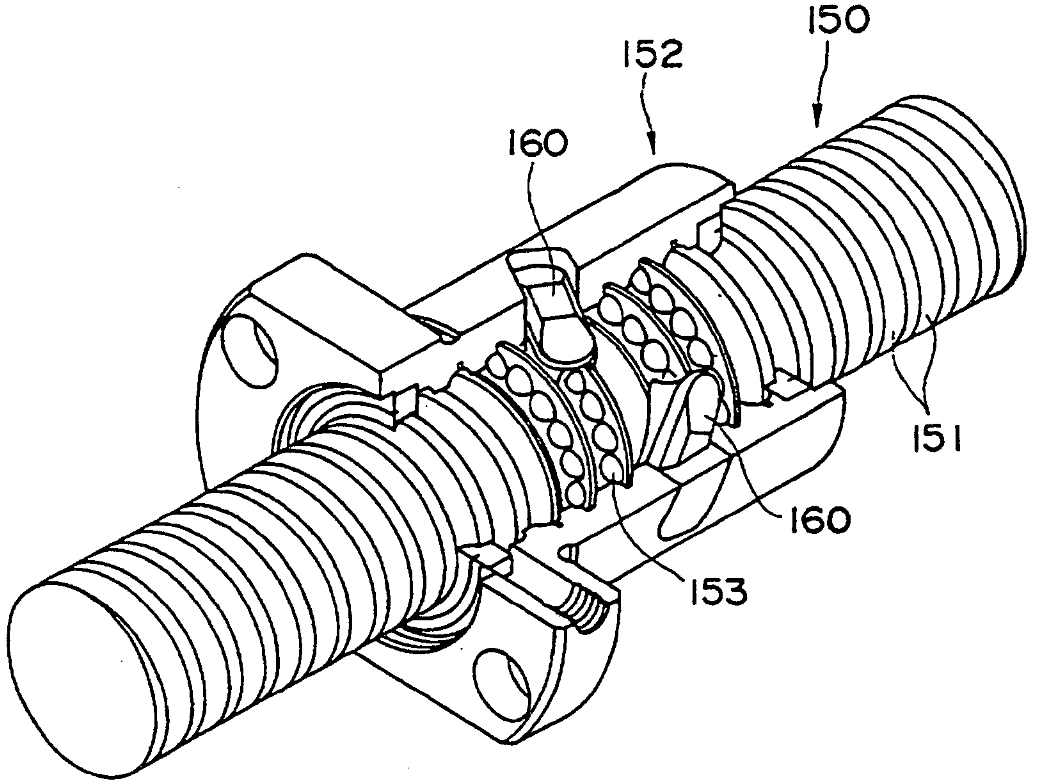


Fig.22

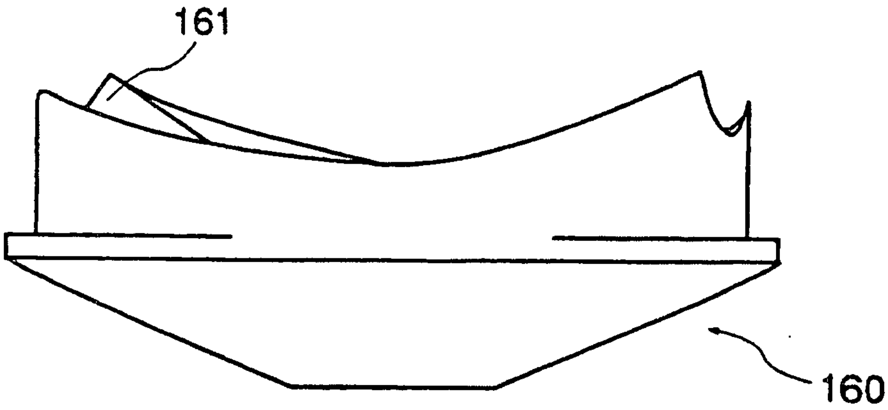


Fig.23

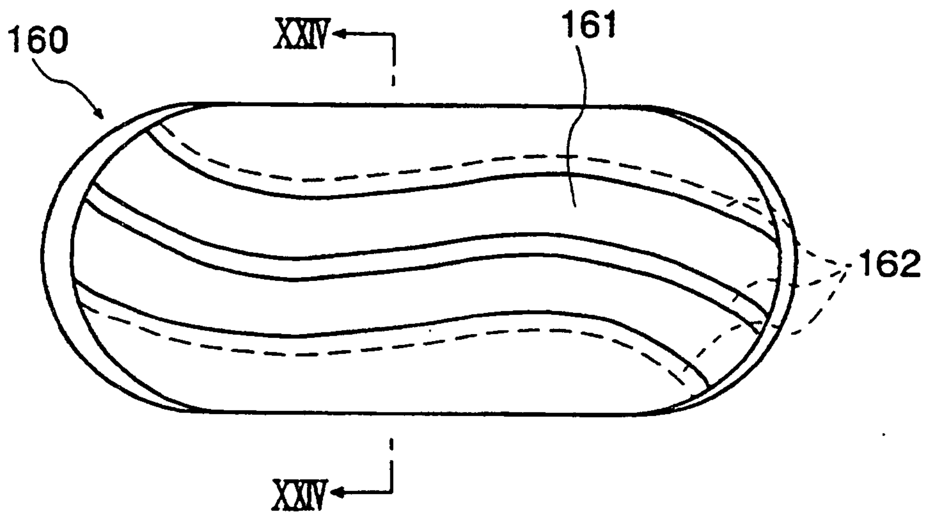
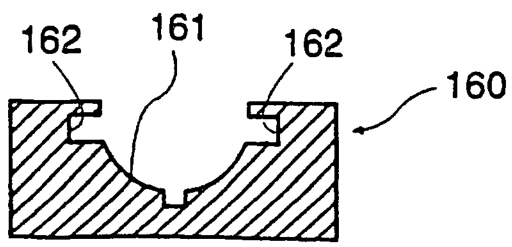
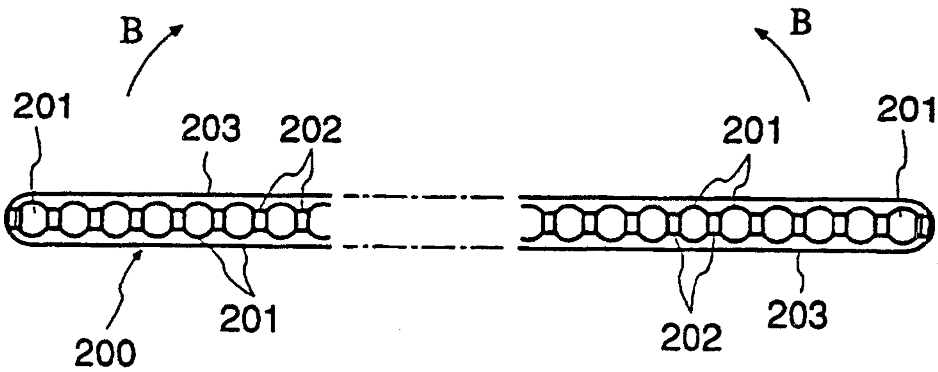


Fig.24



F i g.25


B
B
201
203
202
201
201
201
200
202
203

F i g.26

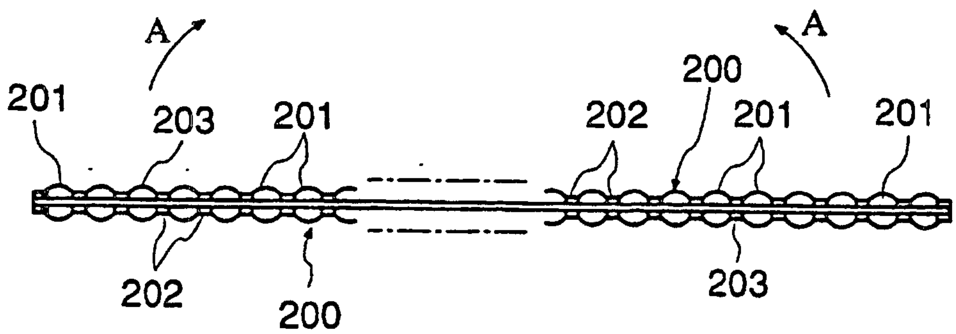
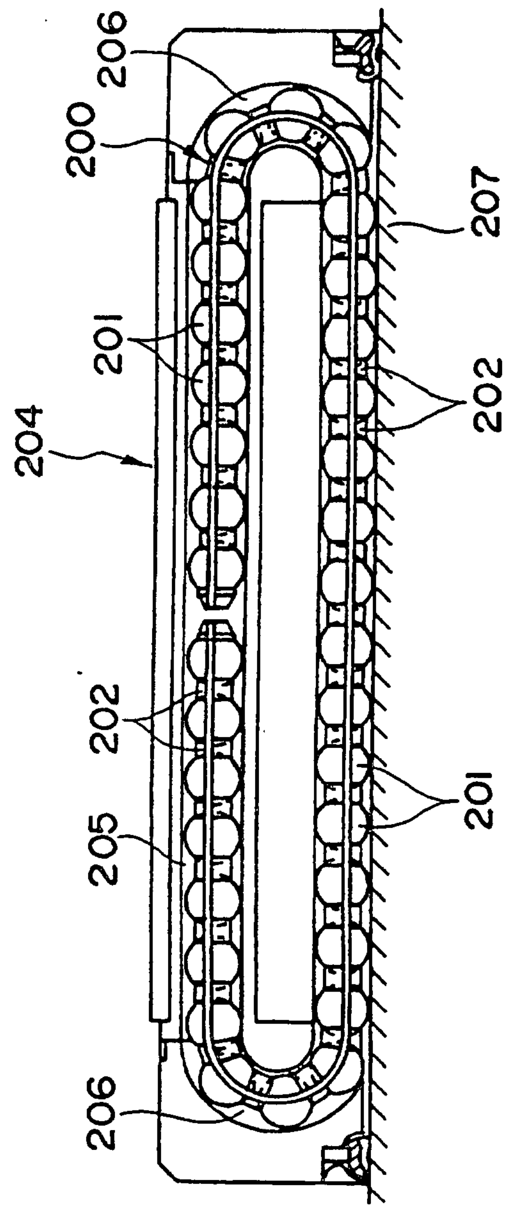
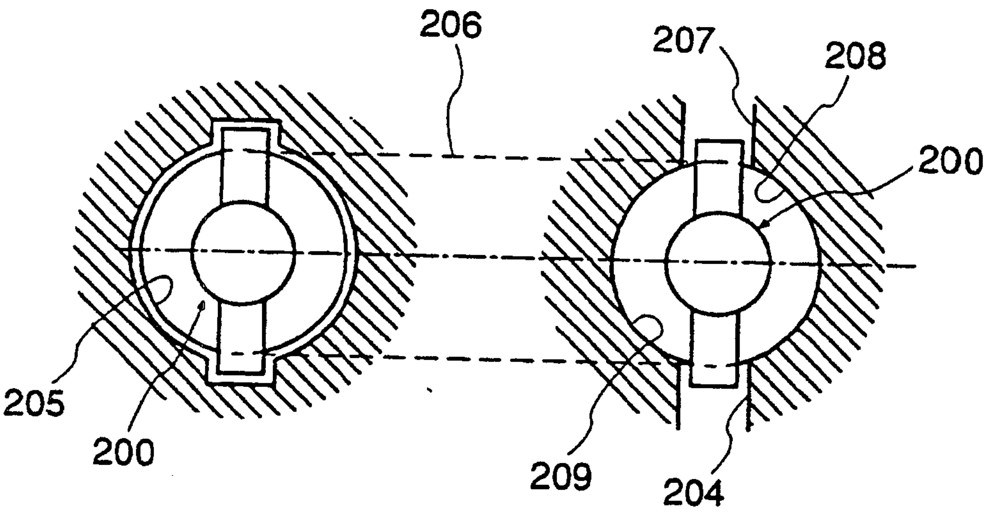

A
A
201
203
201
200
202
201
201
202
200
203

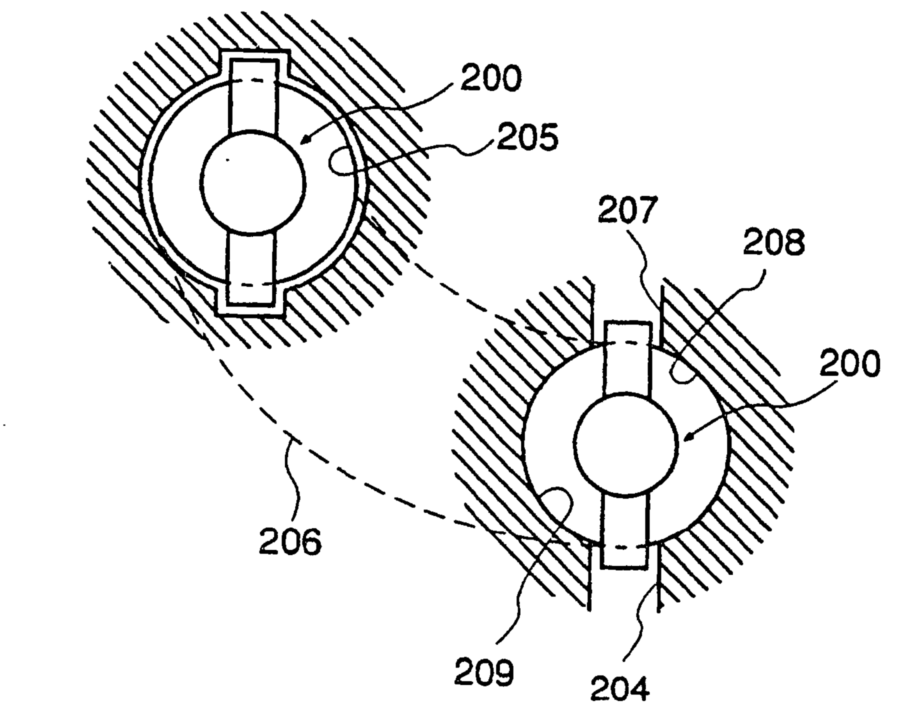
Fig.27



F i g.28



F i g.29



(19) **Bundesrepublik Deutschland**
Deutsches Patent- und Markenamt

(10) **DE 601 16 013 T2** 2006.07.13

(12) # Übersetzung der europäischen Patentschrift

(97) **EP 1 186 790 B1**
(21) Deutsches Aktenzeichen: **601 16 013.4**
(96) Europäisches Aktenzeichen: **01 307 785.4**
(96) Europäischer Anmeldetag: **12.09.2001**
(97) Erstveröffentlichung durch das EPA: **13.03.2002**
(97) Veröffentlichungstag der Patenterteilung beim EPA: **21.12.2005**
(47) Veröffentlichungstag im Patentblatt: **13.07.2006**

(51) Int Cl.[8]: ***F16C 29/06*** (2006.01)
F16C 33/38 (2006.01)

(30) Unionspriorität:
2000276443 12.09.2000 JP

(84) Benannte Vertragsstaaten:
DE, GB

(73) Patentinhaber:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Grünecker, Kinkeldey, Stockmair & Schwanhäusser, 80538 München

(72) Erfinder:
Shirai, Takeki, Shinagawa-ku, Tokyo, JP; Niwa, Hiroshi, Shinagawa-ku, Tokyo, JP; Nishimura, Kentarou, Shinagawa-ku, Tokyo, JP; Abe, Yasuyuki, Shinagawa-ku, Tokyo, JP; Tamura, Kiyomi, Shinagawa-ku, Tokyo, JP

(54) Bezeichnung: **Trennkörper für die Wälzelemente von Wälzelementführungen**

Beschreibung

[0001] Diese Erfindung bezieht sich auf Wälzelement-Abstandsteile für verschiedene Typen von Wälzführungseinheiten, wie beispielsweise eine lineare Führungseinheit, eine Kugelspindeleinheit, und dergleichen, versehen mit einem endlosen Zirkulationsdurchgangsweg für Wälzelemente, wie beispielsweise Kugeln und Rollen, wobei die Wälzelement-Abstandsteile so angepasst sind, um zwischen benachbarten Wälzelementen in dem endlosen Zirkulationsdurchgangsweg angeordnet zu werden, um die Abrasion und die Erzeugung von Wärme der Wälzelemente zu verringern und das Laufen der Wälzelemente zu beruhigen.

[0002] Die bekannten Wälzführungseinheiten, in denen ein Paar von Elementen relative Bewegungen kontinuierlich über eine Reihe von endlos zirkulierenden Kugeln oder Rollen vornimmt, umfassen eine lineare Führungseinheit, verwendet in einem linearen Führungsbereich eines Maschinenwerkzeugs und einer Überführungsvorrichtung, und so angepasst, um ein bewegbares Element, wie beispielsweise einen Tisch auf einen fixierten Bereich, wie beispielsweise einem Bett oder einem Auflageschuh, zu führen; und eine Kugelumlaufspindel, verwendet in Verbindung mit dieser linearen Führungseinheit und so angepasst, um Hübe von linearen Bewegungen auf das bewegbare Element entsprechend einem Drehumfang eines Motors aufzubringen.

[0003] Die erste erwähnte, lineare Führungseinheit umfasst eine Laufschiene, die an einem solchen fixierten Bereich, wie er vorstehend erwähnt ist, vorgesehen ist und Rollflächen besitzt, die sich in der Längsrichtung, für die Wälzelemente, erstrecken; und einen Gleitblock, der Lastwälzflächen gegenüberliegend zu den Wälzflächen der Laufschiene über eine Mehrzahl von Wälzelementen besitzt, und der mit endlosen Zirkulationsdurchgangswegen für die Wälzelemente, die auf diesen Lastwälzflächen rollen, versehen ist, wobei der bewegbare, die Teile tragende Gleitblock linear und kontinuierlich entlang der Laufschiene bewegbar ist. Umgekehrt sind einige lineare Führungseinheiten so gebildet, dass eine Laufschiene in Bezug auf den fixierten Gleitblock bewegt wird.

[0004] Die zweite, erwähnte Kugelspindel umfasst eine Spindelwelle, versehen mit einer spiralförmigen Kugellaufnut, gebildet unter einem vorbestimmten Führungswinkel; und ein Mutterelement, das eine Lastrollnut gegenüberliegend zu der Kugelwälznut über mehrere Kugeln besitzt und mit einem endlosen Zirkulationsdurchgangsweg für die Kugeln, die auf dieser Lastlaufnut rollen, versehen ist; wobei die Kugeln in dem endlosen Zirkulationsdurchgangsweg entsprechend der relativen Drehbewegungen dieser Spindelwelle und des Mutterelements zirkuliert werden, wobei das Mutterelement und die Spindelwelle dadurch relativ in der axialen Richtung bewegt werden.

[0005] In solchen Wälzführungseinheiten berührt ein Wälzelement, wie beispielsweise die Kugeln und Rollen, die in dem endlosen Zirkulationsdurchgangsweg zirkulieren, die Wälzelemente, positioniert an der Vorder- und Rückseite davon. Deshalb ist dort, wenn die Wälzführungseinheiten unter einer hohen Geschwindigkeit verwendet werden, die Möglichkeit vorhanden, dass sich die Wälzelemente vergleichbar früh aufgrund der gegenseitigen Abrasion von, zum Beispiel, den Wälzelementen abnutzen, und dass sich die Wälzelemente und die Lastrollfläche aufgrund von Reibungswärme festfressen. Wenn die Bewegungsrichtung umgekehrt wird, d.h. wenn die Richtung, in der die Wälzelemente zirkuliert werden, umgekehrt wird, ist die Anordnung der Wälzelemente in den endlosen Zirkulationsdurchgangswegen leicht dafür anfällig, dass sie durcheinander gelangen. In einem extremen Fall tritt ein sogenanntes Blockierphänomen auf, bei dem die Wälzelemente in dem endlosen Zirkulationsdurchgangsweg angehalten werden, so dass dort die Möglichkeit vorhanden ist, dass die Wälzführungseinheit selbst nicht mehr arbeitet. Die japanische Patentoffenlegung Nr. 315835/1999 offenbart eine Wälzführungseinheit, die so angepasst ist, um diese Nachteile einer Wälzführungseinheit zu vermeiden, in der Wälzelement-Abstandsteile zwischen Wälzelementen, benachbart zueinander in einem endlosen Zirkulationsdurchgangsweg, zwischengefügt sind.

[0006] In der Wälzführungseinheit, die in dieser Veröffentlichung offenbart ist, sind Wälzelement-Abstandsteile aus einem synthetischen Harz, bezeichnet als „Separator", alternierend mit Kugeln in dem endlosen Zirkulationsdurchgangsweg angeordnet, und der Kontakt einer Kugel mit einer anderen wird dadurch verhindert. Solche Separatoren sind in der Form einer Scheibe gebildet, wobei der äußere Durchmesser davon kleiner als der Durchmesser der Kugeln ist, und sind an sowohl der vorderen als auch der hinteren Fläche davon mit Kugelrückhaltesitzen versehen, wobei der Krümmungsradius davon größer als derjenige der sphärischen Oberfläche jeder Kugel ist. Wenn die Kugeln und Separatoren dadurch alternierend angeordnet sind, ohne dass Freiräume in dem endlosen Zirkulationsdurchgangsweg auftreten, wird jede Kugel zwischen einem Paar von Separatoren, angrenzend an die vordere und die hintere Seite davon, gehalten. Dementsprechend werden gerade dann, wenn die Richtung, in der die Kugeln zirkuliert werden, umgekehrt wird, die Kugeln mit den Separatoren in dem endlosen Zirkulationsdurchgangsweg zirkuliert, ohne zu bewirken, dass die Reihe der Kugeln und der Separatoren durcheinandergebracht wird.

[0007] Allerdings treten, wenn die Kugelrückhaltesitze, die gleitend die Kugeln berühren, konkav mit einem Krümmungsradius größer als derjenige der sphärischen Oberfläche jeder Kugel gebildet sind, gerade wie solche der Rollelement-Abstandsteile, offenbart in der japanischen Patentoffenlegung Nr. 315835/1999, Freiräume zwischen einem Umfangsbereich des Kugelrückhaltesitzes und den Kugeln auf, und die Kugeln wackeln in Bezug auf die Rollelement-Abstandsteile. Deshalb kann die mäanderförmige Bewegung der Kugeln in dem endlosen Zirkulationsdurchgangsweg nicht vollständig beseitigt werden.

[0008] Von dem Gesichtspunkt der Verhinderung einer solchen mäanderförmigen Bewegung der Kugeln in dem endlosen Zirkulationsdurchgangsweg ist es notwendig, dass sich die Kugeln setzen, ohne dass sie sich an den Kugelrückhaltesitzen der Wälzelement-Abstandsteile schütteln. Um das Erfordernis zu erfüllen, ist es notwendig, dass die Kugelrückhaltesitze so gebildet sind, dass sie konkave Oberflächen haben, die im Wesentlichen mit den sphärischen Oberflächen der Kugeln übereinstimmen. Allerdings wird, wenn die Kugelrückhaltesitze so gebildet sind, dass sie solche konkaven Oberflächen haben, der Kontaktoberflächenbereich jeder Kugel und ein relativer Kugelrückhaltesitz groß. Dies bringt eine Gefahr dahingehend mit sich, dass eine Vergrößerung in dem Gleitkontaktwiderstand der Wälzelement-Abstandsteile in Bezug auf die Kugeln, eine frühe Abnutzung an den Wälzelement-Abstandsteilen, usw., auftreten.

[0009] Die DE-A-19925040 offenbart Wälzelement-Abstandsteile, die die Wälzelemente nur an zwei äußeren Bereichen jedes Rückhaltesitzes auf einer Ebene senkrecht zu der Drehachse jedes Wälzelements berühren. Allerdings sind dabei bestimmte Nachteile vorhanden.

[0010] Die vorliegende Erfindung ist im Hinblick auf die vorstehend angegebenen Umstände gemacht worden und schafft Wälzelement-Abstandsteile, die dazu geeignet sind, die Stabilität von Wälzelementen in Bezug auf Rückhaltesitze mit einem hohen Niveau zu verbessern, die Ausrichtung der Wälzelemente und der Wälzelement-Abstandsteile in den endlosen Zirkulationsdurchgangswegen zu stabilisieren und den Gleitkontaktwiderstand, ausgeübt auf die Wälzelemente, zu verringern.

[0011] Gemäß einem Aspekt der vorliegenden Erfindung werden Wälzelement-Abstandsteile geschaffen, die in einer Wälzführungseinheit verwendet werden, in der ein Paar von Elementen eine kontinuierliche, relative Bewegung über eine Reihe von endlos zirkulierten Wälzelementen, zwischengefügt zwischen benachbarten Wälzelementen in einem endlosen Zirkulationskanal, und zirkuliert mit den Wälzelementen, vornimmt, wobei jedes der Wälzelement-Abstandsteile mit einem Paar von Rückhaltesitzen versehen ist, mit denen die Wälzelemente in Kontakt stehen, wobei die Wälzelemente nur die zwei Bereiche jedes Rückhaltesitzes berühren, die sich in der Nähe der beiden Enden davon befinden, und zwar auf einer Wälzelement-Schnittebene senkrecht zu der Drehachse jedes Wälzelements, dadurch gekennzeichnet, dass jeder Rückhaltesitz in einer konvexen Form gebildet ist.

[0012] Demzufolge besitzen die Wälzelement-Abstandsteile ein Paar von Rückhaltesitzen, mit denen die Wälzelemente gleitend in Kontakt stehen, wobei jeder Rückhaltesitz und ein relatives Wälzelement miteinander an Wälzelement-Schnittebenen senkrecht zu der Drehachse davon, an nur zwei Bereichen des Rückhaltesitzes, die sich in der Nähe beider Enden davon befinden, in Kontakt treten, und wobei jeder Rückhaltesitz eine konvexe Form besitzt.

[0013] Entsprechend solchen technischen Vorrichtungen berühren jeder Rückhaltesitz und jedes relative Wälzelement einander an Wälzelement-Schnittebenen senkrecht zu der Drehachse davon, und zwar nur an den zwei Bereichen des Rückhaltesitzes, die sich in der Nähe der beiden Enden davon befinden. Deshalb passen die spiralförmige Oberfläche einer Kugel oder die äußere Umfangsfläche einer Rolle in einem stabilen Zustand in einem relativen Rückhaltesitz zueinander und der einsitzende Zustand des Wälzelements in Bezug auf den Rückhaltesitz wird stabil. Demzufolge werden, wenn solche Wälzelement-Abstandsteile und Wälzelemente alternierend in den endlosen Zirkulationsdurchgangswegen in einer Wälzführungseinheit angeordnet sind, die Ausrichtung dieser Wälzelemente und der Wälzelement-Abstandsteile stabilisiert, und die mäanderförmige Bewegung der Wälzelemente in den endlosen Zirkulationsdurchgangswegen kann verhindert werden.

[0014] An den Wälzelement-Schnittebenen, senkrecht zu der Drehachse davon, berühren sich jeder Rückhaltesitz und jedes relative Wälzelement miteinander an nur zwei Bereichen in der Nähe der beiden Enden des Rückhaltesitzes. Zum Beispiel berühren sich, wenn das Wälzelement eine Kugel ist, die Kugel und ein relativer Rückhaltesitz miteinander ringförmig. Da nämlich die Mitte jedes Rückhaltesitzes und des relativen Wälzelements nicht in einem sich berührenden Zustand vorliegen, wird es möglich, den Kontaktbereich des Rückhaltesitzes und des Wälzelementes zu minimieren, und dadurch den Gleitkontaktwiderstand, ausgeübt auf das Wälzelement, zu verringern.

[0015] Weiterhin befinden sich, gemäß der vorliegenden Erfindung, die Mitte jedes Rückhaltesitzes und eines relativen Wälzelements in einem nicht berührenden Zustand, und die Mitte jedes Rückhaltesitzes trägt insgesamt nicht zu der Ausrichtung der Wälzelemente bei. Deshalb kann ein Verbindungsdurchgangsloch, das sich zwischen den Rückhaltesitzen erstreckt, vorgesehen werden, und dieses Verbindungsloch kann als ein Schmierölreservoir verwendet werden.

[0016] In der Kugelspindeleinheit variiert die Rollgeschwindigkeit der Kugeln, gehalten in einer spiralförmig geformten Lastwälznut einer Mutter und Kugelwälznut einer Spindelwelle, fein aufgrund von Fehlern einer Bildung dieser Nuten, so dass ein Abstand zwischen den Kugeln, die rollen, wenn sie eine Last auf die Nut der Mutter aufbringen, auch variiert. Deshalb werden, wenn die Wälzelement-Abstandsteile eine hohe Steifigkeit in der Wälzelement-Anordnungsrichtung haben, die Kugeln und die Wälzelement-Abstandsteile in einen erzwungen, drückenden Zustand in Bezug zueinander in dem endlosen Zirkulationsdurchgangsweg zu dem Zeitpunkt des Auftretens einer Verringerung in dem Abstand zwischen den Kugeln aufgrund der vorstehend angegebenen Gründe versetzt, und die Kugeln werden in dem endlosen Zirkulationsdurchgangsweg angehalten. Demzufolge ist es, im Hinblick auf die Notwendigkeit, eine feine Variation des Abstands zwischen den benachbarten Kugeln zu absorbieren, bevorzugt, den Wälzelement-Abstandsteilen in der Wälzelement-Anordnungsrichtung eine Elastizität zu geben, indem Nuten in den äußeren Umfangsoberflächen, die die Umfänge der Rückhaltesitze umgeben, angeordnet werden.

[0017] Wie vorstehend beschrieben ist, passen, gemäß den Wälzelement-Abstandsteilen der vorliegenden Erfindung, die sphärischen Oberflächen der Kugeln oder die äußeren Umfangsflächen der Rollen stabil in die Rückhaltesitze, und der Sitzzustand der Wälzelemente in Bezug auf die Rückhaltesitze wird stabil. Da sich die Mitte jedes Rückhaltesitzes und eines relativen Wälzelements in einem nicht berührenden Zustand befindet, wird es möglich, den Kontaktbereich jedes Rückhaltesitzes und eines relativen Wälzelements zu verringern, den einsitzenden Zustand der Wälzelemente in Bezug auf die Rückhaltesitze zu verbessern, die Ausrichtung der Wälzelemente und der Wälzelement-Abstandsteile in einem endlosen Zirkulationsdurchgangsweg zu stabilisieren und einen Gleitwiderstand, ausgeübt auf die Wälzelemente, zu verringern.

[0018] Eine Ausführungsform der Erfindung wird nun, anhand nur eines Beispiels, unter Bezugnahme auf die beigefügten Zeichnungen beschrieben, wobei:

[0019] Fig. 1 zeigt eine geschnittene Seitenansicht, die ein Beispiel einer Kugelspindeleinheit darstellt, in der Wälzelement-Abstandsteile gemäß der vorliegenden Erfindung mit Kugeln in einem endlosen Zirkulationsdurchgangsweg angeordnet sind;

[0020] Fig. 2 zeigt eine vordere Schnittansicht der Kugelspindeleinheit, dargestellt in Fig. 1;

[0021] Fig. 3 zeigt eine perspektivische Ansicht, die ein Wälzelement-Abstandsteil darstellt, das durch den Anmelder vorgesehen ist und zu dem Zweck einer Erläuterung beschrieben ist;

[0022] Fig. 4 zeigt eine Schnittansicht, die das Wälzelement-Abstandsteil der Fig. 3, zwischengefügt zwischen Kugeln, darstellt;

[0023] Fig. 5 zeigt eine perspektivische Ansicht, die eine andere Anordnung eines Wälzelement-Abstandsteils für den Zweck einer Erläuterung darstellt;

[0024] Fig. 6 zeigt eine perspektivische Ansicht, die eine Ausführungsform eines Wälzelement-Abstandsteils gemäß der vorliegenden Erfindung darstellt; und

[0025] Fig. 7 zeigt eine Schnittansicht, die das Wälzelement-Abstandsteil der dargestellten Ausführungsform, zwischengefügt zwischen Kugeln, darstellt.

[0026] Eine Ausführungsform eines Wälzelement-Abstandsteils gemäß der vorliegenden Erfindung wird nun im Detail auf der Grundlage der beigefügten Zeichnungen beschrieben. Zuvor werden allerdings zwei Anordnungen eines Wälzelement-Abstandsteils, vorgesehen durch den Anmelder, zu dem Zweck einer Erläuterung beschrieben.

[0027] Die Fig. 1 und Fig. 2 stellen ein Beispiel einer Kugelspindeleinheit dar, in der Wälzelement-Abstandsteile gemäß der vorliegenden Erfindung mit Kugeln in einem endlosen Zirkulationsdurchgangsweg angeordnet werden können. In denselben Zeichnungen bezeichnet ein Bezugszeichen **1** eine Spindelwelle, **2** bezeichnet Kugeln und **3** ein Mutterelement, das auf die Spindelwelle **1** über die Mehrzahl von Kugeln **2** geschraubt ist.

[0028] Die Spindelwelle **1** ist in einer äußeren Umfangsfläche davon mit einer spiralförmigen Kugelwälznut **10** versehen, während das Mutterelement **3** in einer inneren Umfangsfläche davon mit einer spiralförmigen Lastwälznut **30**, gegenüberliegend zu der Kugelwälznut **10** der Spindelwelle **1**, versehen ist. Diese Kugelwälznut **10** und die Lastwälznut **30** bilden einen spiralförmigen Lastkugeldurchgangsweg zwischen der Spindelwelle **1** und dem Mutterelement **3**. Wenn nämlich eine relative Drehbewegung an der Spindelwelle **1** und dem Mutterelement **3** auftritt, rollen die Kugeln **2** spiralförmig in dem Lastkugeldurchgangsweg, da die Kugeln **2** eine Last auf demselben Durchgangsweg aufbringen. Das Mutterelement **3** ist mit einem Rückführrohr **4** versehen, das beide Enden des Lastkugeldurchgangswegs miteinander in Verbindung setzt und miteinander verbindet, und dadurch einen endlosen Zirkulationsdurchgangsweg für die Kugeln **2** bildet. Die Kugeln **2**, die ein Rollen bzw. Wälzen in dem Lastkugeldurchgangsweg beendet haben, und die in Bezug auf eine Belastung freigegeben worden sind, werden in einen Nicht-Last-Zustand versetzt und rollen in das Rückführrohr **4**. Die Kugeln **2** springen dann über eine Distanz entsprechend zu mehreren Windungen der Kugelwälznut **10** und werden zu einem Einlass des Lastkugeldurchgangswegs zurückgeführt. Deshalb rollen, wenn die Spindelwelle **1** und das Mutterelement **3** eine relative Drehbewegung vornehmen, die Kugeln **2** von dem Lastkugelkanal zu dem Rückführrohr **4** und von dem Rückführrohr **4** zu dem Lastkugelkanal, d.h. die Kugeln werden in dem Inneren des Endlos-Zirkulationskanals, gebildet aus diesem Lastkugelkanal und dem Rückführrohr **4**, zirkuliert.

[0029] In dieser Kugelspindeleinheit sind Wälzelement-Abstandsteile **5** zwischen benachbarten Kugeln **2**, **2** so zwischengefügt, um zu verhindern, dass die Kugeln **2**, eingesetzt in dem endlosen Zirkulationsdurchgangsweg, miteinander in Kontakt treten. Obwohl es nicht entsprechend der vorliegenden Erfindung ist, stellen, zum Zwecke einer Erläuterung, die Fig. 3 und Fig. 4 Wälzelement-Abstandsteile **5** dar, die durch Bilden eines synthetischen Harzes im Wesentlichen in der Form einer Scheibe erhalten sind, und die an sowohl der vorderen als auch der Rückseite davon Rückhaltesitze **50** besitzen, mit denen die Kugeln **2** gleitend in Kontakt stehen. Die Kugeln **2** und die Wälzelement-Abstandsteile **5** sind alternierend in dem endlosen Zirkulationskanal angeordnet. Dies verhindert, dass die Kugeln **2**, die in dem endlosen Zirkulationskanal rollen, miteinander in Kontakt treten, und ermöglicht, dass die Kugeln **2** sanft zirkuliert werden, eine Drehbewegung des Mutterelements **3** in Bezug auf die Spindelwelle **1** glatt auftritt und das Auftreten von Geräuschen einer Kollision der Kugeln während eines Betriebs der Kugelspindeleinheit verringert wird.

[0030] Der Rückhaltesitz **50** ist im Wesentlichen konisch gebildet und durch Drehen einer Kurve, wobei der Krümmungsradius davon größer als derjenige der Oberfläche der Kugel **2** ist, um eine Mittenachse **0** eines Wälzelement-Abstandsteils **5** erhalten. Der Rückhaltesitz **50** ist nämlich an einer Kugelschnittebene senkrecht zu der Mitte C einer Drehung der Kugel **2** aus einer Kombination von zwei Bögen gebildet. Die Kugel **2** berührt ringmäßig und linear den Rückhaltesitz **50**. Wie in Fig. 4 dargestellt ist, berührt, auf einer Kugelschnittebene senkrecht zu der Mitte C einer Drehung der Kugel **2**, jeder Rückhaltesitz **50** die Kugel **2** an nur den zwei Bereichen des ersteren, die sich in der Nähe der beiden Enden davon befinden. Es ist nämlich ein Freiraum notwendigerweise zwischen der Kugel **2** und dem Kugelrückhaltesitz **50** so gebildet, dass sich die Breite des Freiraums stufenweise zu der Mitte des Kugelrückhaltesitzes **50** erhöht. Der Rückhaltesitz **50** und die Kugel **2** sind so angeordnet, dass sich ein Kontaktbereich des Rückhaltesitzes **50** und der Kugel **2** in der Richtung erweitert, in der die Kugel **2** rollt, d.h. unter einem Winkel von 45° in Bezug auf die Mittenachse **0** des Wälzelement-Abstandsteils **5**. Aufgrund dieser Anordnung passt, wenn die Kugeln **2** und die Wälzelement-Abstandsteile **5** so angeordnet sind, ohne dass bewirkt wird, dass Freiräume unter diesen Teilen in dem endlosen Zirkulationskanal der Kugelspindeleinheit auftreten, die sphärische Oberfläche jeder Kugel **2** in den relativen, im Wesentlichen konisch geformten Rückhaltesitz **50** hinein, und jede Kugel **2** sitzt stabil in dem relativen Rückhaltesitz **50** ein. Deshalb wackeln die Kugeln **2** nicht instabil auf den Kugelrückhaltesitzen **50** des Wälzelement-Abstandsteils **5**, so dass die Kugeln **2** und die Wälzelement-Abstandsteile **5** zirkuliert werden können, ohne dass bewirkt wird, dass sich diese Teile in einem solchen endlosen Zirkulationskanal mäanderförmig bewegen.

[0031] Jedes Wälzelement-Abstandsteil **5** ist in der Mitte davon mit einem Verbindungsloch **51** so versehen, dass sich das Verbindungsloch durch ein Paar von Rückhaltesitzen **50** davon erstreckt, die in entgegengesetzten Richtungen weisen, wobei ein Schmiermittel, das auf den relativen Kugeln **2** niedergeschlagen ist, in diesem Verbindungsloch **51** gesammelt wird. Wie vorstehend erwähnt ist, sind, in der Nähe der Mitten der Rückhaltesitze **50**, Freiräume zwischen den Kugeln **2** und den Rückhaltesitzen **50** so vorhanden, dass die Freiräume, wobei die Breite davon sehr klein ist, zwischen den Kugeln **2** und den Rückhaltesitzen **50** gerade in Bereichen um das Verbindungsloch **51** herum existieren. Deshalb wird, wenn sich die Kugeln **2** drehen, das Schmiermittel in den Verbindungslöchern **51** zwischen die Kugeln **2** und die Rückhaltesitze **50** gebracht und die Oberflächen der Wälzelement-Abstandsteile **5** und solcher der Kugeln **2** werden geschmiert.

[0032] Weiterhin ist eine ringförmige Nut **52** in der äußeren Umfangsfläche jedes Wälzelement-Abstandsteils **5**, das die Rückhaltesitze **50** davon umgibt, gebildet, und ein äußerer Umfangskantenbereich eines solchen Wälzelement-Abstandsteils **5** ist in zwei, d.h. ein Paar von ringförmigen Vorsprüngen **53**, **53**, unterteilt. Die Kugel **2** berührt nur den Bereich eines relativen, ringförmigen Vorsprungs **53** eines relativen Kugelrückhaltesitzes **50**, der sich in der Nähe eines freien Endes davon befindet, und berührt nicht den Rückhaltesitz **50** des Wälzelement-Abstandsteils **5** an dem Bereich, der sich in der Nähe der Mitte davon befindet. Deshalb werden, wenn sich ein Abstand zwischen angrenzenden Kugeln **2**, **2** während der Zirkulation davon in dem endlosen Zirkulationskanal verringert, die ringförmigen Vorsprünge **53** elastisch einfach deformiert, um die Variation des Abstands zwischen den Kugeln **2** zu absorbieren. Die Wälzelement-Abstandsteile **5**, die so gebildet sind, übernehmen nämlich die Rollen von Kissen, die die Variation des Abstands zwischen den Kugeln **2** absorbieren, und beseitigen das Problem von sich gegenseitig behindernden Bewegungen der Kugeln **2** in dem endlosen Zirkulationskanal. Diese Wälzelement-Abstandsteile tragen zu einer Vergleichmäßigung der Zirkulation solcher Kugeln **2** bei.

[0033] Fig. 5 stellt einen zweiten Typ eines Wälzelement-Abstandsteils, der durch den Anmelder vorgesehen ist, dar. Ein Wälzelement-Abstandsteil **5a** besitzt eine Struktur im Wesentlichen identisch zu derjenigen des Wälzelement-Abstandsteils **5**, das in Fig. 3 und Fig. 4 dargestellt ist. In dem Wälzelement-Abstandsteil der Fig. 5 ist der Durchmesser eines Verbindungslochs **51**, gebildet in der Mitte davon, größer als derjenige des Wälzelement-Abstandsteils **5** des ersten Abstandsteils, so dass eine solche Menge eines Schmiermittels, die dem im Durchmesser vergrößerten Bereich des Verbindungslochs **51** entspricht, zusätzlich darin bevorratet werden kann. Genauer gesagt beträgt der Durchmesser des Verbindungslochs **51** ungefähr 2/3 desjenigen, mit dem das Wälzelement-Abstandsteil **5a** gebildet wurde. Ein Rückhaltesitz **54**, den die Kugel **2** berührt, ist in eine konkave Form im Wesentlichen in Übereinstimmung mit der Form der sphärischen Oberfläche der Kugel **2** so gebildet, dass die gesamte Oberfläche des Rückhaltesitzes **54** die sphärische Oberfläche der Kugel **2** berührt. Sogar dann, wenn die Kugel **2** demzufolge die gesamte Oberfläche des Rückhaltesitzes **54** berührt, erhöht sich der Kontaktbereich der Kugel **2** und des Rückhaltesitzes **54** nicht extrem, da das Verbindungsloch **51** ausreichend groß gebildet ist, und da das Wälzelement-Abstandsteil **5a** nicht im Wesentlichen einen Gleitkontaktwiderstand der Kugel **2** verursacht, um sich so im Vergleich zu dem Wälzelement-Abstandsteil **5** der ersten Ausführungsform zu erhöhen. Die Strukturen in dieser Anordnung, die identisch zu den entsprechenden Strukturen in der ersten Anordnung sind, sind mit Bezugszeichen, identisch zu solchen in der ersten Anordnung, bezeichnet, und eine detaillierte Beschreibung davon wird weggelassen.

[0034] In dem Wälzelement-Abstandsteil **5a**, das so gebildet ist, passt auch die sphärische Oberfläche der Kugel **2** in den Rückhaltesitz **54** hinein und die Kugel **2** sitzt in einem stabilen Zustand in dem Rückhaltesitz **54** ein. Dementsprechend können die Kugeln **2** in dem endlosen Zirkulationskanal zirkuliert werden, ohne zu verursachen, dass die Kugeln **2** instabil auf den Kugelrückhaltesitzen **54** der Wälzelement-Abstandsteile **5a** wackeln, und ohne zu bewirken, dass sich die Kugeln **2** und die Wälzelement-Abstandsteile **5a** in demselben Zirkulationskanal mäanderförmig bewegen.

[0035] Als nächstes stellen die Fig. 6 und die Fig. 7 eine Ausführungsform des Wälzelement-Abstandsteils gemäß der vorliegenden Erfindung dar. Ein Wälzelement-Abstandsteil **5b** dieser Ausführungsform besitzt eine Struktur im Wesentlichen identisch zu derjenigen des Wälzelement-Abstandsteils **5a**, dargestellt in Fig. 5, allerdings ist die Form des Rückhaltesitzes **55**, mit dem die Kugel **2** in Kontakt tritt, unterschiedlich gegenüber derjenigen des Rückhaltesitzes **50** in Fig. 3 und Fig. 4 oder des Rückhaltesitzes **54** in Fig. 5. Wie in einer Schnittansicht der Fig. 7 dargestellt ist, ist ein solcher Rückhaltesitz **55** nicht in einer konkaven Form, sondern in einer konvexen Form, gebildet, so dass die sphärische Oberfläche der Kugel **2** in Form einer Linie den Rückhaltesitz ringförmig berührt. Ein Kontaktbereich des Rückhaltesitzes **55** und der Kugel **2** ist so vorgesehen, um sich in der Wälzrichtung der Kugel **2** zu erweitern, d.h. unter einem Winkel von 45° in Bezug auf die Mitte **0** des Wälzelement-Abstandsteils **5b**. Das Wälzelement-Abstandsteil dieser Ausführungsform ist identisch in Bezug auf solche mit den Bezugszeichen **5**, **5a** der ersten und der zweiten Anordnung, die zur Erläuterung beschrieben sind.

[0036] Aufgrund dieser Anordnung wackeln, wenn die Kugeln **2** und die Wälzelement-Abstandsteile **5b** der dargestellten Ausführungsform so angeordnet sind, ohne dass ein Freiraum dazwischen in dem endlosen Zirkulationskanal in der Kugelspindeleinheit hervorgerufen wird, die Kugeln **2** nicht instabil auf irgendeinen der Kugelrückhaltesitze **50** des Wälzelement-Abstandsteils **5b**, und die Kugeln **2** und die Wälzelement-Abstandsteile **5b** können zirkuliert werden, ohne zu bewirken, dass sich dieselben Teile mäanderförmig in dem endlosen Zirkulationskanal bewegen.

[0037] In dieser Ausführungsform ist die Beschreibung anhand der Wälzelement-Abstandsteile vorgenommen worden, die unter den Kugeln **2** zwischengefügt sind, die als Beispiel herangezogen sind, allerdings kann die Ausführungsform in derselben Art und Weise auch dann gebildet werden, wenn die Wälzelemente Rollen sind.

Patentansprüche

1. Wälzelement-Abstandsteile, verwendet in einer Wälzführungseinheit, in der ein Paar von Elementen (**1**, **3**) eine kontinuierliche, relative Bewegung über eine Reihe von endlos zirkulierten Wälzelementen (**2**), zwischengefügt zwischen benachbarten Wälzelementen (**2**) in einem endlosen Zirkulationskanal, und zirkuliert mit den Wälzelementen (**2**) vornimmt, wobei jedes der Wälzelement-Abstandsteile (**5b**) mit einem Paar von Rückhaltesitzen (**55**) versehen ist, mit denen die Wälzelemente (**2**) in Kontakt stehen, wobei die Wälzelemente (**2**) nur die zwei Bereiche jedes Rückhaltesitzes (**55**) berühren, die sich in der

Nähe der beiden Enden davon befinden, und zwar auf einer Wälzelement-Schnittebene senkrecht zu der Drehachse jedes Wälzelements (**2**), **dadurch gekennzeichnet**, dass jeder Rückhaltesitz (**55**) in einer konvexen Form gebildet ist.

2. Wälzelement-Abstandsteile nach Anspruch 1, wobei die Wälzelemente (**2**) Kugeln sind und wobei die sphärische Oberfläche der Kugeln jeden Rückhaltesitz (**55**) entlang einer ringförmigen Linie berührt.

3. Wälzelement-Abstandsteile nach Anspruch 1 oder 2, wobei die zwei Kontaktbereiche, gebildet durch den Rückhaltesitz (**55**) und das Wälzelement (**2**), so vorgesehen sind, um sich unter einem Winkel von 45° in der Wälzrichtung des Wälzelements zu erweitern.

4. Wälzelement-Abstandsteile nach Anspruch 1, 2 oder 3, wobei zentrale Bereiche des Paars der Rückhaltesitze (**55**) mit einem Durchgangsverbindungsloch (**51**) versehen sind, das sich zwischen diesen Rückhaltesitzen (**55**) erstreckt, wobei der Durchmesser des Durchgangsverbindungslochs ungefähr 2/3 des Durchmessers des Wälzelement-Abstandsteils beträgt.

5. Wälzelement-Abstandsteile nach einem vorhergehenden Anspruch, wobei eine Nut (**52**) in einer äußeren Umfangsfläche, die einen Umfang der Rückhaltesitze (**55**) umgibt, gebildet ist, wodurch jedem Wälzelement-Abstandsteil (**5b**) eine Elastizität in der Richtung der Anordnung der Wälzelemente (**2**) gegeben wird.

6. System aus Wälzelementen und Wälzelement-Abstandsteilen zur Verwendung in einer Wälzführungseinheit, in der ein Paar von Elementen (**1**, **3**) so angepasst ist, um eine kontinuierliche, relative Bewegung über eine Reihe von endlos zirkulierten Wälzelementen (**2**) vorzunehmen, wobei das System eine Mehrzahl von Wälzelementen (**2**) und eine Mehrzahl von Wälzelement-Abstandsteilen (**5b**), angepasst so, um zwischen benachbarten solchen der Wälzelemente (**2**) in einem endlosen Zirkulationskanal einer Wälzführungseinheit zwischengefügt zu sein, um mit den Wälzelementen (**2**) zu zirkulieren, aufweist, wobei jedes der Wälzelement-Abstandsteile (**5b**) mit einem Paar von Rückhaltesitzen (**55**) versehen ist, die die Wälzelemente (**2**) berühren, wobei die Wälzelemente (**2**) nur die zwei Bereiche jedes Rückhaltesitzes (**55**) berühren, die sich in der Nähe von beiden Enden davon, an einer Wälzelement-Schnittebene, senkrecht zu der Drehachse jedes Wälzelements (**2**), befinden, dadurch gekennzeichnet, dass jeder Rückhaltesitz (**55**) in einer konvexen Form gebildet ist.

Es folgen 5 Blatt Zeichnungen

Anhängende Zeichnungen

Fig.1

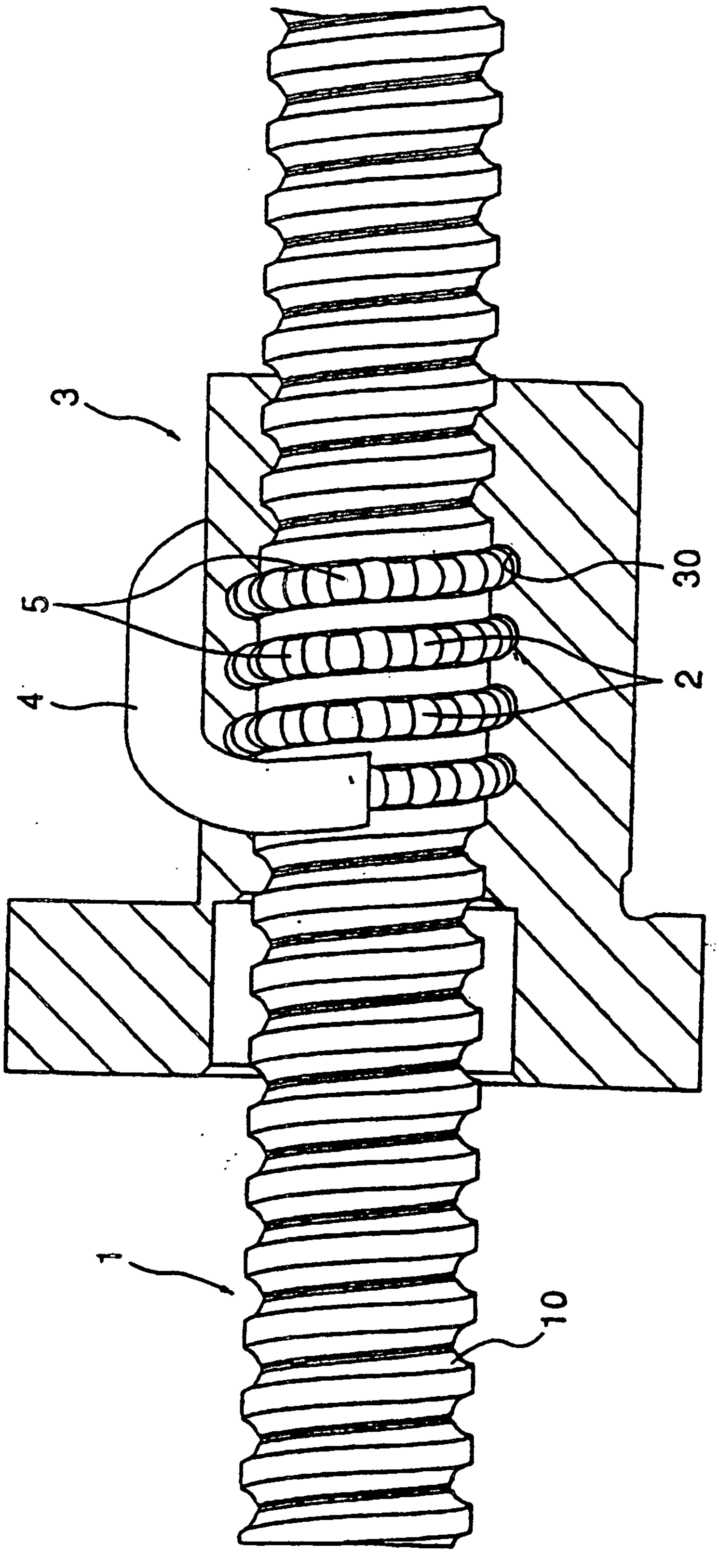


Fig.2

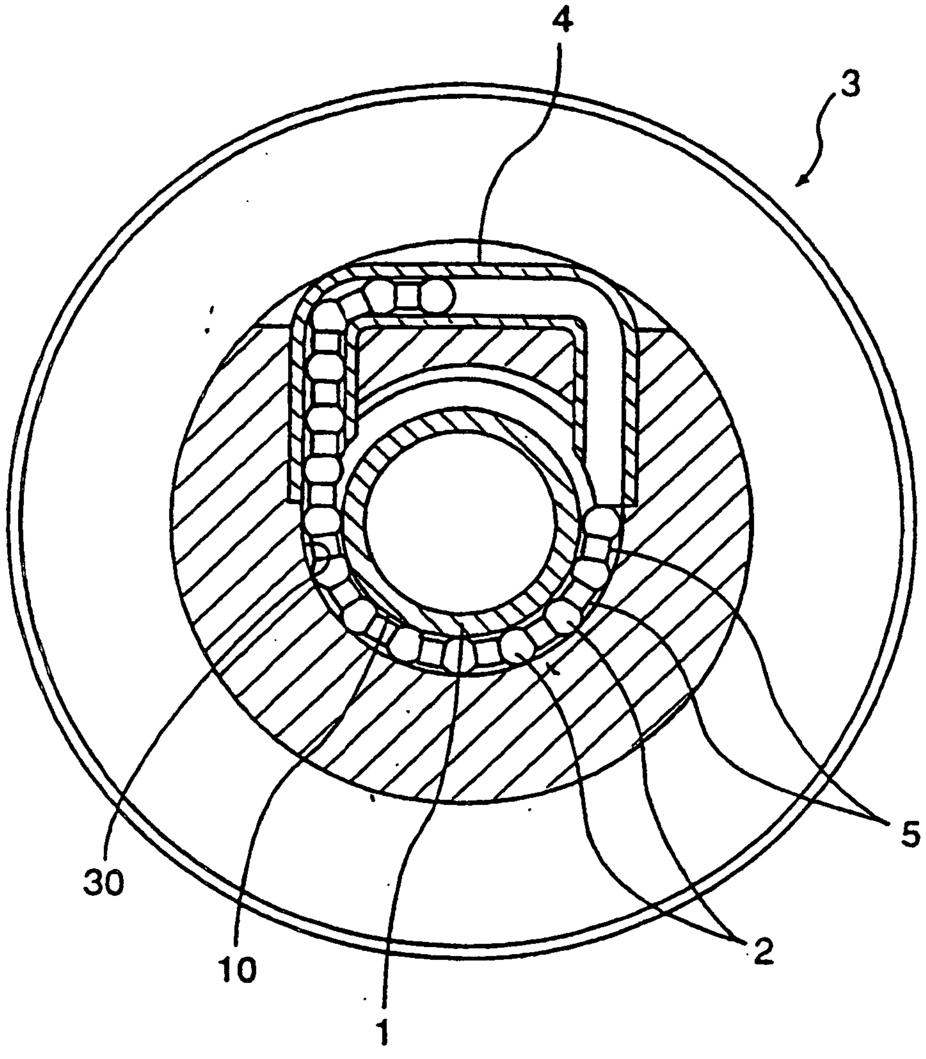


Fig.3

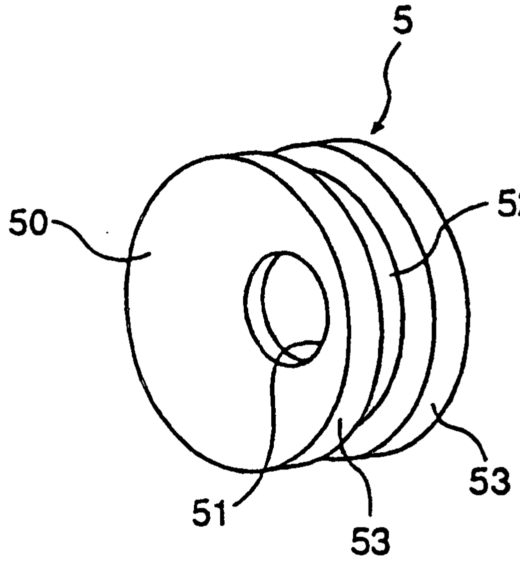


Fig.4

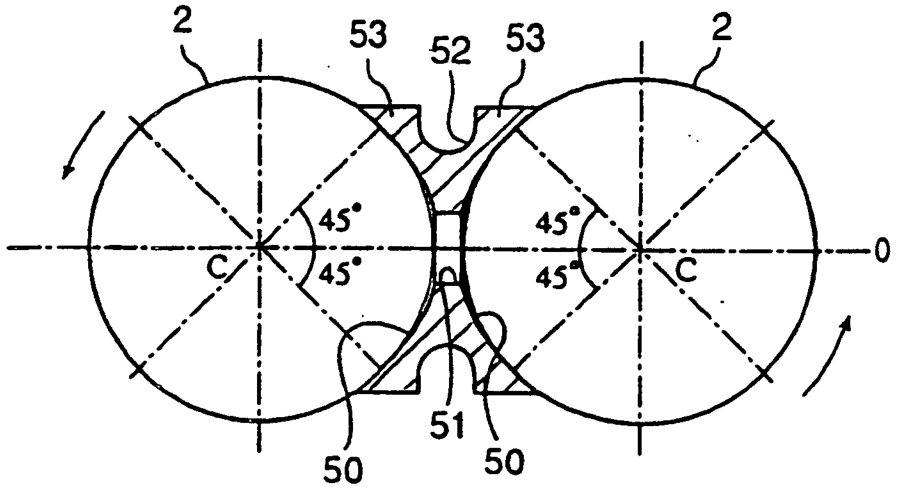


Fig.5

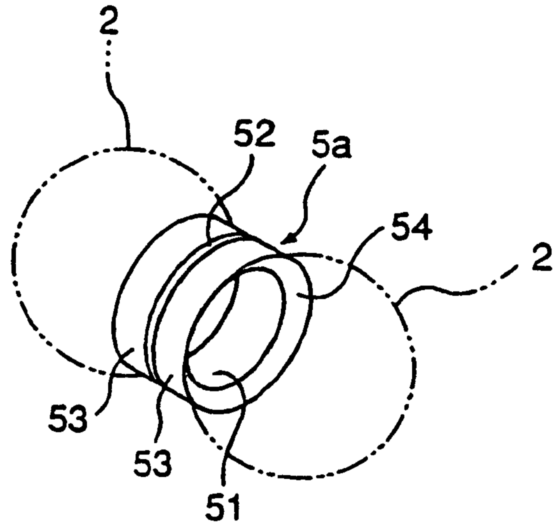


Fig.6

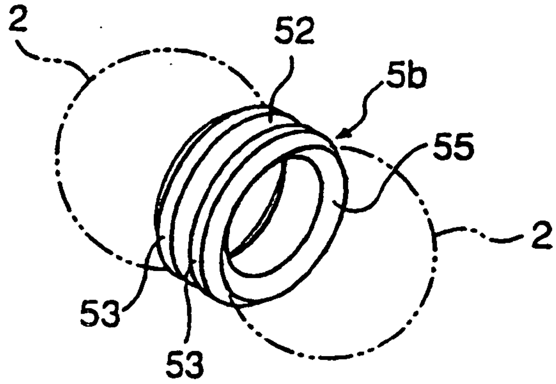
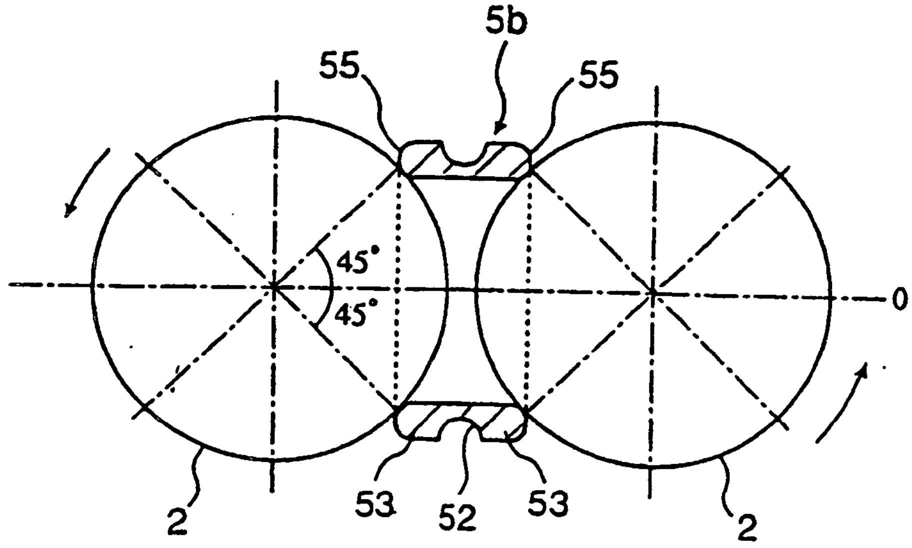


Fig.7



(19) **Bundesrepublik Deutschland**
Deutsches Patent- und Markenamt

(10) **DE 600 22 253 T2** 2006.05.18

(12) # Übersetzung der europäischen Patentschrift

(97) **EP 1 048 860 B1**
(21) Deutsches Aktenzeichen: **600 22 253.5**
(96) Europäisches Aktenzeichen: **00 303 557.3**
(96) Europäischer Anmeldetag: **27.04.2000**
(97) Erstveröffentlichung durch das EPA: **02.11.2000**
(97) Veröffentlichungstag der Patenterteilung beim EPA: **31.08.2005**
(47) Veröffentlichungstag im Patentblatt: **18.05.2006**

(51) Int Cl.[8]: ***F16C 19/20*** (2006.01)

(30) Unionspriorität:
12409299   30.04.1999   JP

(84) Benannte Vertragsstaaten:
DE, GB, IT

(73) Patentinhaber:
THK Co., Ltd., Tokio/Tokyo, JP

(72) Erfinder:
Konomoto, Masashi, Tokyo-to, JP; Michioka, Hidekazu, Tokyo-to, JP

(74) Vertreter:
Grünecker, Kinkeldey, Stockmair & Schwanhäusser, 80538 München

(54) Bezeichnung: **Distanzstück für Linearführungen und mit einem solchen ausgerüstete Linearführung**

Beschreibung

[0001] Die vorliegende Erfindung bezieht sich auf ein Distanzstück, das zwischen Rollen, angeordnet in einem endlosen Zirkulationsdurchgangsweg einer Linearbewegungsvorrichtung, zwischengefügt ist, und bezieht sich auch auf eine Linearbewegungsvorrichtung, die mit einem solchen Distanzstück versehen ist.

[0002] Es ist herkömmlich bekannt, Distanzstücke zwischen Rollelementen, wie beispielsweise Kugeln oder Rollen, aufgenommen und angeordnet in dem Endlosroll-Element-Zirkulationsdurchgangsweg einer Linearrollbewegungsführungsvorrichtung, einer Kugel-Spindel, Kugel-Keilwellen, oder dergleichen, zwischenzufügen, die hier allgemein als „Linearbewegungsvorrichtung" bezeichnet werden. Die Anordnung solcher Distanzstücke verhindert, dass die Rollelemente direkt miteinander in Kontakt treten, wobei ein geeignetes Distanzstück beibehalten wird, um den Betrieb der Linearbewegungsvorrichtung störungsfrei zu gestalten und effektiv die Entwicklung von Geräusch, verursacht durch das Aufeinandertreffen der jeweiligen Rollelement, zu verhindern.

[0003] Allerdings ist es in der Anordnung, in der die Distanzstücke jeweils zwischen den Rollelementen zwischengefügt sind, unvermeidbar, einen dimensionsmäßigen Fehler zwischen einer gesamten Länge einer Endlosreihe der Rollelemente und den Distanzstücken, angeordnet alternierend in dem Zustand, dass sie miteinander in Berührung stehen, und einer Gesamtlänge des Endlos-Zirkulationsdurchgangswegs, in dem diese Rollelemente und die Distanzstücke aufgenommen sind, zu verursachen. Um einen solchen Defekt zu vermeiden, ist mindestens ein Distanzstück, das eine Länge unterschiedlich zu derjenigen eines anderen Distanzstücks besitzt, als ein einen Fehler absorbierendes Distanzstück eingesetzt.

[0004] In einem Fall eines Anpassens der Struktur, in der ein einen solchen Fehler absorbierendes Distanzstück eingesetzt ist, ist es, um die geeignetesten Anordnungs-Zustände der Rollelemente für eine Vielzahl von Vorrichtungen oder unterschiedlichen Arten von Vorrichtungen zu erhalten oder zu realisieren, notwendig, eine Vielzahl von Fehler absorbierenden Distanzstücken zu präparieren, die unterschiedliche Längen haben, und sie durch geeignetes Auswählen für jede der Linearbewegungsanordnungen oder -vorrichtungen einzusetzen. Allerdings ist es mühsam und unbequem für die Wartung der Teile oder dergleichen, immer eine Vielzahl von Fehler absorbierenden Distanzstücken für diese unterschiedlichen Arten von Anordnungen oder Vorrichtungen zu präparieren oder zu reservieren. Weiterhin ist es, da die Distanzstücke gewöhnlich aus Harzmaterialen gebildet sind, auch notwendig, eine Vielzahl von Arten von Formen zu präparieren oder herzustellen, um die Distanzstücke herzustellen, was Kosten mit sich bringt, was demzufolge nicht passend ist.

[0005] Noch weiter ist dabei eine Möglichkeit vorhanden, dass ein leichter Zwischenraum zwischen den Rollelementen und den festen Distanzstücken sogar dann vorhanden ist, wenn das Fehler absorbierende Distanzstück eingesetzt wird, und ein solcher Zwischenraum kann aufgrund einer Abnutzung der Distanzstücke über eine langzeitige Benutzung auch dann erhöht werden, wenn die Anordnung oder Vorrichtung mit im Wesentlichen keinem dimensionsmäßigen Fehler zum Zeitpunkt der Montage zusammengebaut wird.

[0006] Um einen solchen Defekt zu beseitigen, wird eine Gegenmaßnahme einer Verwendung eines elastischen Distanzstücks, das eine Elastizität besitzt, vorgenommen. Wenn solche elastischen Distanzstücke verwendet werden, werden die elastischen Distanzstücke in der endlosen Reihe geschrumpft, um dadurch einen im Wesentlichen vollständigen (dichten) Kontakt-Zustand zwischen den Rollelementen und den Distanzstücken zu erhalten, und sogar dann, wenn die Rollelement und die Distanzstücke abgenutzt sind, werden die Distanzstücke durch deren Elastizität expandiert, so dass die dichten Kontakt-Zustände beibehalten werden können.

[0007] Es existieren bekannte Beispiele, die solche elastischen Distanzstücke, wie sie in der Japanischen Gebrauchsmuster-Offenlegung No. SHO 53-90158 offenbart sind, die eine Struktur darstellt, bei der eine Feder zwischen einem Paar von scheibenähnlichen Kugel-Rückhalteteüen zwischengefügt ist, und auch wie sie in dem US-Patent Nr. 2,827,345 offenbart sind, das eine Struktur mit zwei scheibenförmigen, elastischen Elementen darstellt, die vertiefte Bereiche angrenzend aneinander haben, verwenden. Allerdings ist in solchen Strukturen, bei denen das elastische Distanzstück aus einer Vielzahl von Bereichen oder Elementen zusammengesetzt ist, eine Gefahr vorhanden, dass sich das Distanzstück während der Benutzung davon zerlegen kann, was demzufolge die Wartung davon schwierig und mühsam gestalten wird, und die Kosten unvermeidbar erhöhen wird, was demzufolge nicht praktikabel ist.

[0008] Weiterhin schafft, um das vorstehende Problem zu lösen, der Stand der Technik weiterhin ein elastisches Distanzstück, das aus einem Einzelelement aufgebaut ist, wie es in der Japanischen Gebrauchsmuster-Veröffentlichung No. SHO 51-10285 offenbart ist, mit einem rohrförmigen Distanzstück-Körper, gebildet mit sphärischen Rückhalteflächen an beiden Endflächen in der Vorschubrichtung davon, um die Kugel zu halten, und ausgebildet mit einem Schlitz, der einen inneren Umfang und einen äußeren Umfang des rohrförmigen Distanzstück-Körpers verbindet. Allerdings ist es, da dieses elastische

Distanzstück elastisch so deformiert wird, dass der Ring an beiden Seiten des Schlitzes geöffnet ist, unmöglich, einen deformierbaren (verschiebbaren) Betrag in der Vorschubrichtung des elastischen Distanzstücks groß zu machen. Hierdurch ist es nicht sicher, dass ein solches elastisches Distanzstück geeignet für verschiedene Arten von Linearbewegungsanordnungen oder -vorrichtungen, um sie herzustellen, verwendbar ist, und dabei kann ein Fall hervorgerufen werden, bei dem eine relative Bewegung der Kugeln, die in den belasteten Bereich und den nicht belasteten Bereich hinein und heraus gehen, auftritt. Demzufolge kann eine störungsfreie Zirkulation der Rollelemente nicht erwartet werden.

[0009] Darüber hinaus schafft ein Stand der Technik ein elastisches Distanzstück, das aus einem einzelnen Element aufgebaut ist, wie dies in der Japanischen Patenveröffentlichung No. Hei 4-27405 offenbart ist, mit einer Struktur, in der das Distanzstück, an seinen beiden Enden in der Vorschubrichtung, mit gekrümmten Rückhalteflächen zum Halten der Rolle versehen ist, und wobei Ausschnitte an den gekrümmten Rückhalteflächen so gebildet sind, um sich in einer axialen Richtung davon zu erstrecken. Allerdings wird ein solches elastisches Distanzstück elastisch so deformiert, dass beide Seiten des Ausschnitts der gekrümmten Rückhalteflächen geöffnet sind, so dass es nicht möglich ist, einen deformierbaren (verschiebbaren) Betrag in der Vorschubrichtung des elastischen Distanzstücks groß zu machen.

[0010] Das Dokument CH-A-621 608 offenbart ein Distanzstück für eine Linearbewegungsvorrichtung, die zwischen Rollen, angeordnet in einem endlosen Zirkulationsdurchgangsweg der Linearbewegungsvorrichtung, zwischengefügt werden soll, wobei das Distanzstück einen massiven Körperbereich, gebildet aus einem elastischen Material, besitzt, und U-förmige Vertiefungen, gebildet in beiden Endbereichen davon in einer Vorschubrichtung des Distanzstücks, wenn es sich in dem endlosen Zirkulationsdurchgangsweg bewegt, aufweist, wobei die U-förmigen Vertiefungen eine Form kleiner als die Umfangsform der Rolle haben, so dass obere und untere Armbereiche des Distanzstücks, die Rollen tragend, elastisch voneinander weg deformierbar sind.

[0011] Die FR-A-1 104 502 offenbart Verbesserungen, die sich auf eine Vorrichtung zum Beibehalten der Beabstandung von Rollelementen in Kugellagern, und dergleichen, beziehen.

[0012] Die LU-A-61 956 offenbart ein Kegelrollenlager und ein Verfahren zum Montieren eines solchen Lagers.

[0013] Die JP-A-06 173946 offenbart eine direkt wirkende Führungsvorrichtung.

[0014] Eine Aufgabe der vorliegenden Erfindung ist es, im Wesentlichen Defekte oder Nachteile, die im Stand der Technik vorhanden sind, der vorstehend erwähnt ist, zu beseitigen, und ein Distanzstück, aufgebaut aus einem Einzelelement, einer Linearbewegungsvorrichtung, geeignet dazu, dass sie einen relativ großen, elastisch deformierbaren Betrag in deren Vorschubrichtung besitzt, zu schaffen, und auch eine Linearbewegungsvorrichtung, versehen mit solchen Distanzstücken, zu schaffen.

[0015] Gemäß einem ersten Aspekt der Erfindung wird ein Distanzstück für eine Linearbewegungsvorrichtung geschaffen, das zwischen Rollen, angeordnet in einem endlosen Zirkulationsdurchgangsweg der Linearbewegungsvorrichtung, zwischengefügt werden soll, wobei das Distanzstück einen Körperbereich besitzt, der gekrümmte Rückhalteflächenbereiche aufweist, die eine Form entsprechend zu einer Umfangsform der Rolle aufweisen, um die Rollen an beiden Endabschnitten davon in einer Vorschubrichtung des Distanzstücks zu tragen, wenn es sich in dem endlosen Zirkulationsdurchgangsweg bewegt, dadurch gekennzeichnet, dass der Körperbereich weiterhin ein Paar eines oberen und unteren Seitenflächenbereichs, die die gekrümmten Rückhalteflächenbereiche verbinden, aufweist, und ein innerer, hohler Bereich in dem Körperbereich des Distanzstücks durch die gekrümmten Rückhalteflächenbereiche und das Paar des oberen und unteren Seitenflächenbereichs definiert ist, wobei sich der innere, hohle Bereich in einer Richtung im Wesentlichen parallel zu einer axialen Richtung der Rolle erstreckt so, dass eine der gekrümmten Rückhalteflächenbereiche elastisch zueinander hin in der Vorschubrichtung deformierbar ist.

[0016] In einer bevorzugten Ausführungsform besitzt der Körperbereich eine Länge in der axialen Richtung der Rolle, die kleiner als eine axiale Länge der Rolle ist, und besitzt eine Höhe kleiner als eine Länge der Rolle in einer Richtung normal zu der axialen Richtung davon. Der Körperbereich kann aus einem synthetischen Harzmaterial über einen Spritzgieß-Vorgang gebildet sein.

[0017] Gemäß dem Distanzstück der Erfindung ist es, da das Distanzstück als ein einzelnes Element ausgebildet ist, einfach, die Distanzstücke zu handhaben oder zu warten, was zu einer Kostenverringerung beiträgt. Weiterhin kann, da eine der Rückhalteflächen elastisch zu der anderen einen davon hin deformierbar ist, das Distanzstück ausreichend elastisch in seiner Vorschubrichtung deformiert werden. Deshalb sind solche Distanzstücke bei vielen Arten von Typen einer Linearbewegungsvorrichtung, oder dergleichen, anwendbar, was demzufolge sehr praktikabel ist.

[0018] Ein sehr elastisch deformierbarer Betrag des

Distanzstücks in der Vorschubrichtung macht es möglich, eine ausreichende, relative Bewegung der Rollen an beiden Seiten des Distanzstücks sicherzustellen, und demzufolge kann die Zirkulation zwischen dem belasteten Bereich und dem nicht belasteten Bereich in dem Rollenzirkulationsdurchgangsweg störungsfrei gestaltet werden. Weiterhin ist, in dem angeordneten Zustand der Distanzstücke in dem Zirkulationsdurchgangsweg, da die Rollen komprimiert und kontrahiert werden, der Raum zwischen der endlosen Reihe der Rollen und der Distanzstücke, alternativ angeordnet in dem Zirkulationsdurchgangsweg, kein Raum (d.h. Minus-Raum) in Bezug auf den Wandbereich davon gebildet, so dass die Distanzstücke unter den vorbestimmten, konstanten Positionen zwischen den Rollen aufgrund der Rückstellkraft positioniert werden können, was demzufolge verhindert, dass die Rollen die Distanzstücke während der Rollbewegung davon einschneiden.

[0019] Gemäß einem bevorzugten Merkmal der Erfindung weist das Distanzstück ein vorstehendes Teil auf, das an einer der oberen und unteren Seitenflächenbereiche des Körperbereichs gebildet ist, so, um sich in einer Richtung senkrecht zu einer axialen Richtung der Rolle zu erstrecken. Gemäß einem weiteren, bevorzugten Merkmal der Erfindung weist das vorspringende Teil ein vorstehendes Ende auf, das eine runde Form besitzt. Das vorspringende Teil kann ein Plattenelement, gebildet an im Wesentlichen dem zentralen Bereich eines Seitenoberflächenbereichs des Distanzstücks in der Vorschubrichtung, sein. Genauer gesagt können die Distanzstücke mit Vorsprungsplatten gebildet sein, die in eine Führungsnut, gebildet an dem Rollenzirkulationsdurchgangsweg, eingesetzt sind, so dass die Rollen störungsfrei entlang der vorbestimmten Spur in dem Zirkulationsdurchgangsweg, ohne darin mäanderförmig zu laufen, bewegt und geführt werden.

[0020] Gemäß einem bevorzugten Merkmal der Erfindung ist der Distanzstück-Körper aus einem einzelnen, elastischen Material gebildet.

[0021] Vorzugsweise besitzt der Körperbereich eine Länge in der axialen Richtung der Rolle, die kleiner als eine axiale Länge der Rolle ist, und besitzt eine Höhe kleiner als eine Länge der Rolle in einer Richtung normal zu der axialen Richtung davon.

[0022] Vorzugsweise ist das Distanzstück als ein einzelnes Element gebildet, so dass es einfach ist, die Distanzstücke zu handhaben oder zu warten, was demzufolge zu einer Kostenverringerung beiträgt. Weiterhin kann, da eine der gekrümmten Rückhalteflächen elastisch zu der anderen einen davon hin deformierbar ist, das Distanzstück ausreichend elastisch in seiner Vorschubrichtung deformiert werden. Deshalb sind die Distanzstücke bei vielen Arten von Typen einer Linearbewegungsvorrichtung, oder dergleichen, anwendbar, so dass sie umfangreich praktikabel sind.

[0023] Gemäß einem zweiten Aspekt der Erfindung wird eine Linearbewegungsvorrichtung geschaffen, die aufweist: ein Führungsschienenelement, ausgebildet mit einer Rollenfläche;
ein Gleitelement, befestigt so, um relativ zu dem Führungsschienenelement, ausgebildet mit einem Rollenzirkulationsdurchgangsweg, umfassend eine belastete Rollenrollnut, die der Rollenrollfläche des Führungsschienenelements gegenüberliegt, wenn sie montiert ist, bewegbar zu sein, wobei das Gleitelement mit einer Führungsnut, die entlang des Rollenzirkulationsdurchgangswegs gebildet ist, versehen ist;
eine Anzahl von Rollen, angeordnet in dem Rollenzirkulationsdurchgangsweg so, um darin in Übereinstimmung mit der relativen Bewegung des Gleitelements in Bezug auf das Führungsschienenelement zu zirkulieren; und eine Anzahl von Distanzstücken, angeordnet zwischen den Rollen in einer alternierenden Art und Weise, wobei jedes der Distanzstücke gemäß dem ersten Aspekt der Erfindung ausgebildet ist.

[0024] In den beigefügten Zeichnungen:

[0025] Fig. 1 zeigt eine perspektivische Ansicht, die eine Linearrollbewegungsführungsvorrichtung darstellt, die mit einem Distanzstück gemäß einer ersten Ausführunsgform der vorliegenden Erfindung versehen ist;

[0026] Fig. 2 zeigt eine Schnittansicht einer Linearrollbewegungsführungsvorrichtung, die mit einem Distanzstück gemäß der ersten Ausführungsform versehen ist;

[0027] Fig. 3 zeigt eine Schnittansicht eines Kugelzirkulations-Durchgangswegs entlang einer axialen Richtung einer Schiene der Linearrollbewegungsvorrichtung der Fig. 1;

[0028] Fig. 4 zeigt eine perspektivische Ansicht des Distanzstücks und der Rollen gemäß der ersten Ausführungsform;

[0029] Fig. 5 zeigt eine Schnittansicht, die das Distanzstück und die Rollen gemäß der ersten Ausführungsform darstellt;

[0030] Fig. 6 zeigt eine Schnittansicht einer Linearfollbewegungsführungsvorrichtung, versehen mit einem Distanzstück, gemäß einer zweiten Ausführungsform der vorliegenden Erfindung;

[0031] Fig. 7 zeigt eine Teilschnittansicht der Fig. 6 in einem vergrößerten Maßstab;

[0032] Fig. 8 zeigt eine Schnittansicht eines Rollenzirkulationsdurchgangswegs entlang einer axialen Richtung einer Schiene der Linearbewegungsvorrichtung der Fig. 6;

[0033] Fig. 9 zeigt eine perspektivische Ansicht des Distanzstücks und der Rollen gemäß der zweiten Ausführungsform; und

[0034] Fig. 10 zeigt eine Schnittansicht, die das Distanzstück und die Rollen gemäß der zweiten Ausführunsform darstellt.

[0035] Wie die Fig. 1 und Fig. 2 zeigen, ist eine Linearrollbewegungsführungsvorrichtung **21**, versehen mit Distanzstücken **20**, gemäß der ersten Ausführungsform der vorliegenden Erfindung so angepasst, um linear ein bewegbares Element, wie beispielsweise einen Tisch, oder dergleichen, an einem fixierten (fixierenden) Element, wie beispielsweise einem Bett, einem Sattel bzw. Schlitten, oder dergleichen, zu führen. Die Linearrollbewegungsführungsvorrichtung **21** weist eine Führungsschiene (Spur-Führungswelle) **22**, angeordnet an dem fixierten Element, und gebildet aus Rollen-(Rollelement)-Rollflächen **22a** und Kugelrollnuten **22b**, die sich entlang einer Längsrichtung davon erstrecken, einem Gleitelement **33**, gebildet mit einem Rollenzirkulationsdurchgangsweg, umfassend eine belastete Rollen-Rollnut **34a** entsprechend zu der Rollen-Rollfläche **22a** der Führungsschiene **22**, und montiert mit der Führungsschiene **22**, um relativ entlang der Führungsschiene **22** bewegbar zu sein, eine Anzahl von Rollen (Rollelementen) **24**, **24**, --, **24**, angeordnet in dem Rollenzirkulationsdurchgangsweg und darin in Übereinstimmung mit der relativen Bewegung des bewegbaren Blocks **33** in Bezug auf die Führungsschiene **22** zirkulierend, und eine Mehrzahl von Distanzstücken **20**, **20**, --, **20**, zwischengefügt alternierend zwischen einer Vielzahl von Rollen **24**, auf. Jede Rolle **24** besitzt eine zylindrische Form, die einen kreisförmigen Querschnitt, geschnitten entlang der Rollrichtung davon, besitzt.

[0036] Die Rollen-Rollfläche **22a** bildet eine horizontal flache Oberfläche und die Kugel-Rollnut **22b** besitzt eine kreisförmige Querschnittsform.

[0037] Die Führungsschiene **22** besitzt ein Element mit einem langen Maßstab, das einen im Wesentlichen rechtwinkligen Querschnitt besitzt. Die zwei Reihen der Rollen-Rollflächen **22a** als Spuren zum Rollen der Rollen **24** sind an Seitenendbereichen der oberen Oberfläche der Führungsschiene **22** so gebildet, um sich entlang der gesamten Längsrichtung davon zu erstrecken, und zwei Reihen der Kugel-Rollennuten **22b** als Führung zum Rollen der Kugeln **25** sind auch an einem oberen Bereich jeder der Seitenflächen der Führungsschiene **22** gebildet, um sich so entlang der gesamten Längsrichtung davon zu erstrecken. Eine Mehrzahl von Schraubenlöchern zum Befestigen der Führungsschiene **22** an dem befestigten Element ist in der Längsrichtung der Führungsschiene **22** gebildet. Weiterhin sollte angemerkt werden, dass eine gekrümmte Führungsschiene anstelle der linearen Führungsschiene, dargestellt in Fig. 1, und in dem dargestellten Beispiel, wie dies vorstehend angegeben ist, verwendet werden kann, obwohl die oberen zwei Reihen der Rollen-Rollflächen **22a** und vier Seitenreihen der Kugel-Rollnuten **22b** (sechs Reihen insgesamt) an der Führungsschiene **22** gebildet sind, wobei die Anzahl der Reihen entsprechend dem Design, der Benutzung, der Aufgaben der Linearbewegungsführungsvorrichtung **21** geändert werden kann.

[0038] Der bewegbare Block **33** weist einen Körperbereich **34** und Endabdeckungen (Platten) **35**, angeordnet an beiden Längsendseiten des Körperbereichs **34**, auf, wobei der Körperbereich **34** und die Endabdeckungen **35** zusammen mittels Schrauben verbunden sind. Wie in Fig. 2 dargestellt ist, ist der Körperbereich **34** aus einem Körperblock **36a** und Form-Produkten **36b** und **36c** aufgebaut. Der Körperblock **36a** besitzt eine feste Struktur, gebildet aus einem festen Material, wie beispielsweise aus Stahl, um so einer Last, aufgebracht auf den bewegbaren Block **33**, standzuhalten, und ist, an seiner oberen Oberfläche, wie sie zu sehen ist, mit Schraubenlöchern (siehe Fig. 1) zum Befestigen eines Objekts, das durch die Führungsvorrichtung geführt werden soll, ausgebildet. Die Form-Produkte **36b** und **36c** sind integral mit dem Körperblock **36a** durch Einspritzen eines geschmolzenen Harzes in eine Form, in der der Körperblock **36a** platziert ist, gebildet, d.h. durch ein so genanntes Einsatz-Formungsverfahren. Weiterhin kann ein Metall, wie beispielsweise Aluminium, anstelle des Harzes verwendet werden, und, in einem solchen Fall, ist der Körperbereich über ein Spritzgießverfahren gebildet. Andererseits können, anstelle des vorstehenden Verfahrens, die Form-Produkte **36b** und **36c** unabhängig von dem Körperblock **36a** hergestellt werden, die später montiert werden, oder können integral über ein MIM (Metallspritzgießform) Verfahren gebildet werden.

[0039] Der Körperbereich **34** weist, um einen umgekehrten, im Wesentlichen U-förmigen Querschnitt, wie dies in Fig. 2 zu sehen ist, zu erreichen, einen horizontalen Bereich **36**, der der oberen Fläche der Führungsschiene **22** gegenüberliegt (dazu hinweist), und bilaterale Rand-(Schenkel)-Bereiche **37**, die sich nach unten von beiden Endbereichen des horizontalen Bereichs **36** erstrecken und gegenüberliegend zu den Seitenflächen der Führungsschienen **22** liegen, wenn der bewegbare Block **33** mit der Führungsschiene **22** zusammengebaut ist, auf.

[0040] Der horizontale Bereich **36** ist mit zwei Reihen von belasteten Rollen-Rollnuten **34a**, jeweils zu den zwei Rollen-Rollflächen **22a**, gebildet an der oberen Fläche der Führungsschiene **22**, gegenüberliegend, ausgebildet, und die Randbereiche **37** sind jeweils mit zwei Reihen der belasteten Kugel-Rollnuten **34b**, die den zwei Reihen der Kugel-Rollnuten **22b**, gebildet an jedem Seitenbereich der Führungsschiene **22**, gegenüberliegen, ausgebildet. Die Rollen-Rollnut **34a** besitzt eine rechtwinklige Querschnittsform, und die Rollen **34** rollen auf oberen Bodenflächen der Rollen-Rollnuten **34a**. Die bilateralen, innenseitigen Flächen der Rollen-Rollnuten **34a** liegen parallel zueinander, und ein kleiner Zwischenraum ist zwischen Endflächen der Rollen **24** und den Innenseitenflächen der Rollen-Rollnut **34a** gebildet. Entsprechend einer solchen Struktur wird die Rolle **24** durch die bilateralen Innenseitenflächen der Rollen-Rollnut **34a** geführt. Die Tiefe der Rollen-Rollnut **34a** ist so gebildet, dass sie kleiner als die radiale Länge der Rolle **34** ist, und ist, zum Beispiel, ungefähr von der Hälfte der Länge des Radius der Rolle **34**.

[0041] Belastete Rollen-Rolldurchgangswege A und belastete Rollen-Rolldurchgangswege A' sind in Kombination mit den Rollen-Rollflächen **22a** und den belasteten Rollen-Rollnuten **34a** und den Kugel-Rollnuten **22b** und den belasteten Kugel-Rollnuten **34b** jeweils gebildet.

[0042] Der horizontale Bereich **36** ist mit zwei Durchgangslöchern ausgebildet, die sich parallel zu den belasteten Rollen-Rollnuten **34a** erstrecken, und rohrförmige Bereiche der Form-Produkte **36c** sind integral mit diesen Durchgangslöchern ausgebildet. Rückführkanäle B sind in den rohrförmigen Bereichen der Form-Produkte **36c**, ausgebildet mit den Durchgangslöchern, zum Zurückführen der Rollen **24**, **24**, --, **24** ausgebildet.

[0043] Die Randbereiche **37** sind auch mit Durchgangslöchern ausgebildet, die sich jeweils parallel zu den belasteten Kugel-Rollnuten **34b** erstrecken, und rohrförmige Bereiche der Form-Produkte **36c** sind integral mit diesen Durchgangslöchern ausgebildet. Rückführkanäle B' sind in den rohrförmigen Bereichen der geformten Produkte **36c**, ausgebildet mit den Durchgangslöchern, zum Zurückführen der Kugeln **25**, **25**, --, **25** ausgebildet.

[0044] Das Form-Produkt **36b** ist integral mit der unteren Oberfläche des horizontalen Bereichs **36** und den gesamten Innenseitenflächen der Randbereiche **37** des Körperblocks **36a** ausgebildet. Rollen-Rückhaltebereiche (Rückhalteeinrichtungen) **39** sind auf dem Form-Produkt **36b** gebildet, um zu verhindern, dass die Blockrollen **24** aus den belasteten Rollen-Rolldurchgangswegen A zu einem Zeitpunkt herauskommen, wenn deren bewegbarer Block **33** von der Führungsschiene **22** entfernt wird.

[0045] Wie Fig. 3 zeigt, ist das Form-Produkt **36c** mit bogenförmigen, inneren Umfangs-Führungsbereichen **36d** ausgebildet, die an beiden Endbereichen des Körperblocks **36a** vorstehen, um einen Rollelement-(Rollen)-Rollrichtungsänderungskanal C zu bilden, und die Endabdeckungen **35** sind mit äußeren Umfangs-Führungsbereichen **35a**, die den Richtungsänderungskanal C in Verbindung mit den inneren Umfangs-Führungsbereichen **36d** bilden, ausgebildet. Das bedeutet, dass, wenn die Endabdeckungen **35** an dem Körperbereich **34** befestigt sind, der innere und der äußere Umfangs-Führungsbereich **36d** und **35a** so montiert werden, um dadurch die U-förmigen Rollen-Rollrichtungsänderungskanäle C an beiden Endbereichen zu bilden. Der endlose Zirkulationsdurchgangsweg ist durch den belasteten Rollen-Rolldurchgangsweg A, den Rückführdurchgangsweg B und die U-förmigen Richtungsänderungs-Durchgangswege C, wenn sie montiert sind, gebildet.

[0046] Entsprechend der Bewegung des bewegbaren Blocks **33** entlang der Führungsschiene **22** werden die Rollen **24**, **24**, --, **24** von einem Ende zu dem anderen Ende des belasteten Rollen-Rolldurchgangsweges A bewegt (gerollt), während sie mit der Last von dem bewegbaren Block **33** beaufschlagt werden, aufgenommen durch einen der Richtungsänderungskanäle C, geführt zu dem Rückführkanal B, und dann zurückgeführt zu einem Ende des belasteten Rollen-Rolldurchgangsweges A durch den anderen einen der Richtungsänderungskanäle C. In dieser Zirkulationsbewegung rollen die Rollen **24**, wobei die Last darauf aufgebracht wird, in dem belasteten Kugel-Rolldurchgangsweg A und Zirkulieren in den nicht belasteten Richtungsänderungskanälen C und den nicht belasteten Rückführkanal B. Allgemein bewegen sich die Rollen **24** unter einer relativ hohen Geschwindigkeit in dem belasteten Bereich und einer relativ niedrigen Geschwindigkeit in dem nicht belasteten Bereich. Gemäß der vorliegenden Erfindung werden die Distanzstücke **20** ausreichend elastisch in deren Vorschubrichtung deformiert, und eine der Rollen **24**, **24**, angeordnet an beiden Seiten des Distanzstücks **20**, kann relativ zu der anderen einen davon bewegt werden, wobei die Rollen **24** ohne Störung durch die Grenzbereiche zwischen dem belasteten Bereich und dem nicht belasteten Bereich in dem Endlos-Zirkulationsdurchgangsweg hindurchführen können, und, demzufolge, störungsfrei darin zirkuliert werden.

[0047] Fig. 4 und Fig. 5 stellen ein Distanzstück **20** dar, das mit der Linearrollbewegungsführungsvorrichtung **21**, dargestellt in Fig. 1, zum Beispiel, verbunden ist. Das Distanzstück **20** ist vorzugsweise aus einem synthetischen Harzmaterial über einen Spritzgieß-Vorgang, zum Beispiel, hergestellt. Jedes der Distanzstücke **20** ist zwischen den Rollen **24** angeordnet und ist mit gekrümmten Rückhalteflächen

28 an beiden Endbereichen in einer Vorschubrichtung (Richtung ① in Fig. 5) des Distanzstücks **20** ausgebildet. Die gekrümmte Rückhaltefläche besitzt eine Form entsprechend zu einer Umfangsform der Rolle **24**. Wenn die gekrümmten Rückhalteflächen **28** des Distanzstücks **20** gegen die Rollen **24** an beiden Endseiten anstoßen, stimmt die Mittellinie des Distanzstücks **20** mit der Linie, die die zentralen Bereiche der Rollen **24**, angeordnet an beiden Seiten davon, verbinden, überein. Das Distanzstück **20** besitzt eine Länge, normal zu der Vorschubrichtung, entsprechend zu der axialen Richtung der Rolle **24**, leicht geringer als die axiale Länge der Rolle, um so nicht in Kontakt mit dem Wandbereich des endlosen Rollenzirkulationsdurchgangswegs zu stehen, und das Distanzstück **20** besitzt auch eine Höhe leicht kleiner als ein Durchmesser der Rolle **24**.

[0048] Das Distanzstück **20** besitzt eine innere, hohle Struktur, die einen Hohlraum **29** so besitzt, dass eine der gekrümmten Rückhalteflächen **28** zu der anderen einen davon hin deformierbar ist, wobei sich der Hohlraum **29** in der Richtung parallel zu der axialen Richtung der Rolle **24** erstreckt. Das bedeutet, dass das Distanzstück **20** ein Paar von Rückhaltebereichen **20a** aufweist, von denen jedes die gekrümmte Rückhaltefläche **28**, gegenüberliegend zueinander in der Vorschubrichtung, und ein Paar von oberen und unteren Verbindungsbereichen **20b**, die die gepaarten Rückhaltebereiche **20a** mit dem Hohlraum **29** dazwischen verbinden, besitzt. Da die Verbindungsbereiche **20b** so ausgebildet sind, dass sie dünn sind, um so leicht gebogen zu werden, ist eine der gekrümmten Rückhalteflächen **28** elastisch zu der anderen einen davon hin deformiert.

[0049] Die Distanzstücke **20** der Struktur, die vorstehend erwähnt ist, und die Rollen **24** sind in dem endlosen Rollenzirkulationsdurchgangsweg in einer alternierenden Anordnung zueinander aufgenommen. Wenn die Distanzstücke **20** und die Rollen **24** darin montiert sind, ist, da die Distanzstücke **20** in dem Zustand eng in der Vorschubrichtung zusammengedrückt angeordnet sind, im Wesentlichen kein Raum oder Zwischenraum zwischen der Reihe der Rollen **24** und den Distanzstücken **20** und dem Wandbereich des endlosen Zirkulationsdurchgangswegs vorhanden. Dementsprechend wird jedes der Distanzstücke **20** fest zwischen den angrenzenden Rollen **24**, **24** an einer konstanten, vorbestimmten Position durch die Rückstellkraft des Distanzstücks **20** selbst festgeklemmt, und demzufolge ist dabei keine Gefahr vorhanden, dass die Rollen **24** in die Distanzstücke **20** während der Zirkulation davon eingreifen.

[0050] Wie Fig. 1 zeigt, rollen, wenn sich der Körperblock **36a** entlang der Führungsschiene **22** bewegt, die Rollen **24**, **24**, --, **24**, während sie mit der Last von dem bewegbaren Block **36a**, in dem belasteten Rollen-Rolldurchgangsweg A von einem Ende zu dem anderen Ende davon, beaufschlagt werden. Danach werden die Rollen **24** durch einen der Rollen-Richtungsänderungs-Durchgangswege C aufgenommen, dann zu dem Rückführ-Durchgangsweg B geführt und danach zu einem Ende des belasteten Rollen-Rolldurchgangswegs A mittels des anderen einen des Rollen-Richtungsänderungs-Kanals C zurückgeführt. In dieser Zirkulationsbewegung rollen die Rollen **24** mit dem belasteten Zustand in dem belasteten Bereich des belasteten Rollen-Rolldurchgangswegs A und Rollen mit dem nicht belasteten Zustand in dem nicht belasteten Bereich der Richtungsänderungs-Durchgangswege C und dem Rückführ-Durchgangsweg B. Allgemein rollen die Rollen **24** schnell in dem belasteten Bereich und langsam in dem nicht belasteten Bereich.

[0051] Gemäß dieser ersten Ausführungsform können, da die Distanzstücke **20** ausreichend elastisch in der Vorschubrichtung deformiert werden und eine der Rollen **24**, angeordnet an beiden Vorschubseiten des Distanzstücks **20**, relativ in Bezug auf die andere Eine der Rollen **24** bewegt werden kann, die Rollen **24** ohne Behinderung zwischen dem belasteten Bereich und dem nicht belasteten Bereich in dem endlosen Rollenzirkulationsdurchgangsweg bewegt werden.

[0052] Die Fig. 6 bis Fig. 8 stellen eine lineare Rollbewegungs-Führungsvorrichtung **31**, versehen mit einem Distanzstück gemäß einer zweiten Ausführungsform der vorliegenden Erfindung, dar.

[0053] Wie die Fig. 6 bis Fig. 8 zeigen, weist die Linearrollbewegungsführungsvorrichtung **31**, ähnlich der Vorrichtung **21** der früheren Ausführungsform, eine Führungsschiene **22**, einen bewegbaren Körperblock **33**, montiert mit der Führungsschiene **22**, um relativ entlang der Führungsschiene **22** bewegbar zu sein, eine Anzahl von Rollen **24**, **24**, --, **24** und eine Anzahl von Kugeln **25**, **25**, --, **25** auf, und dementsprechend sind entsprechende Bezugszeichen zu den Merkmalen entsprechend zu solchen der Führungsvorrichtung **21** hinzugefügt und die detaillierte Beschreibung davon kann hier weggelassen werden.

[0054] Der bewegbare Block **33** ist aus einem Körperbereich **34** und einem Paar von Endabdeckungen **35**, die miteinander mittels Schrauben, oder dergleichen, befestigt sind, aufgebaut. Der Körperbereich **34** weist einen Körperblock **36a** und geformte Produkte **36b** und **36c** auf, und die geformten Produkte **36b**, **36c** sind integral mit dem Körperblock **36a** durch Einspritzen eines geschmolzenen Harzes in eine Form, in der der Körperblock **36a** zuvor eingesetzt ist, mittels einem so genannten Einsetzgieß-Vorgang, gebildet.

[0055] Weiterhin besitzt der Körperbereich **34** einen horizontalen Bereich **36**, der zu der oberen Fläche der Führungsschiene **22** in einem montierten Zustand gegenüberliegt, und ein Paar von bilateralen Rand-(Schenkel)-Bereichen **37**, die sich nach unten von beiden Seitenenden des horizontalen Bereichs **36** erstrecken, um so zu den Seitenflächen der Führungsschiene **22** in dem montierten Zustand gegenüber zu liegen. Der horizontale Bereich **36** ist mit zwei Rollen-Rollnuten **34a**, **34a**, als belastete Rollen-Rollflächen, die den Rollen-Rollflächen **22a** der oberen Fläche der Führungsschiene **22** gegenüberliegen, ausgebildet. Die Randbereiche **37** sind mit oberen und unteren, belasteten Kugel-Rollnuten **34b**, **34b** entsprechend zu den Kugel-Rollnuten **22b**, **22b**, gebildet auf den Seitenflächen der Führungsschienen **22**, ausgebildet. Die Rollen-Rollflächen **22a** und die Rollen-Rollnuten **34a** bilden die belasteten Rollen-Rolldurchgangswege A in Kombination, und andererseits bilden die Kugel-Rollnuten **22b**, **22b** und die belasteten Kugel-Rollnuten **34b**, **34b** den belasteten Kugel-Rolldurchgangsweg A'.

[0056] Der horizontale Bereich **36** ist auch mit zwei Durchgangslöchern ausgebildet, die sich parallel zu den Rollen-Rollflächen **22a** der Führungsschiene **22** in der Längsrichtung des bewegbaren Blocks **33** erstrecken. Ringförmige Bereiche der Form-Produkte **36c**, **36c** sind in diese Durchgangslöcher integral eingesetzt, und die rohrförmigen Bereiche besitzen innere, hohle Bereiche, die als Rollen-Rückführkanäle B gebildet sind. Jeder der Randbereiche **37** ist auch mit zwei (vier insgesamt) Durchgangslöchern in jeder Seite, sich parallel zu den belasteten Kugel-Rollnuten **34b**, **34b** erstreckend, ausgebildet. Die rohrförmigen Bereiche des geformten Produkts **36c** sind in diese Durchgangslöcher integral eingesetzt, und die rohrförmigen Bereiche besitzen innere, hohle Bereiche, die als Kugel-Rückführ-Durchgangswege B' ausgebildet sind.

[0057] Wie Fig. 7 zeigt, ist das geformte Produkt **36b** integral mit der gesamten, inneren Oberfläche des Körperblocks **36a**, umfassend die untere Fläche des horizontalen Bereichs **36** und die innenseitigen Flächen der Randbereiche **37**, gebildet. Zu dem geformten Produkt **36b** sind Rollen-Rückhaltebereiche (Rückhalteeinrichtungen) **39** vorgesehen, um zu verhindern, dass die Rollen **24** aus den belasteten Rollen-Rolldurchgangswegen A zu dem Zeitpunkt eines Herausziehens des bewegbaren Blocks **33** von der Führungsschiene **22** herauskommen, und dort sind auch Kugel-Rückhaltebereiche (Rückhalteeinrichtungen) **40** vorgesehen, um zu verhindern, dass die Kugeln **25** von dem belasteten Kugel-Rolldurchgangsweg A' zu der Herausziehzeit des bewegbaren Blocks heraus kommen.

[0058] Wie Fig. 8 zeigt, sind bogenförmige, innere Umfangs-Führungsbereiche **36d**, **36d** an beiden Endbereichen des Körperblocks **36a** so gebildet, um nach außen vorzustehen, um dadurch Rollrichtungsänderungs-Durchgangswege C zu dem geformten Produkt **36c** zu bilden, und an den Endabdeckungen **35** sind äußere Umfangs-Führungsbereiche **35a**, **35a** zum Bilden der Rollen-Richtungsänderungs-Durchgangswege C in Kombination mit den inneren Umfangs-Führungsbereichen **36d**, **36d** gebildet, wenn die Endabdeckungen **35**, **35** an dem Körperblock **36a** befestigt sind. Wie vorstehend erwähnt ist, ist der Endlos-Rollenzirkulationsdurchgangsweg so durch die Kombination (Montage) des belasteten Rollen-Rolldurchgangswegs A, der U-förmigen Rollen-Richtungsänderungs-Durchgangswege C und des Rückführ-Durchgangswegs B gebildet.

[0059] Gemäß der Linearrollbewegungsführungsvorrichtung **31** der vorliegenden Ausführungsform, die den vorstehenden Aufbau besitzt, werden, wenn die Rollen **24** zirkuliert werden, Distanzstücke **45** zweidimensional in deren Richtungen geändert. Das bedeutet, dass die Rollen **24** rollen und in den Rollrichtungen von dem linearen, belasteten Rolldurchgangsweg A, dem U-förmigen, eine Richtung ändernden Durchgangsweg C, dem Rückführ-Durchgangsweg B und dem U-förmigen anderen Richtungsänderungs-Durchgangswegs C geändert werden.

[0060] Dabei ist eine Führungsnut **43** (siehe Fig. 6–Fig. 8) an der inneren Umfangsseite des Endlos-Rollenzirkulationsdurchgangswegs zum Aufnehmen von vorstehenden Platten **41** der Distanzstücke **45** gebildet, und, in diesem Zusammenhang, besitzt die Führungsnut **43** eine Breite leicht größer als eine Dicke der vorstehenden Platte **41**. Wenn die Rollen **24**, d.h. die Distanzstücke **45**, in dem Endlos-Rollenzirkulationsdurchgangsweg bewegt werden, bewegen sich die vorstehenden Platten **41** der Distanzstücke **45** entlang der Führungsnut **43**.

[0061] Fig. 9 und Fig. 10 stellen die Distanzstücke **45** der zweiten Ausführungsform, die in die Linearrollbewegungsführungsvorrichtung **31** eingesetzt werden, dar.

[0062] Das Distanzstück **45** ist auch über den Formungsvorgang eines Harzes wie in der ersten Ausführungsform, wie dies vorstehend erwähnt ist, gebildet. Das Distanzstück **45** ist mit gekrümmten Rückhalteflächen **42** an deren beiden Enden in der Vorschubrichtung davon gebildet, wobei die Rückhalteflächen **42** eine Form entsprechend zu der äußeren Umfangsform der Rolle **24** besitzen. Das Distanzstück **45** ist mit einem inneren, hohlen Bereich (Hohlraum) **46** ausgebildet, der sich in einer Richtung parallel zu der axialen Richtung der Rolle **24** erstreckt, so dass eine der gekrümmten Rückhalteflächen **42** elastisch zu der anderen davon hin deformierbar ist, wenn ein Druck aufgebracht wird.

[0063] Weiterhin ist, wie kurz vorstehend erwähnt ist, das Distanzstück **45** mit der vorstehenden Platte

41, unterschiedlich gegenüber dem Distanzstück **20** in der früheren Ausführungsform, ausgebildet, sich nach außen (nach oben) in einer Richtung normal zu der axialen Richtung der Rolle **24** erstreckend. Die vorstehende Platte **41** ist an im Wesentlichen dem zentralen Bereich einer der Verbindungsplatten **45a**, die beide gekrümmten Rückhalteflächen verbindet, gebildet. Der vorstehende Endbereich der vorstehenden Platte **41** ist in die Führungsnut **43**, gebildet auf der inneren Umfangsfläche des Endlos-Rollenzirkulationsdurchgangswegs, eingesetzt. Weiterhin ist es bevorzugt, dass der vorstehende Endbereich der vorstehenden Platte **41** eine kreisförmige, äußere Form für ein einfaches Einsetzen und eine störungsfreie Zirkulation in der Führungsnut **43** besitzt.

[0064] Das Distanzstück **45** dieser zweiten Ausführungsform kann im Wesentlichen dieselben Funktionen wie solche der ersten Ausführungsform erreichen, und zusätzlich kann, gemäß dem Distanzstück **45** der zweiten Ausführungsform, da die vorstehenden Platten **41** der Distanzstücke **45** entlang des vorbestimmten Wegs in der Führungsnut **43** geführt werden können, die Rollen **24**, getragen durch die Distanzstücke **45**, störungsfrei und stabil in dem Endlos-Rollenzirkulationsdurchgangsweg bewegt und zirkuliert werden, ohne in einer mäanderförmigen Art und Weise, zum Beispiel, zu rollen. Insbesondere kann, da die Distanzstücke **45** nicht in der mäanderförmigen Art und Weise in der Rollen-Axialrichtung bewegt werden, die Kollision der axialen Endflächen der Distanzstücke **45** gegen den Wandbereich des endlosen Rollenzirkulationsdurchgangswegs effektiv verhindert werden.

[0065] Die Distanzstücke **20** und **45** gemäß der vorliegenden Erfindung können, anders als die Linearrollbewegungsführungsvorrichtungen **21** und **33**, die jeweils vorstehend erwähnt sind, bei einer Rollen-Schraub- bzw. Spindelvorrichtung und einer Rollen-Keilwellenvorrichtung angewandt werden, wobei die letztere eine Keilwelle als ein Führungselement und ein Gleitelement als ein äußeres, zylindrisches Element, befestigt so, um zu der Keilwelle über eine Anzahl von Rollen bewegbar zu sein, aufweist.

Patentansprüche

1. Distanzstück (**45**) für eine Linearbewegungsvorrichtung (**31**), das zwischen Rollen (**24**), angeordnet in einem endlosen Zirkulationsdurchgangsweg der Linearbewegungsvorrichtung, zwischengefügt werden soll, wobei das Distanzstück einen Körperbereich besitzt, der gekrümmte Rückhalteflächenbereiche (**20a**, **42**) aufweist, die eine Form entsprechend zu einer Umfangsform der Rolle (**24**) aufweisen, um die Rollen an beiden Endabschnitten davon in einer Vorschubrichtung des Distanzstücks zu tragen, wenn es sich in dem endlosen Zirkulationsdurchgangsweg bewegt, wobei der Körperbereich weiterhin ein Paar eines oberen und unteren Seitenflächenbereichs (**20b**, **45a**), die die gekrümmten Rückhalteflächenbereiche verbinden, aufweist, und ein innerer, hohler Bereich (**46**) in dem Körperbereich des Distanzstücks durch die gekrümmten Rückhalteflächenbereiche und das Paar des oberen und unteren Seitenflächenbereichs (**20b**, **45a**) definiert ist, wobei sich der innere, hohle Bereich in einer Richtung im Wesentlichen parallel zu einer axialen Richtung der Rolle erstreckt so, dass die gekrümmten Rückhalteflächenbereiche elastisch zueinander hin in der Vorschubrichtung deformierbar sind.

2. Distanzstück (**45**) für eine Linearbewegungsvorrichtung (**31**) nach Anspruch 1, die weiterhin ein vorstehendes Teil (**41**), gebildet an einem des oberen und des unteren Seitenflächenbereichs (**25b**, **45a**) des Körperbereichs, aufweist, um sich so in einer Richtung senkrecht zu einer axialen Richtung der Rolle (**24**) zu erstrecken.

3. Distanzstück (**45**) für eine Linearbewegungsvorrichtung (**31**) nach Anspruch 2, wobei das vorstehende Teil ein vorstehendes Ende besitzt, das eine runde Form besitzt.

4. Distanzstück (**45**) für eine Linearbewegungsvorrichtung (**31**) nach einem der Ansprüche 1 bis 3, wobei der Körperbereich des Distanzstücks aus einem einzelnen, elastischen Material gebildet ist.

5. Linearbewegungsvorrichtung (**31**), die aufweist:
ein Führungsschienenelement (**2**), ausgebildet mit einer Rollenfläche;
ein Gleitelement (**3**), befestigt so, um relativ zu dem Führungsschienenelement, ausgebildet mit einem Rollenzirkulationsdurchgangsweg, umfassend eine belastete Rollenrollnut (A), die der Rollenrollfläche des Führungsschienenelements gegenüberliegt, wenn sie montiert ist, bewegbar zu sein, wobei das Gleitelement mit einer Führungsnut (**43**), die entlang des Rollenzirkulationsdurchgangswegs gebildet ist, versehen ist;
eine Anzahl von Rollen (**24**), angeordnet in dem Rollenzirkulationsdurchgangsweg so, um darin in Übereinstimmung mit der relativen Bewegung des Gleitelements in Bezug auf das Führungsschienenelement zu zirkulieren; und
eine Anzahl von Distanzstücken (**45**), angeordnet zwischen den Rollen in einer alternierenden Art und Weise, wobei jedes der Distanzstücke gemäß einem der vorhergehenden Ansprüche ausgebildet ist.

Es folgen 8 Blatt Zeichnungen

Anhängende Zeichnungen

FIG. 1

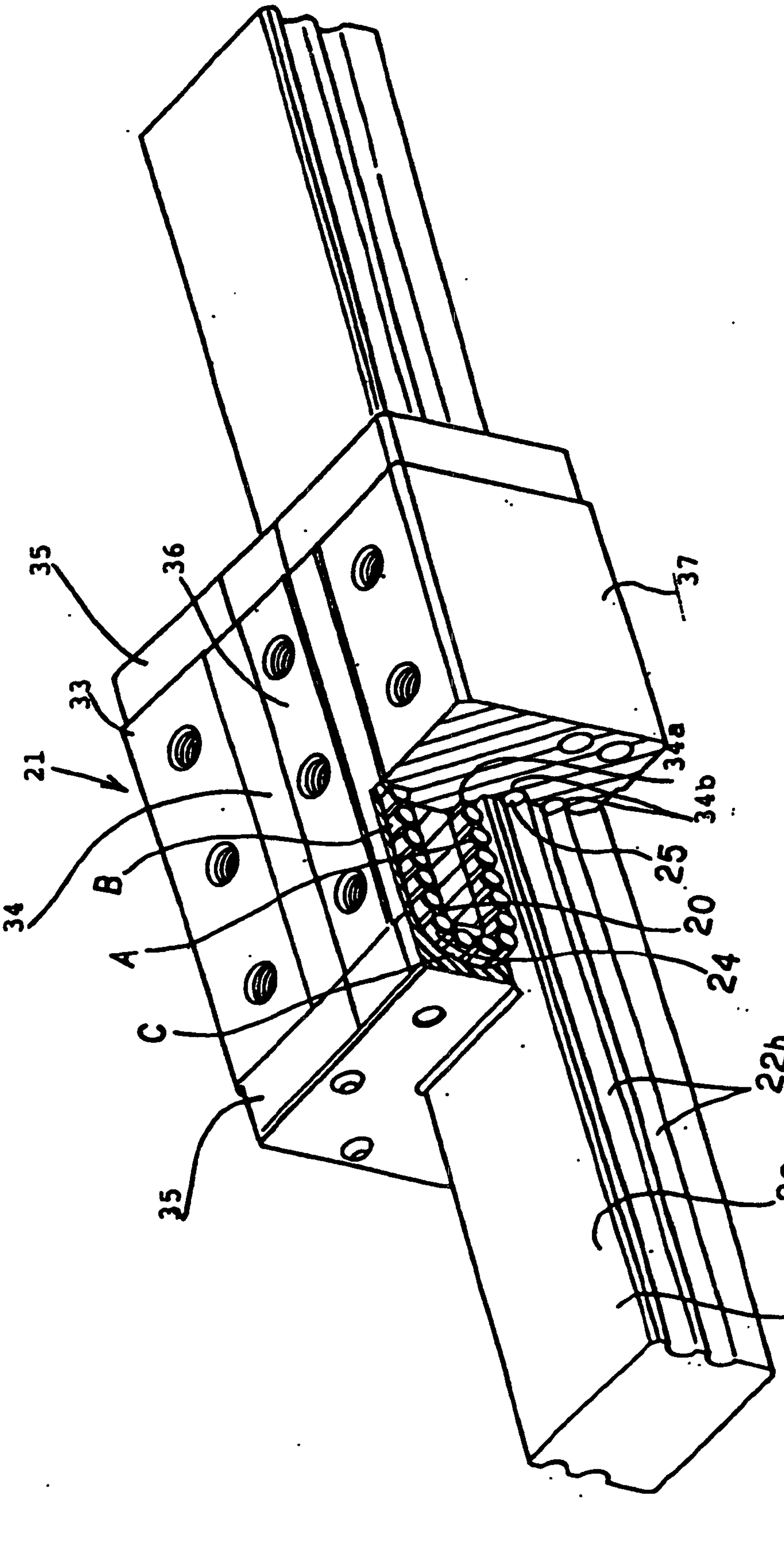


FIG. 2

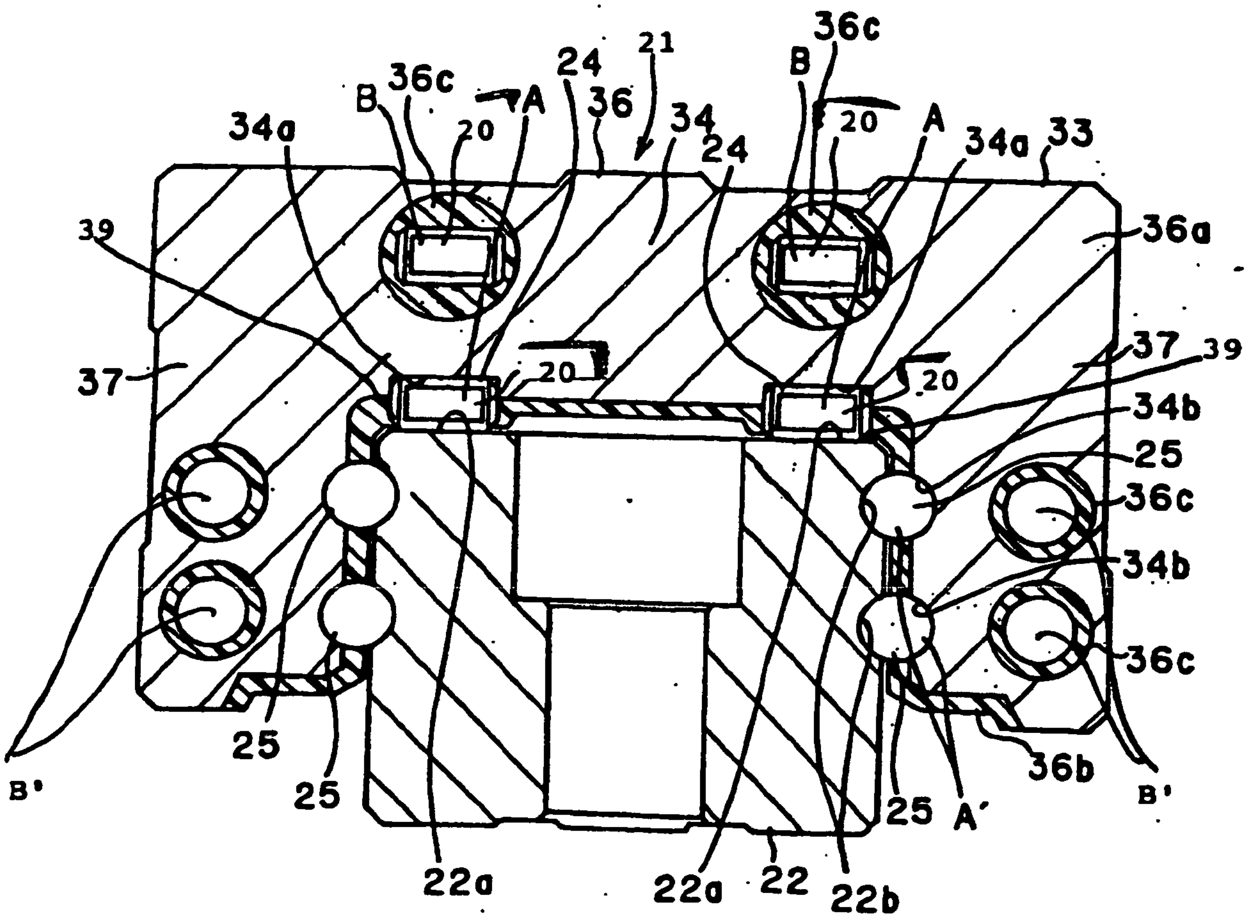

21
36c
B
36c
24
A
36
34
B
20
A
34a
33
34a
20
24
39
36a
37
20
20
37
39
34b
25
36c
34b
36c
B'
25
25
36b
B'
25
A'
22a
22a
22
22b

FIG. 3

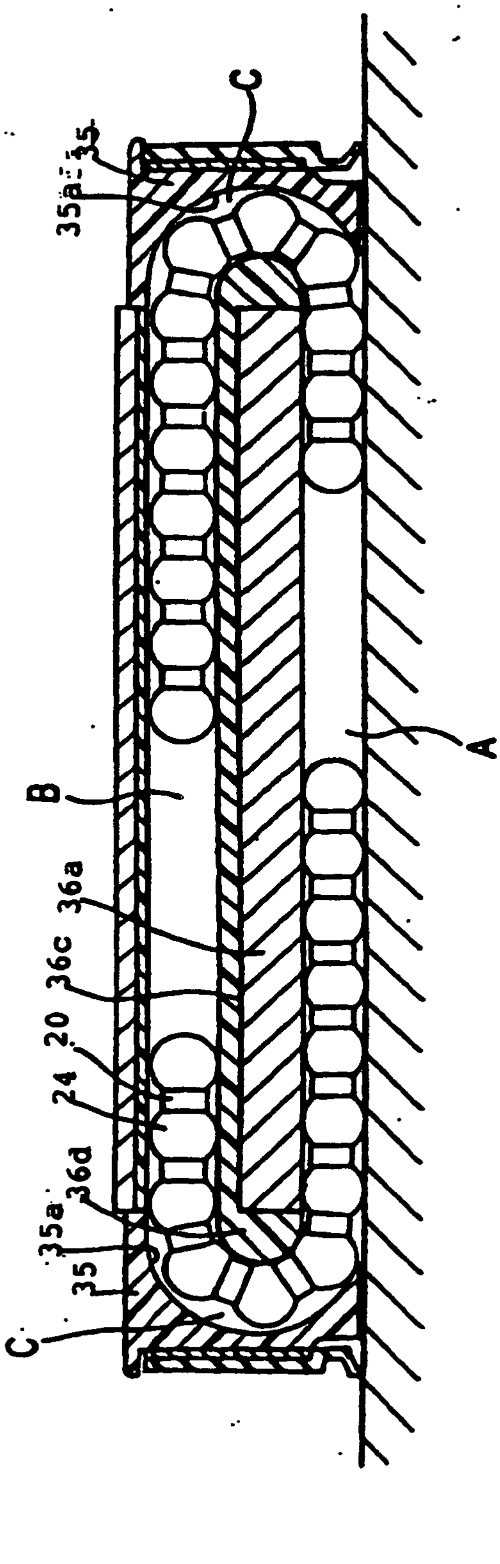


FIG. 4

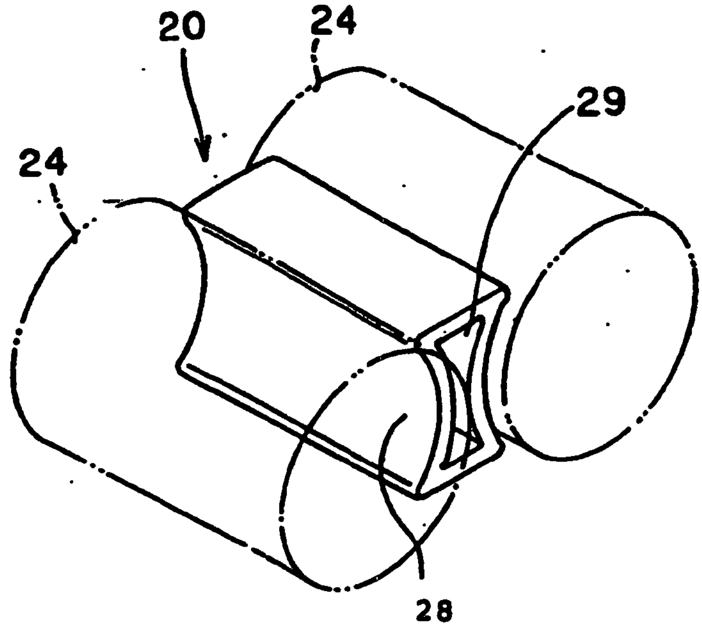


FIG. 5

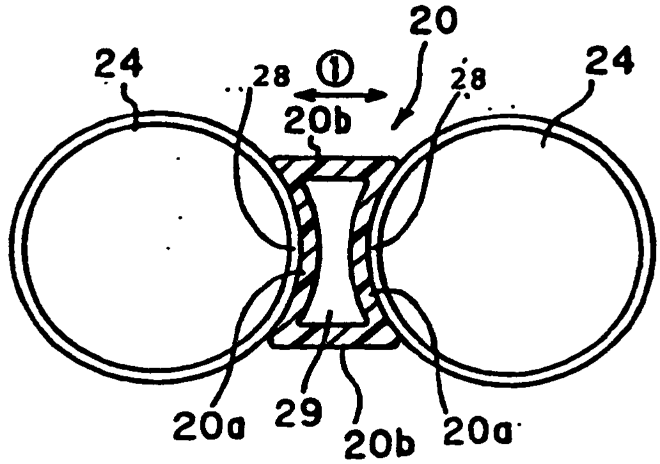


FIG. 6

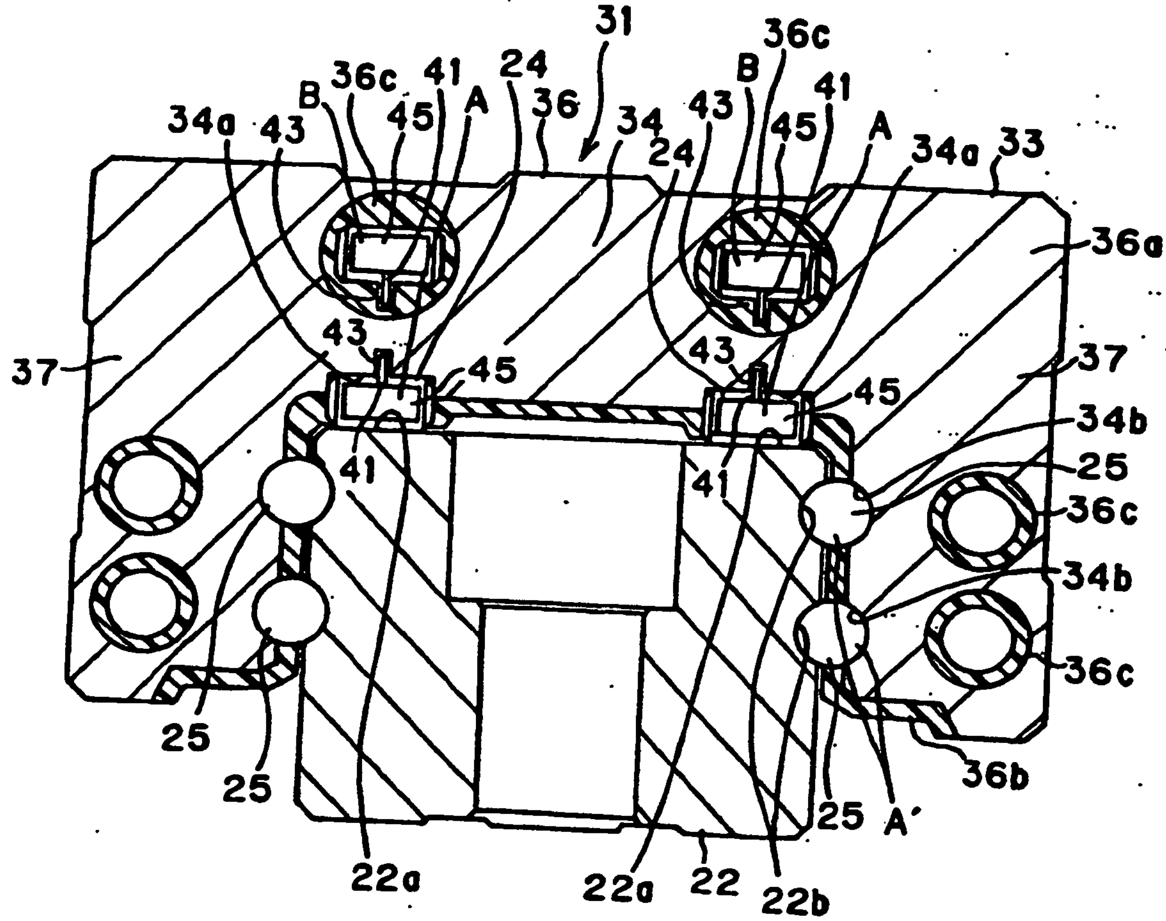

31
36c
24
B
36c
41
A
45
36
34
34a
43
43
24
B
45
41
A
34a
33
36a
37
43
45
43
45
37
34b
41
41
25
36c
34b
36c
25
25
25
36b
25
A'
22a
22a
22
22b

FIG. 7

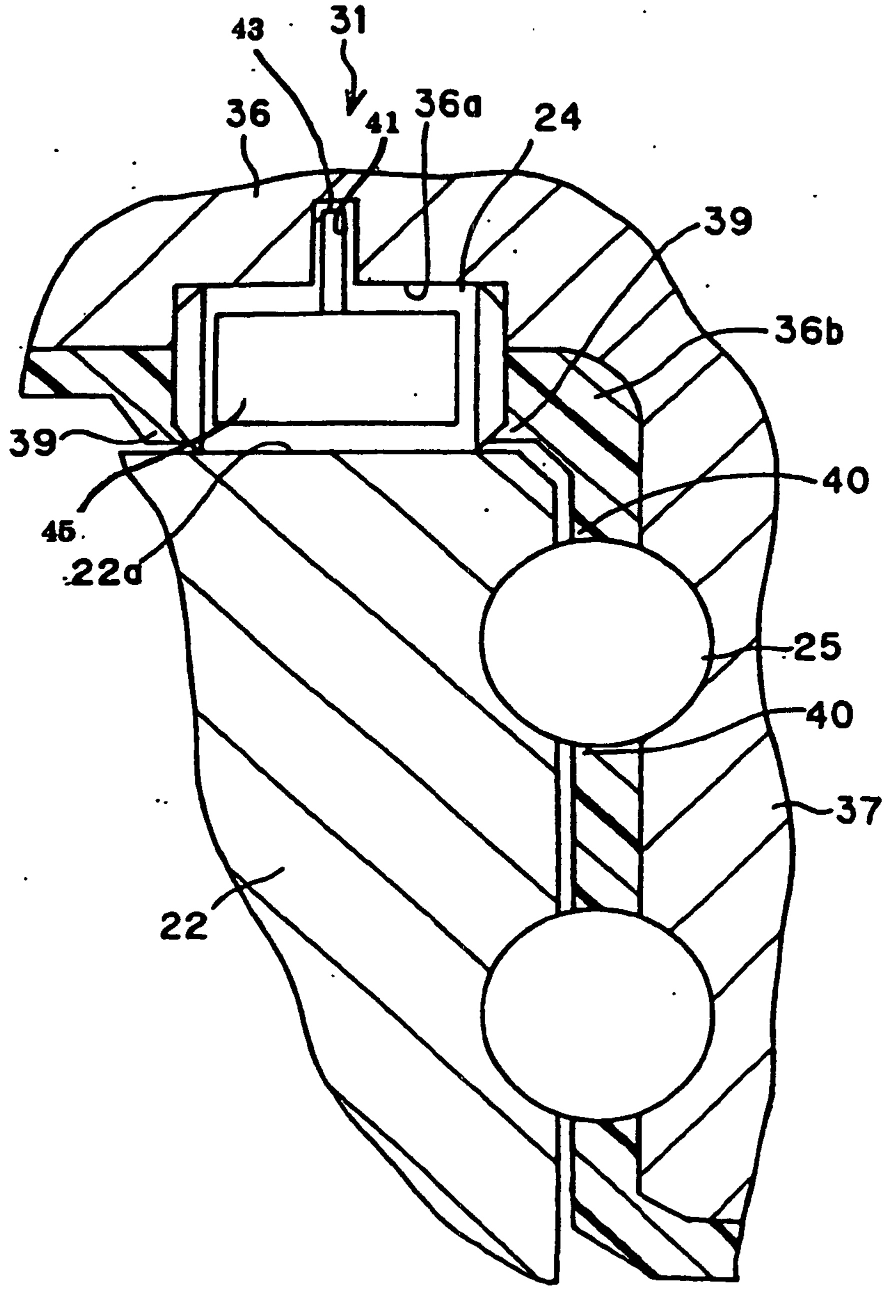


FIG. 8

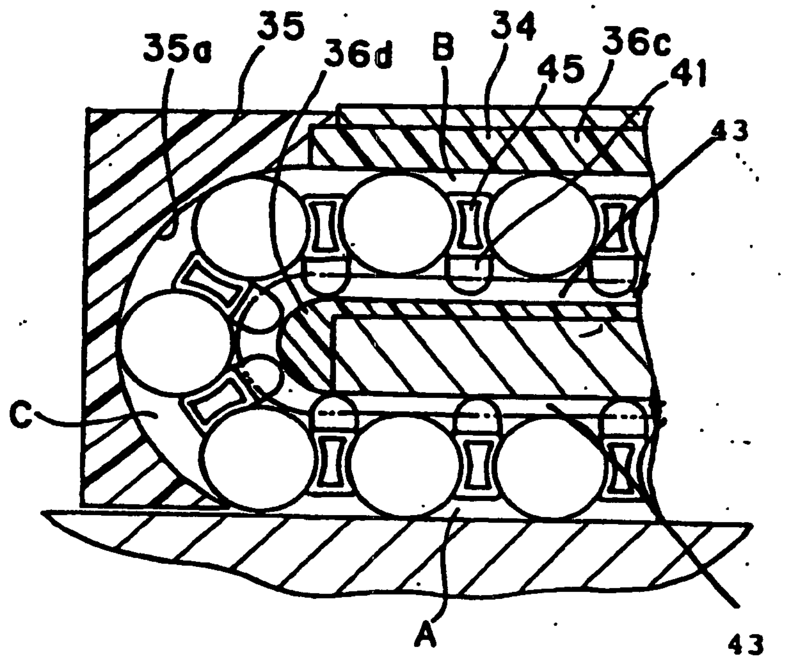


FIG. 9

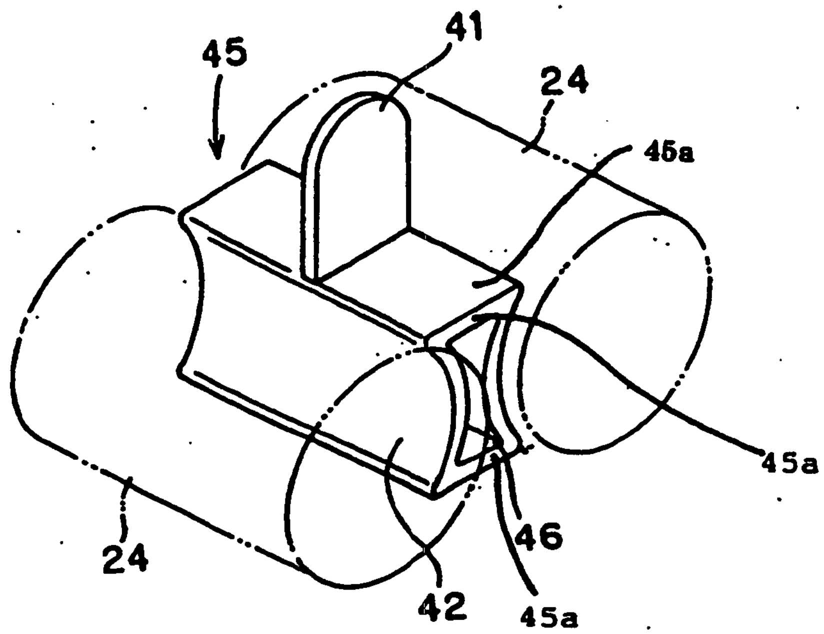
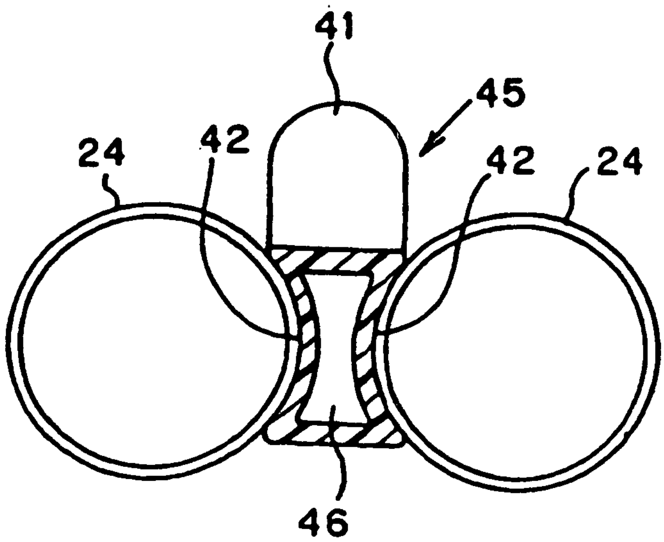


FIG. 10



(19) Bundesrepublik Deutschland
Deutsches Patent- und Markenamt

(10) **DE 600 18 846 T2** 2006.04.13

(12) # Übersetzung der europäischen Patentschrift

(97) **EP 1 059 464 B1**
(21) Deutsches Aktenzeichen: **600 18 846.9**
(96) Europäisches Aktenzeichen: **00 304 937.6**
(96) Europäischer Anmeldetag: **09.06.2000**
(97) Erstveröffentlichung durch das EPA: **13.12.2000**
(97) Veröffentlichungstag der Patenterteilung beim EPA: **23.03.2005**
(47) Veröffentlichungstag im Patentblatt: **13.04.2006**

(51) Int Cl.[8]: ***F16C 29/06*** (2006.01)

(30) Unionspriorität:
16255799 09.06.1999 JP
27680799 29.09.1999 JP

(84) Benannte Vertragsstaaten:
DE, FR, GB, IT

(73) Patentinhaber:
THK Co., Ltd., Tokio/Tokyo, JP

(72) Erfinder:
Michioka, Hidekazu, Tokyo, JP; Hoshide, Kaoru, Tokyo, JP; Mochizuki, Hiroaki, Yamanashi-ken, JP; Kouchi, Minoru, Tokyo, JP

(74) Vertreter:
Grünecker, Kinkeldey, Stockmair & Schwanhäusser, 80538 München

(54) Bezeichnung: **Universalführungsvorrichtung und damit versehener beweglicher Tisch**

Beschreibung

Gebiet der Erfindung und Stand der Technik

1. Gebiet der Erfindung

[0001] Die Erfindung betrifft eine Universalführungsvorrichtung, die in Gleitabschnitten verschiedener Werkzeugmaschinen, Güter fördernder Systeme und dergleichen zum Einsatz kommt und in der Lage ist, einen beweglichen Gegenstand oder ein bewegliches Material entlang einer Förderstrecke zu führen, die sowohl geradlinige wie auch krummlinige Bereiche umfasst.

2. Stand der Technik

[0002] Sind in einer Fabrik beispielsweise in einer Fertigungsstraße oder dergleichen sämtliche Verarbeitungsstationen linear angeordnet, so ist dies problemfrei. Es kann jedoch in Abhängigkeit von den räumlichen Gegebenheiten in der die Maschinen beherbergenden Fabrik oder in Abhängigkeit von den Verarbeitungsgegebenheiten an den einzelnen Verarbeitungsstationen notwendig sein, die Förderrichtung der zu verarbeitenden Materialien zwischen zwei benachbarten Verarbeitungsstationen zu ändern. In diesem Fall ist, um eine Änderung der Förderrichtung vorzunehmen, die Verwendung eines Palettenwechslers oder dergleichen üblich. Nachteiligerweise erfordert dies zusätzlichen Raum und zieht zusätzliche Kosten bedingt durch die Aufstellung des Palettenwechslers oder dergleichen nach sich.

[0003] Bekannte auf einen Palettenwechsler verzichtende Mittel zur Änderung der Förderrichtung von Materialien oder Gegenständen umfassen Universalführungsvorrichtungen (wie in den japanischen Patentveröffentlichungen JP63293319A (US4,844,624A) und JP6050333A (US5,308,170A) beschrieben, die sämtliche Merkmale des Oberbegriffes von Anspruch 1 offenbaren), die in der Lage sind, Materialien entlang einer Strecke aus sowohl geradlinigen wie auch krummlinigen Abschnitten kontinuierlich zu führen, sowie krummlinige Führungsvorrichtungen (wie in der japanischen Patentveröffentlichung JP63186028A beschrieben), die in der Lage sind, Materialien entlang einer ringförmigen Strecke kontinuierlich zu führen.

[0004] Die Universalführungsvorrichtungen und die krummlinigen Führungsvorrichtungen umfassen jeweils eine Bahnschiene, einen Gleiter und eine Mehrzahl von Kugeln. Die Schiene bildet sich in Längsrichtung erstreckende Flächen aus, an denen die Kugeln rollen. Der Gleiter ist derart angebracht, dass er die Schiene überspannt. Lastrollflächen gegenüber den Rollflächen der Schiene und eine Endlosringstrecke für die Kugeln sind an und in dem Gleiter ausgebildet. Die Endlosringstrecke enthält die Lastrollflächen. Die Kugeln rollen in der Endlosringstrecke des Gleiters und zwischen den Rollflächen der Schiene, wobei die Lastrollflächen des Gleiters eine Last tragen. Der Gleiter bewegt sich entsprechend der Rollbewegung der Kugeln entlang der Schiene.

[0005] Bei den bekannten Universalführungsvorrichtungen ist jede Lastrollfläche des Gleiters in geradlinige Lastbereiche, die linear ausgebildet sind, und krummlinige Lastbereiche, die in Entsprechung zur Krümmung der Schiene als Bogen ausgebildet sind, unterteilt. In jedem geradlinigen Lastbereich der Schiene wird die auf den Gleiter wirkende Last von denjenigen Kugeln getragen, die in dem geradlinigen Lastbereich rollen. In jedem krummlinigen Bereich wird die Last von denjenigen Kugeln getragen, die in dem krummlinigen Bereich rollen. Dies führt dazu, dass sich auch für den Fall, dass geradlinige und krummlinige Bereiche an ein und derselben Bahnschiene vorhanden sind, der Gleiter entlang der Schiene durch die geradlinigen und krummlinigen Bereiche kontinuierlich bewegen kann.

[0006] Bei der genannten krummlinigen Führungsvorrichtung ist die Bahnschiene als Bogen mit einer gegebenen Krümmung ausgebildet. Die Lastrollfläche des Gleiters ist in Entsprechung zur Krümmung der Schiene als Bogen ausgebildet. Sämtliche zwischen der Lastrollfläche des Gleiters und der Rollfläche der Schiene befindlichen Kugeln rollen, während sie die an dem Gleiter anliegende Last tragen. Infolgedessen kann der Gleiter eine krummlinige Bewegung entlang der Schiene ausführen.

[0007] Bei derartigen herkömmlichen Universalführungsvorrichtungen und krummlinigen Führungsvorrichtungen ist die Lastrollnut beziehungsweise Lastrolllaufbahn in dem Gleiter in Entsprechung zur Krümmung der Bahnschiene als Bogen ausgebildet, um eine Bewegung des Gleiters durch die krummlinigen Bereiche der Schiene zu ermöglichen. Es ist daher notwendig, die Lastrollfläche in Entsprechung zur Krümmung der Schiene herzustellen. Es ist jedoch nicht möglich, die Gleiter herkömmlicher, auf dem Markt erhältlicher und in Massenfertigung hergestellter linearer Führungsvorrichtungen direkt einzusetzen, was die Herstellungskosten nach oben treibt. Darüber hinaus bedarf jede Bahnschiene mit einer anderen Krümmung eines anderen Gleiters. Herstellung und Handhabung der Gleiter sind daher aufwändig.

[0008] Wird die Lastrollfläche eines Gleiters in Bogenform ausgebildet, so ist die Krümmungsrichtung des krummlinigen Bereiches der Bahnschiene auf eine Richtung, nämlich entweder links oder rechts, beschränkt. Obwohl es möglich ist, Materialien und Gegenstände auf einer Ringbahn zu befördern, ist es nicht möglich, Materialien entlang einer Schiene mit zwei krummlinigen Bereichen zu fördern, die in verschiedene Richtungen gekrümmt sind, wie dies beispielsweise bei einer S-förmigen Schiene der Fall ist.

[0009] Demgegenüber treten an einer Strecke zwischen zwei benachbarten Bearbeitungsstationen in einer Fertigungsstraße für den Fall, dass Materialien transportiert werden, keinerlei Probleme auf. Es wird davon ausgegangen, dass die Fähigkeit, sehr große Lasten zu tragen, in den krummlinigen Bereichen der Schiene nicht vorhanden sein muss. Dennoch muss während des Fertigungsvorgangs eine während der Bearbeitung auf ein Material einwirkende Kraft von der Führungsvorrichtung verlässlich aufgenommen werden. Geradlinige Bereiche der Schiene müssen die Fähigkeit aufweisen, größere Lasten zu tragen, als dies bei krummlinigen Bereichen der Fall ist. Bei der vorstehend genannten herkömmlichen Universalführungsvorrichtung ist die an dem Gleiter ausgebildete Lastrollfläche in geradlinige und krummlinige Lastbereiche unterteilt. Daher weisen die geradlinigen Bereiche der Schiene in geringerem Maße die Fähigkeit auf, Lasten zu tragen. Infolgedessen kann eine bei der Bearbeitung auf Materialien einwirkende Kraft nicht in ausreichendem Maße aufgenommen werden.

[0010] Werden Materialien in der Praxis unter Verwendung derartiger Universalführungsvorrichtungen befördert, so ist der Einbau einer sich bewegenden Tischvorrichtung zwischen zwei oder mehreren Universalführungsvorrichtungen erforderlich, um die Materialien stabil zu fördern. Insbesondere sind zwei Bahnschienen parallel zueinander angeordnet. Mehrere Gleiter sind auf jeder Bahnschiene angebracht. Ein Tisch ist derart angeordnet, dass er sämtliche Gleiter überspannt. Die zu fördernden Materialien sind auf diesem Tisch angeordnet.

[0011] Wird der Tisch nur durch einen linearen Bereich oder nur durch einen krummlinigen Bereich gefördert, so treten für den Fall, dass sämtliche Gleiter direkt an dem Tisch angebracht sind, keinerlei Probleme auf. Der Tisch kann gleichmäßig bewegt werden. Wird der Tisch jedoch kontinuierlich aus einem krummlinigen Bereich in einen geradlinigen Bereich oder umgekehrt bewegt, so bestehen aufgrund des Vorhandenseins anderer Gleiter für den Fall, dass die Gleiter direkt an ein und demselben Tisch angebracht sind, Beschränkungen mit Blick auf die Ausgestaltung des Gleiters gegenüber der Bahnschiene. Hierdurch wird es schwierig, den Tisch gleichmäßig zu bewegen. Entsprechend ist es für den Fall, dass mehrere Universalführungsvorrichtungen mit vorstehend beschriebenem Aufbau verwendet werden, um die sich bewegende Tischvorrichtung zu bilden, unmöglich, die Gleiter direkt an dem Tisch anzubringen.

[0012] Eingedenk des vorstehend geschilderten Problems wurde die vorliegende Erfindung gemacht. Es ist Aufgabe der vorliegenden Erfindung, eine Universalführungsvorrichtung bereitzustellen, bei der wenigstens bei den bevorzugten Ausführungsbeispielen Gleiter, die bislang in herkömmlichen linearen Führungsvorrichtungen verwendet wurden, eingesetzt werden können, und bei der nicht jeweils ein anderer Gleiter für eine Bahnschiene mit anderem Radius verwendet werden muss, wodurch die Herstellung vorzugsweise zu niedrigeren Kosten erfolgen kann, als dies bislang der Fall ist.

[0013] Eine weitere Aufgabe wenigstens bevorzugter Ausführungsbeispiele der Erfindung besteht darin, eine Universalführungsvorrichtung bereitzustellen, bei der sich Gleiter auch dann kontinuierlich durch zwei krummlinige Bereiche einer Bahnschiene entlang der Schiene bewegen können, wenn die beiden krummlinigen Bereiche in verschiedene Richtungen gekrümmt sind, und bei der sich die Gleiter kontinuierlich von einem geradlinigen Bereich in einen krummlinigen Bereich oder umgekehrt bewegen können, ohne dass die Schiene die Fähigkeit verlieren würde, eine Last in dem geradlinigen Bereich zu tragen, und dies auch dann, wenn die Schiene sowohl geradlinige wie auch krummlinige Bereiche umfasst.

[0014] Eine weitere Aufgabe wenigstens bevorzugter Ausführungsbeispiele der Erfindung besteht in der Bereitstellung einer sich bewegenden Tischvorrichtung mit mehreren parallelen Bahnschienen und mehreren an jeder Bahnschiene angebrachten Gleitern, wobei sich die bewegliche Tischvorrichtung dadurch auszeichnet, dass eine gleichmäßige Bewegung der Gleiter auch dann sichergestellt ist, wenn der Tisch von vier oder mehr Gleitern getragen wird.

[0015] Zur Lösung der vorstehend aufgeführten Aufgaben ist gemäß einem Aspekt der Erfindung eine erfindungsgemäße Universalführungsvorrichtung vorgesehen, die umfasst: eine Bahnschiene mit einem geradlinigen Bereich und einem krummlinigen Bereich, der als Bogen mit einem gegebenen Krümmungsradius ausgebildet ist, sowie mit Kugelrollflächen an ihren beiden Seitenflächen, wobei sich die Kugelrollflächen in Längsrichtung erstrecken; einen sattelförmigen Querschnitt aufweisenden Gleiter, der derart angebracht ist, dass er die Bahnschiene überspannt; Lastrollflächen, die an dem Gleiter ausgebildet und jeweils gegenüber den Rollflächen der Schiene angeordnet sind; sowie eine Endlosringstrecke für eine Anzahl von Kugeln. Die Ringstrecke ist an dem Gleiter ausgebildet und enthält die Lastrollflächen. Die zahlreichen Kugeln tragen eine Last zwischen jeder Rollfläche der Bahnschiene und jeder Lastrollfläche des Gleiters. Sämtliche an dem Gleiter ausgebildeten Lastrollflächen sind linear ausgebildet. Die Breite des krummlinigen Bereiches der Bahnschiene ist im Vergleich zum geradlinigen Bereich der Schiene kleiner gewählt.

[0016] Bei der erfindungsgemäßen Universalführungsvorrichtung sind die an dem Gleiter ausgebildeten Lastrollflächen nicht als Bogen entsprechend der Krümmung des krummlinigen Bereiches der Bahnschiene ausgebildet. Die Lastrollflächen sind vielmehr in Entsprechung zu den Rollflächen des geradlinigen Bereiches der Bahnschiene linear ausgebildet. Bei einer derartigen Anordnung ist der krummlinige Bereich der Schiene im Vergleich zum geradlinigen Bereich der Schiene schmäler ausgebildet. Daher kann für den Fall, dass die Rollflächen der Schiene die Form eines Bogens aufweisen, und die Lastrollflächen des Gleiters linear sind, der Gleiter mit den krummlinigen Bereichen der Schiene in Eingriff treten und sich entlang der krummlinigen Bereiche problemlos bewegen.

[0017] Bewegt sich der Gleiter durch den krummlinigen Bereich der Bahnschiene, so werden die Kugeln zwischen den in Längsrichtung entlang der Schiene ausgebildeten bogenförmigen Rollflächen und den an dem Gleiter ausgebildeten linearen Lastrollflächen zusammengeschoben und rollen entlang der Lastrollflächen, wobei sie die Last tragen. Mit Blick auf die Mehrzahl der an den Lastrollflächen rollenden Kugeln tragen nur einige der Kugeln die Last zwischen den Rollflächen der Schiene und den Lastrollflächen des Gleiters.

[0018] Bei der erfindungsgemäßen Universalführungsvorrichtung sind die an dem Gleiter ausgebildeten Lastrollflächen nicht als Bogen, sondern linear ausgebildet. Aus diesem Grunde können die Gleiter linearer Führungsvorrichtungen unverändert verwendet werden. Darüber hinaus kann auf den Vorgang der maschinellen Ausbildung der Lastrollfläche als Bogen entsprechend der Krümmung der Bahnschiene verzichtet werden. Es ist daher möglich, eine Universalführungsvorrichtung zu vergleichsweise niedrigen Kosten herzustellen. Darüber hinaus weisen die linear ausgebildeten Lastrollflächen keine Vorzugsrichtung auf. Infolgedessen kann sich sogar für den Fall, dass zwei krummlinige Bereiche mit verschiedenen Krümmungsrichtungen an der Schiene vorhanden sind, der Gleiter kontinuierlich durch diese krummlinigen Bereiche bewegen.

[0019] Darüber hinaus liegen bei der vorstehend beschriebenen Universalführungsvorrichtung sämtliche an den Lastrollflächen des Gleiters rollenden Kugeln an den Rollflächen der Bahnschiene innerhalb des geradlinigen Bereiches der Schiene an. Aus diesem Grunde wird die Fähigkeit des Gleiters, eine Last zu tragen, nicht beeinträchtigt, was im Gegensatz zu demjenigen Fall ist, in dem lediglich einige Kugeln an den Rollflächen in einem krummlinigen Bereich anliegen. Liegen große Lasten an dem Gleiter an, so können die Lasten in ausreichendem Maße getragen werden.

[0020] Bei derartigen Anordnungen berühren für den Fall, dass die Kugelrollflächen an der Bahnschienenseite an den Flächen der Schiene ausgebildet sind, die eine Reihe bildenden und an der Lastrollfläche des Gleiters rollenden Kugeln die bogenförmige Rollfläche an der Schienenseite nicht gleichzeitig. Daher kann die Rollfläche auf gleiche Weise ausgebildet sein, wie dies bei der Rollfläche einer krummlinigen Führungsvorrichtung aus dem Stand der Technik der Fall ist, ohne dass irgendein besonderer Bearbeitungsvorgang von Nöten wäre. Darüber hinaus kann diese Bahnschiene einfach hergestellt werden, da eine Fläche der Schiene und die darauf ausgebildete bogenförmige Rollfläche gleichzeitig geschliffen werden können. Ist jedoch eine nach oben weisende Rollfläche an der oberen Fläche einer Bahnschiene ausgebildet, so bedarf diese Rollfläche einer speziellen maschinellen Bearbeitung. Insbesondere ist bei einigen Ausführungsbeispielen eine nach unten weisende Lastrollfläche linear an dem Gleiter in zu der nach oben weisenden Rollfläche der Bahnschiene entgegengesetzter Ausrichtung ausgebildet. Infolgedessen muss die Breite der nach oben weisenden Rollfläche derart gewählt sein, das die eine Reihe bildenden und an der nach unten weisenden Rollfläche des Gleiters rollenden Kugeln die nach oben weisende Fläche gleichzeitig berühren.

[0021] Bei der erfindungsgemäßen Universalführungsvorrichtung kann sich der Gleiter sowohl durch die geradlinigen wie auch durch die krummlinigen Bereiche der Bahnschiene frei bewegen. Setzt sich die Schiene daher ausschließlich aus krummlinigen Bereichen zusammen, so kann sich der Gleiter entlang der ringförmigen Schiene bewegen. Dies bedeutet mit Blick auf die krummlinigen Bereiche der Schiene, dass die Universalführungsvorrichtung entsprechend der vorliegenden Erfindung als krummlinige Führungsvorrichtung betrachtet werden kann.

[0022] Wie vorstehend erwähnt, weisen die geradlinigen und die krummlinigen Bereiche der Bahnschiene der Universalführungsvorrichtung der vorliegenden Erfindung unterschiedliche Breiten auf. Bei bevorzugten Ausführungsbeispielen ist daher das Bereitstellen eines Übergangsschienenabschnittes vorteilhaft, der die geradlinigen und die krummlinigen Bereiche der Schiene derart verbindet, dass die Breite der Schiene in dem Übergangsschienenabschnitt kontinuierlich variiert.

[0023] Darüber hinaus kann eine sich bewegende Tischvorrichtung unter Verwendung der Universalführungsvorrichtungen mit vorstehend geschildertem erfindungsgemäßem Aufbau bereitgestellt werden.

[0024] Insbesondere werden mehrere Bahnschienen parallel zueinander an einem festen Abschnitt, so beispielsweise an einem Sockel oder einem Fundament, angebracht. Ein Tisch wird derart angebracht, dass er Gleiter überspannt, die sich an diesen

Schienen bewegen. Sind zwei oder mehr Gleiter an jeder Schiene angebracht, und sind sämtliche Gleiter direkt an demselben Tisch angebracht, so können Schwierigkeiten bei der gleichmäßigen Bewegung des Tisches zwischen den geradlinigen und den krummlinigen Bereichen der Schiene, wie vorstehend erläutert, auftreten.

[0025] Eingedenk dessen werden erste und zweite Bahnschienen parallel zueinander angeordnet. Mehrere Gleiter sind an diesen Schienen angeordnet. Vorzugsweise ist eine feste Platte derart angeordnet, dass sie einen an der ersten Schiene angeordneten Gleiter und einen an der zweiten Schiene angeordneten Gleiter derart überspannt, dass die beiden Gleiter gekoppelt sind. Eine weitere Festplatte überbrückt einen an der erste Schiene angeordneten Gleiter und einen an der zweiten Schiene angeordneten Gleiter, und so weiter. Vorzugsweise ist der Tisch derart angebracht, dass er gegenüber den festen Platten drehbar ist. Ist die sich bewegende Tischvorrichtung auf diese Weise aufgebaut, so gilt sogar für den Fall, dass der Tisch von vier Gleitern getragen wird, dass die erste feste Platte, die die erste Reihe von Gleitern (in Bewegungsrichtung vorauseilend) überspannt, und die zweite feste Platte, die die zweite Reihe von Gleitern überspannt, derart drehen, dass die Gleiter in tangentialer Richtung der Schienen ausgerichtet sind. Der Abstand zwischen den Gleitern an den Schienen ist variabel gewählt. Aus diesem Grunde können sich die Gleiter gleichmäßig bewegen.

[0026] Darüber hinaus kann sich der Tisch gleichmäßig zwischen den geradlinigen und den krummlinigen Bereichen der Schiene dadurch bewegen, dass die ersten und zweiten Schienen parallel zueinander angeordnet sind, dass mehrere Gleiter an jeder Schiene angeordnet sind, und dass der Tisch derart angebracht ist, dass er gegenüber den Gleitern drehbar ist. Bewegen sich in diesem Aufbau die Gleiter durch die krummlinigen Bereiche der Schiene, so drehen sie in beliebige Richtungen, um sich selbst in tangentiale Richtung der Schienen auszurichten. Dies ermöglicht eine gleichmäßige Bewegung der Gleiter.

[0027] Wie beschrieben, müssen bei den Universalführungsvorrichtungen entsprechend wenigstens den bevorzugten Ausführungsbeispielen der vorliegenden Erfindung, die an den Gleitern ausgebildeten Lastrollflächen nur linear und nicht bogenförmig ausgebildet werden. Aus diesem Grunde können die verschiedensten auf dem Markt erhältlichen linearen Führungsvorrichtungen unverändert verwendet werden. Darüber hinaus ist eine Herstellung der Lastrollflächen in Entsprechung zur Krümmung der Schienen nicht erforderlich. Daher können die Gleiter einfach und kostengünstig hergestellt werden.

[0028] Da die an den Gleitern ausgebildeten Lastrollflächen keine Vorzugsrichtung aufweisen, können sich für den Fall, dass jede Bahnschiene zwei krummlinige Bereiche mit verschiedenen Krümmungsrichtungen aufweist, die Gleiter kontinuierlich entlang der Schiene durch die krummlinigen Bereiche bewegen. So können beispielsweise Materialien frei und mit hohem Freiheitsgrad entlang einer Schiene (die beispielsweise aus einer Kombination aus geradlinigen Abschnitten und krummlinigen Abschnitten zusammengesetzt ist, wie dies beispielsweise bei einer S-förmigen Schiene der Fall ist) bewegt werden.

[0029] Da die an den Gleitern ausgebildeten Lastrollflächen linear sind, liegen sämtliche an den Lastrollflächen rollenden Kugeln an der Schiene in den geradlinigen Bereichen an und tragen die Last. Daher weisen die Gleiter in ausreichendem Maße die Fähigkeit auf, die Last in diesen geradlinigen Bereichen zu tragen. Treten an der Schiene sowohl geradlinige wie auch krummlinige Abschnitte auf, so können sich die Gleiter kontinuierlich durch die linearen und die krummlinigen Bereiche bewegen, ohne dass die Fähigkeit der Schiene verloren ginge, die Last in den geradlinigen Bereichen zu tragen.

[0030] Weitere Aufgaben und Merkmale der Erfindung erschließen sich im Laufe der nachfolgenden Beschreibung derselben.

[0031] Ausführungsbeispiele der Erfindung werden nachstehend beispielhalber anhand der begleitenden Zeichnung beschrieben, die sich wie folgt zusammensetzt.

[0032] Fig. 1 ist eine Skizzenansicht einer Universalführungsvorrichtung entsprechend einem ersten Ausführungsbeispiel der vorliegenden Erfindung.

[0033] Fig. 2 ist eine perspektivische Ansicht eines Gleiters des in Fig. 1 gezeigten geradlinigen Führungsschienenabschnittes.

[0034] Fig. 3 ist ein im Querschnitt genommener Frontaufriss des Gleiters und des in Fig. 2 gezeigten geradlinigen Führungsschienenabschnittes, wobei der Gleiter an der Schiene angeordnet ist.

[0035] Fig. 4 ist eine im Querschnitt genommene Skizzenansicht des Gleiters und der in Fig. 2 und Fig. 3 gezeigten geradlinigen Führungsschiene, wobei gezeigt ist, wie die Kugeln rollen und entlang einer Ringstrecke umlaufen, wenn sich der Gleiter entlang der Schiene bewegt.

[0036] Fig. 5 ist ein im Querschnitt genommener Frontaufriss ähnlich demjenigen von Fig. 3, wobei jedoch der Gleiter an einem krummlinigen Führungsschienenabschnitt angeordnet ist.

[0037] Fig. 6 ist eine im Querschnitt genommene

Skizzenansicht des Gleiters und des in Fig. 5 gezeigten krummlinigen Führungsschienenabschnittes, wobei gezeigt ist, wie die Kugeln entlang der Ringstrecke rollen, wenn sich der Gleiter entlang der Schiene bewegt.

[0038] Fig. 7 ist eine fragmentarische Skizzenansicht einer an der oberen Fläche eines krummlinigen Führungsschienenabschnittes ausgebildeten Rollfläche, wobei gezeigt ist, wie die Kugeln an der Rollfläche rollen.

[0039] Fig. 8 ist ein vergrößerter Querschnitt einer an der oberen Fläche eines krummlinigen Führungsschienenabschnittes ausgebildeten Rollfläche und einer Lastrollfläche eines Gleiters, wobei gezeigt ist, wie die Kugeln zwischen der Rollfläche an der Schiene und der Lastrollfläche des Gleiters rollen.

[0040] Fig. 9 ist eine Skizzenansicht einer Universalführungsvorrichtung, die dadurch hergestellt werden kann, dass eine Kombination aus geradlinigen Führungsschienenabschnitten und krummlinigen Führungsschienenabschnitten entsprechend dem ersten Ausführungsbeispiel gebildet wird.

[0041] Fig. 10(a) und Fig. 10(b) sind Skizzenansichten S-förmiger Schienen, wobei jede aus zwei getrennten Führungsschienenabschnitten besteht.

[0042] Fig. 11 ist eine fragmentarische Skizzenansicht eines Übergangsschienenabschnittes entsprechend dem ersten Ausführungsbeispiel der Erfindung.

[0043] Fig. 12 ist eine fragmentarische vergrößerte Skizzenansicht eines Abschnittes A von Fig. 11.

[0044] Fig. 13 ist eine vergrößerte Skizzenansicht eines Abschnittes B von Fig. 11.

[0045] Fig. 14 ist eine im Querschnitt genommene Frontansicht einer Universalführungsvorrichtung entsprechend einem zweiten Ausführungsbeispiel der Erfindung.

[0046] Fig. 15 ist ein vergrößerter Querschnitt von Hauptabschnitten der in Fig. 14 gezeigten krummlinigen Führungsschienenabschnitte.

[0047] Fig. 16 ist eine Querschnittsansicht der in Fig. 14 und Fig. 15 gezeigten krummlinigen Führungsschienenabschnitte, wobei der Schienenabschnitt an beiden Seitenflächen derart geschliffen wurde, dass er eine bestimmte Breite aufweist.

[0048] Fig. 17 ist eine fragmentarische Skizzenansicht einer sich bewegenden Tischvorrichtung, die ein drittes Ausführungsbeispiel der Erfindung darstellt, wobei bei der sich bewegenden Tischvorrichtung eine Universalführungsvorrichtung entsprechend der Erfindung zum Einsatz kommt.

[0049] Fig. 18 ist eine Querschnittsansicht bezüglich der Linie XVIII-XVIII von Fig. 17.

[0050] Fig. 19 ist eine perspektivische Ansicht eines Drehlagers, das bei der in Fig. 17 und Fig. 18 gezeigten sich bewegenden Tischvorrichtung verwendet wird.

[0051] Fig. 20 ist eine Skizzenansicht der sich bewegenden Tischvorrichtung, wobei gezeigt ist, wie der Tisch bewegt wird.

[0052] Fig. 21 ist eine Skizzenansicht einer fragmentarischen Skizzenansicht einer sich bewegenden Tischvorrichtung, die ein viertes Ausführungsbeispiel der Erfindung darstellt, und bei der eine Universalführungsvorrichtung entsprechend der vorliegenden Erfindung verwendet wird.

[0053] Fig. 22 ist ein Diagramm, das die Anordnung des Gleiters der in Fig. 21 gezeigten sich bewegenden Tischvorrichtung in einem krummlinigen Bereich zeigt.

[0054] In Fig. 1 ist eine Universalführungsvorrichtung entsprechend einem ersten Ausführungsbeispiel der vorliegenden Erfindung gezeigt. Eine Bahnschiene **1** ist in einem festen Abschnitt, so beispielsweise einem Sockel oder einem Fundament, angebracht. Gleiter **2** können sich entlang der Schiene **1** bewegen. Die Schiene **1** ist aus einem geradlinigen Führungsschienenabschnitt **1A**, einem krummlinigen Führungsschienenabschnitt **1B**, der als Bogen mit gegebenem Radius ausgebildet ist, und einem Übergangsschienenabschnitt **1C**, der die Schienenabschnitte **1A** und **1B** verbindet, zusammengesetzt. Die Gleiter **2** können sich entlang der Schienenabschnitte **1A**, **1B** und **1C** frei bewegen.

[0055] Fig. 2 ist eine perspektivische Ansicht des geradlinigen Führungsschienenabschnittes **1A**, wobei ein Gleiter **2** an dem Schienenabschnitt **1A** angeordnet ist. Fig. 3 ist eine Frontansicht in einem Querschnitt, der axial bezüglich des geradlinigen Führungsschienenabschnittes **1A** genommen ist. Der geradlinige Schienenabschnitt **1A** weist im Wesentlichen rechteckigen Querschnitt auf. Zwei seitliche Kugelrollflächen **10a** und zwei obere Kugelrollflächen **10b** erstrecken sich in Längsrichtung. Kugeln **3** rollen an den vier Rollflächen **10a**, **10b**. Die beiden seitlichen Kugelrollflächen **10a** sind an den gegenüberliegenden Seitenflächen des geradlinigen Führungsschienenabschnittes **1A** ausgebildet, wohingegen die beiden oberen Kugelrollflächen **10b** jeweils um die gegenüberliegenden Kanten der oberen Fläche des Führungsschienenabschnittes **1A** ausgebildet sind. Die seitlichen Kugelrollflächen **10a** sind unter einem Winkel von 30° in der Zeichnung aus der Horizontalen nach unten gekippt. Die oberen Kugelrollflächen **10b** weisen vertikal nach oben. Bolzenanbringlöcher **11** sind in dem geradlinigen Führungsschienenabschnitt **1A** ausgebildet und in Längsrichtung entlang des Schienenabschnittes **1A** gleichmäßig voneinander beabstandet. Ankerbolzen (nicht gezeigt) sind in die Bolzenanbringlöcher **11** eingebracht, sodass der Schienenabschnitt **1A** fest an dem festen Abschnitt angebracht ist.

[0056] Insbesondere Fig. 2 und Fig. 3 zeigen, dass jeder der vorstehend genannten Gleiter **2** einen beweglichen Block **4** und zwei Abdeckungen **5** umfasst, die jeweils am den vorderen und hinteren Endflächen des Blockes **4** angebracht sind. Der bewegliche Block **4** ist mit Gewindelöchern **42** versehen, in die die Ankerbolzen eingeschraubt sind. Der bewegliche Block **4** weist eine Anbringfläche **41** auf, an der ein bewegliche Körper, so beispielsweise ein Tisch, angebracht ist. Eine Endlosringstrecke für die Kugeln **3** ist im Inneren des Gleiters dadurch ausgebildet, dass die Abdeckungen **5** an dem beweglichen Block **4** angebracht sind. Abdichtungselemente **6**, die einen Gleitkontakt mit der Bahnschiene **1** herstellen, sind jeweils an den Abdeckungen **5** angebracht, wodurch verhindert wird, dass an der Schiene **1** anhaftender Staub während der Bewegung des Gleiters in den Gleiter **2** eintritt.

[0057] Wie insbesondere in Fig. 3 gezeigt ist, weist der vorgenannte bewegliche Block **4** einen horizontalen Abschnitt **4a** und ein Paar von Berandungsabschnitten **4b** auf, die von dem horizontalen Abschnitt **4a** ausgehen. Der Block **4** weist einen sattelartigen Querschnitt auf. Der Anbringabschnitt **41** ist in dem horizontalen Abschnitt **4a** ausgebildet. Zwei geradlinige Lastrollflächen **43a** sind an den Innenflächen der Berandungsabschnitte **4b** des beweglichen Blockes **4** ausgebildet und gegenüber den seitlichen Kugelrollflächen **10a** des geradlinigen Führungsschienenabschnittes **1A** angeordnet. Zwei geradlinige Lastrollflächen **43b** sind an der unteren Fläche des horizontalen Abschnittes **4a** ausgebildet und gegenüber den oberen Kugelrollflächen **10b** des geradlinigen Führungsschienenabschnittes **1A** angeordnet. Kugelrücklauflöcher **44a**, die den Lastrollflächen **43a** zugeordnet sind, sind jeweils in den Berandungsabschnitten **4b** ausgebildet. Kugelrücklauflöcher **44b**, die den Lastrollflächen **43b** zugeordnet sind, sind in dem horizontalen Abschnitt **4a** ausgebildet. U-förmige Richtungsänderungsstrecken **51** (Fig. 4) sind jeweils in den Abdeckungen **5** ausgebildet, um die Lastrollflächen **43a** und **43b** jeweils mit den Kugelrücklauflöchern **44a** und **44b** zu verbinden, wodurch eine Endlosringstrecke für die Kugeln gebildet ist.

[0058] Einige der Kugeln **3** tragen eine Last zwischen der Kugelrollfläche **10a** des geradlinigen Führungsschienenabschnittes **1A** und der Lastrollfläche **43b** des beweglichen Blockes **4**. Die anderen Kugeln **3** tragen eine Last zwischen der oberen Kugelrollfläche **10b** des geradlinigen Führungsschienenabschnittes **1A** und der Lastrollfläche **43b** des beweglichen Blockes **4**. Mit der Bewegung jedes Gleiters **2** führen die Kugeln **3** eine Rollbewegung über die Lastrollflächen **43a** und **43b** aus. Anschließend werden die Kugeln **3** entlastet und treten in die Richtungsänderungsstrecke **51** in der einen Abdeckung **5** ein. Die Kugeln rollen sodann durch die Kugelrücklauflöcher **44a** und **44b** in dem beweglichen Block **4** in der zur Richtung der Rollbewegung an den Lastrollflächen **43a** und **43b** entgegengesetzten Richtung, wobei sie in einem unbelasteten Zustand verbleiben. Nach der Rollbewegung durch die Kugelrücklauflöcher **44a** und **44b** treten die Kugeln **3** erneut in den Spalt zwischen der geradlinigen Führungsschiene **1A** und dem beweglichen Block **4** durch die Richtungsänderungsstrecke **51** in der anderen Abdeckung **5** ein und rollen anschließend an den Lastrollflächen **43a** und **43b**, wobei sie eine Last tragen.

[0059] Kugelhalteplatten **45** und **46** sind jeweils an den unteren Enden der Berandungsabschnitte **4b** und dem horizontalen Abschnitt **4a** des beweglichen Blockes **4** angeordnet. Die Kugelhalteplatten **45** und **46** werden aus einer Metallplatte ausgestanzt oder aus einem synthetischen harten Harz mittels Spritzgießen oder mittels eines anderen Verfahrens hergestellt. Die Kugelhalteplatten **45** und **46** verhindern, dass die an den Kugelrollflächen **10a** und **10b** rollenden Kugeln **3** den Gleiter **2** verlassen, wenn der Gleiter **2** von der Bahnschiene **1** entfernt wird.

[0060] Fig. 4 zeigt, wie die Kugeln **3** an den seitlichen Rollflächen **10a** rollen, die an den Seitenflächen des geradlinigen Führungsschienenabschnittes **1A** ausgebildet sind, wobei die Kugeln entlang der Strecke umlaufen, wenn sich jeder Gleiter **2** entlang des geradlinigen Führungsschienenabschnites **1A** bewegt. Die Kugeln **3**, die an den an der oberen Fläche des geradlinigen Führungsschienenabschnittes **1A** ausgebildeten oberen Kugelrollflächen **10b** rollen, führen eine ähnliche Roll- und Umlaufbewegung aus.

[0061] Wie vorstehend erwähnt wurde, sind die den Lastrollflächen **43a** und **43b** entsprechenden Richtungsänderungsstrecken **41** in den beiden Abdeckungen **5** ausgebildet, die jeweils an gegenüberliegenden Endflächen des beweglichen Blockes **4** ausgebildet sind. Durch Anbringen der Abdeckungen **5** an dem beweglichen Block **4** bildet der Gleiter **2**, wie gezeigt, eine Endlosringstrecke für die Kugeln **3**. Die Rollflächen **10a** und **10b** erstrecken sich linear und in Längsrichtung entlang des geradlinigen Führungsschienenabschnittes **1A**. Darüber hinaus sind die Lastrollflächen **43a** und **43b** des Gleiters **2** gegenüber den Rollflächen **10a** und **10b** jeweils linear ausgebildet. Aus diesem Grund sind sämtliche gleichzeitig an den Lastrollflächen **43a** und **43b** rollenden Kugeln **3** in Kontakt mit den Rollflächen **10a** beziehungsweise **10b** des geradlinigen Führungsschienenabschnittes **1A**, was in Fig. 4 gezeigt ist. Dies bedeutet, dass, während sich der Gleiter **2** entlang des geradlinigen Führungsschienenabschnittes **1A** bewegt, keine der Kugeln **3** unbelastet ist, ohne dass die Last zwischen der Rollfläche **10a** oder **10b** an der Seite der Führungsschiene **1** und der Lastrollfläche **43a** oder **43b** an der Seite des Gleiters **4** getragen wäre. Liegt eine große Last an dem Gleiter **2** an, so wird die Last verlässlich getragen, wobei sich der Gleiter **2** gleichmäßig bewegen kann.

[0062] Fig. 5 ist eine im Querschnitt genommene Frontansicht des krummlinigen Führungsschienenabschnittes **1B**, wobei ein Gleiter **2** hieran angebracht ist. Der krummlinige Führungsschienenabschnitt **1B** weist eine Querschnittsform auf, die ähnlich derjenigen des vorstehend beschriebenen geradlinigen Führungsschienenabschnittes ist. Der krummlinige Führungsschienenabschnitt **1B** ist als Bogen ausgebildet, der eine gegebene Krümmung R in Längsrichtung aufweist. Seitliche Rollflächen **12a**, die jeweils an die seitlichen Rollflächen **10a** anschließen, die wiederum an den gegenüberliegenden Seitenflächen des geradlinigen Führungsschienenabschnittes **1A** angeordnet sind, sind an den gegenüberliegenden Seitenflächen des krummlinigen Führungsschienenbereiches **1B** angeordnet. Obere Rollflächen **12b**, die jeweils an die oberen Rollflächen **10b** anschließen, die wiederum an der oberen Fläche des geradlinigen Führungsschienenabschnittes **1A** ausgebildet sind, sind an der oberen Fläche des krummlinigen Führungsschienenabschnittes **1B** ausgebildet.

[0063] Da der krummlinige Führungsschienenabschnitt **1B** derart ausgebildet ist, dass er eine gegebene Krümmung aufweist, ergibt sich für den Fall, dass die Breite L_2 des krummlinigen Führungsschienenabschnittes **1B** gleich der Breite L_1 des geradlinigen Führungsschienenabschnittes **1A** gewählt ist, dass die innere Seitenfläche des krummlinigen Führungsschienenabschnittes **1B** durch die Berandungsabschnitte **4b** oder im Zusammenhang mit den Abdeckungen **5** begrenzt ist. Aus diesem Grunde ist die Breite L_2 des krummlinigen Führungsschienenabschnittes **1B** kleiner als die Breite L_1 des geradlinigen Führungsschienenabschnittes **1A** gewählt. Zum Vergleich ist der Querschnitt des geradlinigen Führungsschienenabschnittes **1A** in der Zeichnung durch eine Punkt-Strich-Linie angedeutet. Wird die Breite L_2 des krummlinigen Führungsschienenabschnittes **1B** kleiner als die Breite L_1 des geradlinigen Führungsschienenabschnittes **1A** gewählt, so muss lediglich die innere Seitenfläche des krummlinigen Führungsschienenabschnittes **1B**, wie in Fig. 5 gezeigt, geschliffen werden. Alternativ können, wie in Fig. 16 gezeigt, sowohl die innere Seitenfläche wie auch die äußere Seitenfläche geschliffen sein.

[0064] Fig. 6 zeigt, wie die Kugeln **3** rollen und entlang der Ringstrecke umlaufen, wenn sich der Gleiter **2** entlang des krummlinigen Führungsschienenabschnittes **1B** bewegt. Es ist gezeigt, wie die Kugeln **3** an den Rollflächen **12a** rollen, die an den gegenüberliegenden Seitenflächen des krummlinigen Führungsschienenabschnittes **1B** ausgebildet sind. Die Rollflächen **12a** sind als Bogen in Längsrichtung der krummlinigen Führungsschienenabschnitte **1B** ausgebildet. Demgegenüber sind die Lastrollflächen **43a** des Gleiters **2** gegenüber den Rollflächen **12a** linear ausgebildet. Daher liegen, wie in Fig. 6 gezeigt, innerhalb des krummlinigen Führungsschienenabschnittes **1B** nur diejenigen Kugeln **3** an den Rollflächen **12a** an, die in der Nähe der beiden Enden der Lastrollflächen **43a** befindlich sind. Außerhalb des krummlinigen Führungsschienenabschnittes **1B** liegen lediglich diejenigen Kugeln an den Rollflächen **12a** an, die in den mittleren Bereichen der Lastrollflächen **43a** befindlich sind. Dies bedeutet, dass für den Fall, dass sich der Gleiter **2** entlang des krummlinigen Führungsschienenabschnittes **1B** bewegt, lediglich derjenige Teil der Kugeln **3**, der an den Lastrollflächen **43a** des Gleiters **2** rollt, eine Last trägt, wohingegen die übrigen Kugeln **3** unbelastet sind und die Last nicht tragen. Es ist einsichtig, dass sämtliche Kugeln **3**, die an den Lastrollflächen **43a** rollen, an den Rollflächen **12a** des krummlinigen Führungsschienenabschnittes **1B** in Abhängigkeit von der Krümmung des krummlinigen Führungsschienenabschnittes **1B** anliegen. Auch in diesem Fall tragen einige Kugeln **3** wenig zum Tragen der Last bei und sind unbelastet. Auch für den Fall, dass einige Kugeln **3** unbelastet sind und nicht auf diese Weise an den Rollflächen **12a** des krummlinigen Führungsschienenabschnittes **1B** anliegen, lösen die Kugeln **3** den Eingriff zwischen den Lastrollflächen **43a** und den Rollflächen **12** nicht, da die Kugelhalteplatte **46** an dem Gleiter **2** angebracht ist.

[0065] Fig. 7 zeigt, wie die Kugeln **3** an den Lastrollflächen **43b** rollen, die an dem horizontalen Abschnitt **4a** des Gleiters **2** ausgebildet sind. Dies bedeutet, dass Fig. 7 eine Perspektive des Gleiters **2** von oberhalb des krummlinigen Führungsschienenabschnittes **1B** darstellt. Da die Lastrollfläche **43b** des Gleiters **2** geradlinig ist, während die gegenüberliegende Rollfläche **12b** des krummlinigen Führungsschienenabschnittes **1B** als Bogen ausgebildet ist, liegen für den Fall, dass die Breite der Rollflächen **12b** gleich der Breite der seitlichen Rollfläche **12a** an dem krummlinigen Führungsschienenabschnitt und der Breite der Lastrollflächen **43b** ist, einige der Kugeln **3**, die an der Lastrollfläche **43b** an der Unterseite des Gleiters **2** rollen, an der inneren Fläche der Rollfläche **12b** an. Die übrigen verlassen die Rollfläche **12b** und liegen an der oberen Fläche des krummlinigen Führungsschienenabschnittes **1B** an. Infolgedessen können die Kugeln **3** gleichmäßig entlang der Endlosringstrecke in dem Gleiter **2** umlaufen.

[0066] Aus diesem Grunde ist die Rollfläche **12b**, die an der oberen Fläche des krummlinigen Führungsschienenabschnittes **1B** ausgebildet ist, derart ausgebildet, dass sie eine größere Nutbreite d als die Lastrollflächen **43b** aufweist, sodass sämtliche Kugeln **3**, die an den Lastrollflächen **43b** rollen, gleichzeitig an den Rollflächen **12b**, wie in Fig. 7 gezeigt, anliegen. Fig. 8 ist eine vergrößerte Ansicht, die zeigt, wie die Kugeln **3** die Rollflächen zwischen der Lastrollfläche **43b** an der Unterseite des Gleiters **2** und der Rollfläche **12b** an der Oberseite des krummlinigen Führungsschienenabschnittes **1B** berühren. Die durchgezogene Linie zeigt, wie die Kugeln die Rollflächen im Querschnitt α-α von Fig. 7 berühren. Die Punkt-Strich-Linie zeigt, wie die Kugeln die Rollflächen im Querschnitt β-β berühren. Die Rollflächen **12b** sind breiter als die Lastrollflächen **43a** gewählt. Darüber hinaus sind die Rollflächen **12b** als Bogen mit einer Krümmung in horizontaler Richtung in der Ebene von Fig. 8 ausgebildet. Aus diesem Grund bewegen sich, wenn die Kugeln **3** an den geradlinigen Lastrollflächen **43b** rollen, die Positionen, an der die Kugeln die Rollflächen **12b** berühren, nach rechts und links. Die Kugeln rollen an den Lastrollflächen **43b**, während die Last zwischen dem Gleiter und dem krummlinigen Führungsschienenabschnitt durchweg gehalten ist.

[0067] Bei der Universalführungsvorrichtung dieses Ausführungsbeispieles ist daher der krummlinige Führungsschienenabschnitt **1B** schmäler als der geradlinige Führungsschienenabschnitt **1A** gewählt. Wann immer eine Rollfläche für die Kugeln **3** für die obere Fläche der Bahnschiene **1** benötigt wird, wird lediglich die Rollfläche **12b** an der oberen Fläche des krummlinigen Führungsschienenabschnittes **1B** breiter als die Lastrollfläche **43b** an der Unterseite des Gleiters **2** gewählt. Daher kann sich der Gleiter **2** frei zwischen dem geradlinigen Führungsschienenabschnitt **1A** und dem krummlinigen Führungsschienenabschnitt **1B** bewegen, obwohl der Gleiter **2** derselbe wie bei der linearen Struktur einer Führungsvorrichtung aus dem Stand der Technik ist.

[0068] Bewegt sich der Gleiter **2** entlang des krummlinigen Führungsschienenabschnittes **1B**, so ist die Anzahl derjenigen Kugeln **3**, die an den seitlichen Rollflächen **12a** des krummlinigen Führungsschienenabschnittes **1B** anliegen, geringer als die Anzahl derjenigen Kugeln **3**, die an den seitlichen Rollflächen **10a** des geradlinigen Führungsabschnittes **1A** anliegen. Es kann daher nicht abgestritten werden, dass die Fähigkeit des Gleiters **2**, eine Last in dem krummlinigen Bereich der Bahnschiene **1** zu tragen, abnimmt. Gleichwohl ist die Fähigkeit des geradlinigen Bereiches, eine Last zu tragen, im Vergleich zum krummlinigen Bereich nicht geschmälert. Wirkt in dem krummlinigen Bereich auf den Gleiter **2** eine große Last, so kann diese Last ausreichend getragen werden.

[0069] Bei der vorstehend beschriebenen Universalführungsvorrichtung entsprechend der vorliegenden Erfindung sind die Lastrollflächen **43a** und **43b** des Gleiters **2** linear ausgebildet und weisen keine Vorzugsrichtung auf. Daher kann sich der Gleiter **2** entlang des krummlinigen Führungsschienenabschnittes **1B** problemlos bewegen, und zwar unabhängig davon, ob der krummlinige Führungsschienenbereich **1B** nach rechts oder nach links gebogen ist. Aus diesem Grund kann sich, wie in Fig. 9 gezeigt, der Gleiter **2** auch entlang einer S-förmigen Bahnschiene **1** bewegen, die sich aus zwei krummlinigen Führungsschienenabschnitten **1B** mit verschiedenen Krümmungsrichtungen zusammensetzt: Darüber hinaus ist nicht von Nöten, dass sämtliche aufeinanderfolgenden krummlinigen Führungsschienenabschnitte **1B** in einer kontinuierlichen Bahnschiene **1** als Bögen mit gleichem Radius ausgebildet sind. Der Gleiter kann auch dann frei bewegt werden, wenn krummlinige Schienenabschnitte verschiedener Radien kombiniert sind.

[0070] Wie in Fig. 10 gezeigt ist, wird der krummlinige Führungsschienenabschnitt **1B**, der mit einer gleichmäßigen Krümmung ausgebildet ist, in zwei Schienenstücke **16** und **17** zerschnitten. Anschließend wird ein Schienenstück **17** um 180° gedreht und mit dem anderen Schienenstück **16** derart kombiniert, dass eine S-förmige Bahnschiene **1** gebildet ist. Auch in diesem Fall kann der Gleiter **2** frei entlang der Bahnschiene **1** bewegt werden.

[0071] In Fig. 11 ist das Übergangsschienenstück **1C** gezeigt, das den geradlinigen Führungsschienenabschnitt **1A** und den krummlinigen Führungsschienenabschnitt **1B** verbindet. Es ist möglich, die Bahnschiene **1** dadurch aufzubauen, dass der geradlinige Führungsschienenabschnitt **1A** und der krummlinige Führungsschienenabschnitt **1B** verbunden werden, ohne dass der Übergangsschienenabschnitt **1C** verwendet würde. Wie vorstehend erwähnt, ist der krummlinige Führungsschienenabschnitt **1B** schmäler als der geradlinige Führungsschienenabschnitt **1A** ausgebildet. Darüber hinaus ist die Rollfläche **12b** des krummlinigen Führungsschienenabschnittes **1B** breiter als die obere Rollfläche **10b** des geradlinigen Führungsschienenabschnittes **1A** gewählt. Aus diesem Grund wird für den Fall, dass der geradlinige Führungsschienenabschnitt **1A** und der krummlinige Führungsschienenabschnitt **1B** direkt miteinander verbunden sind, die gleichmäßige Bewegung des Gleiters **2** unter Umständen leicht behindert. Aus diesem Grund ist bei dem dargestellten Ausführungsbeispiel der Übergangsschienenabschnitt **1C** zwischen den geradlinigen Führungsschienenabschnitt **1A** und den krummlinigen Führungsschienenabschnitt **1B**

geschaltet, um den Gleiter **2** gleichmäßig von dem geradlinigen Führungsschienenabschnitt **1A** zu dem krummlinigen Führungsschienenabschnitt **1B** und umgekehrt zu fördern.

[0072] Der Übergangsschienenabschnitt **1C** weist eine Querschnittsform auf, die ähnlich derjenigen des geradlinigen Führungsschienenabschnittes **1A** ist, und erstreckt sich linear. Der Übergangsschienenabschnitt **1C** weist Kugelrollflächen auf, die an die Kugelflächen **10a** und **10b** des geradlinigen Führungsschienenabschnittes **1A** und an die Rollflächen **12a** und **12b** des krummlinigen Führungsschienenabschnittes **1B** anschließen. Da der krummlinige Führungsschienenabschnitt **1B** schmäler als der geradlinige Führungsschienenabschnitt **1A** ausgebildet ist, ist die Seitenfläche **14** des Übergangsschienenabschnittes **1C**, die an die innere Seitenfläche des krummlinigen Führungsschienenabschnittes **1B** anschließt, schräg an der Seite an dem Ende des krummlinigen Führungsschienenabschnittes **1B**, wie durch die Punkt-Strich-Linie in Fig. 13 angedeutet, abgeschnitten. Die Breite nimmt von dem geradlinigen Führungsschienenabschnitt **1A** zu dem krummlinigen Führungsschienenabschnitt **1B** hin allmählich ab. Daher schließt die seitliche Rollfläche **10a**, die an der Seite des geradlinigen Führungsschienenabschnittes **1A** ausgebildet ist, an die Rollfläche **12b** an, die an der Seitenfläche des krummlinigen Führungsschienenabschnittes **1B** angeordnet ist, ohne dass stufenartige Änderungen auftreten. Die Kugeln können daher gleichmäßig zwischen den Rollflächen **10a** und **12a** rollen.

[0073] Wie in Fig. 11 gezeigt ist, ist eine Kugelrollfläche **13a**, die an die Rollfläche **10b** des geradlinigen Führungsschienenabschnittes **1A** und an die Rollfläche **12b** des krummlinigen Führungsschienenabschnittes **1B** anschließt, an der oberen Fläche des Übergangsschienenabschnittes **1C** ausgebildet. Wie in Fig. 12 und Fig. 13 gezeigt ist, nimmt die Breite der Kugelrollfläche **13B** an der Seite am Ende des krummlinigen Führungsschienenabschnittes **1B** allmählich zu. Dies erzeugt eine Verbindung zwischen den Rollflächen **10a** und **12b** mit unterschiedlichen Breiten, ohne dass stufenartige Änderungen vorhanden wären. Aus diesem Grund rollen Kugeln, die an der Rollfläche **12b** des krummlinigen Führungsschienenabschnittes **1B** gerollt sind, auf die obere Rollfläche **10b** des schmäler als die Rollfläche **12b** seienden geradlinigen Führungsschienenabschnittes, ohne dass sie hiervon in Eingriff genommen würden. Auf diese Weise kann sich der Gleiter gleichmäßig von dem krummlinigen Bereich in den geradlinigen Bereich der Bahnschiene bewegen.

[0074] In Fig. 14 ist eine Universalführungsvorrichtung entsprechend einem zweiten Ausführungsbeispiel der vorliegenden Erfindung gezeigt. Eine Bahnschiene **7** und ein Gleiter **8** weisen einen ähnlichen Grundaufbau wie die jeweiligen Entsprechungen beim vorstehend beschriebenen ersten Ausführungsbeispiel auf. Im Unterschied hierzu weist die Schiene **7** zwei Kugelrollflächen **71a** und zwei Kugelrollflächen **71b** an gegenüberliegenden Seiten, ein Paar über dem anderen, auf. Die oberen Rollflächen **71a** sind unter einem Winkel von 45° nach oben verkippt. Die unteren Rollflächen **71b** sind unter einem Winkel von 45° nach unten verkippt. Der Gleiter **8** weist Lastrollflächen **81a** und **81b** auf, die unter Winkeln verkippt sind, die den Kugelrollflächen **71a** beziehungsweise **71b** entsprechen.

[0075] Fig. 14 zeigt, wie der Gleiter **8** an dem geradlinigen Bereich der Bahnschiene **7**, das heißt an dem geradlinigen Führungsschienenabschnitt **7A**, angeordnet ist. Ein krummliniger Führungsschienenabschnitt **7B**, der an den geradlinigen Führungsschienenabschnitt **7A** anschließt, ist schmäler als der geradlinige Führungsschienenabschnitt **7A** gewählt, und zwar auf gleiche Weise wie beim ersten Ausführungsbeispiel. Fig. 15 ist eine im Querschnitt genommene Frontansicht des krummlinigen Führungsschienenabschnittes **7B**, in der der Umriss des geradlinigen Führungsschienenabschnittes **7A** zudem durch eine Punkt-Strich-Linie angedeutet ist.

[0076] Bei der auf diese Weise aufgebauten Universalführungsvorrichtung entsprechend dem zweiten Ausführungsbeispiel der Erfindung ist der krummlinige Führungsschienenabschnitt **7B** schmäler als der geradlinige Führungsschienenabschnitt **7A** gewählt, und zwar auf dieselbe Weise, wie dies beim ersten Ausführungsbeispiel der Fall ist. Infolgedessen kann sich der Gleiter **8** frei zwischen dem geradlinigen Führungsschienenabschnitt **7A** und dem krummlinigen Führungsschienenabschnitt **7B** bewegen.

[0077] Bei den vorstehend angegebenen Ausführungsbeispielen findet die vorliegende Erfindung bei Universalführungsvorrichtungen Verwendung. Wird eine ringförmige Bahnschiene dadurch zusammengestellt, dass mehrere krummlinige Führungsschienenabschnitte mit vorstehend beschriebener Struktur kombiniert werden, so kann sich der Gleiter entlang dieser Schiene bewegen. Eine krummlinige Führungsvorrichtung kann einfach konstruiert werden.

[0078] Bei den dargestellten Ausführungsbeispielen sind die Lastrollflächen **43a** und **43b**, die an dem Gleiter **2** ausgebildet sind, linear ausgebildet. Aus diesem Grunde kann eine Universalführungsvorrichtung dadurch hergestellt werden, dass Gleiter bestehender linearer Führungsvorrichtungen direkt eingesetzt werden. Entsprechend wird bei den vorstehend beschriebenen Ausführungsbeispielen der krummlinige Führungsschienenabschnitt **1B** schmäler als der geradlinige Führungsschienenabschnitt **1A** gewählt, um zu ermöglichen, dass sich der Gleiter der geradlinigen Führungsvorrichtung leicht entlang des krummlinigen Führungsschienenabschnittes **1B** bewegt. Aufgrund des Krümmungsradius des krummlinigen Führungsschienenabschnittes **1B** kann es jedoch unmöglich sein, die Struktur in ausreichendem Maße allein durch eine Verringerung der Breite des krummlinigen Führungsschienenabschnittes **1B** anzupassen. Der krummlinige Führungsschienenabschnitt **1B** kann durch die Berandungsabschnitte **4b** der Gleiter **2** oder im Zusammenhang mit den Abdeckungen **5** in seiner Bewegung beeinträchtigt werden. Entsprechend wird in diesem Fall die Länge des Gleiters **2**, genommen in Längsrichtung bezüglich der Bahnschiene **1**, verringert, wodurch eine Wechselwirkung zwischen dem krummlinigen Führungsschienenabschnitt **1B** und dem Gleiter **2** verhindert wird.

[0079] In Fig. 17 und Fig. 18 ist eine sich bewegende Tischvorrichtung gezeigt, bei der eine Universalführungsvorrichtung entsprechend einem Ausführungsbeispiel der vorliegenden Erfindung zum Einsatz kommt, wobei die sich bewegende Tischvorrichtung ein drittes Ausführungsbeispiel der Erfindung darstellt. Bahnschienen **1** und **1'** sind an einem festen Abschnitt, so beispielsweise an einem Sockel oder einem Fundament, angebracht. Gleiter **2** können sich entlang der Schienen **1** und **1'** bewegen. Ein Tisch **92** ist an den Gleitern angeordnet.

[0080] Die Bahnschienen **1** und **1'** setzen sich aus der ersten Schiene **1** und der zweite Schiene **1'** zusammen, die sich parallel erstrecken und gleichmäßig voneinander beabstandet sind. Die Schiene **1** umfasst einen geradlinigen Führungsschienenabschnitt **1A**, einen krummlinigen Führungsschienenabschnitt **1B**, der als Bogen mit gegebener Krümmung ausgebildet ist, sowie einen Übergangsschienenabschnitt **1C**, der den geradlinigen Führungsschienenabschnitt **1A** und den krummlinigen Führungsschienenabschnitt **1B** verbindet. Auf ähnliche Weise umfasst die Schiene **1'** einen geradlinigen Führungsschienenabschnitt **1'A**, einen krummlinigen Führungsschienenabschnitt **1'B**, der als Bogen mit gegebener Krümmung ausgebildet ist, sowie einen Übergangsschienenabschnitt **1'C**, der den geradlinigen Führungsschienenabschnitt **1'A** und den krummlinigen Führungsschienenabschnitt **1'B** verbindet. Die Krümmungsradien der krummlinigen Führungsschienenabschnitte **1B** und **1'B** seien R1 beziehungsweise R2. Die Mittelpunkte der Krümmungsradien fallen zusammen.

[0081] Mehrere Gleiter **2** (beispielsweise zwei) sind an jeder der Schienen **1** und **1'** angebracht. Insgesamt vier Gleiter tragen den Tisch. Die Gleiter **2** können sich frei an der ersten Schiene **1** (**1A**, **1B**, **1C**) und an der zweiten Schiene **1'** (**1'A**, **1'B**, **1'C**) bewegen. Ein Paar fester Platten **91** ist über den ersten und zweiten Reihen der Gleiter **2** – in Bewegungsrichtung an den Schienen **1** und **1'** betrachtet – angeordnet. Die festen Platten **91** weisen längliche Rechteckform auf und sind an den oberen Flächen der Gleiter **2** mittels Befestigungsmitteln, so beispielsweise mittels Schrauben, angebracht. Dies bedeutet, dass die festen Platten **91** – in Längsrichtung der Schienen **1** und **1'** betrachtet (das heißt in Richtung der Anordnung der Schienenabschnitte) – Gleiter **2** überspannen, die einander benachbart sind.

[0082] Der Tisch **92** ist derart angeordnet, dass er gegenüber den festen Platten drehbar ist. Eine Welle **93** ist an der unteren Fläche des Tisches **2** angeordnet. Drehlager **90** zum drehbaren Halten der Welle **93** sind an den oberen Flächen der festen Platten **91** angebracht. Die Drehlager **90** ermöglichen, dass der Tisch **92** gegenüber den festen Platten eine Drehung ausführt, während die Lager eine Last von dem Tisch **92** aufnehmen. Die Drehlager **90** sind in Gehäusen **94** angebracht, die wiederum in den festen Platten **91** angebracht sind. Jedes der Drehlager **90** weist eine äußere Laufbahn **90a**, die an dem Gehäuse angebracht ist, sowie eine innere Laufbahn **90b**, die an der Welle **93** angebracht ist, auf.

[0083] Fig. 19 zeigt eines der Drehlager **90**. Eine V-förmige Rollfläche ist sowohl an der äußeren Laufbahn **90a** wie auch an der inneren Laufbahn **90b** angeordnet. Eine Kugelrollstrecke von im Wesentlichen rechteckigem Querschnitt ist zwischen diesen Rollflächen ausgebildet. Mehrere Rollkörper **95** sind in der Rollkörperrollstrecke angeordnet und abwechselnd in Drehrichtung rechtwinklig zueinander verkippt. Die Rollkörper **95** rollen entlang der Rollkörperrollstrecke, wobei sie eine Last aufnehmen. Abstandshalter **96** sind zwischen benachbarten Rollkörpern **95** angeordnet, um die Rollkörper **95** in einem gegebenen Abstand zu halten.

[0084] Entlang der Rollkörperrollstrecke weisen zwei horizontal an denselben Abstandshalter **96** angrenzende Rollkörper **95** Achsen auf, die senkrecht zueinander sind. Die Rollkörper **95** werden in nach außen weisende Rollkörper **95a** und nach innen weisende Rollkörper **95b** unterteilt. Die Abstandshalter **96** halten die nach außen weisenden Rollkörper **95a** in einer derartigen Anordnung, dass deren Achsen C zur Drehmitte B hin weisen, die in der Drehmitte der äußeren Laufbahn **90a** und der inneren Laufbahn **90b** liegen.

[0085] Fig. 20 zeigt, wie die Bahnschienen **1** und **1'**, die jeweils aus den Schienenabschnitten **1A**, **1B** und **1C** sowie aus den Schienenabschnitten **1'A**, **1'B** und **1'C** bestehen, kombiniert werden, um eine S-Form zu erhalten. Die festen Platten **91** und der Tisch **92** bewegen sich entlang der S-förmigen Schiene. Während der Bewegung an den krummlinigen Schienenabschnitten **1B** und **1'B** sind die Gleiter **2** in tangentiale Richtung der krummlinigen Schienenabschnitte **1B** und **1'B** gerichtet. Daher drehen sich die an den

Gleitern **2** angebrachten festen Platten **91** um die Mitte O des Krümmungsradius. Als Ergebnis nimmt der Abstand zwischen den Gleitern **2**, die sich an der inneren Bahnschiene **1** bewegen, ab, wohingegen der Abstand zwischen den Gleitern **2**, die sich an der äußeren Bahnschiene **1'** bewegen, zunimmt. Da die festen Platten **91** drehbar an dem Tisch **92** angebracht sind, lassen die Platten derartige Abstandsschwankungen zwischen den Gleitern zu und ermöglichen so eine gleichmäßige Bewegung der Gleiter **2**.

[0086] Fig. 21 und Fig. 22 zeigen eine sich bewegende Tischvorrichtung, die bei einer Universalführungsvorrichtung entsprechend einem Ausführungsbeispiel der vorliegenden Erfindung zum Einsatz kommt, wobei die sich bewegende Tischvorrichtung ein viertes Ausführungsbeispiel der vorliegenden Erfindung darstellt. Beim vierten Ausführungsbeispiel sind die erste Bahnschiene **1** und die zweite Bahnschiene **1'** parallel zueinander angeordnet, wobei zwei Gleiter **2** an beiden Schienen **1** und **1'** angebracht sind. Diese vier Gleiter **2** tragen den Tisch **92** auf dieselbe Weise, wie dies beim dritten Ausführungsbeispiel der Fall ist. Gleichwohl unterscheidet sich die bewegliche Tischvorrichtung entsprechend dem vierten Ausführungsbeispiel von der beweglichen Tischvorrichtung entsprechend dem dritten Ausführungsbeispiel dadurch, dass die vier Gleiter **2** jeweils eigene Drehlager **90** aufweisen, und der Tisch **92** drehbar von dem Drehlager **90** gehalten wird. Die Drehlager **90** sind strukturell den Drehlagern beim dritten Ausführungsbeispiel ähnlich. An den vier Ecken des Tisches **92** angebrachte Wellen sind drehbar gehalten.

[0087] Bei der drehbaren Tischvorrichtung entsprechend diesem Ausführungsbeispiel tragen die Gleiter **2** die vier Ecken des Tisches **92**, weshalb der Tisch **92** stabiler als beim dritten Ausführungsbeispiel gehalten werden kann. Da die vier Gleiter **2** drehbar an dem Tisch gehalten werden, drehen sich die Gleiter **2**, die sich entlang der krummlinigen Führungsschienenabschnitte **1B** und **1'B** bewegen, beliebig und unabhängig voneinander und werden in tangentiale Richtung θ1, θ2, θ3 und θ4 der krummlinigen Führungsschienenabschnitte **1B**, **1'B**, wie in Fig. 22 gezeigt, ausgerichtet. Dies ermöglicht eine gleichmäßige Bewegung der Gleiter **2**.

[0088] Bewegt sich der Tisch **92** zwischen Bahnschienen **1** und **1'**, die verschiedene Krümmungsradien aufweisen, was beispielsweise dann der Fall ist, wenn eine Bewegung von den geradlinigen Bereichen **1A**, **1'A** der Schienen **1**, **1'** in die krummlinigen Bereiche **1B**, **1'B** erfolgt, so wird für den Fall, dass der Abstand zwischen den Gleitern **2** konstant gehalten wird, verhindert, dass die Gleiter **2** in ihrer Bewegung durch die Schienen **1** und **1'** beeinträchtigt werden, was eine gleichmäßige Bewegung des Tisches **2** verhindern würde. Gleichwohl sind Spalten zwischen den Gleitern **2** der Schienen **1**, **1'** dadurch vorgesehen, dass die Breite der Schienen **1** und **1'** schmäler als vorstehend beschrieben gewählt wird. Die Spalte beseitigen die Wechselwirkung zwischen den Gleitern **2** und den Schienen **1**, **1'**, sodass eine gleichmäßige Bewegung der Gleiter **2** sichergestellt ist.

Patentansprüche

1. Universalführungsvorrichtung, umfassend:
eine Bahnschiene (**1**; **7**) mit einem geradlinigen Bereich (**1A**; **7A**) und wenigstens einem krummlinigen Bereich (**1B**; **7B**), der als Bogen mit einem gegebenen Krümmungsradius ausgebildet ist, sowie mit Kugelrollflächen (**10a**, **12a**; **71a**, **71b**), die an zwei gegenüberliegenden Seitenflächen in Längsrichtung der Bahnschiene ausgebildet sind;
einen Sattelform aufweisenden Gleiter (**2**; **8**), der bei Verwendung an der Bahnschiene (**1**; **7**) angeordnet ist und Lastrollflächen (**43a**; **81a**, **81b**), die gegenüber den Kugelrollflächen (**10a**, **12a**; **71a**, **71b**) der Bahnschiene (**1**; **7**) angeordnet sind, sowie Endlosringstrecken, die die Lastrollflächen enthalten, aufweist;
eine Anzahl von Kugeln (**3**), die in den in dem Gleiter (**2**; **8**) ausgebildeten Endlosringstrecken rollen und bei Verwendung eine Last zwischen den Kugelrollflächen (**10a**, **12a**; **71a**, **71b**) der Bahnschiene und den Lastrollflächen (**43a**; **81a**, **81b**) des Gleiters tragen;
dadurch gekennzeichnet,
dass sämtliche an dem Gleiter (**2**; **8**) ausgebildeten Lastrollflächen (**43a**; **81a**, **81b**) linear ausgebildet sind, und der krummlinige Bereich (**1B**; **7B**) der Bahnschiene (**1**; **7**) schmäler als der geradlinige Bereich (**1A**; **7A**) der Bahnschiene ausgebildet ist.

2. Universalführungsvorrichtung nach Anspruch 1, bei der die Kugeln (**3**) eine Last zwischen den bogenförmigen Kugelrollflächen (**12a**; **71a**, **71b**) in Längsrichtung der Bahnschiene (**1**; **7**) und den an dem Gleiter (**2**; **8**) ausgebildeten geradlinigen Lastrollflächen (**43a**; **81a**, **81b**) tragen, wenn sich der Gleiter durch den krummlinigen Bereich (**1B**; **7B**) der Bahnschiene bewegt.

3. Universalführungsvorrichtung nach Anspruch 1, bei der einige der an den Lastrollflächen (**43a**; **81a**, **81b**) an dem Gleiter (**2**; **8**) rollenden Kugeln (**3**) eine Last zwischen den Kugelrollflächen (**12a**; **71a**, **71b**) an der Bahnschiene (**1**; **7**) und den Lastrollflächen (**43a**; **81a**, **81b**) an dem Gleiter tragen, wenn sich der Gleiter durch den krummlinigen Bereich (**1B**; **7BB**) der Bahnschiene bewegt.

4. Universalführungsvorrichtung nach einem der vorhergehenden Ansprüche, bei der die Bahnschiene (**1**) eine nach oben weisende Kugelrollfläche (**10b**, **12b**) aufweist, die an einer oberen Fläche der Bahnschiene ausgebildet ist, bei der der Gleiter (**2**) eine nach unten weisende Lastrollfläche (**43b**) gegenüber

der nach oben weisenden Kugelrollfläche (**10b**, **12b**) der Bahnschiene aufweist, und bei der die Breite der nach oben weisenden Kugelrollfläche (**12b**) in dem krummlinigen Bereich (**1B**) der Bahnschiene (**1**) derart gewählt ist, dass sämtliche an der nach unten weisenden Lastrollfläche (**43b**) des Gleiters (**2**) rollenden Kugeln (**3**) die nach oben weisende Kugelrollfläche (**12b**) gleichzeitig berühren.

5. Universalführungsvorrichtung nach einem der vorhergehenden Ansprüche, bei der die Bahnschiene (**1**) zwei in verschiedene Richtungen gekrümmte krummlinige Bereiche (**16**, **17**) aufweist, wobei sich der eine der krummlinigen Bereiche nach rechts krümmt, und sich der andere der krummlinigen Bereiche nach links krümmt.

6. Universalführungsvorrichtung nach einem der vorhergehenden Ansprüche, bei der die Führungsschiene (**1**) dadurch gebildet wird, dass eine geradlinige Führungsschiene (**1A**) und eine krummlinige Führungsschiene (**1B**) kombiniert werden.

7. Universalführungsvorrichtung nach Anspruch 6, bei der die Bahnschiene (**1**) eine Übergangsschiene (**1C**) aufweist, die die geradlinige Führungsschiene (**1A**) und die krummlinige Führungsschiene (**1B**) verbindet, wobei die Übergangsschiene (**1C**) eine Breite aufweist, die vom Ende der geradlinigen Führungsschiene bis zum Ende der krummlinigen Führungsschiene kontinuierlich variiert.

8. Bewegliche Tischvorrichtung mit mehreren parallel zueinander angeordneten Universalführungsvorrichtungen und von den Universalführungsvorrichtungen geführter Tisch (**92**), wobei jede Universalführungsvorrichtung entsprechend Anspruch 1 festgelegt ist.

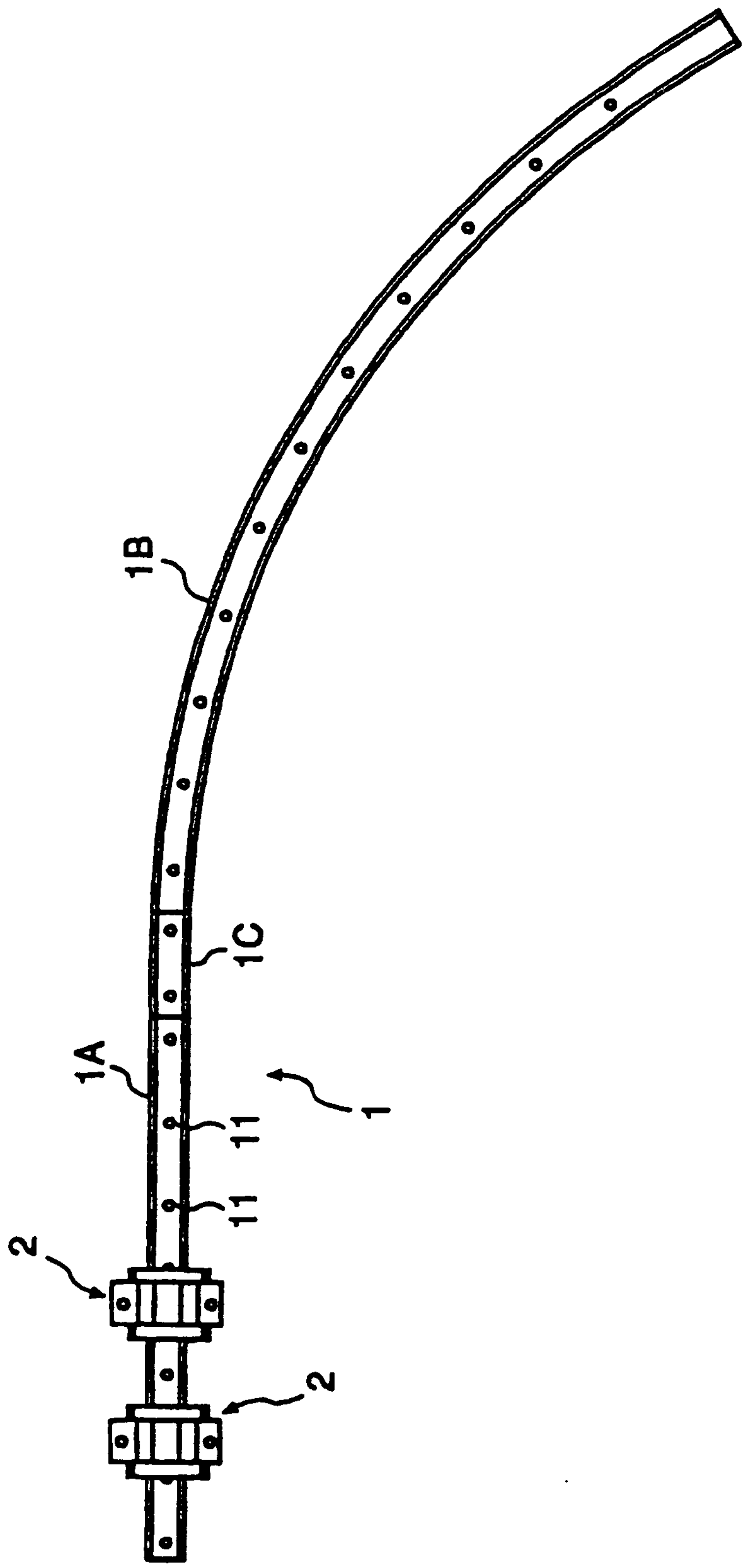
9. Bewegliche Tischvorrichtung nach Anspruch 8, bei der eine Mehrzahl von Bahnschienen (**1**, **1'**) parallel zueinander angeordnet ist, eine Mehrzahl von Gleitern (**2**) an jeder der Bahnschienen (**1**, **1'**) angeordnet ist, einander benachbarte und an verschiedenen Schienen (**1**, **1'**) befindliche Gleiter (**2**) durch feste Platten (**91**) verbunden sind, und der Tisch (**92**) derart angebracht ist, dass er gegenüber den festen Platten drehbar ist.

10. Bewegliche Tischvorrichtung nach Anspruch 8, bei der eine Mehrzahl von Bahnschienen (**1**, **1'**) parallel zueinander angeordnet ist, eine Mehrzahl von Gleitern (**2**) an jeder der Bahnschienen angeordnet ist, und der Tisch (**92**) derart angebracht ist, dass er gegenüber den Gleitern (**2**) drehbar ist.

Es folgen 19 Blatt Zeichnungen

Anhängende Zeichnungen

Fig 1



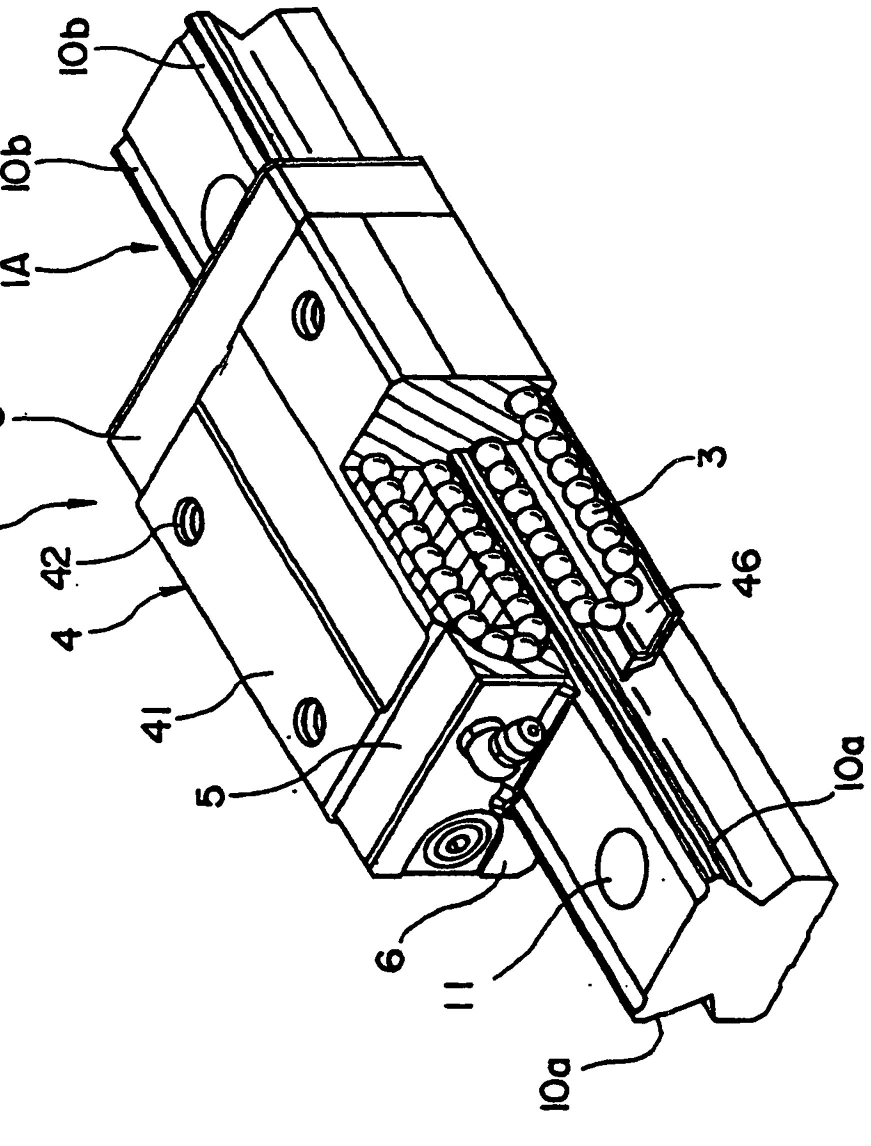


Fig 2

Fig 3

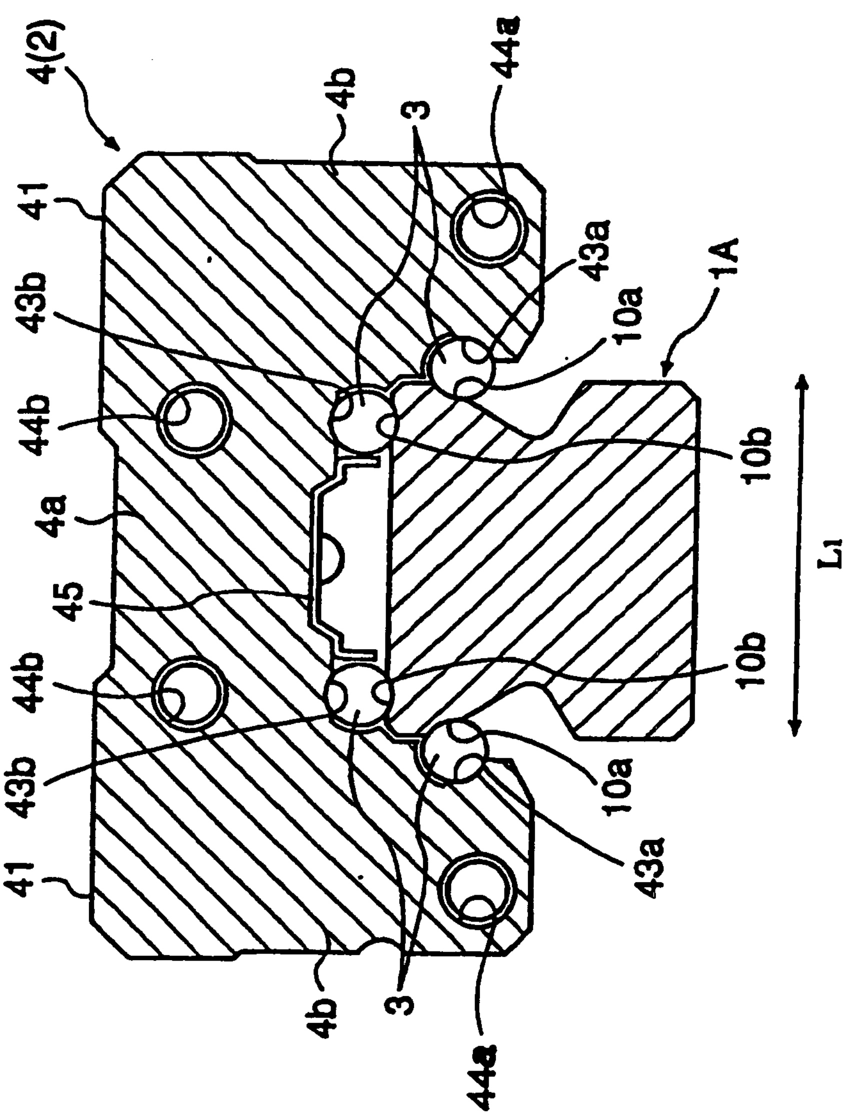


Fig 4

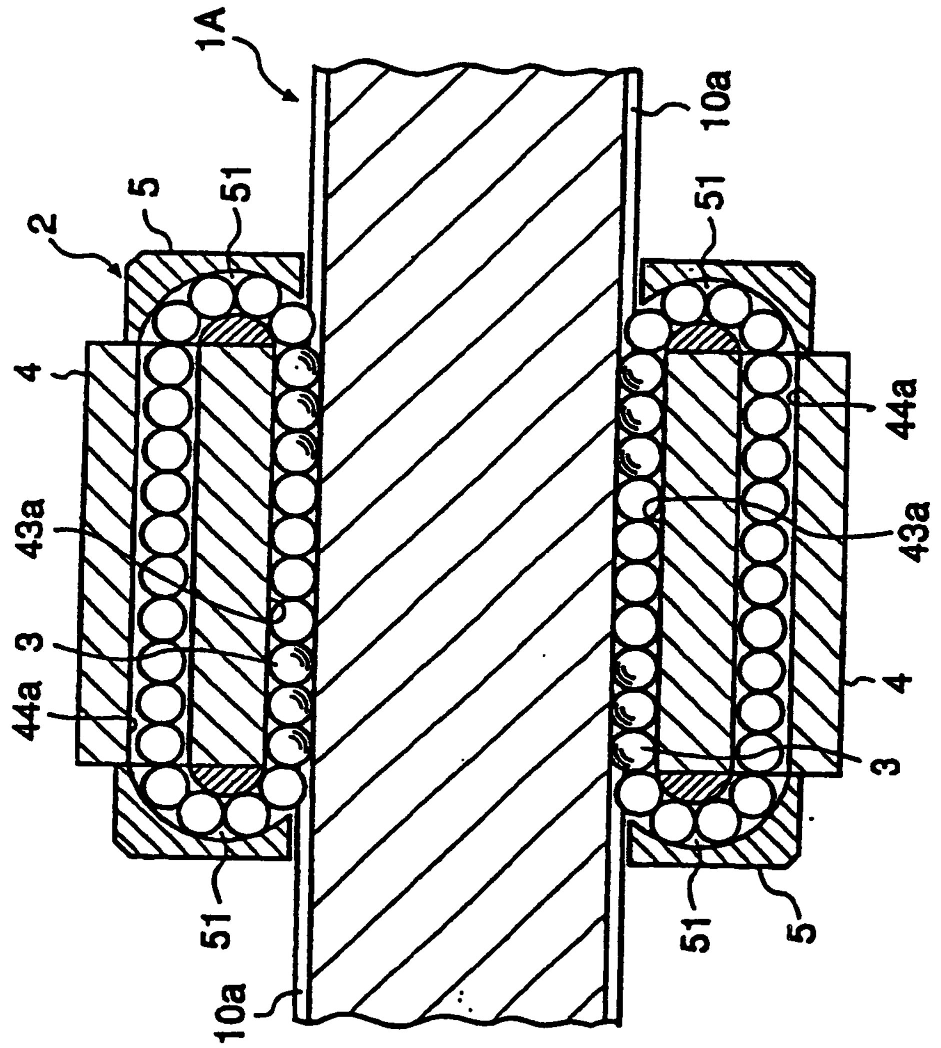


Fig 5

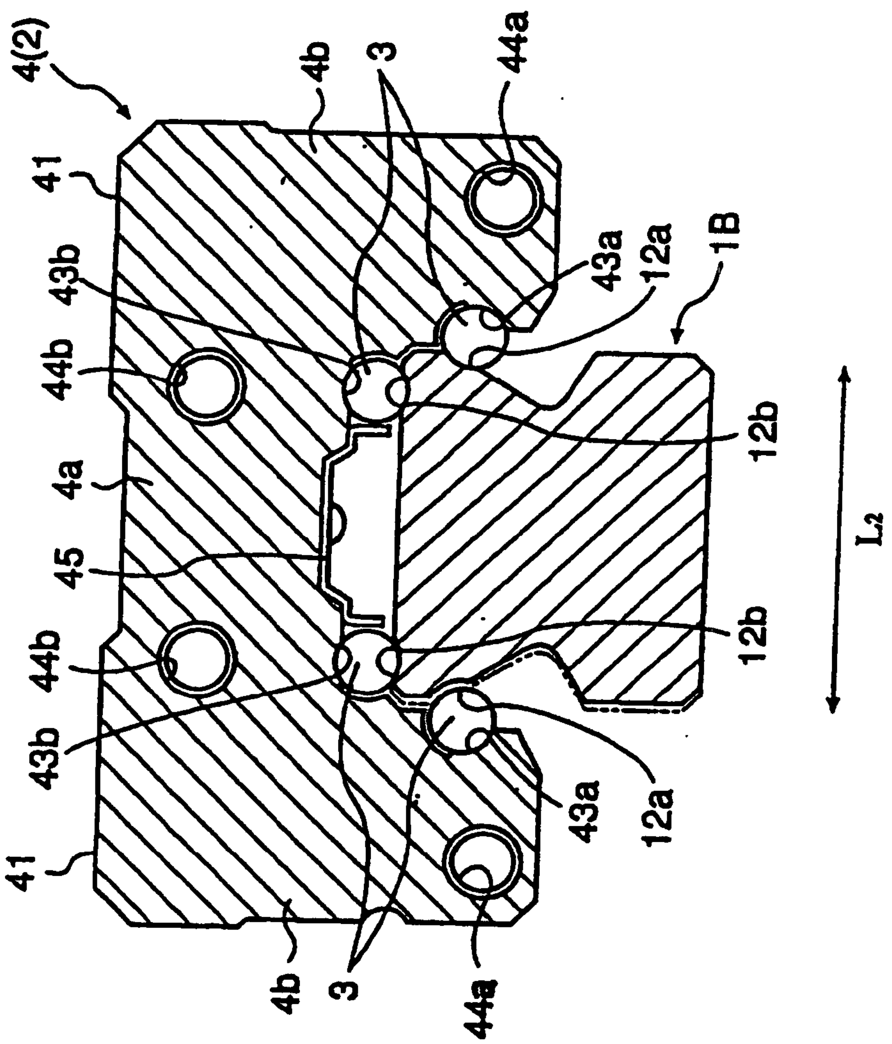


Fig 6

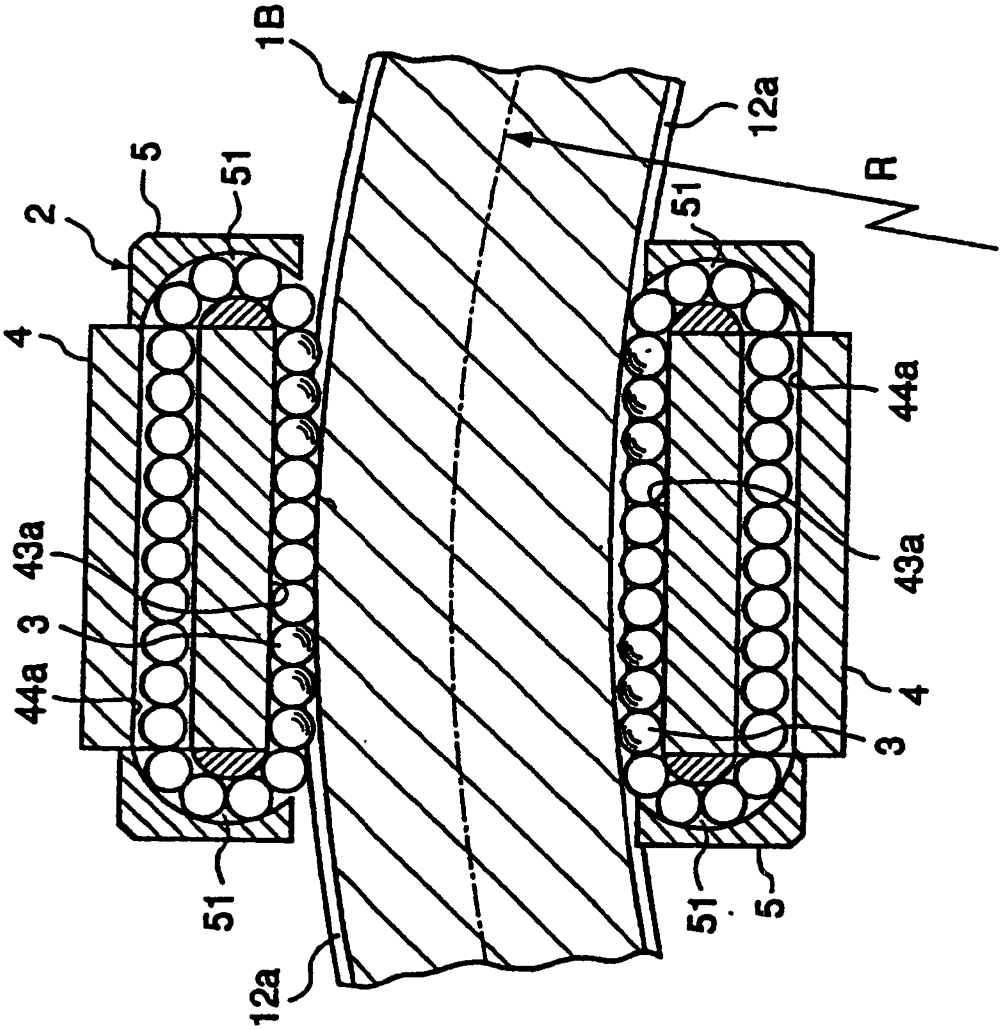


Fig 7

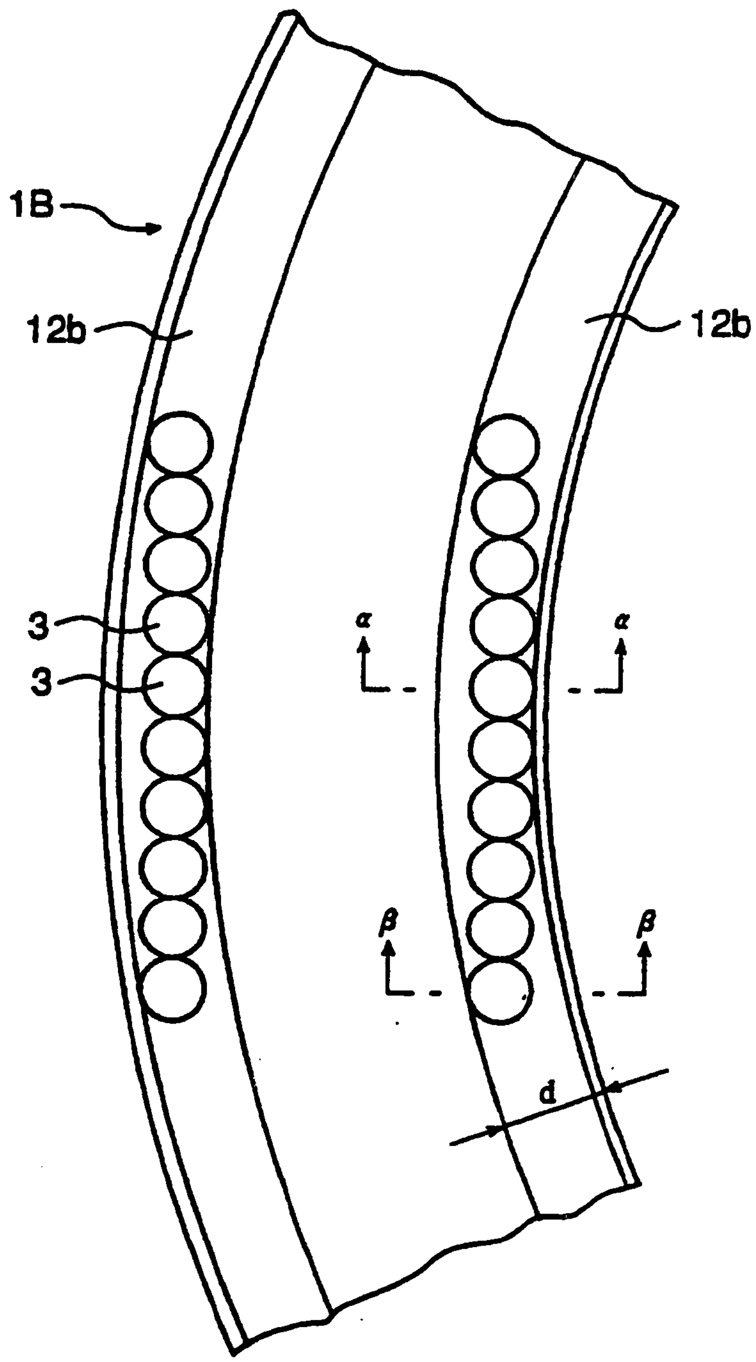


Fig 8

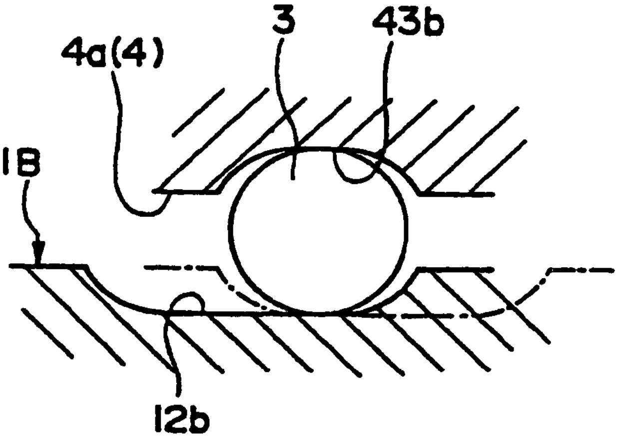
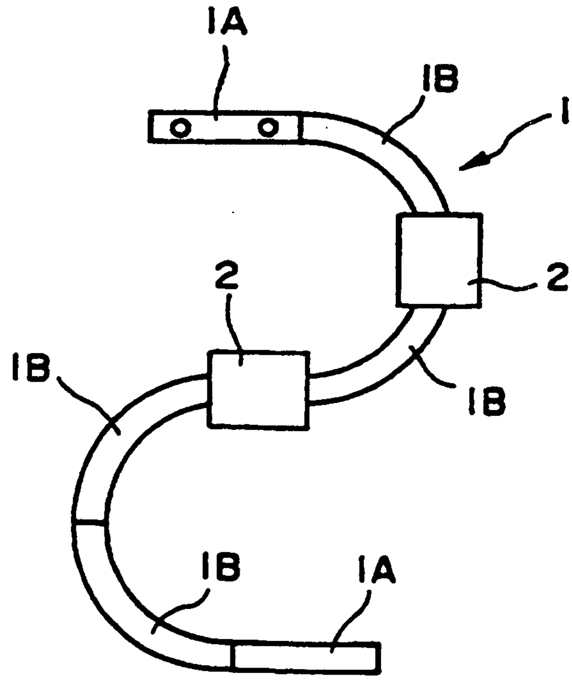


Fig 9



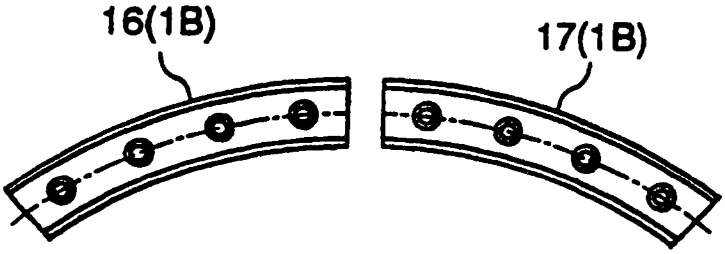


Fig 10(a)

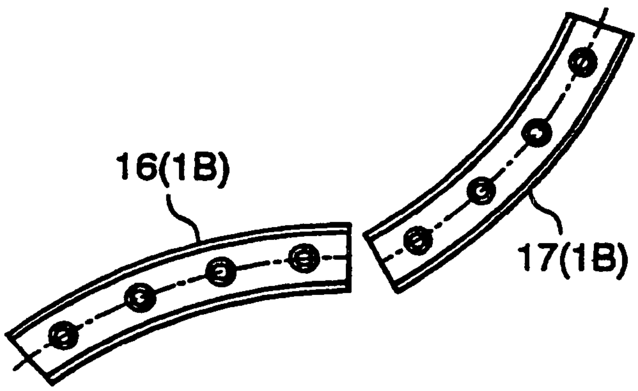


Fig 10(b)

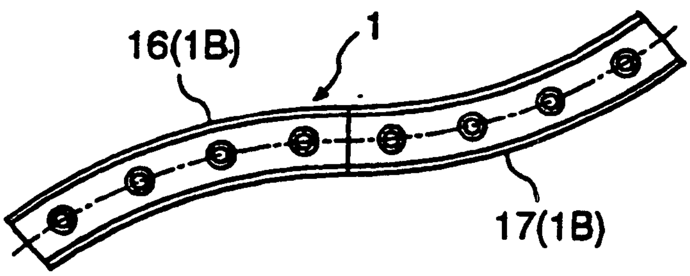


Fig 10(c)

Fig 11

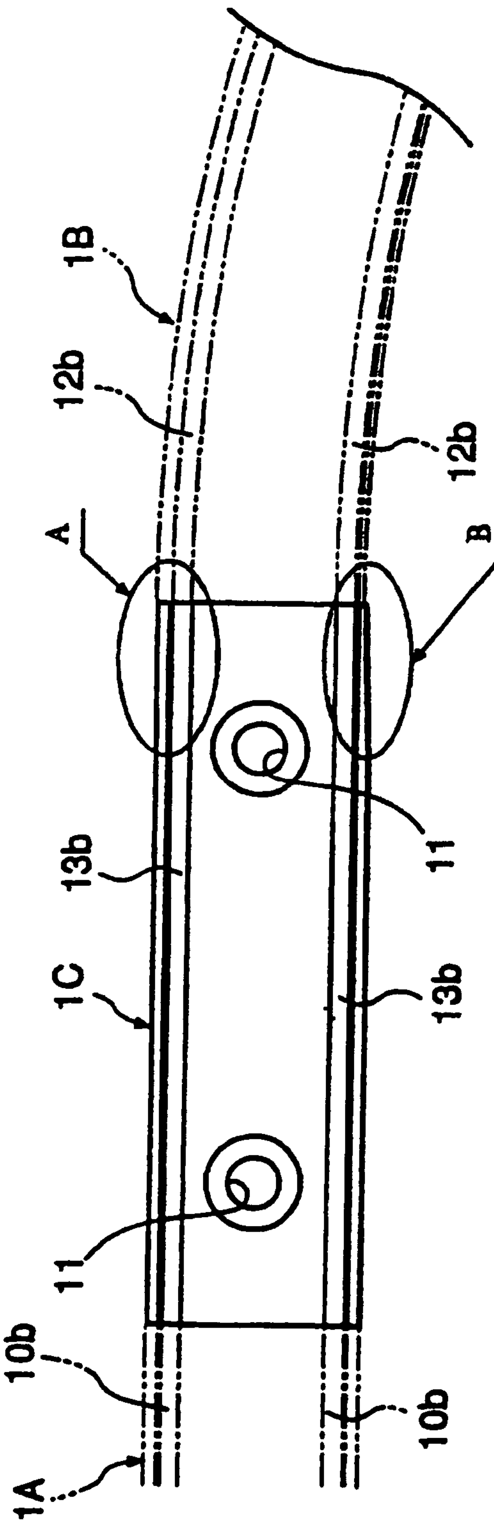


Fig 12

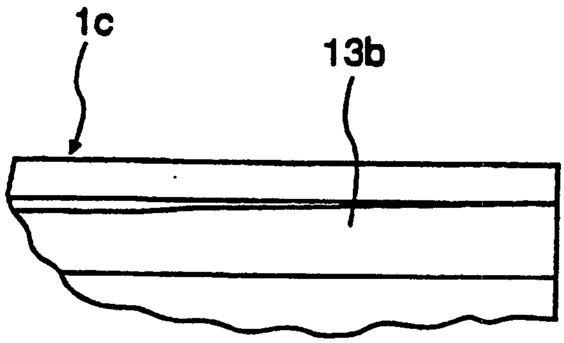


Fig 13

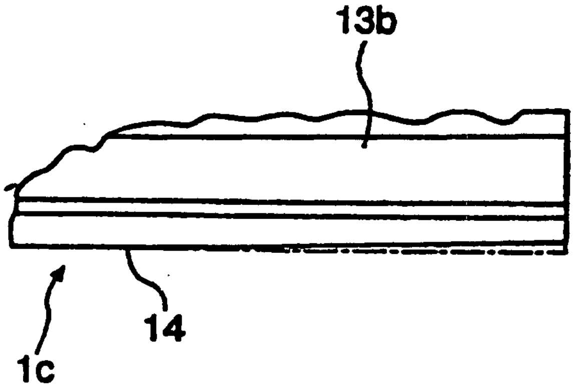


Fig 14

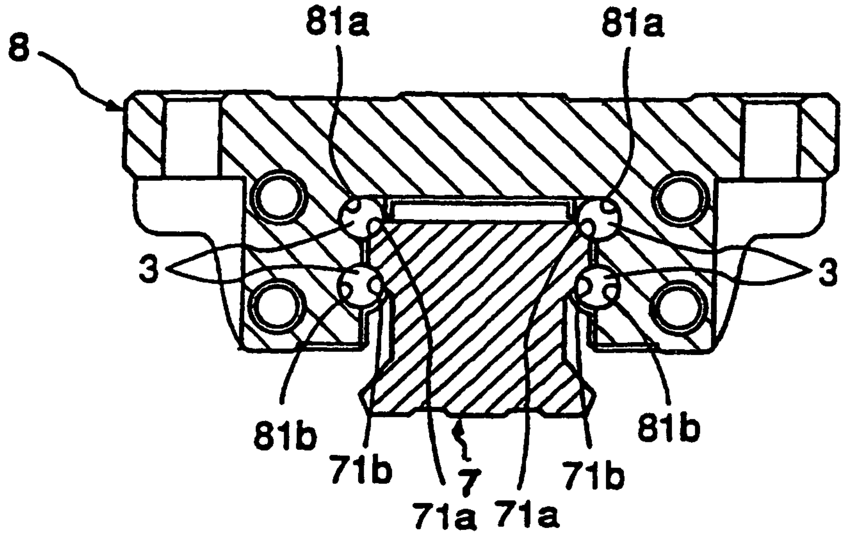


Fig 15

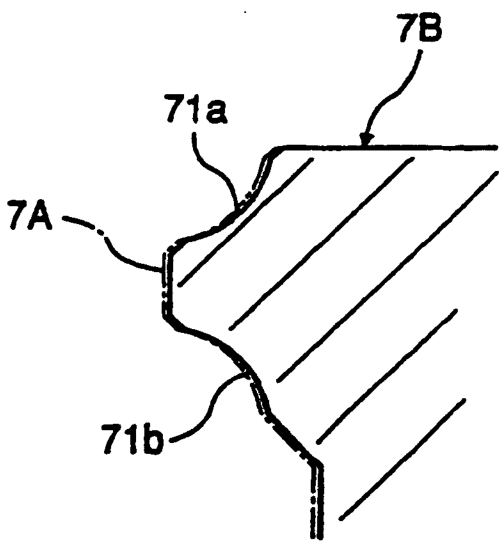
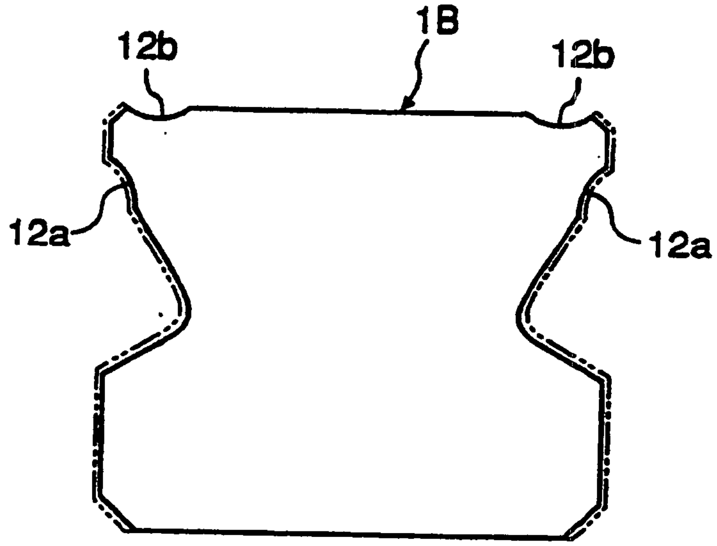


Fig 16



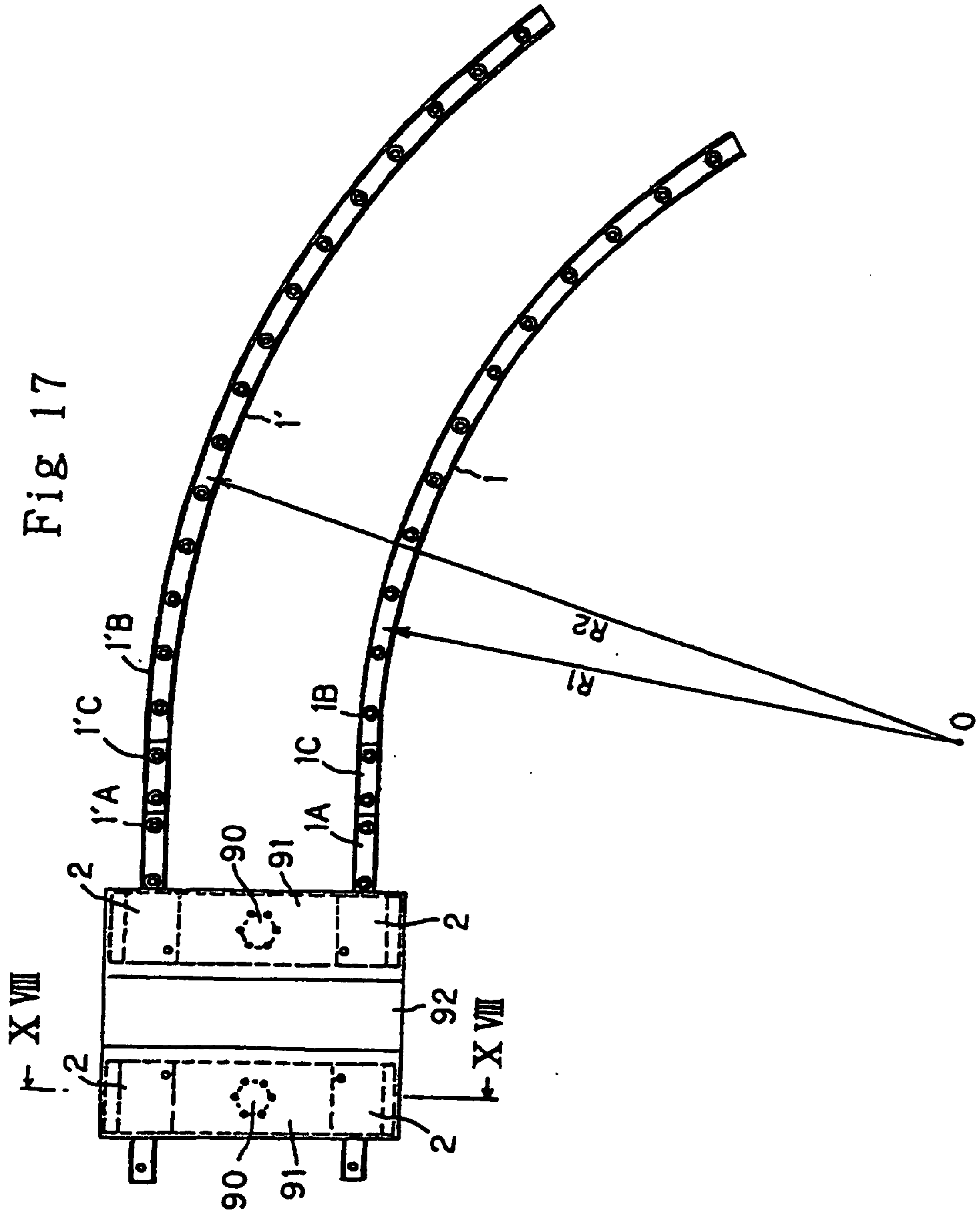


Fig 17

Fig 18

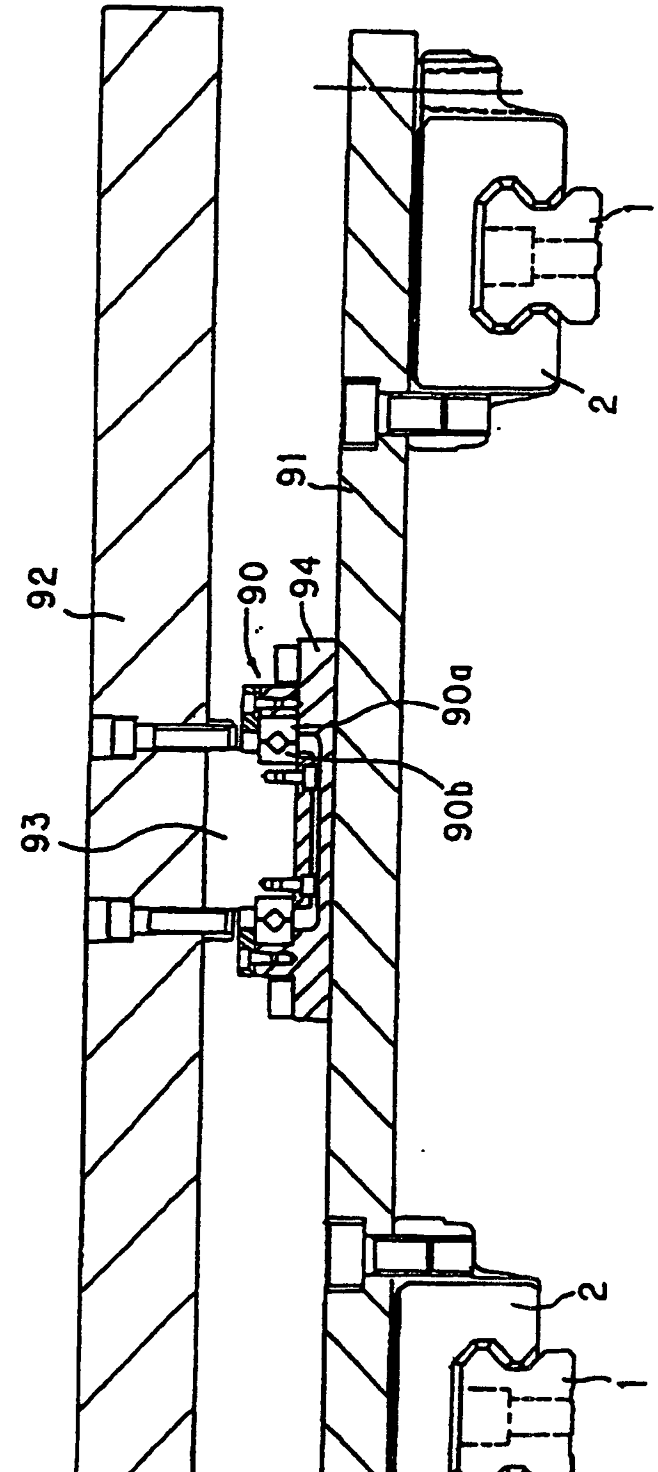
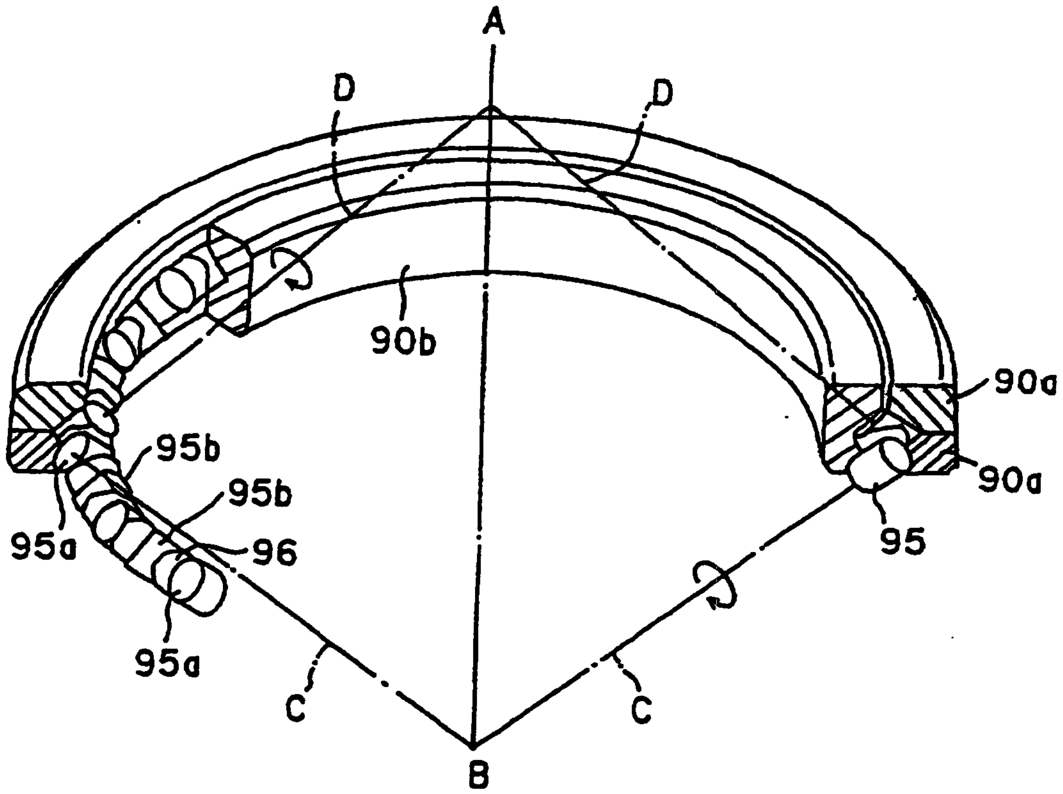


Fig 19



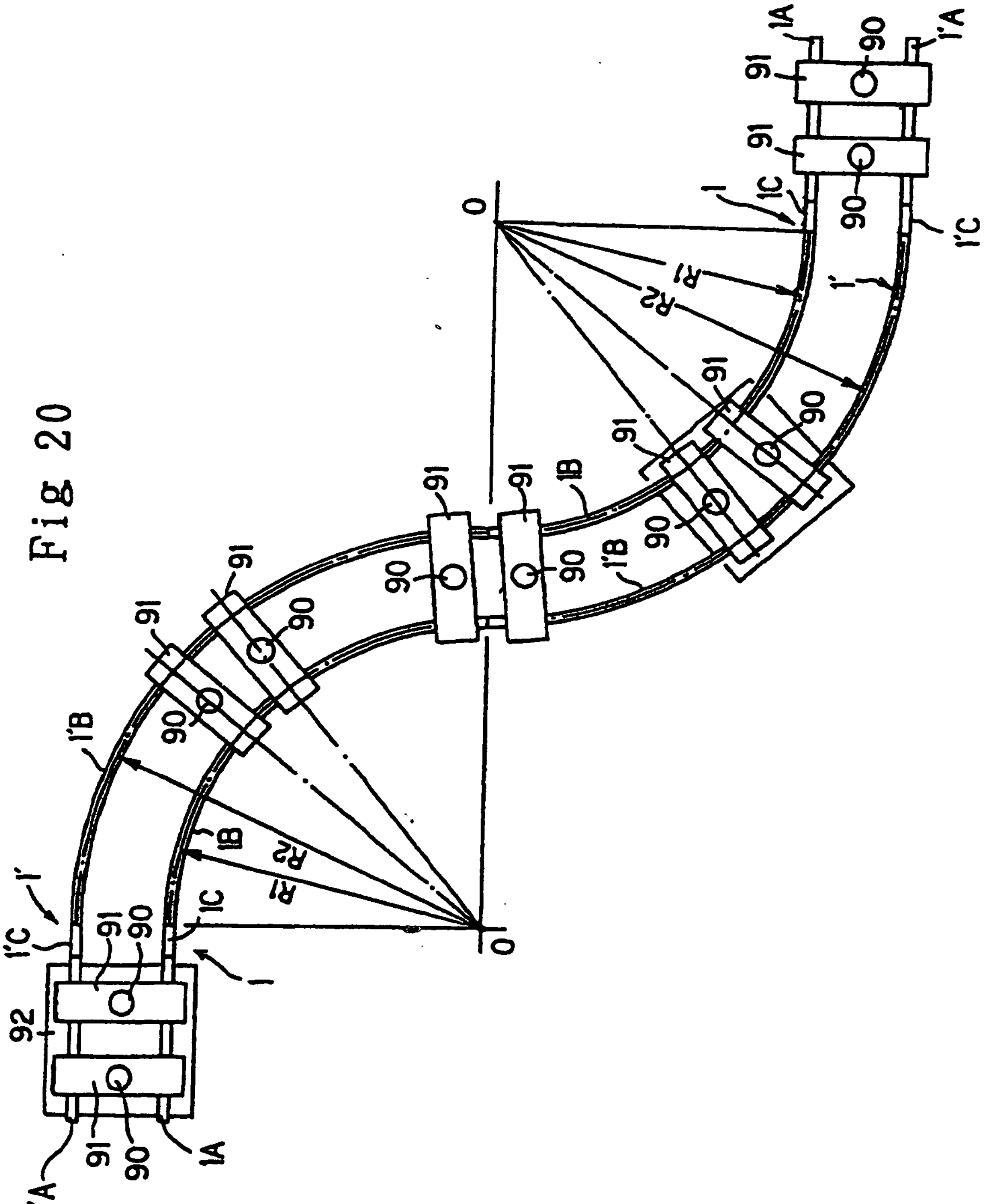


Fig 20

Fig 21

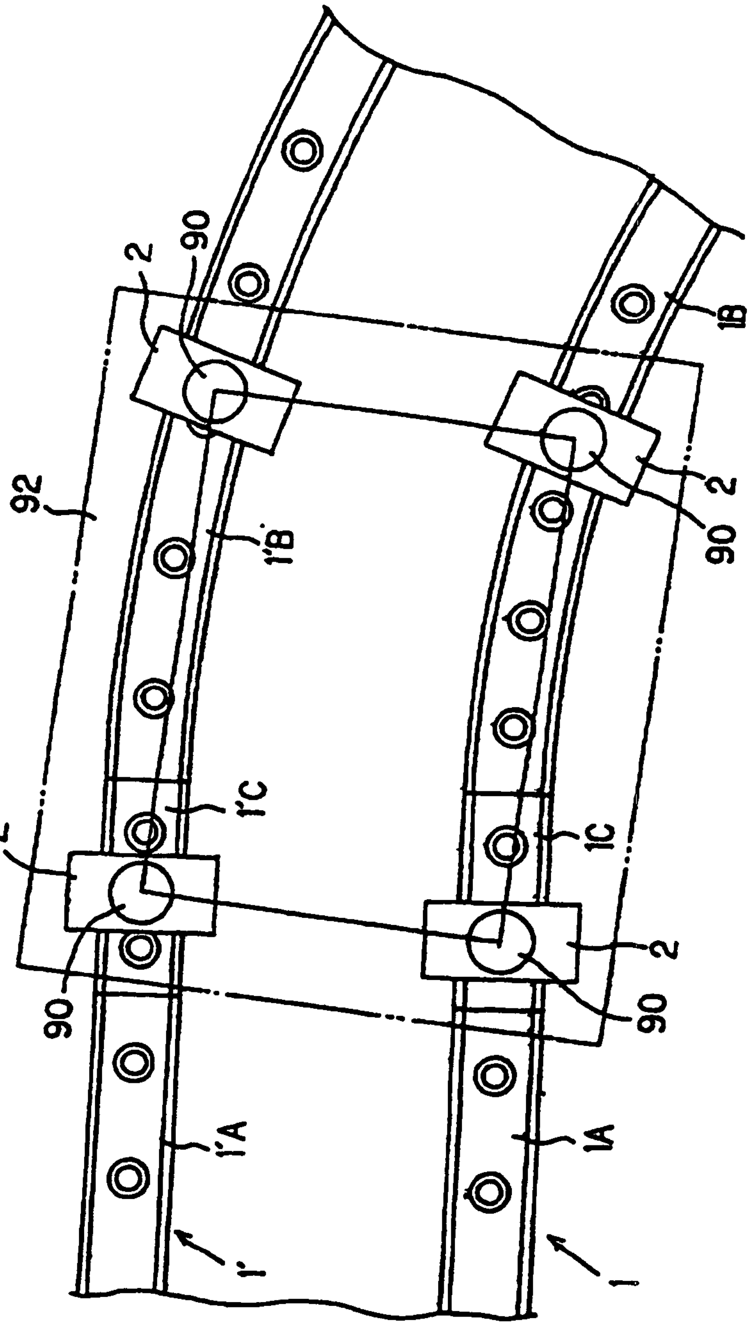
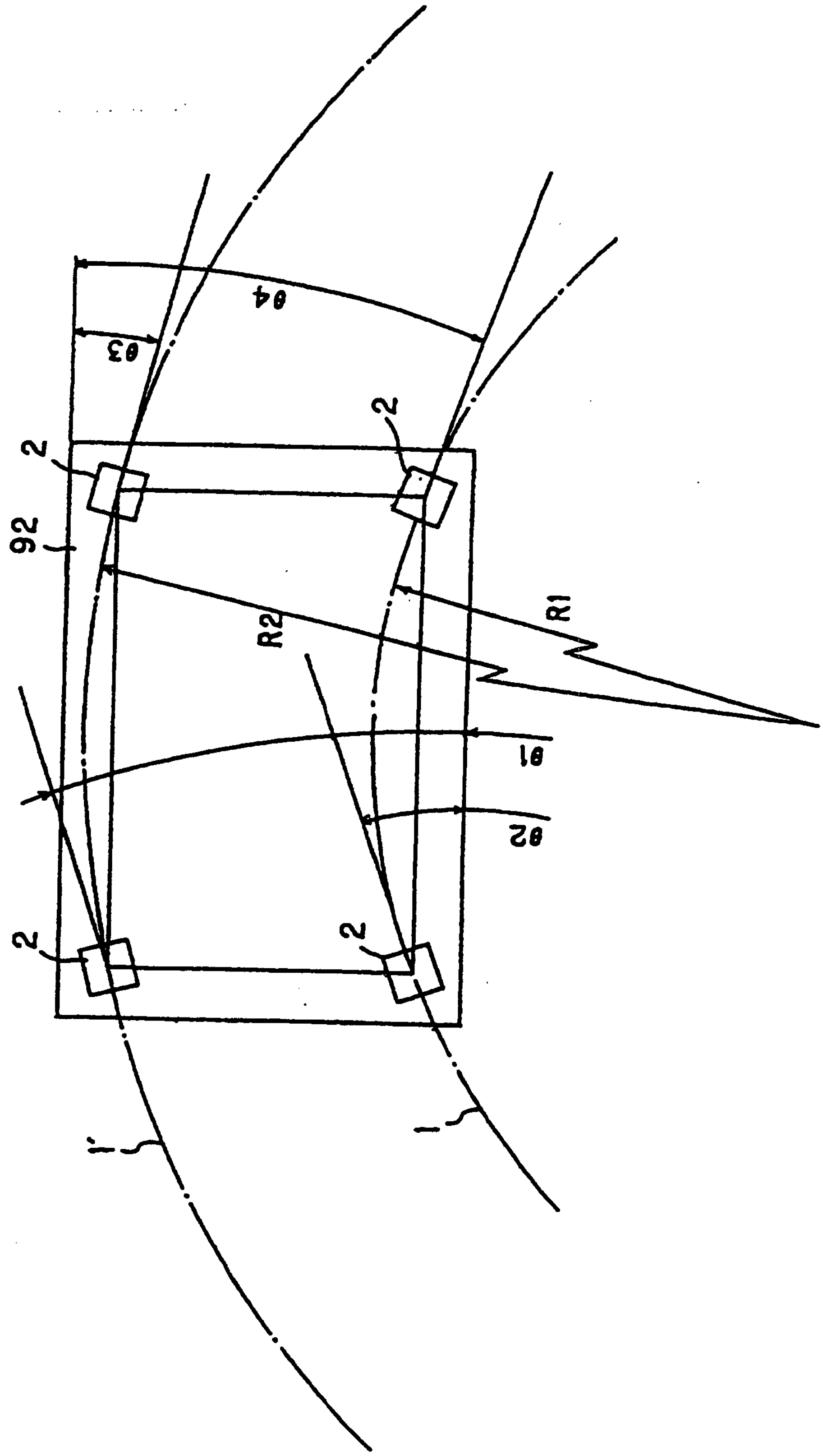


Fig 22



(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 199 56 966 A 1**

(51) Int. Cl.^{7}:
F 16 C 29/06

(21) Aktenzeichen: 199 56 966.5
(22) Anmeldetag: 26. 11. 1999
(43) Offenlegungstag: 31. 5. 2000

(30) Unionspriorität:
10-336821 27. 11. 1998 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

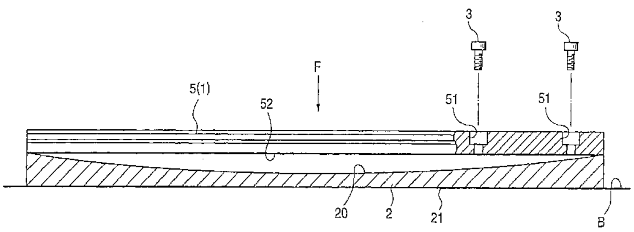
(74) Vertreter:
HOFFMANN · EITLE, 81925 München

(72) Erfinder:
Michioka, Hidekazu, Tokio/Tokyo, JP; Kinomoto, Masashi, Tokio/Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Verfahren zur Herstellung einer krummlinigen Führungsschiene und krummlinige Führungsschiene

(57) Bei einem Verfahren zur Herstellung einer krummlinigen Führungsschiene zum Führen eines sich bewegenden Körpers entlang einer gekrümmten Linie mit einer gegebenen Krümmung wird die untere Fläche einer geradlinigen Führungsschiene (5) zum Führen eines sich bewegenden Körpers auf geradlinige Art und Weise gegen eine gekrümmte Schienenanbringfläche (20) gepresst, die mit einem gegebenen Krümmungsradius ausgebildet ist, um dadurch die geradlinige Führungsschiene (5) elastisch auf krummlinige Art und Weise zu verformen, und die geradlinige Führungsschiene (5) wird dann an die Schienenanbringfläche (20) befestigt, während die geradlinige Führungsschiene (5) elastisch verformt bleibt, wodurch eine krummlinige Führungsschiene erzeugt wird.



DE 199 56 966 A 1

DE 199 56 966 A 1

Beschreibung

Technisches Gebiet

Die vorliegende Erfindung betrifft ein Verfahren zur Herstellung einer krummlinigen Führungsschiene zum Führen eines sich bewegenden Körpers entlang einer Kurve mit einer gegebenen Krümmung in einer krummlinigen Führungsvorrichtung zur Verwendung in einem Schwingungs-Isolierapparat, der bei einem Präzisionsgerät, einer Kunst- oder Handwerksvitrine oder ähnlichem angewendet wird, sowie eine krummlinige Führungsschiene, die gemäß dem erfindungsgemäßen Verfahren hergestellt wird.

Stand der Technik

In herkömmlicher Weise wird als eine Erdbeben-Maßnahme für Immobilien, wie z. B. ein Gebäude oder ein Haus, oder als eine Schwingungsmaßnahme, wenn ein Präzisionsgerät, eine Kunstvitrine oder ähnliches transportiert wird, eine Vibrations-Isoliervorrichtung verwendet, welche die Schwingungen der Erde oder eines Bodens absorbiert, um die Schaukelbewegung desselben zu mildern. Als eine Schwingungs-Isoliervorrichtung ist eine Vorrichtung bekannt, bei der eine krummlinige Führungsvorrichtung verwendet wird, die einen sich bewegenden Körper in einer krummlinigen Art und Weise entlang einer krummlinigen Führungsschiene führt (es sei beispielsweise auf die ungeprüfte japanische Patentveröffentlichung mit der Nr. Hei 10-122238 verwiesen).

Fig. 4 zeigt ein Beispiel einer Schwingungs-Isoliervorrichtung **100** mit einer krummlinigen Führungsvorrichtung. Die Schwingungs-Isoliervorrichtung **100** weist eine erste krummlinige Führungsvorrichtung **60**, die an einen Boden **50** befestigt ist, eine zweite krummlinige Führungsvorrichtung **70**, die an einen gelagerten Körper **51**, wie z. B. ein Präzisionsgerät, von dem Schwingungen durch die Vorrichtung **100** isoliert werden sollen, befestigt ist, und eine universelle Kupplung **80** auf, welche die beiden krummlinigen Führungsvorrichtungen **60** und **70** miteinander verbindet. Die erste und zweite krummlinige Führungsvorrichtung **60** und **70** sind derart angeordnet, dass sie unter einem rechten Winkel aufeinander treffen.

Ferner weisen die beiden krummlinigen Führungsvorrichtungen **60** und **70** jeweils krummlinige Führungsschienen **61** und **71**, die jeweils auf gekrümmte Art und Weise mit ihren jeweiligen gegebenen Krümmungen ausgebildet sind, und sich bewegende Körper **62** und **72** auf, die sich jeweils entlang ihrer zugeordneten krummlinigen Führungsschienen **61** und **71** bewegen. Die universelle Kupplung **80** verbindet die sich bewegenden Körper **62** und **72** der ersten und zweiten krummlinigen Führungsvorrichtung **60** und **70** miteinander. Die beiden krummlinigen Führungsvorrichtungen **60** und **70** werden vorangehend durch Biegen mit ihren jeweiligen Krümmungen ausgebildet, so dass sie nicht unmittelbar an den Boden zu befestigen sind, der eine Ebene bildet. Deshalb werden sie jeweils an den Boden **50** und an den gelagerten Körper **51** über ihre zugeordneten Befestigungsbasen **63** und **73** befestigt, die in gekrümmten Formen jeweils mit der gleichen Krümmung wie diejenige der krummlinigen Führungsvorrichtung **61** und **71** ausgebildet sind. In dieser Beschreibung bedeutet der Begriff "Biegen" ein "Biegen, bei dem plastische Verformung auftritt", d. h. er bedeutet, dass, nachdem die Schiene einmal durch Biegen ausgebildet ist, die Schiene nicht mehr unter normalen Umständen zu ihrer Ausgangsform zurückgebracht werden kann.

Fig. 5 ist eine schematische Ansicht der wie oben beschrieben aufgebauten Schwingungs-Isoliervorrichtung, wobei ein spezielles Verfahren zu deren Verwendung gezeigt ist. Wie **Fig.** 5 zeigt, bezeichnet die Referenznummer **50** einen Boden (eine Bodenoberfläche), und **51** steht für einen gelagerten Körper, wie z. B. eine Kunstvitrine. Vier Schwingungs-Isoliervorrichtungen **100** der oben beschriebenen Art sind jeweils an vier Stellen zwischen dem Boden **50** und dem gelagerten Körper **51** derart angeordnet, dass sie den gelagerten Körper **51** lagern. Dank dieser Anordnung bewegen sich, wenn der Boden infolge eines Erdbebens oder ähnlichem veranlasst wird, zu schwanken, die sich bewegenden Körper **62** und **72** der ersten und zweiten krummlinigen Führungsvorrichtung auf ihren jeweiligen krummlinigen Führungsschienen **61** und **71** derart, dass die Schaukelbewegung des Bodens **50** absorbiert wird, wodurch verhindert wird, dass sich die Schwingungen des Bodens **50** zu dem gelagerten Körper **51** übertragen.

Jedoch unterliegt die oben erwähnte, herkömmliche, krummlinige Führungsvorrichtung dem folgenden Problem. Es liegt darin, dass eine Führungsschiene, die durch Ziehen derart verformt wurde, dass sie einen bestimmten Querschnitt aufweist und immer noch in einer linearen Form verbleibt, einem Biegen unterworfen wird, wodurch eine krummlinige Führungsschiene erzeugt wird. Ferner ist es bei dem Biegevorgang erforderlich, die Führungsschiene mit einer bestimmten Krümmung zu biegen. Im Ergebnis erfordert es Zeit und Arbeit, um eine krummlinige Führungsschiene zu erzeugen.

Ferner wird, wenn eine Kugelrollfläche an einer krummlinigen Führungsschiene ausgebildet wird, weil die Kugelrollfläche nicht durch Schleifen der krummlinigen Führungsschiene ausgebildet werden kann, nachdem die krummlinige Führungsschiene gebogen wurde, eine entsprechende Schleifbearbeitung vor dem Biegevorgang durchgeführt. Zusätzlich ist es, da die Härte der Kugelrollfläche verbessert werden muss, erforderlich, eine Wärmebehandlung, wie z. B. ein Abbindungshärten der Oberfläche der Führungsschiene, durchzuführen, bevor der Schleifvorgang durchgeführt wird. Wenn jedoch Edelstahl als das Ausbildungsmaterial der Führungsschiene verwendet wird, um den Anforderungen beispielsweise im Hinblick auf eine Korrosionsvermeidung zu entsprechen, härtet die Härtebehandlung nicht nur die Oberfläche der Führungsschiene, sondern auch deren mittleren Abschnitt. Im Ergebnis entsteht, wenn die Führungsschiene über deren elastisch verformbare Grenze hinaus gebogen wird, das Problem, dass ein Riss in der krummlinigen Führungsschiene auftritt, die durch ein derartiges Biegen erzeugt wird.

Darstellung der Erfindung

Die vorliegende Erfindung wurde gemacht, um die Nachteile der obengenannten, herkömmlichen, krummlinigen Führungsschiene zu beheben, und es ist deshalb eine Aufgabe der Erfindung, ein Verfahren zur Herstellung einer krummlinigen Führungsschiene zu schaffen, das, wenn eine krummlinige Führungsschiene einer krummlinigen Führungsvorrichtung zum Führen eines sich bewegenden Körpers entlang einer gekrümmten Linie mit einer gegebenen Krümmung hergestellt wird, in der Lage ist, eine krummlinige Führungsschiene herzustellen, ohne dass unnötig Zeit und Arbeitskraft verwendet werden muss, und die somit bei geringen Kosten herzustellen ist.

Es ist eine weitere Aufgabe der Erfindung, eine krummlinige Führungsschiene zu schaffen, die mit geringem Aufwand an Zeit und Arbeit und bei geringen Kosten hergestellt werden kann.

Um die genannten Aufgaben zu lösen, wird gemäß einem

Aspekt der Erfindung ein Verfahren zur Herstellung einer krummlinigen Führungsschiene zum Führen eines sich bewegenden Körpers entlang einer gekrümmten Linie mit einer gegebenen Krümmung geschaffen, wobei das Verfahren folgende Schritte aufweist: Vorbereiten einer geraden Führungsschiene zum Führen eines sich bewegenden Körpers in geradliniger Art und Weise; Pressen einer unteren Fläche der geraden Führungsschiene zum Führen des sich bewegenden Körpers in einer geradlinigen Art und Weise gegen eine gekrümmte Schienenanbringfläche einer Schienenbefestigungsbasis, die mit einem gegebenen Krümmungsradius ausgebildet ist, um die geradlinige Führungsschiene elastisch auf krummlinige Art und Weise zu verformen; und Befestigen der geradlinigen Führungsschiene an die Schienenanbringfläche, während die geradlinige Führungsschiene elastisch verformt bleibt, so dass eine krummlinige Führungsschiene erzeugt wird.

Gemäß einem weiteren Aspekt der Erfindung wird eine krummlinige Führungsschiene zum Führen eines sich bewegenden Körpers entlang einer gekrümmten Linie mit einer gegebenen Krümmung geschaffen, wobei die krummlinige Führungsschiene folgendes aufweist: eine Schienenbefestigungsbasis mit einer gekrümmten Schienenanbringfläche, die mit einer gegebenen Krümmung ausgebildet ist; einen Schienenhauptkörper, der in eine geradlinige Form ausgebildet ist und in einer krummlinigen Art und Weise elastisch verformbar ist, wenn der Schienenhauptkörper gegen die Schienenanbringfläche der Schienenbefestigungsbasis gepresst wird; und eine Schienenbefestigungseinrichtung zum Befestigen des Schienenhauptkörpers an die Schienenanbringfläche.

Gemäß der Erfindung wird die untere Fläche der geraden Führungsschiene gegen die Schienenanbringfläche gepresst, die in eine gekrümmte Form ausgebildet ist, und die gerade Führungsschiene wird an die Schienenanbringfläche befestigt, während die gerade Führungsschiene innerhalb ihres elastisch verformbaren Bereichs verformt bleibt, wodurch eine krummlinige Führungsschiene zum Bewegen eines sich bewegenden Körpers entlang einer gekrümmten Linie mit einer gegebenen Krümmung ausgebildet wird. Infolge dieser Maßnahme wird nicht nur ein Biegevorgang, der Zeit und Arbeitskraft erfordert, weggelassen, sondern es kann ferner eine krummlinige Führungsschiene leicht hergestellt werden, und zwar indem eine gegenwärtig bereits bestehende lineare Führungsschiene verwendet wird, die auf dem Markt leicht erhältlich ist, was es ermöglicht, eine krummlinige Führungsschiene mit einer gegebenen Krümmung bei niedrigen Kosten herzustellen.

Ferner ist es gemäß der vorliegenden Erfindung erforderlich, eine Schienenbefestigungsbasis vorzusehen, gegen welche die untere Fläche der geraden Führungsschiene gepresst wird. In ähnlicher Weise ist es, auch bei der herkömmlichen krummlinigen Führungsschiene, wenn diese an einen Boden oder ähnliches befestigt wird, erforderlich, eine Schienenbefestigungsbasis mit einer gekrümmten Schienenanbringfläche zu verwenden. Jedoch wird gemäß der Erfindung die Anzahl der Einzelteile, die zur Befestigung der Schiene erforderlich ist, nicht über diejenige der herkömmlichen Führungsschiene hinaus vermehrt, jedoch kann eine krummlinige Führungsschiene bei Kosten hergestellt werden, die um ein Ausmaß gesenkt werden, das dem Weglassen des Biegevorgangs entspricht.

Ferner besteht bei der Erfindung, da die geradlinige Führungsschiene, die gegen die untere Fläche der Schienenanbringfläche gepresst wird, einfach innerhalb ihres elastisch verformbaren Bereichs verformt wird, auch wenn sie an die Schienenanbringfläche in dem verformten Zustand befestigt wird, nicht die Gefahr, dass ein Riss in der so befestigten geradlinigen Führungsschiene auftreten kann, und deshalb ist, auch wenn eine krummlinige Führungsschiene unter Verwendung eines derartigen Materials hergestellt wird, das durch einen Biegevorgang, bei dem plastische Verformung auftritt, brechen kann, das vorliegende Herstellungsverfahren sicher in der Lage, dieses Problem zu beheben, d. h. die Gefahr auszuschalten, dass ein Riss in der Führungsschiene auftritt.

Deshalb schafft die vorliegende Erfindung wirkungsvoll die Herstellung einer krummlinigen Führung durch Verwendung eines derartigen Materials, das schwierig zu biegen ist, nachdem es gehärtet wurde.

Ferner kann als die Schienenbefestigungseinrichtung zum Befestigen einer geradlinigen Führungsschiene, die gegen die gekrümmte Schienenanbringfläche gepresst und in einer gekrümmten Art und Weise elastisch verformt wurde, an die Schienenanbringfläche, während die geradlinige Führungsschiene elastisch verformt bleibt, eine beliebige Befestigungseinrichtung verwendet werden, vorausgesetzt, dass sie in der Lage ist, die geradlinige Führungsschiene an der Schienenanbringfläche gegen die elastische Kraft der geradlinigen Führungsschiene zu halten, welche die geradlinige Führungsschiene in ihre ursprüngliche Form zurückführen wird. Beispielsweise kann ein Befestigungsbolzen durch die geradlinige Führungsschiene eingeführt und mittels eines Gewindes mit der Schienenanbringfläche in Eingriff gebracht werden.

Kurze Beschreibung der Zeichnung

Fig. 1 ist eine Vorderansicht einer geradlinigen Führungsschiene, die durch ein Verfahren zur Herstellung einer krummlinigen Führungsschiene gemäß der Erfindung erhalten wird;

Fig. 2 ist eine perspektivische Ansicht einer geradlinigen Führungsvorrichtung, die bei der Verbesserung eines Verfahrens zur Herstellung einer krummlinigen Führungsschiene gemäß der Erfindung verwendet wird;

Fig. 3 ist eine schematische Ansicht zum Zeigen eines Teils eines Vorgangs zum Verbessern eines Verfahrens zur Herstellung einer krummlinigen Führungsschiene gemäß der Erfindung;

Fig. 4 ist eine Vorderansicht eines Beispiels einer Schwingungs-Isoliervorrichtung unter Verwendung einer krummlinigen Führungsvorrichtung; und

Fig. 5 ist eine schematische Ansicht eines Verwendungsbeispiels der Schwingungs-Isoliervorrichtung gemäß **Fig.** 4.

Ausführliche Beschreibung bevorzugter Ausführungsformen der Erfindung

Nachfolgend wird im einzelnen ein Verfahren zur Herstellung einer krummlinigen Führungsschiene gemäß der Erfindung unter Bezugnahme auf die beigefügten Zeichnungen beschrieben.

Fig. 1 zeigt eine krummlinige Führungsschiene, die durch ein Verfahren zur Herstellung einer krummlinigen Führungsschiene gemäß der Erfindung hergestellt wird. In **Fig.** 1 bezeichnet Referenznummer **1** einen Schienenhauptkörper, **2** bezeichnet eine Schienenbefestigungsbasis zum Anbringen des Schienenhauptkörpers **1** an eine feste Oberfläche B, wie z. B. die Oberfläche eines Bodens oder die Oberfläche eines gelagerten Körpers, und **3** bezeichnet einen Befestigungsbolzen, der als eine Schienenbefestigungseinrichtung dient, die durch den Schienenhauptkörper **1** eingeführt und mittels eines Gewindes mit der Schienenbefestigungsbasis **2** in Eingriff gebracht werden kann.

Eine Laufschiene (geradlinige Führungsschiene) **5**, wie in

Fig. 2 gezeigt ist, wird als der Schienenhauptkörper **1** verwendet. Wie in **Fig.** 2 gezeigt ist, weist die lineare Führungsvorrichtung die Laufschiene **5**, die in eine geradlinige Form ausgebildet ist und zwei Streifen von Krümmungen **50** aufweist, die jeweils entlang deren Längsrichtung ausgebildet sind, sowie einen sich bewegenden Körper **7** auf, der in eine sattelähnliche Form ausgebildet ist und rittlings auf der Laufschiene **5** sitzt und durch Kugeln **6** mit der Laufschiene **5** in Eingriff gebracht werden kann, so dass er frei entlang der Laufschiene **5** in der Längsrichtung gleitbar ist. Der sich bewegende Körper **7** weist nicht nur eine Last-Kugelrollfläche **70** auf, die mit der Kugelrollfläche **50** an der Laufschiene **5** zusammenwirkt, um die Kugel **6** zwischen diesen einzuschließen, sondern auch einen endlosen Zirkulationsdurchgang **71**, entlang dem die Kugeln **6**, die entlang der Last-Kugelrollfläche **70** gerollt sind, zirkuliert werden können. Mit dem obengenannten Aufbau einer geradlinigen Führungsvorrichtung wird, wenn sich der sich bewegende Körper **7** entlang der Laufschiene **5** bewegt, für die Kugeln **6** zugelassen, dass sie innerhalb des endlosen Zirkulationsdurchgangs **71** zirkulieren. Der sich bewegende Körper **7** weist ferner eine Anbringfläche **72** zum Anbringen eines beweglichen Elements daran auf, und in der Schwingungs-Isoliervorrichtung, die in **Fig.** 4 gezeigt ist, ist die universelle Kupplung **80** an die Anbringoberfläche **72** befestigt. In **Fig.** 2 bezeichnet Referenznummer **51** ein Bolzenanbringloch, durch welches der Befestigungsbolzen **3** zum Befestigen der Laufschiene **5** an die Schienenbefestigungsbasis **2** eingeführt werden kann.

Andererseits weist die Schienenbefestigungsbasis **2** nicht nur eine Schienenanbringfläche **20** auf, die in einer gekrümmten Form mit einer gegebenen Krümmung (beispielsweise 4–6 m) ausgebildet ist, sondern auch eine eben geformte untere Fläche **21**, die mit der oben erwähnten festen Oberfläche B in Berührung gebracht werden soll, während die Schienenbefestigungsbasis **2** auch als eine Klammer zur Anbringung des Schienenhauptkörpers **1** an die feste Oberfläche B dient. Ferner ist in der Schienenanbringfläche **20** eine Gewindeöffnung **22** geöffnet, in welche der Befestigungsbolzen **3** mittels eines Gewindes in Eingriff gebracht werden kann. Die Gewindeöffnung **22** ist entlang der unteren Fläche **21** der Schienenbefestigungsbasis **2** mit derselben Teilung wie diejenige der Bolzenanbringöffnung **51** der Laufschiene **5** ausgebildet.

Fig. 3 zeigt einen Vorgang zum Befestigen der geradlinig geformten Laufschiene **5** an die Schienenbefestigungsbasis **2** zur Erzeugung einer krummlinigen Führungsschiene.

Insbesondere wird die Laufschiene **5** der geradlinigen Führungsvorrichtung, wobei die Kugelrollfläche **50** und die Bolzenanbringöffnung **51** daran bereits ausgebildet sind, an der Schienenanbringfläche der Schienenbefestigungsbasis **2** angeordnet, eine Last F wird von oberhalb der Laufschiene **5** aufgebracht, um die untere Fläche **52** der Laufschiene **5** gegen die Schienenanbringfläche **20** zu pressen und somit die Laufschiene **5** elastisch zu verformen, und die Befestigungsbolzen **3** werden jeweils durch ihre zugeordneten Bolzenanbringöffnungen **51** eingeführt und nacheinander in ihre jeweils zugeordneten Gewindeöffnungen **22** der Schienenbefestigungsbasis **2** eingeschraubt. Im Ergebnis wird die Laufschiene **5** elastisch mit einer Krümmung verformt, die identisch zu der Krümmung **5** der Schienenanbringfläche **20** ist, und dann an die Schienenbefestigungsbasis **2** befestigt, während ihr elastisch verformter Zustand aufrechterhalten wird, um dadurch den oben beschriebenen Schienenhauptkörper **1** zu schaffen (vgl. **Fig.** 1). Da die Laufschiene einfach in einer krummlinigen Art und Weise innerhalb ihres elastisch verformbaren Bereichs verformt wird, wird, auch nachdem die Laufschiene **5** einmal an die Schienenanbringfläche **20** durch die Befestigungsbolzen **3** befestigt wurde, wenn die Befestigungsbolzen **3** entfernt werden, für die Laufschiene **5** zugelassen, dass sie in ihre ursprüngliche Form, zurück zu ihrer ursprünglichen geradlinigen Form zurückkehrt, und zwar mittels ihrer eigenen elastischen Kräfte.

Da die Gewindeöffnungen **22** derart ausgebildet sind, dass sie sich nicht entlang der Schienenanbringfläche **20** erstrecken, sondern entlang der unteren Fläche **21** der Schienenbefestigungsbasis **2**, und zwar mit der gleichen Teilung wie derjenigen der Bolzenbefestigungsöffnungen **51** in der Laufschiene **5**, könnte die Gefahr bestehen, dass die Bolzenanbringöffnungen **51** der Laufschiene **5** nicht mit den Gewindeöffnungen **22** der Schienenanbringfläche **20** in einem Zustand in Übereinstimmung gebracht werden können, wenn die Laufschiene **5** elastisch auf gekrümmte Art und Weise verformt wird. Jedoch wird im Normalzustand der Innendurchmesser einer jeden Bolzenanbringöffnung **51** größer ausgebildet als der Nenndurchmesser einer jeden Gewindeöffnung **22**, und in dem Fall, dass die Krümmung der Schienenanbringfläche **20** klein ist, besteht, auch wenn die Laufschiene **5** elastisch in gekrümmter Art und Weise verformt wird, keine Möglichkeit, dass die Bolzenanbringöffnung **51** und die Gewindeöffnung **22** in großem Umfang voneinander versetzt sind. Deshalb können die Befestigungsbolzen **3**, die jeweils durch die Bolzenanbringöffnungen **51** eingeführt wurden, mittels des Gewindes mit Leichtigkeit mit den Gewindeöffnungen **22** in Eingriff gebracht werden. Auch wenn die Krümmung der Schienenanbringfläche **20** groß ist, werden, wenn die Bolzenanbringöffnungen **51** der Laufschiene **5** jeweils in längliche Öffnungen ausgebildet werden, die Befestigungsbolzen **3**, die jeweils durch die Bolzenanbringöffnungen **51** eingeführt wurden, mittels des Gewindes mit den Gewindeöffnungen **22** mit Leichtigkeit in Eingriff gebracht, unabhängig von dem Ausmaß der elastischen Verformung der Laufschiene **5**.

Wie oben beschrieben, wird bei der krummlinigen Führungsschiene gemäß dieser Ausführungsform, da die Laufschiene **5** der geradlinigen Führungsvorrichtung, wenn sie gegen die Schienenanbringfläche **20** der Schienenbefestigungsbasis **2** gedrückt wird und an dieser befestigt wird, um eine krummlinige Führungsschiene mit einer Krümmung auszubilden, die zu der Krümmung der Schienenanbringfläche **20** identisch ist, die Notwendigkeit ausgeschaltet, eine Biegeoperation an der Laufschiene **5** durchzuführen, bei der eine plastische Verformung auftritt, was zu dem Ergebnis führt, dass, auch wenn das Material der Laufschiene **5** schwierig zu biegen ist, nicht die Gefahr besteht, dass ein Riss in der Laufschiene **5** auftreten kann. Ferner kann, weil die krummlinige Führungsschiene mit einer Krümmung, die identisch ist zu der Krümmung der Schienenanbringfläche **20** dadurch erhalten wird, dass einfach die Laufschiene **5** an die Schienenanbringfläche **20** befestigt wird, der Biegevorgang der Laufschiene **5** ohne die Notwendigkeit durchgeführt werden, deren Krümmung im einzelnen zu messen, so dass die krummlinige Führungsschiene sehr leicht hergestellt werden kann.

Wenn die Krümmung des Schienenhauptkörpers **1**, der an die Schienenbefestigungsbasis **2** befestigt ist, klein ist, kann die sich bewegende Basis **7** der geradlinigen Führungsvorrichtung so verwendet werden, wie sie vorliegt, da sich die bewegende Basis, die sich entlang der krummlinigen Führungsschiene bewegt, die so hergestellt wurde, ohne die Notwendigkeit zur Ausführung zusätzlicher Arbeitsvorgänge an der beweglichen Basis **7** der geradlinigen Führungsvorrichtung, hierfür eignet. Andererseits kann, wenn die Krümmung des Schienenhauptkörpers **1** groß ist, wenn die Last-Kugelrollfläche **70** der sich bewegenden Basis **7** ebenso wie die gemäß der Krümmung des Schienenhauptkörpers **1** mit einer Krümmung versehen wird, die Bewegung des sich bewegenden Körpers **7** an dem Schienenhauptkörper **1** sanft ausgeführt werden.

Wie oben beschrieben, wird als die Schienenbefestigungseinrichtung bei der vorangehend beschriebenen Ausführungsform der Befestigungsbolzen **3** verwendet, er kann jedoch durch bekannte Klebeverfahren, Schweißen, usw. ersetzt werden.

Wie vorangehend beschrieben wurde, kann durch Verwendung eines Verfahrens zur Herstellung einer krummlinigen Führungsschiene gemäß der Erfindung, bei dem eine geradlinige Führungsschiene an eine Schienenanbringfläche befestigt wird, die in einer gekrümmten Oberfläche mit einer gegebenen Krümmung derart ausgebildet ist, dass die geradlinige Führungsschiene elastisch verformt wird, eine krummlinige Führungsschiene mit einer gegebenen Krümmung ohne Biegen der geradlinigen Führungsschiene hergestellt werden. Infolge dieser Maßnahme wird nicht nur Zeit und Arbeitskraft für die Ausführung der ansonsten erforderlichen Biegebearbeitung weggelassen, sondern es kann ferner eine krummlinige Führungsschiene auf einfache Weise unabhängig von dem Material der Schiene hergestellt werden, so dass eine krummlinige Führungsschiene mit einer gegebenen Krümmung bei geringen Kosten hergestellt werden kann.

Patentansprüche

1. Verfahren zur Herstellung einer krummlinigen Führungsschiene zum Führen eines sich bewegenden Körpers entlang einer gekrümmten Linie mit einer gegebenen Krümmung, wobei das Verfahren folgende Schritte aufweist:
Pressen einer unteren Fläche einer geradlinigen Führungsschiene zum Führen des sich bewegenden Körpers in einer geradlinigen Art und Weise gegen eine gekrümmte Schienenanbringfläche einer Schienenbefestigungsbasis, die mit einem gegebenen Krümmungsradius ausgebildet ist, um die geradlinige Führungsschiene elastisch auf krummlinige Art und Weise zu verformen; und
Befestigen der geradlinigen Führungsschiene an die Schienenanbringfläche, während die geradlinige Führungsschiene elastisch verformt bleibt, so dass eine krummlinige Führungsschiene erzeugt wird.
2. Verfahren nach Anspruch 1, wobei die geradlinige Führungsschiene aus Edelstahlmaterial ausgeführt ist.
3. Krummlinige Führungsschiene (**5**) zum Führen eines sich bewegenden Körpers (**7**) entlang einer gekrümmten Linie mit einer gegebenen Krümmung, mit:
einer Schienenbefestigungsbasis (**2**) mit einer gekrümmten Schienenanbringfläche (**20**), die mit einer gegebenen Krümmung ausgebildet ist;
einem Schienenhauptkörper (**1**), der in eine geradlinige Form ausgebildet ist und in einer krummlinigen Art und Weise elastisch verformbar ist, wenn der Schienenhauptkörper (**1**) gegen die Schienenanbringfläche (**20**) der Schienenbefestigungsbasis (**2**) gepresst wird; und
einer Schienenbefestigungseinrichtung (**3**) zum Befestigen des Schienenhauptkörpers (**1**) an die Schienenanbringfläche (**20**).
4. Krummlinige Führungsschiene nach Anspruch 3, wobei der Schienenhauptkörper (**1**) aus Edelstahlmaterial ausgeführt ist.
5. Krummlinige Führungsschiene nach Anspruch 3, wobei die Schienenbefestigungseinrichtung (**3**) mehrere Befestigungsbolzen aufweist;
wobei die Schienenbefestigungsbasis (**2**) mehrere Bolzenanbringöffnungen (**51**) darin definiert, wobei die Schienenbefestigungsbasis mehrere Gewindeöffnungen (**22**) definiert, die den darin ausgebildeten Bolzenanbringöffnungen (**51**) zugeordnet sind, und die Gewindeöffnungen (**22**) entlang einer Bodenfläche der Schienenbefestigungsbasis mit der gleichen Teilung wie derjenigen der Bolzenanbringöffnungen (**51**) ausgebildet sind; und
wobei die Befestigungsbolzen (**3**) durch die zugeordneten Bolzenanbringöffnungen (**51**) treten und mittels eines Gewindes mit den zugeordneten Gewindeöffnungen (**22**) in Eingriff kommen.
6. Krummlinige Führungsschiene nach Anspruch 3, wobei die Bolzenanbringöffnungen (**51**) in ihrem Durchmesser größer sind als die Gewindeöffnungen (**22**).
7. Krummlinige Führungsschiene nach Anspruch 3, wobei die Bolzenanbringöffnungen aus länglichen Öffnungen bestehen.

Hierzu 4 Seite(n) Zeichnungen

- Leerseite -

FIG. 1

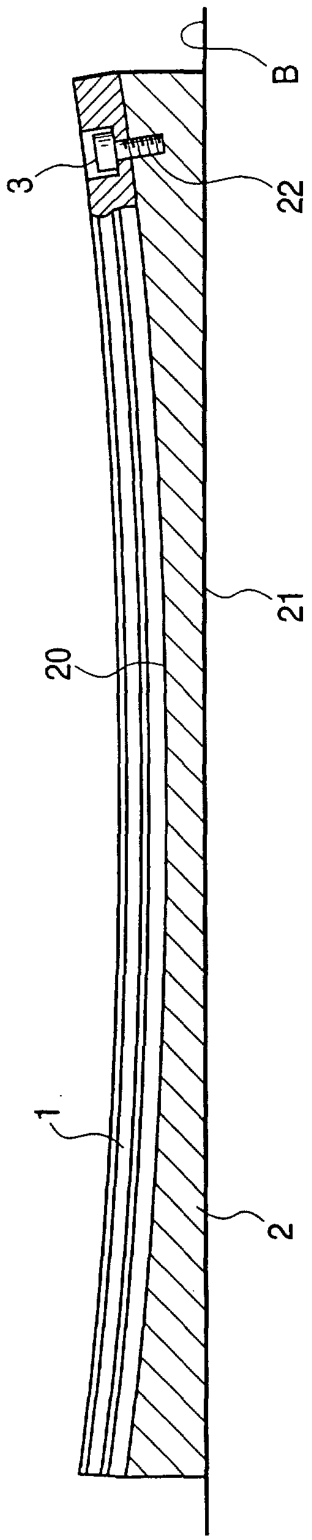
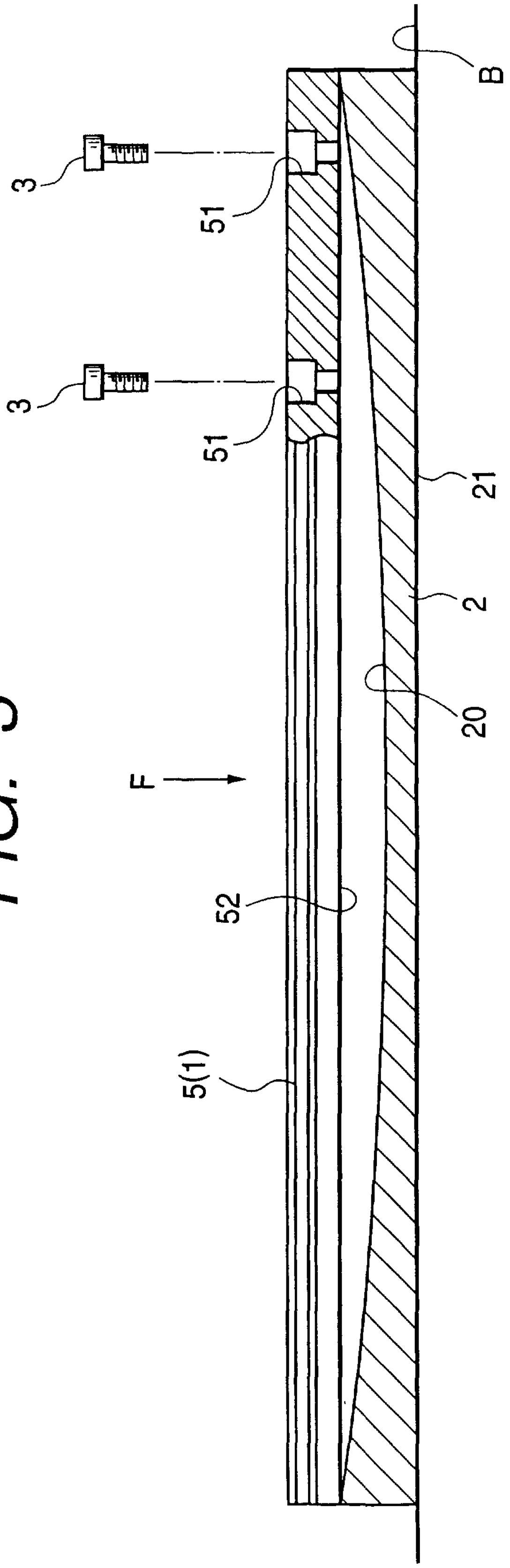
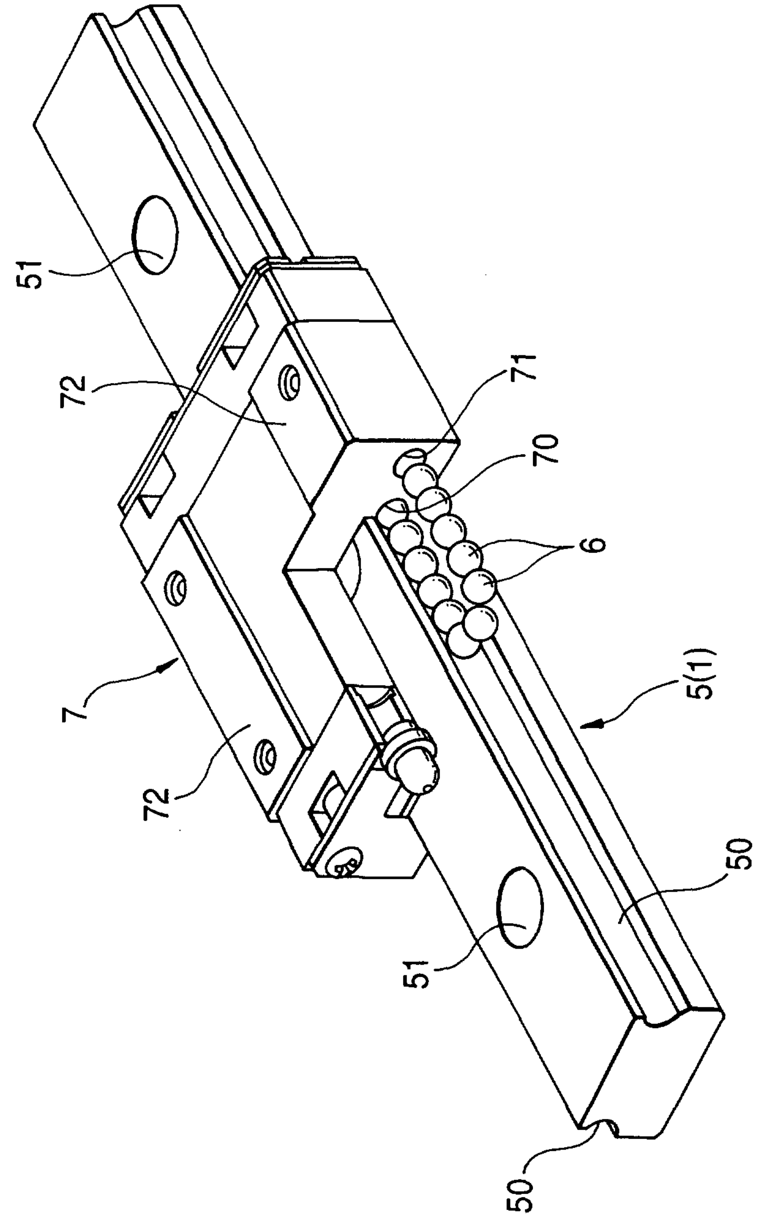


FIG. 3



Nummer: **DE 199 56 966 A1**
Int. Cl.⁷: **F 16 C 29/06**
Offenlegungstag: 31. Mai 2000

FIG. 2



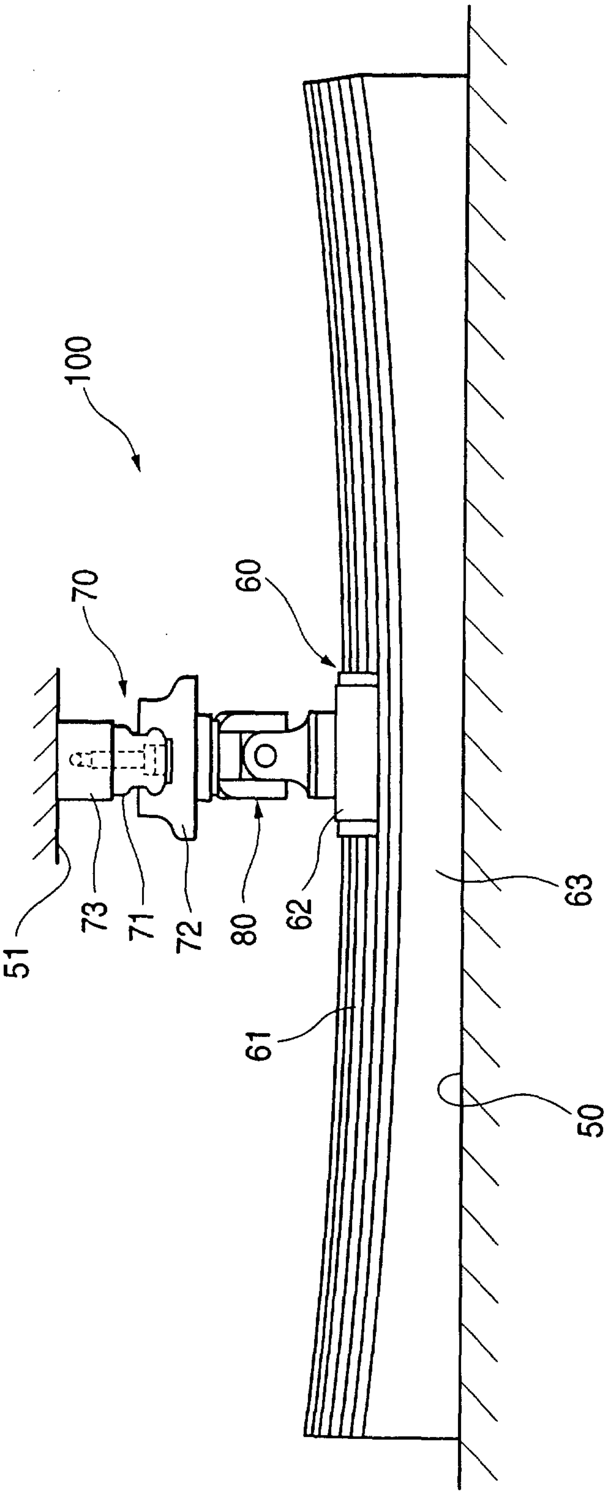
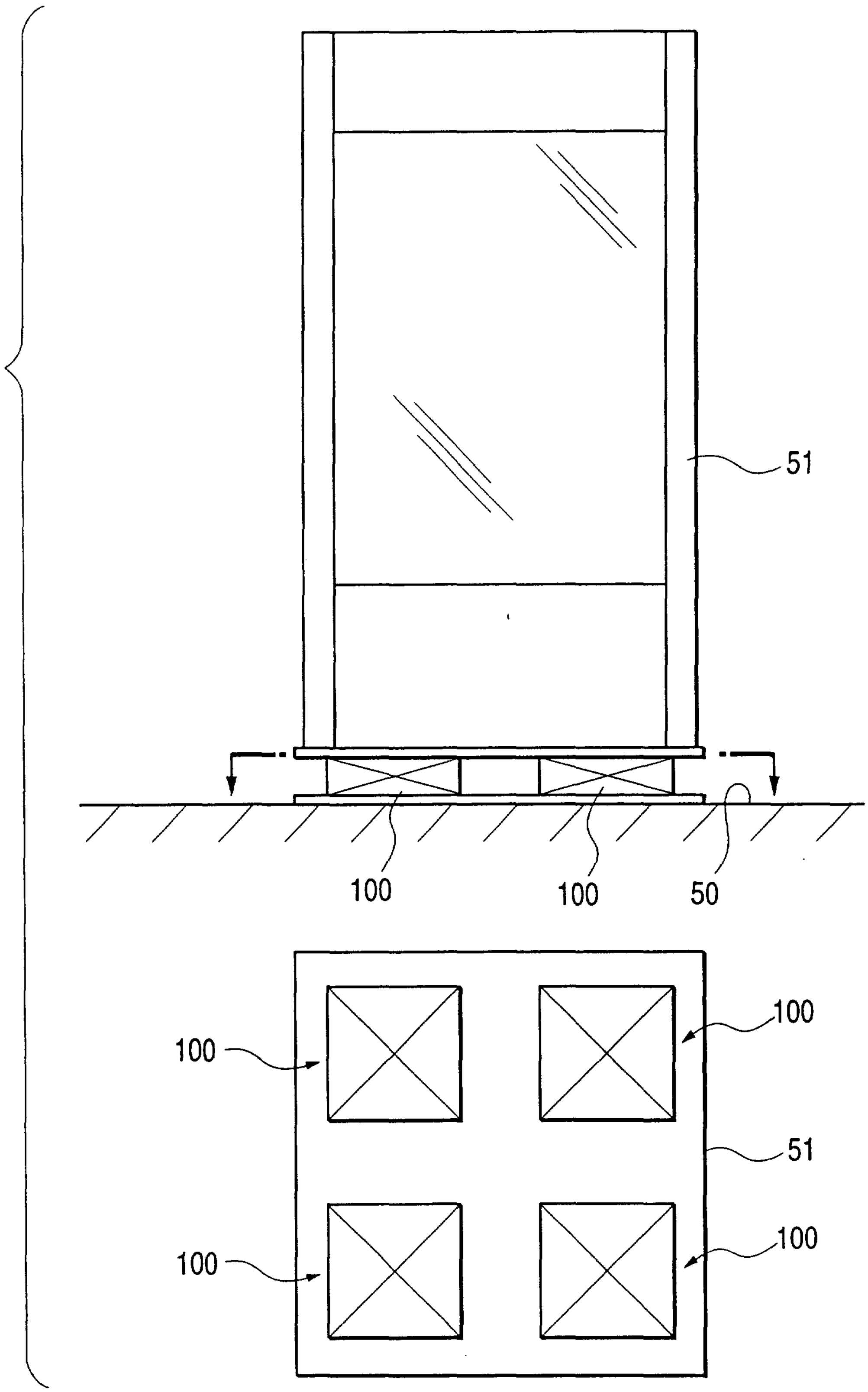


FIG. 4

Nummer: DE 199 56 966 A1
Int. Cl.[7]: F 16 C 29/06
Offenlegungstag: 31. Mai 2000

FIG. 5



(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 198 30 578 A 1**

(51) Int. Cl.[6]:
F 16 C 29/04

DE 198 30 578 A 1

(21) Aktenzeichen: 198 30 578.8
(22) Anmeldetag: 8. 7. 98
(43) Offenlegungstag: 4. 2. 99

(30) Unionspriorität:
9-199338 09. 07. 97 JP

(71) Anmelder:
THK Co., Ltd., Tokyo-to, JP

(74) Vertreter:
Grünecker, Kinkeldey, Stockmair & Schwanhäusser, Anwaltssozietät, 80538 München

(72) Erfinder:
Shirai, Takeki, Tokio/Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Linearführungsapparat

(57) Eine Führungsschiene weist zwei Rollenlaufoberflächen und zwei Kugellaufnuten auf. Ein beweglicher Block weist ein horizontales Bauteil, welches der oberen Oberfläche der Führungsschiene gegenüberliegt, und Flügelbauteile auf, die jeweils den Seitenoberflächen der Führungsschiene gegenüberliegen. Das horizontale Bauteil weist auf seiner unteren Oberfläche zwei Rollenlaufgegenoberflächen auf, die den beiden Rollenlaufoberflächen der Führungsschiene entsprechen. Jedes der Flügelbauteile weist an seinen inneren Oberflächen zwei Kugellaufgegennuten auf, die den beiden Kugellaufnuten der Führungsschiene entsprechen. Zwei Reihen von Rollen sind jeweils zwischen den beiden Rollenlaufoberflächen und den beiden Rollenlaufgegenoberflächen angeordnet, um rollbar zu sein. Zwei Reihen von Kugeln sind zwischen den beiden Kugellaufnuten und den beiden Kugellaufgegennuten angeordnet, in jeder der Lücken zwischen den Seitenoberflächen der Führungsschiene und den inneren Oberflächen der Flügelbauteile, um rollbar zu sein.

DE 198 30 578 A 1

Beschreibung

HINTERGRUND DER ERFINDUNG

Gebiet der Erfindung

Die vorliegende Erfindung bezieht sich auf einen Linearführungsapparat für schwere Lasten, in welchem in Kombination Rollen und Kugeln als Rollelemente verwendet werden.

Beschreibung des verwandten Standes der Technik

In bezug auf einen konventionellen Linearführungsapparat für schwere Lasten, ist ein Linearführungsapparat bekannt, bei welchem eine Vielzahl von Reihen von Rollelementen nur aus Rollen **101** besteht, wie dies im Beispiel in **Fig.** 5(a) dargestellt ist.

Genauer gesagt, bei einem solchen Linearrollenführungsapparat ist ein beweglicher Block **103** entlang einer Führungsschiene **102** durch die Rollen **101**, **101**, **101**, **101** beweglich geführt, welche vorgesehen sind, um zwei Reihen von Rollen auf jeder der rechten und linken Seitenoberflächen der Führungsschiene **102** zu bilden, um insgesamt eine Anzahl von vier Reihen zu bilden.

Solch ein Vollrollentyp eines Linearführungsapparates hat jedoch Probleme, daß die auf die Rollen **101** aufgebrachte Vorspannung, eine inverse radiale Last (eine anhebende Last), die die Funktion eines Ziehens des beweglichen Blockes **103** weg von der oberen Oberfläche der Führungsschiene **102** hat, und eine Querlast, die die Funktion eines horizontalen Verschiebens des beweglichen Blockes **103** relativ zur Führungsschiene **102** hat, leicht verursachen kann, daß die rechten und linken Flügelbauteile **104**,**104** des beweglichen Blockes **103** in Richtung nach außen deformiert werden, so daß sie aufgrund des Momentes voneinander beabstandet sind. Solch eine Deformation der Flügelbauteile **104**, **104** macht es unmöglich, eine genaue Parallelität der Rollenlaufoberfläche **105** der Führungsschiene **102** und der Rollengegenlauffläche **106** des beweglichen Blockes **103**, zwischen welchen die Rollen gehalten sind, wie dies übertrieben in **Fig.** 5(b) dargestellt ist, beizubehalten. Entsprechend kann ein guter linearer Kontakt der Rolle **101** mit diesen Oberflächen **105**, **106** nicht beibehalten werden, mit dem Ergebnis, daß die Belastungskonzentration an dem Rollenende **101**a auftreten kann, wodurch die Belastungskapazität, wie auch die Haltbarkeit herabgesetzt wird, und es unmöglich wird, die Belastbarkeit der Rolle **101** vollständig auszunutzen.

Wenn eine Vorspannung z. B. auf die Rolle **101** aufgebracht wird, wie das in **Fig.** 5(c) dargestellt ist, werden die inneren Oberflächen der beiden Flügelbauteile des beweglichen Blockes **103** durch eine Reaktionskraft **104** des beweglichen Blockes **103** durch eine Reaktionskraft Fi der Vorspannung der Rolle **101** gedrückt und das Moment Mi, das die Funktion des Ausdehnens der Flügelbauteile **104**, **104** hat, wird erzeugt, was sich in einem Deformieren der Flügelbauteile **104**, **104** auswirkt.

Die inverse Radiallast Fu wird auf dem beweglichen Block **103** über einen Bolzen **108** aufgebracht, durch welchen ein Bauteil **107**, das geführt werden soll, an dem beweglichen Block **103** befestigt ist, wie dies in **Fig.** 5(d) dargestellt ist. Die unteren Rollen **101**, die auf den rechten und linken Seiten der Führungsschiene **102** angeordnet sind, nehmen die obengenannte Last Fu auf. Da der Bolzen **108**, auf welchem die Belastung aufgebracht wird, jedoch von der Rolle **101** in horizontaler Richtung beabstandet ist, bilden die inverse Radiallast Fu und die Reaktionskraft Nu des Kontaktabschnittes der Rolle **101** ein Kräftepaar, was sich in dem Auftreten des Momentes Mu auswirkt, das die Funktion des Ausdehnens der Flügelbauteile **104**, **104** hat, um eine Deformation der Flügelbauteile **104**, **104** hervorzurufen.

Die Querlast F_T wird auf dem beweglichen Block **103** durch den Bolzen **108** aufgebracht, wie dies in **Fig.** 5(e) dargestellt ist. Die beiden Reihen von Rollen **101**, die auf dem einen Flügelbauteil **104** angeordnet sind, nehmen die obengenannte Last F_T auf. Da der Bolzen **108**, auf welchem die Last aufgebracht wird, jedoch von der Rolle **101** in vertikaler Richtung beabstandet ist, hat das Moment M_T die Funktion des Ausdehnens des einen Flügelbauteiles **104**, um eine Deformation des Flügelbauteiles **104** hervorzurufen.

ZUSAMMENFASSUNG DER ERFINDUNG

Ein Ziel der vorliegenden Erfindung ist es daher, einen Linearführungsapparat für schwere Lasten bereitzustellen, der es erlaubt, eine genaue Linearbewegung des beweglichen Blockes beizubehalten, sogar wenn die Flügelbauteile des beweglichen Blockes deformiert sind.

Um das zuvor genannte Ziel zu erreichen, weist ein Linearführungsapparat auf:

eine Führungsschiene, die mit zwei Rollenlaufoberflächen, die auf der oberen Oberfläche der Führungsschiene ausgebildet sind und mit zwei Kugellaufnuten versehen sind, die auf jeder der Seitenoberflächen der Führungsschiene ausgebildet sind;

einen beweglichen Block, der mit einem horizontalen Bauteil versehen ist, das der oberen Oberfläche der Führungsschiene gegenüberliegt, und mit einem Paar von Flügelbauteilen, die jeweils den Seitenoberflächen der Führungsschiene gegenüberliegen, wobei das horizontale Bauteil an einer seiner Unterseiten zwei Rollenlaufgegenoberflächen aufweist, die den beiden Rollenlaufflächen der Führungsschiene entsprechen, und jedes der Flügelbauteile auf seiner inneren Oberfläche zwei Kugellaufgegennuten aufweist, die den beiden Kugellaufnuten der Führungsschiene entsprechen;

zwei Reihen von Rollen, die jeweils zwischen den beiden Rollenlaufoberflächen der oberen Oberfläche der Führungsschiene und den beiden Rollenlaufgegenoberflächen des horizontalen Bauteiles des beweglichen Blockes angeordnet sind, um rollbar zu sein; und

zwei Reihen von Kugeln zwischen den beiden Kugellaufnuten der Seitenoberflächen der Führungsschiene und den zwei Kugellaufgegennuten der inneren Oberflächen des Flügelbauteiles, jeweils in Lücken zwischen den Seitenoberflächen der Führungsschiene und den inneren Oberflächen des Flügelbauteiles, um rollbar zu sein.

Es wird bevorzugt, eine Struktur anzuwenden, bei der jede der Kugeln jeweils an zwei einander gegenüberliegenden Punkten von ihr in Kontakt mit der Kugellaufnut der Führungsschiene und der Kugellaufgegennut des beweglichen Blockes in Kontakt kommt, und eine Kontaktwinkellinie, die die beiden einander gegenüberliegenden Punkte miteinander verbindet, nach oben in Richtung zur Führungsschiene geneigt ist, in Beachtung der inversen Radiallast, die auf den beweglichen Block aufgebracht wird.

Bei der obengenannten vorliegenden Erfindung kann die radiale Last, die die Funktion des Pressens des horizontalen Bauteiles des beweglichen Blockes auf die Führungsschiene aufweist, im wesentlichen durch die zwei Reihen von Rollen aufgenommen werden, die auf der oberen Oberfläche der Führungsschiene angeordnet sind. Es ist daher möglich, einen Linearführungsapparat bereitzustellen, der eine geringere Größe aufweist und das Tragen schwerer Lasten erlaubt.

Die inverse Radiallast, die eine Funktion des Wegziehens des horizontalen Bauteiles des beweglichen Blockes von der oberen Oberfläche der Führungsschiene hat, kann durch die beiden Reihen von Kugeln aufgenommen werden, die auf jeder der Seitenoberflächen der Führungsschiene angeordnet sind.

Wenn die inverse Radiallast auf den beweglichen Block aufgebracht wird, ist es nicht möglich, eine Deformation der Flügelbauteile zu vermeiden, die durch das Moment hervorgerufen wird das die Funktion des Ausdehnens der Flügelbauteile hat. Sogar wenn die Flügelbauteile auf diese Weise deformiert sind, ist der Kontaktwinkel zwischen den Kontaktwinkellinien der Kugeln und der horizontalen Linie geringfügig geändert, ohne irgendwelche Probleme zu verursachen, da die Rollbauteile, die auf den Seitenoberflächen der Führungsschiene angeordnet sind, aus den Kugeln bestehen.

Die Querlast, die eine Funktion des Verschiebens des Flügelbauteiles des beweglichen Blockes relativ zur Seitenoberfläche der Führungsschiene aufweist, kann im wesentlichen durch die beiden Reihen von Kugeln aufgenommen werden, die auf der Seitenoberfläche der Führungsschiene angeordnet sind, und die Flügelbauteile werden deformiert aufgrund des Momentes, welches eine Funktion des Ausdehnens der Flügelbauteile hat. Sogar wenn die Flügelbauteile auf diese Weise deformiert werden, ist der Kontaktwinkel der Kugel geringfügig geändert, ohne irgendwelche Probleme zu verursachen, da die Rollbauteile, die auf den Seitenoberflächen der Führungsschiene angeordnet sind, aus den Kugeln bestehen.

Aufbringen der Vorspannung auf die Kugeln verursacht ein Deformieren der Flügelbauteile aufgrund des Momentes, welches eine Funktion des Ausdehnens der Flügelbauteile hat. Sogar wenn die Flügelbauteile auf diese Weise deformiert sind, ist der Kontaktwinkel der Kugel geringfügig geändert, ohne irgendwelche Probleme zu verursachen.

Sogar wenn die Flügelbauteile derart deformiert werden, um durch Aufbringen der inversen Radiallast oder der Querlast auf den beweglichen Block ausgedehnt werden, oder durch Aufbringen der Vorspannung auf die Kugeln in dieser Weise, wird der Kontaktwinkel der Kugel nur geringfügig geändert, so daß die Richtung der Last, welche auf den Kugeln getragen wird, ungefähr beigehalten wird. Die Kugeln können daher als Rollbauteile innerhalb ihrer Belastungskapazität dienen, und ein gleichmäßiges Laufen der Kugeln kann beibehalten werden. Spezieller, die Deformation der Flügelbauteile des beweglichen Blockes, die durch ein Aufbringen der radialen Gegenkraft hervorgerufen wird, kann absorbiert werden durch eine geringfügige Bewegung der Kontaktpunkte der Kugel gegenüber der Kugellaufnut und der Kugellaufgegennut (z. B. eine geringfügige Änderung des Kontaktwinkels der Kugel), und solche eine Deformation übt keinerlei Einfluß auf die Belastungskapazität der Kugel und ihren glatten Lauf aus.

Wenn das Moment, welches die Funktion des Ausdehnens der Flügelbauteile aufweist, erzeugt wird, wird das andere Moment, welches die Funktion des Ziehens des mittigen Abschnittes des horizontalen Bauteiles des beweglichen Blockes weg von dem im führenden Bauteil hat, simultan erzeugt. Das horizontale Bauteil des beweglichen Blockes neigt jedoch nicht dazu, durch solch ein Moment leicht verformt zu werden, da die obere Oberfläche des horizontalen Bauteiles fest mit dem zu führenden Bauteil verbunden ist. Als ein Ergebnis kann ein genauer Zustand beibehalten werden, in welchem die Rollen mit einem linearen Abschnitt ihres Randes in Kontakt mit der Rollenlaufgegenoberfläche kommen, die an der unteren Oberfläche des horizontalen Bauteiles des beweglichen Blockes ausgebildet ist, durch das Auftreten der Belastungskonzentration am Rollenende behindert wird.

Allgemein weist eine Rolle eine Belastungskapazität auf, die größer ist als die einer Kugel. Die innere Radialkraft kann von den vier Reihen von Kugeln aufgenommen werden, welche gebildet werden durch zwei Reihen von Kugeln, die auf einer Seitenoberfläche der Führungsschiene angeordnet sind, und die anderen beiden Reihen von Kugeln, die auf ihrer anderen Seitenoberfläche angeordnet sind. Die vier Reihen von Kugeln weisen die gleiche Belastungskapazität auf wie die beiden Reihen von Rollen, die die radialen Lasten aufnehmen. Zusätzlich kann die Querlast von den beiden Reihen von Kugeln aufgenommen werden, die eine hohe Festigkeit aufweisen, die jedoch nicht so groß ist wie die Belastungskapazität gegen die inverse Radiallast. Solche Reihen von Kugeln stellen genügend Belastungskapazität gegen die Lasten in vier Richtungen bereit, d. h. in radialer Richtung, in radialer Gegenrichtung, und in die rechten und linken Querrichtungen.

Insbesondere wenn die Belastungskapazität in radialer Richtung der Rolle derart vorherbestimmt ist, so daß sie zweimal oder dreimal so groß ist wie die Belastungskapazität in inverser Radialrichtung der Kugel, kann die Belastungskapazität für die inverser Radiallast, welche durch vier Reihen von Kugeln erhalten wird, derart eingestellt werden, um im wesentlichen gleich der Belastungskapazität für die radiale Belastung zu sein, welche durch die beiden Reihen von Kugeln aufgenommen wird. Obwohl die Belastungskapazität für die Querlast, welche nur durch die beiden Reihen von Kugeln aufgenommen wird, auf im wesentlichen die Hälfte der inversen Radiallast begrenzt ist, kann eine Struktur bereitgestellt werden, bei welcher die Lasten in vier Richtungen, d. h. in radialer Richtung, in inverser Radialrichtung, und in die rechten und linken Querrichtungen, ungefähr gleich zueinander gehalten werden können. Der Linearführungsapparat hat daher hervorragende Haltbarkeit gegen die Lasten in jede Richtung und kann unter beliebigen Bedingungen verwendet werden, um für verschiedene Zwecke verwendet zu werden.

Wenn der Linearführungsapparat als ein Führungsapparat für eine Werkzeugmaschine verwendet wird, wird der Arbeitstisch durch eine Vielzahl von beweglichen Blöcken gestützt. Sogar bei solche einer einfachen Führung in einer Ebene kann eine innere Radiallast auf einen der beweglichen Blöcke aufgebracht werden. Wenn eine gegebene Belastungskapazität für die innere Radiallast besteht, die im wesentlichen identisch zur Belastungskapazität für die Radialbelastung ist, ist es möglich, eine einfache Berechnung für die Haltbarkeit und die Lebensdauer durchzuführen, die für das Bestimmen der mechanischen Struktur nützlich ist.

Die vorliegende Erfindung weist auch das Merkmal auf, daß das horizontale Bauteil des beweglichen Blockes Bolzenlöcher aufweist, welche zwischen den beiden Reihen von Rollen, jeweils außerhalb jeder der beiden Reihen von Rollen angeordnet sind.

Eine Kraft, die die Funktion des Ausdehnens eines Flügelbauteiles, z. B., eine Vorgewinnung, die auf die Kugeln aufgebracht wird, oder die innere Radiallast oder die Querlast, die auf dem beweglichen Block simultan aufgebracht wird, ruft das Moment hervor, daß eine Funktion des Wegziehens des mittigen Abschnittes des horizontalen Bauteils des beweglichen Blockes weg von dem zu führenden Bauteil, wie z. B. ein Arbeitstisch oder dergleichen hat, um die Flügelbauteile wie oben erwähnt auszudehnen. Wenn ein mittiger Abschnitt des horizontalen Bauteiles des beweglichen Blockes an dem zu führenden Bauteil durch Bolzen befestigt ist, ist es möglich, das horizontale Bauteil daran zu hindern, deformiert zu werden, und das Auftreten des Problems zu verhindern, daß die Rolle nicht mit einem linearen Abschnitt an ihrem Rand mit der Rollenlaufgegenoberfläche in Kontakt kommt.

Die vorliegende Erfindung hat auch das Merkmal, daß jede der Kugellaufnut und der Kugellaufgegennut einen Kurvenradius aufweist, der geringer ist als ein Wert von 52% des Durchmessers der Kugel.

Gemäß diesem Merkmal kann Differenzialschlupf leicht auftreten, wodurch die Dämpfungskapazität verbessert wird.

KURZE BESCHREIBUNG DER ZEICHNUNGEN

Fig. 1(a) ist eine Frontquerschnittsansicht, welche einen Linearführungsapparat der ersten Ausführungsform der vorliegenden Erfindung darstellt, und**Fig.** 1(b) ist eine beschreibende Ansicht, welche einen Kontaktwinkel jeweils einer Rolle und einer Kugel darstellt;

Fig. 2(a) ist eine Seitenansicht, welche eine teilweise Schnittansicht des in **Fig.** 1(a) dargestellten Apparates zeigt **Fig.** 2(b) ist eine vergrößerte Querschnittsansicht, welche die Umgebung einer Richtungsänderungspassage, wie sie in **Fig.** 2(a) dargestellt ist, illustriert, in welcher die Kugeln weggelassen sind, 2(c) ist eine Draufsicht, welche einen teilweise Schnittansicht des in **Fig.** 1(a) dargestellten Apparates zeigt, und **Fig.** 2(d) ist eine vergrößerte Schnittansicht, welche die Umgebung der Richtungsänderungspassage, wie sie in **Fig.** 2(c) dargestellt ist, zeigt, bei welcher die Kugeln weggelassen sind;

Fig. 3(a) bis 3(h) sind beschreibende Darstellungen, welche einen Rollenverbinder und einen Kugelverbinder darstellen, welche bei dem in **Fig.** 1(a) dargestellten Apparat verwendet werden;

Fig. 4(a) bis 4(d) sind beschreibende Ansichten, welche den in **Fig.** 1(a) dargestellten Linearführungsapparat illustrieren, auf welchen die Last aufgebracht wird; und

Fig. 5(a) ist eine Schnittansicht, welche den konventionellen Linearführungsapparat darstellt, **Fig.** 5(b) ist eine beschreibende Ansicht, die übertrieben den Zustand darstellt, in welchem die Last auf ein Ende der Rolle aufgebracht wird, und **Fig.** 5(c) bis 5(e) sind beschreibende Ansichten, welche den konventionellen Linearführungsapparat darstellen, auf welchen die Last aufgebracht wird.

DETAILLIERTE BESCHREIBUNG DER BEVORZUGTEN AUSFÜHRUNGSFORMEN

Nun werden Ausführungsformen des Linearführungsapparates der vorliegenden Erfindung im Detail mit Bezug auf die beigefügten Zeichnungen beschrieben.

Fig. 1 und 2 zeigen einen Linearführungsapparat einer Ausführungsform der vorliegenden Erfindung.

Die gesamte Struktur des Linearführungsapparates ist durch das Bezugszeichen **1** gekennzeichnet. Der Apparat **1** weist eine Führungsschiene **2**, einen beweglichen Block **3**, der derart angeordnet ist, um entlang der Führungsschiene **2** beweglich zu sein, zwei Reihen von Rollen **4**, die auf der oberen Oberfläche der Führungsschiene **2** angeordnet sind, und zwei Paar von zwei Reihen von Kugeln **5**, **6**; **5**, **6**, auf, wobei jedes Paar auf jeder der rechten und linken Seitenoberflächen der Führungsschiene **2** angeordnet ist.

Die Führungsschiene **2** weist einen rechtwinkligen Querschnitt auf. Zwei Rollenlaufoberflächen **41**, **41** sind auf die obere Oberfläche der Führungsschiene **2** ausgebildet, und zwei Kugellaufnuten **51**, **61** sind auf jede der rechten und linken Oberflächen der Führungsschiene **2** ausgebildet. Die zwei Rollenlaufoberflächen **41**, **41** sind in der Nähe der Seitenkanten der oberen Oberfläche der Führungsschiene **2** angeordnet. Die Führungsschiene **2** weist eine Vielzahl von Bolzenlöchern **7** auf zum Sichern der Führungsschiene **2**, die wie in dem mittleren Abschnitt der Führungsschiene **2** entlang einer geraden Linie ausgebildet sind, die sich in Längsrichtung der Führungsschiene **2** erstreckt.

Jede der Rollenlaufoberflächen **41**, **41** ist als eine flache horizontale Oberfläche ausgebildet. Jede der Kugellaufnuten **51**, **61**; **51**, **61** ist auf der anderen Seite als eine sogenannte Kreisbogennut ausgebildet, die eine konstante Krümmung im Querschnitt aufweist.

Der bewegliche Block **3** besteht aus einem horizontalen Bauteil **8**, welches der oberen Oberfläche der Führungsschiene **2** gegenüberliegt, und rechten und linken Flügelbauteilen **9**, **9**, welche sich nach unten von beiden Enden des horizontalen Bauteiles **8** aus erstrecken und den rechten und linken Seitenoberflächen der Führungsschiene **2** gegenüberliegen.

Das horizontale Bauteil des beweglichen Blockes **3** weist an seiner unteren Oberfläche zwei Rollenlaufgegenoberflächen **42**, **42** auf, welche den beiden Rollenlaufoberflächen **41**, **41** der Führungsschiene **2** entsprechen. Jedes der Flügelbauteile **9**, **9** der Führungsschiene **2** weist auf seiner inneren Oberfläche **2** Kugellaufgegennuten **52**, **62** auf, welche den beiden Kugellaufnuten **51**, **61** der Führungsschiene **2** entsprechen.

Jede der Rollenlaufgegenoberflächen **42**, **42** wird definiert durch die Bodenoberfläche jeder der Rollennuten **10**, **10**, welche auf der unteren Oberfläche des horizontalen Bauteiles **8** ausgebildet sind und weisen einen rechteckigen Querschnitt auf. Die Rollennut **10** weist die rechten und linken Seitenoberflächen auf, welche parallel zueinander sind und den beiden Enden der Rollen **4** gegenüberliegen, um eine extrem kleine Lücke zwischen den Seitenoberflächen der Rollennut **10** und den beiden Enden der Rolle **4** zu bilden. Solche Seitenoberflächen der Rollennut **10** bilden Rollenendenführungswände **10**a, **10**a. Die Rollennut **10** weist eine Tiefe auf, welche geringer ist als der Radius der Rolle, und in dem in den **Fig.** 1(a) und 1(b) gezeigten Beispiel ist die Tiefe der Rollennut **10** gleich der Hälfte des Radiuses der Rolle **4**.

Jede der beiden Kugellaufgegennuten **52**, **62** auf den inneren Oberflächen der Flügelbauteile **9**, **9** des bewegliches Blockes **3** ist ebenfalls als eine sogenannte Kreisbogennut ausgebildet, die eine konstante Krümmung in ihrem Querschnitt aufweist. Die Kugellaufnuten **51**, **61** der Führungsschiene **2** und die Kugellaufgegennuten **52**, **62** des beweglichen Blockes **3** können als eine sogenannte gotische Bogennut ausgebildet sein, bei welcher die innere Oberfläche durch zwei Bögen in ihrem Querschnitt gebildet wird.

Zwei Reihen von Rollen **4** sind zwischen den Rollenlaufoberflächen **41** der Führungsschiene **2** und den Rollenlaufgegenoberflächen **42** auf der unteren Oberfläche des horizontalen Bauteiles **8** des beweglichen Blockes **3** angeordnet, um darauf zu laufen. Zwei Reihen von Kugeln **5**, **6** sind zwischen den Kugellaufnuten **51**, **61** der Führungsschiene **2** und den Kugellaufgegennuten **52**, **62** auf der inneren Oberfläche der Flügelbauteile **9**, **9** des beweglichen Blockes **3** angeordnet, um darin zu laufen.

Wie in den **Fig.** 2(a) und 2(b) dargestellt, weist der bewegliche Block **3** einen Rollenrücklaufdurchgang **43** auf, in welchem keine Last auf die Rollen aufgebracht wird, um die Rollen **4** von einem Ende der Rollenlaufgegenoberfläche **42** zu ihrem anderen Ende zu fördern. Wie in den **Fig.** 2(c) und 2(d) dargestellt ist, weist der bewegliche Block **3** auch Kugelrückführdurchgänge **53**, **63** auf, in welchen keine Last auf die Kugeln aufgebracht wird, die zum Zirkulieren der Kugeln **5**, **6** von dem einen Ende der jeweiligen Kugellaufgegennuten **52**, **62** zu ihren anderen Enden vorgesehen sind.

Wie in den **Fig.** 2(a) und 2(b) dargestellt ist, besteht der Rollenrückführdurchgang **43** aus einem Rollenrückführloch **44**, welches parallel zur Rollenlaufoberfläche **41** als eine belastete Zone ausgebildet ist, um sich linear im beweglichen Block **3** zu erstrecken, und einem Paar von Richtungsänderungsdurchgängen **45**, **45** zum Verbinden der Enden der Rollenlaufoberfläche **41** mit den Enden des Rollenrückführloches **44**, um die Laufrichtung der Rollen entlang eines U-förmigen Durchganges zu ändern. Ein Laufdurchgang für belastete Rollen, der zwischen der Rollenlaufoberfläche **41** der Führungsschiene **2** und der Rollenlaufgegenoberfläche **42** des beweglichen Blockes **3** angeordnet ist, die Richtungsänderungsdurchgänge **45**, **45** und das Rollenrückführloch **44** bilden einen endlosen Zirkulierdurchgang.

Wie in **Fig.** 2(c) dargestellt ist, besteht der Kugelrückführduchgang **53** (**63**) aus einem Kugelrückführloch **54** (**64**), welches parallel zur Kugellaufgegennut **52** (**62**) ausgebildet ist, um sich linear in den beweglichen Block **3** hineinzuerstrecken, und einem Paar von Richtungsänderungsdurchgängen **55**, **55** (**65**, **65**) zum Verbinden der Enden der Kugellaufgegennut **52** (**62**) mit den Enden des Kugelrückführloches **54** (**64**), um die Laufrichtung der Kugel entlang eines U-förmigen Durchganges zu ändern. Ein Laufdurchgang für belastete Kugeln, der zwischen der Kugellaufnut **51** (**61**) der Führungsschiene **2** und der Kugellaufgegennut **52** (**62**) des beweglichen Blockes **3** ausgebildet ist, die Richtungsänderungsdurchgänge **55**, **55** (**65**; **65**) und das Kugelrückführloch **54** (**64**) bilden einen endlosen Zirkulationsdurchgang.

Der bewegliche Block **3** besteht aus einem metallischen Blockkörper **31** und Endplatten **32**, **32**, die an beiden Enden des Blockkörpers **31** befestigt sind. Die Rollenlaufgegenoberfläche **42** und das Rollenrückführloch **44** sind in einem horizontalen Bauteil **8** des Blockkörpers **31** ausgebildet. Die Kugellaufgegennuten **52**, **62** und die Kugelrückführlöcher **54**, **64** sind auf jedem der Flügelbauteile **9**, **9** des Blockkörpers **31** ausgebildet. Der Richtungsänderungsdurchgang **45** für die Rollen und die Richtungsänderungsdurchgänge **55**, **65** für die Kugeln sind in jeder der Endplatten **32** ausgebildet. Das Rollenrückführloch **44** erstreckt sich linear durch das horizontale Bauteil **8** des Blockkörpers **31**. Jedes der Kugelrückführlöcher **54**, **64** erstreckt sich linear durch jedes der Flügelbauteile **9**, **9** des Blockkörpers **31**.

Eine Vielzahl von Bolzenlöchern **33** sind auf dem oberen Abschnitt des Blockkörpers **31** des beweglichen Blockes **3** ausgebildet, der zwischen den beiden Reihen von Rollen **4** angeordnet ist, um in einer Linie ausgerichtet zu sein, die sich in einer Längsrichtung des beweglichen Blockes **3** erstreckt. Eine andere Vielzahl von Bolzenlöchern **33** ist auf dem oberen Abschnitt des Blockkörpers **31** ausgebildet, der dem Ursprung des einen Flügelbauteiles **9** entspricht und zwischen der Kugellaufgegennute **52** und dem Kugelrückführloch **54** angeordnet ist, um in einer Linie ausgerichtet zu sein, die sich in einer Längsrichtung des beweglichen Blockes **3** erstreckt. Eine weitere andere Vielzahl von Bolzenlöchern **33** ist auf dem oberen Abschnitt des Blockkörpers **31** ausgebildet, der dem Ursprung des anderen Flügelbauteiles **9** entspricht und zwischen der Kugellaufgegennut **52** und dem Kugelrückführloch **54** angeordnet ist, um in einer Linie ausgerichtet zu sein, die sich in einer Längsrichtung des beweglichen Blockes **3** erstreckt.

Ein Rollenkontaktwinkel $\alpha 1$ zwischen einer horizontalen Linie H1, die sich durch eine mittige Achse der Rolle erstreckt, und eine Kontaktwinkellinie S1, welche identisch mit einer normalen Linie zur Rollenlaufoberfläche **41** ist (oder der Rollenlaufgegenoberfläche **42**) werden derart beibehalten, daß sie im wesentlichen gleich 90 Grad sind. Das Rollenrückführloch **44** ist auf der obengenannten Kontaktwinkellinie S1 der Rolle **4** angeordnet. Die Rolle **4** kann in einem geneigten Zustand angeordnet sein, so daß ihre mittige Achse die horizontale Linie schneidet. Die Rollen **4** sind nicht auf den obenbeschriebenen zylindrischen Typ beschränkt, der einen konstanten Durchmesser aufweist, die auf einer flachen Oberfläche laufen, sondern können einen Durchmesser aufweisen, der in einer Längsrichtung der Rolle variiert.

Mit Bezug auf die Kontaktstruktur der Kugel **5**, **6** mit den Kugellaufnuten **51**, **61** und den Kugellaufgegennuten **52**, **62**, wie dies in **Fig.** 1(b) dargestellt ist, gelangt die Kugel **5** (**6**) jeweils an zwei einander gegenüberliegenden Punkten von ihr in Kontakt mit der Kugellaufnut **51**(**61**) und der Kugellaufgegennut **52**, **62**. Eine Kontaktwinkellinie S2 (S3), die die obengenannten beiden einander gegenüberliegenden Punkte miteinander verbindet, neigt sich nach oben in Richtung zum mittigen Abschnitt der Führungsschiene **2** relativ zur horizontalen Linie H2 (H3), die sich durch ein Zentrum der Kugel **5** (**6**) erstreckt. Das Kugelrückführloch **54** (**64**) ist auf der gleichen Höhe wie die Kugellaufgegennut **52** (**62**) angeordnet, und ist nämlich auf der horizontalen Linie H2 (H3) angeordnet.

Der Kontaktwinkel $\alpha 2$ zwischen der Kontaktwinkellinie S2 und der horizontalen Linie H2 ist identisch zum Kontaktwinkel $\alpha 3$ zwischen der Kontaktwinkellinie S3 und der Horizontallinie H3. Diese Kontaktwinkel $\alpha 2$ und $\alpha 3$ werden derart beibehalten, so daß sie im wesentlichen identisch 45 Grad bei der Ausführungsform der vorliegenden Erfindung sind.

Die Kontaktwinkel $\alpha 2$ und $\alpha 3$ sind nicht auf die oben beschriebenen Winkel von 45 Grad beschränkt sondern können z. B. im Bereich von 30 bis 60 Grad liegen. Die Kontaktwinkel $\alpha 2$ und $\alpha 3$ sind relativ groß und die Kugelführungsnuten **51**, **52** und die Kugelführungsgegennuten **61**, **62** weisen eine große Tiefe auf.

Es wird bevorzugt, den Krümmungsradius jeder der Kugellaufnuten **51**, **61** und der Kugellaufgegennuten **52**, **62** innerhalb eines Bereiches von über 50 bis unter 52% des Durchmessers der Kugeln **5**, **6** zu halten. Ein noch mehr bevorzugter Wert des obengenannten Krümmungsradius, ist ungefähr 51% des Durchmessers der Kugeln **5**, **6**. Solch eine Konstruktion ermöglicht, daß ein Differenzialschlupf leicht auftreten kann, wodurch die Dämpfungsfähigkeit verbessert wird. In dieser Ausführungsform ist der Durchmesser der Kugeln **5**, **6** identisch zueinander und die Krümmungsradien der Kugellaufnuten **51**, **61** und der Kugellaufgegennuten **52**, **62** sind auch identisch zueinander.

Die Kugel **5** (**6**) weist einen Durchmesser auf, der größer ist als der Abstand zwischen der Kugellaufnut **51**(**61**) und der Kugellaufgegennut **52** (**62**), so daß eine Vorspannung auf die Kugel **5** (**6**) aufgebracht wird. Eine Vorspannung wird auch auf die Rolle **4** aufgebracht und die Kugeln **5**, **6** nehmen die Reaktionskraft der Vorspannung auf, die auf die Rolle **4** aufgebracht wird. Spezieller wird die Reaktionskraft der Vorspannung, die die Funktion des Wegziehens des horizontalen Bauteiles weg von der Führungsschiene **2** aufweist, welche Kraft durch die Rolle **4** gegeben wird, mit einer vertikalen Komponente der Reaktionskraft der Vorspannung ausgeglichen, die auf die Kontaktpunkte der Kugeln **5** (**6**) mit der Kugellaufnut **51**(**61**) und der Kugellaufgegennut **52** (**62**) in einer Richtung der Kontaktwinkellinie S2 (S3) aufgebracht wird, so daß der vorgeschriebene Kontaktwinkel $\alpha 2$ ($\alpha 3$) beibehalten wird. Mit anderen Worten können die Kontaktwinkel $\alpha 2$, $\alpha 3$ durch nach oben verlagern der Position der Kugellaufgegennuten **52** (**62**) der Flügelbauteile **9**, **9** des beweglichen Blockes **3** relativ zu den Kugellaufnuten **51**, **61** der Führungsschiene **2** durch die Rollen **4** bestimmt werden, die angeordnet sind, um zwischen der oberen Oberfläche der Führungsschiene **2** und dem horizontalen Bauteil **8** des beweglichen Blockes **3** zu rollen.

Die Reaktionskraft der Vorspannung, die auf die Kugeln **5, 6; 5, 6** aufgebracht wird, verursacht, daß das Moment, das auf die Flügelbauteile **9, 9** aufgebracht wird, die Flügelbauteile **9, 9** geringfügig ausdehnt, was in einem geringfügigen Verschieben der Kugeln **5, 6** in den Kugellaufnuten **51, 61** und den Kugellaufgegennuten **52, 62** resultiert. Der Kontaktwinkel $\alpha 2$ (α) wird in einem Zustand bestimmt, in dem die Vorspannung auf diese Weise aufgebracht wurde. Nach dem Bestimmen des vorgeschriebenen Kontaktwinkels der Kugeln **5, 6** kann ein tatsächliches Aufbringen der Vorspannung durchgeführt werden. In diesem Fall wird der Kontaktwinkel $\alpha 2$ ($\alpha 3$) geringfügig geändert und es ist trotzdem keine Störung der Belastungskapazität vorhanden.

In einem Ort, auf welchen keine Hebelast aufgebracht wird und nur die Radiallast und die Querlast aufgebracht wird, kann der Kontaktwinkel $\alpha 2$ ($\alpha 3$) mit Null Grad bestimmt werden. Es kann auch eine Struktur verwendet werden, bei der die Kontaktwinkel $\alpha 2$, $\alpha 3$ graduell abnehmen, so daß die Kontaktwinkellinien S2, S3 graduell näher zur Mitte der Führungsschiene liegen, entsprechend dem Bewegen der Kugeln **5, 6** in Längsrichtung der Führungsschiene **2**. Die Kontaktwinkel $\alpha 2$, $\alpha 3$ können bestimmt werden, um verschieden voneinander zu sein.

Wie in **Fig.** 2 dargestellt ist, in dieser Ausführungsform, sind die Rollen **4** miteinander in der Form einer Kette verbunden durch einen flexiblen Rollenverbinder **40**, und die Kugeln **5, 6** sind auch miteinander verbunden in der Form einer Kelle jeweils durch flexible Kugelverbinder **50, 60**.

Wie in den **Fig.** 3(a) bis 3(c) dargestellt ist, besteht der Rollenverbinder **40** aus einem Paar von-flexiblen Bändern **40**b und einer Vielzahl von Abstandsabschnitten **40**c, von denen jeder zwischen den flexiblen Bändern **40**b angeordnet ist. Die benachbarten zwei Abstandsabschnitte **40**c, **40**c bilden ein Rollenloch **40**a, in welchem die Rolle **4** aufgenommen ist. Die Kontaktoberfläche des Abstandsabschnittes **40**c mit der Rolle **4** ist in einer konkaven Form ausgebildet, welche der zylindrischen Umfangsoberfläche der Rolle **4** entspricht, so daß die Rolle **4** zwischen den zwei benachbarten Abstandsabschnitten **40**c, **40**c gehalten werden kann.

Wie in den **Fig.** 3(e) bis 33(g) dargestellt ist, bestehen die Kugelverbinder **50** (**60**) aus einem Paar von flexiblen Bändern **50**b (**60**b) und einer Vielzahl von Abstandsabschnitten **50**c (**60**c), von denen jeder zwischen den flexiblen Bändern **50**b (**60**b) angeordnet ist. Die benachbarten beiden Abstandsabschnitte **50**c, **50**c (**60**c, **60**c) bilden ein Kugelloch **50**a (**60**a), in welchem die Kugel **5** (**6**) aufgenommen ist. Die Kontaktoberfläche des Abstandsabschnittes **50**c (**60**c) mit der Kugel **5** (**6**) ist konkavförmig ausgebildet, was der sphärischen Oberfläche der Kugel **5** (**6**) entspricht, so daß die Kugel **5** (**6**) zwischen den beiden benachbarten Abstandsabschnitten **50**c, **50**c (**60**c, **60**c) gehalten werden kann.

Jeder der obenbeschriebenen Rollenverbinder **40** und der Kugelverbinder **50** (**60**) weist einander gegenüberliegende Abschnitte auf, wodurch sich ein streifenförmiges Band ergibt. Diese Verbinder **40, 50** (**60**) können jedoch als endloses Band ausgebildet sein durch Verbinden ihrer einander gegenüberliegenden Endabschnitte miteinander.

Der Rollenverbinder **40** oder der Kugelverbinder **50** (**60**) hat die fundamentale Funktion dafür zu sorgen, daß die Rolle **4** oder die Kugeln **5, 6** sanft und gleichmäßig rollen.

Das Rollen der Rolle **4** wird nachfolgend als Beispiel erklärt. Wenn der bewegliche Block **3** entlang der Führungsschiene **2** bewegt wird, werden die Rollen **4**, die zwischen der Rollenlaufoberfläche **41** und der Rollenlaufgegenoberfläche **42** in der belasteten Zone angeordnet sind, gerollt, um auf der Rollenlaufoberfläche **41** der Führungsschiene **2** in Bewegungsrichtung des beweglichen Blockes **3** zu rollen, während die Rollen **4** durch den Rollenverbinder **40** zurückhalten werden. Eine der Rollen **4** wird herausgedrückt aus dem hinteren Ende der Rollenlaufgegenoberfläche **42** des Blockkörpers **31** zum Richtungsänderungsdurchgang **45** als ein nicht belasteter Bereich. Die derart herausgedrückte Rolle **4** tritt in das Rollenrückführloch **44** von seinem hinteren Ende her ein und wird dann geschoben, um in Bewegungsrichtung des beweglichen Blockes **3** zu laufen. Die geschobene Rolle **4** bewegt sich vom vorderen Ende des Rollenrückführloches **44** zum Richtungsänderungsdurchgang **45** und bewegt sich dann vom vorderen Ende des beweglichen Blockes zur Rollenlaufoberfläche **41** und der Rollenlaufgegenoberfläche **42**.

Wenn der Rollenverbinder **40** nicht verwendet wird, werden die Rollen **3** im Rollenrückführdurchgang **43** hintereinander geschoben, um in das vordere Ende der Rollenlaufgegenoberfläche **42** durch den Druck der Rolle **3** einzutreten, die vom hinteren Ende der Rollenlaufoberfläche **41** und der Rollenlaufgegenoberfläche **42** als belastete Zone herausgedrückt wird. Wenn der Rollenverbinder **40** verwendet wird, sind die Rollen **4** beabstandet voneinander durch die Abstandsabschnitte **40**c, mit dem Ergebnis, daß die Rollen **4** herausgedrückt werden, ohne miteinander zu kollidieren, während sie fluchtend zueinander ausgerichtet durch den Rollenverbinder **40** gehalten werden. Die Rollen **4** werden sequentiell in das vordere Ende der Rollenlaufoberfläche **41** und der Rollenlaufgegenoberfläche **42** als belastete Zone durch den Rollenverbinder **40** hereingezogen, wodurch ein sanfter Übergang der Rollen **4** in die belastete Zone möglich wird. Die Kugelverbinder **50, 60** haben die gleiche Funktion wie die der obenbeschriebenen Rollenverbinder **40**.

Ein Rollenverbinder-Rückhaltebauteil **46** zum Führen des Rollenverbinders **40** ist auf dem in Längsrichtung einander gegenüberliegenden Ecken der Rollenlaufgegenoberfläche **42** als die belastete Zone auf der unteren Oberfläche des horizontalen Bauteiles **8** des Blockkörpers **31** ausgebildet, wie dies in **Fig.** 1(a) und **Fig.** 3(d) dargestellt ist. Kugelverbinder-Rückhaltebauteile **56, 66** zum Führen der Kugelverbinder **50, 60** sind auf den in Längsrichtung an der gegenüberliegenden Ecken der Kugellaufgegennuten **52, 62**, die auf den jeweilig inneren Oberflächen der Flügelbauteile **9, 9** ausgebildet sind, angeordnet, wie dies in **Fig.** 1(a) und **Fig.** 3(h) dargestellt ist.

Das Rollenverbinder-Rückhaltebauteil **46** besteht aus Kunstharz, um integral mit der unteren Oberfläche des horizontalen Bauteiles **8** des Blockkörpers **31** ausgebildet zu sein. Das Rollenverbinder-Rückhaltebauteil **35** ist mit einem Paar von Führungsnuten **47, 47** versehen, in welches die Seitenkantenabschnitte des Bandes **40**b, welche gegenüber beiden Enden der Rolle **4** vorstehen, eingesetzt werden. In dem in den **Fig.** 1(a) und **Fig.** 3(d) dargestellten Beispiel wird ein aus Kunstharz geformter Körper verwendet, der Führungsnuten **47, 47** aufweist.

Wie in **Fig.** 2(b) dargestellt, sind ein weiteres Paar von Führungsnuten **47, 47** zum Führen der Seitenkantenabschnitte des Rollenverbinders **40** ebenso kontinuierlich in den Richtungsänderungsdurchgang **44** für die Rollen und dem Rollenrückführloch **45** als nicht belastete Zonen ausgebildet.

Das Rollenverbinderrückhaltebauteil **46** verhindert, daß der Rollenverbinder **40** von dem beweglichen Block **3** absinkt, wenn der bewegliche Block **3** von der Führungsschiene **2** entfernt wird. Die Abstandsabschnitte **40**c, **40**c des Rollenverbinders **40** verhindern, daß Rollen vom Rollenverbinder **40** abfallen.

Gemäß einem konventionellen Verfahren werden die Rollen an ihren sich verjüngenden Umfangsendkanten durch einen Rückhalter gehalten, um zu verhindern, daß die Rollen vom Rückhalter abfallen. In solch einem Fall ist die Länge der Kontaktabschnitte der Rolle mit der Rollenlaufoberfläche durch die Gesamtlänge der sich verjüngenden Endkanten verringern, wodurch die Belastungskapazität reduziert wird. Die Konstruktion, die auf dieser Ausführungsform basiert, daß der Rollenverbinder **40** durch das Rollenverbinder-Rückhaltebauteil **46** zurückgehalten wird und der Rollenverbinder **40** verhindert, daß die Rollen **4** aus dem Rollenverbinder **40** herausfallen, erlaubt das effektive Benutzen der gesamten Länge der Rolle, wodurch das Reduzieren der Belastungskapazität verhindert wird.

Das Kugelverbinder-Rückhaltebauteil **56** (**66**) besteht aus Kunstharz, um integral mit der inneren Oberfläche des Flügelbauteiles **9** des Blockkörpers **31** ausgebildet zu sein. Das Kugelverbinder-Rückhaltebauteil **56** (**66**) ist mit einem Paar von Führungsnuten **57**, **57** (**67**, **67**) versehen, in welchen die Seitenkantenabschnitte des Bandes **50**b (**60**b), die gegenüber beiden Enden der Kugeln **5** (**6**) vorstehen, eingesetzt werden. In dem in **Fig.** 1(a) und **Fig.** 3(h) dargestellten Beispiel werden die Führungsnuten **57**, **57** (**67**, **67**) durch den metallischen Blockkörper **31** gebildet.

Wie in **Fig.** 2(d) dargestellt, wird ein weiteres Paar von Führungsnuten **57**, **57** (**67**, **67**) zum Führen der Seiteneckabschnitte des Kugelverbinders **50** (**60**) ebenfalls kontinuierlich auf dem Kugelrückführloch **54** (**64**) und dem Richtungsänderungsdurchgang **55** (**65**) für die Kugeln als nicht belastete Zonen ausgebildet.

Das Kugelverbinder-Rückhaltebauteil **56** (**66**) verhindert auch, daß der Kugelverbinder **50** (**60**) von dem beweglichen Block **3** absinkt, wenn der bewegliche Block **3** von der Führungsschiene **2** entfernt wird. Die Abstandsabschnitte **50**c, **50**c (**60**c, **60**c) des Kugelverbinders **50** (**60**) hindern die Kugeln **5** (**6**) vom Herausfallen aus dem Kugelverbinder **50** (**60**). Der Abstand zwischen jeder der Seitenoberflächen der Führungsschiene **2** und der inneren Oberfläche jedes der Flügelbauteile **9**, **9** des beweglichen Blockes **3** ist kleiner als der Durchmesser eines Kreises, der durch zwei benachbarte Abstandsabschnitte **50**c, **50**c (**60**c, **60**c) gebildet wird, so daß die Tiefe jeder der Kugelführungsnuten **51**, **61** und der Kugelführungsgegennuten **52**, **62** so tief wie möglich ausgebildet wird, wodurch die Kontaktwinkel $\alpha 2$, $\alpha 3$ vergrößert werden.

Ein Linearbewegungsführungsapparat, der die obenbeschriebene Struktur aufweist, wird unter einer Bedingung verwendet, daß die Führungsschiene **2** an einer Basis **12** durch Bolzen **11** gesichert ist, ein zu führendes Bauteil **13** wie z. B. ein Tisch ist an der oberen Oberfläche des beweglichen Blockes **3** durch Bolzen **14**a, **14**b, **14**c, wie in **Fig.** 4 dargestellt, gesichert.

Die **Fig.** 4(a) bis 4(d) sind beschreibende Ansichten, welche den Linearführungsapparat darstellen, auf welchen Belastungen in verschiedene Richtungen aufgebracht werden.

Wenn eine Radiallast F_R, die die Funktion des Drückens des beweglichen Blockes **3** gegen die Führungsschiene **2** hat, aufgebracht wird, wie dies in **Fig.** 4(a) dargestellt ist, wird die Radiallast F_R von den Rollen **4**, **4** aufgenommen, die eine hohe Festigkeit aufweisen. Eine schwere Last in radialer Richtung kann durch diese Rollen **4**, **4** abgestützt werden. In dieser Ausführungsform kann die hohe Festigkeit der Rollen **4**, **4** vollständig genutzt werden, da der Kontaktwinkel $\alpha 1$ 90 Grad beträgt und die Rollen durch den Rollenverbinder **40** zurückgehalten werden, so daß die Kontaktlänge der Rollen **4** mit der Rollenlaufoberfläche **41** und der Rollenlaufgegenoberfläche **42** im wesentlichen identisch zur Gesamtlänge der Rolle **4** ist. Die Kugeln **5**, **6**; **5**, **6** nehmen keine Radiallast auf, wie oben beschrieben, aufgrund des genau beibehaltenen Kontaktwinkels.

Fig. 4(b) stellt einen Zustand dar, in welchem eine inverse Radiallast F_u, die die Funktion des Wegziehens des beweglichen Blockes **3** von der Führungsschiene **2** hat, aufgebracht wird. Diese inverse Radiallast F_u von den vier Reihen von Kugeln **5**, **6**; **5**, **6** aufgenommen.

Wenn die inverse Radiallast Fu auf den beweglichen Block aufgebracht wird, da die Kugeln **14**a, **14**c, durch welche der bewegliche Block **3** an dem zu führenden Bauteil **13** befestigt ist, von den Kugeln **5**, **6** in horizontaler Richtung beabstandet sind, bilden die inverse Radiallast F_u (d. h. die anhebende Last), die durch die Bolzen **14**a, **14**c aufgebracht wird, und die Reaktionskraft Nu des Kontaktabschnittes der Kugeln **5**, **6** ein Kräftepaar, was zum Auftreten des Momentes Mu führt, daß die Funktion des Ausdehnens der Flügelbauteile **9**, **9** hat, um eine Deformation der Flügelbauteile **9**, **9** hervorzurufen. Sogar wenn die Flügelbauteile **9**, **9** auf diese Weise ausgedehnt werden, werden die Kontaktwinkel $\alpha 2$, $\alpha 3$ kaum geändert, wodurch kein Problem verursacht wird, da das was auf der Innenoberfläche des Flügelbauteiles **9** angeordnet ist, die Kugeln **5**, **6** sind. Spezieller gesagt wird das relative Versetzen der Kugellaufgegennuten **52**, **62** zu den Kugellaufnuten **51**, **61** durch das Verschieben der Kontaktpunkte der Kugeln **5**, **6** mit diesen Nuten absorbiert.

Das obengenannte Moment Mu verursacht das Erzeugen einer Kraft, die die Funktion des Wegziehens des mittigen Abschnittes des horizontalen Bauteiles **8** des beweglichen Blockes **3** weg vom zu führenden Bauteil **13** hat. Die Rollenlaufgegenoberfläche **41** des horizontalen Bauteiles **8** wird jedoch horizontal gehalten, ohne eine Änderung der Kontaktbedingung der Rolle **4** hervorzurufen, da der mittige Abschnitt des horizontalen Bauteiles **8** an den zuführenden Bauteil **13** gesichert ist durch die Bolzen **14**b. Es ist daher möglich, einen Zustand beizubehalten, in dem die Rolle **4** an ihrem längs verlaufenen Linearabschnitt in Kontakt mit der Rollenlaufgegenoberfläche **41** kommt, die auf der unteren Oberfläche des horizontalen Bauteiles **8** angeformt ist, wodurch das Auftreten eine Belastungskonzentration am Ende der Rolle **4** verhindert wird.

Fig. 4(c) stellt einen Zustand dar, in welchem eine Querlast F_T, die die Funktion des Drückens des beweglichen Blockes **3** quer gegen die Führungsschiene **2** aufweist, aufgebracht wird. Die Querlast F_T wird von dem zu führenden Bauteil **13** auf den beweglichen Block **3** durch den Bolzen **14** aufgebracht. Die Querlast F_T wird von den beiden Reihen von Kugeln **5**, **6** pro Seite aufgenommen. Da die Querlast F_T auf den beweglichen Block **3** über die Bolzen **14** aufgebracht wird, bildet die Reaktionskraft, die auf die Kugeln **5**, **6** aufgebracht wird, ein Kräftepaar, um ein Moment M_T zu erzeugen, das die Funktion des Auseinanderdrückens der Flügelbauteilen **9** nach außen in der Nähe des Verbindungsabschnittes des Bolzens als mittigen Punkt hat, was sich in einem geringfügigen Ausdehnen der Flügelbauteile **9** äußert. Sogar wenn das Flügelbauteil **9** auf diese Weise auseinandergedrückt wird, tritt leichtes Versetzen der Kugeln **5**, **6** in den Kugellaufbahnen **51**, **61** und den Kugellaufgegennuten **52**, **62** auf, und die Kontaktwinkel $\alpha 2$, $\alpha 3$ werden kaum geändert, wodurch kein Problem verursacht wird, da das was auf der Innenoberfläche des Flügelbauteiles **9** angeordnet ist, die Kugeln **5**, **6** sind. Spezieller gesagt, wird ein relatives Verschieben der Kugellaufgegennuten **52**, **62** zu den Kugellaufnuten **51**, **61** absorbiert durch das Verschieben der Kontaktpunkte der Kugeln **5**, **6** gegenüber dieser Nuten.

Das obengenannte Moment N_T wird verursacht durch das Erzeugen einer Kraft, die die Funktion des Wegziehens des mittigen Abschnittes des horizontalen Bauteiles **8** des beweglichen Blockes **3** weg von dem zu führenden Bauteil **13** hat. Die Deformation des horizontalen Bauteiles **8** tritt jedoch nicht auf, da der mittige Abschnitt des horizontalen

Bauteiles **8** an dem zuführenden Bauteil **13** ist durch die Bolzen **14** gesichert. Es ist daher möglich, die Rollenlaufgegenoberfläche **42** horizontal zu halten, die an der unteren Oberfläche des horizontalen Bauteiles **8** angeordnet ist, ohne ein Variieren der Kontaktbedingung der Rolle **4**.

Sogar wenn die Deformation des Flügelbauteiles **9**, **9** in dieser Weise auftritt aufgrund des Aufbringens einer inversen Radiallast FU oder der Querlast F_T auf den beweglichen Block **3**, oder das Aufbringen der Vorspannung auf die Kugeln **5**, **6**, werden die Kontaktwinkel $\alpha 2$, $\alpha 3$ kaum geändert, wodurch ein Beibehalten der Richtung der Last, welche durch die Kugeln **5**, **6** aufgenommen wird, beibehalten wird. Die Belastungskapazität der Kugeln **5**, **6** wird daher nicht geändert und ein gleichmäßiger Lauf der Kugeln **5**, **6** wird auch beibehalten. Spezieller gesagt, sogar wenn die Flügelbauteile **9**, **9** durch die inverse Radiallast Fu deformiert werden, werden solche Deformationen durch die geringfügige Verschiebung der Kontaktpunkte der Kugeln **5**, **6** (d. h. die kleine Änderung des Kontaktwinkels), absorbiert, ohne irgend einen Einfluß auf die Belastungskapazität und das gleichmäßige Laufen der Kugeln **5**, **6** auszuüben.

Im allgemeinen weist die Rolle **4** eine Belastungskapazität auf, die größer ist als die der Kugeln **5**, **6**. Wenn die Belastungskapazität in radialer Richtung der Rolle **4** derart bestimmt wird, da sie zwei- bis dreimal so groß wie die Belastungskapazität in der inversen Radialrichtung der Kugeln **5**, **6** ist, und zwei Reihen von Kugeln **5**, **6**, die die inverse Last (die hebende Last) und die Querlast tragen, auf jeden der Flügelbauteile angeordnet sind, kann eine lasttragende Struktur erhalten werden, in welcher die Lasten in den vier Richtungen (d. h. die radiale Richtung, die inverse radiale Richtung, und die rechten und linken Richtungen) ungefähr gleich zueinander sind. Die Linearführungsvorrichtung weist daher eine exzellente Haltbarkeit gegen Belastungen aus jeglichen Richtungen auf, und kann unter jeglichen Bedingungen verwendet werden, um für verschiedene Anwendungen benutzt werden zu können.

Spezieller gesagt, wird die Radiallast von zwei Reihen von Rollen **4** aufgenommen, wird die inverse Radiallast Fu von zwei Reihen von Kugeln **5**, **6**; **5**, **6** aufgenommen, die jeweils auf den Flügelbauteilen angeordnet sind, um eine Gesamtzahl von vier Reihen zu bilden, und die Querlast F_T wird von den jeweiligen zwei Reihen von Kugeln **5**, **6** pro Seite der Führungsschiene **2** aufgenommen. Entsprechend kann die Radiallast F_R und inverse Radiallast Fu gleichmäßig aufgenommen werden. Die Querlasten F_T in Rechts- und Linksrichtung können gleichmäßig getragen werden, obwohl die Belastungskapazität für jede der Querlasten halbiert wird.

Mit Bezug auf die Rollrichtungsdrehmomentbelastung, die die Funktion des Ausschwingens des beweglichen Blokkes **3** hat, wobei die Längsachse der Führungsschiene **2** als Achse für das Rollen dient, kann solche eine Belastung gleichmäßig an den rechten und linken Seiten durch die einzelnen Reihen von Rollen **4** und die beiden Reihen von Kugeln **5**, **6** pro Seite aufgenommen werden.

Mit Bezug auf die Kippmomentbelastung, die die Funktion des Schwingens des vorderen Endes des beweglichen Blockes **3** nach oben und unten zur Horizontalachse hat, die die Längsachse des beweglichen Blockes **3** im rechten Winkel als Kippachse schneidet, kann die Radiallast (d. h. die Hebelast), die auf irgendeine der vorderen oder hinteren Enden des beweglichen Blockes **3** aufgebracht wird, durch die vier Reihen von Kugeln **5**, **6**; **5**, **6** aufgenommen werden, die zwei Reihen von Kugeln **5**, **6** aufweisen, die auf jede der rechten und linken Seiten der Führungsschiene **2** angeordnet sind. Die Radiallast, die auf die anderen der vorderen und hinteren Enden des beweglichen Blockes aufgebracht werden, können gleichmäßig von den zwei Reihen von Rollen **4**, **4** aufgenommen werden.

Bezüglich einer Gierdrehmomentlast, die die Funktion des Schwingens des vorderen Endes des beweglichen Blokkes **3** nach rechts und links um eine vertikale Achse hat, die die Längsachse des beweglichen Blockes **3** im rechten Winkel als Gierachse schneidet, kann die Querlast, die auf irgendeine der vorderen und hinteren Enden des beweglichen Blockes **3** aufgebracht wird, von den beiden Reihen von Kugeln **5**, **6** aufgenommen werden, die auf jeder der rechten und linken Seiten der Führungsschiene **2** angeordnet sind. Die Querlast, die auf das andere vordere und hintere Ende des beweglichen Blockes **3** aufgebracht wird, kann gleichmäßig auf die von den anderen beiden Reihen von Kugeln **5**, **6** aufgenommen werden, die auf den anderen rechtend und linken Seiten der Führungsschiene **2** angeordnet sind.

Der Linearführungsapparat hat daher exzellente Haltbarkeitseigenschaften gegen Belastungen in jegliche Richtungen, und kann unter beliebigen Bedingungen verwendet werden, um für verschiedene Zwecke auf diese Weise eingesetzt werden zu können.

Fig. 4(d) stellt den Linearführungsapparat beispielhaft dar, der als Führungsapparat für eine Werkzeugmaschine verwendet wird.

Eine Vielzahl von beweglichen Blöcken **3**, **3**, **3**, **3** ist verschieblich auf einem Paar von Führungsschienen **2**, **2** angeordnet, die an einer Schiene **201** befestigt sind, um parallel zueinander zu sein. Ein Arbeitstisch **200** ist an den beweglichen Blöcken **3**, **3**, **3**, **3** befestigt, um linear durch einen Zustellmechanismus, wie z. B. eine Kugelrollspindel bewegt zu werden. Ein Arbeitsstück **203** ist stationär auf dem Arbeitstisch **200** angeordnet, so daß ein Bearbeiten, wie z. B. ein Fräsen an dem Werkstück **203** durch ein Werkzeug **205** durchgeführt werden kann, das stationär auf einer Spindel **204** gehalten ist.

In solch einem Fall, wo der Linearführungsapparat zum Führen des Arbeitstisches **200** verwendet wird, verursacht das Aufbringen einer horizontal gerichteten Kraft des Werkzeuges **205** auf das Werkstück **203** z. B. eine Reaktionskraft, die erzeugt wird, so daß die Radiallast F_R auf einige der beweglichen Blöcke **3**, **3** aufgebracht wird, und die inverse Radiallast Fu auf die anderen beweglichen Blöcke **3**, **3** aufgebracht wird. Nicht nur die Radiallast F_R, sondern auch die inverse Radiallast Fu der Querbelastung F_T wird auch die beweglichen Blöcke **3**, **3**, **3**, **3** in dieser Weise aufgebracht. Wenn der Linearführungsapparat eine Struktur hat, in welcher die Belastungen in die vier Richtungen, d. h., die Radialrichtung, die inverse Radialrichtung und die rechten und linken Querrichtungen, ungefähr gleich zueinander gehalten werden, ist es möglich, eine einfache Berechnung für Festigkeit und Lebensdauer durchzuführen, die nützlich ist, um die mechanische Struktur zu bestimmen.

Gemäß der vorliegenden Erfindung, wie im Detail beschrieben, ist es möglich, schwere Lasten in radialer Richtung durch Anordnen zweier Reihen von Rollen zwischen der oberen Oberfläche der Führungsschiene und der unteren Oberfläche des horizontalen Bauteiles des beweglichen Blockes aufzunehmen, und die schweren Lasten in Querrichtung und inverser Radialrichtung durch Anordnen zweier Reihen von Rollen auf jeder der rechten und linken Seiten der Führungsschiene aufzunehmen.

Sogar wenn die Führungsbauteile des beweglichen Blokkes deformiert werden, um durch die Vorspannung ausgedehnt zu werden, die auf die Kugeln aufgebracht wird, die auf der inneren Oberflächenseite des Flügelbauteiles des beweglichen Blockes angeordnet sind, oder durch eine inverse Radiallast oder eine Querlast, welche auf den beweglichen Block aufgebracht wird, werden die Kontaktwinkel der Kugeln nur geringfügig und wenig verändert, so daß die Richtung der Last, welche auf die Kugeln aufgebracht wird, ungefähr beibehalten wird. Fast keine Änderung der Belastungskapazität der Kugeln, welche durch den Kontaktwinkel der Kugeln bestimmt wird, und ein gleichmäßiges Laufen der Kugeln kann beibehalten werden. Spezieller gesagt, das Deformieren der Flügelbauteile des beweglichen Blokkes, die durch das Aufbringen der inversen Radiallast verursacht wird, kann durch eine geringfügige Bewegung Kontaktpunkte der Kugeln gegenüber der Kugellaufnut und der Kugellaufgegennut absorbiert werden (d. h., eine geringfügige Änderung des Kontaktwinkels der Kugeln) und eine solche Deformation übt keinen Einfluß auf die Belastungskapazität der Kugeln und ihren gleichmäßigen Lauf aus.

Im allgemeinen weist die Kugel eine Belastungskapazität auf, die kleiner ist als die der Rollen. Die inverse Radiallast kann von den vier Reihen von Kugeln aufgenommen werden, die aus zwei Reihen von Kugeln, die auf einer Seitenoberfläche der Führungsschiene angeordnet sind, und die anderen beiden Reihen von Kugeln bestehen, die auf der anderen Seite angeordnet sind. Die vier Reihen von Kugeln weisen gleiche Belastungskapazität wie die beiden Reihen von Rollen auf, die die Radiallast tragen. Zudem kann die Querlast von den beiden Reihen von Kugeln aufgenommen werden, die eine hohe Festigkeit haben, die jedoch nicht so groß ist wie die Belastungskapazität gegen die inverse Radiallast. Solche Reihen von Kugeln können gleichmäßig schwere Lasten in vier Richtungen tragen, d. h., die radiale Richtung, die inverse Radialrichtung und die rechten und linken Querrichtungen.

Insbesondere, wenn die Belastungskapazität der Radialrichtung der Rollen derart vorbestimmt ist, um zwei- bis dreimal so groß zu sein wie die Belastungskapazität in inverser Radialrichtung der Kugeln, kann die Belastungskapazität für die inverse Radiallast, welche durch die vier Reihen von Kugeln erhalten wird, derart eingestellt werden, um im wesentlichen gleich der Belastungskapazität für die Radiallast zu sein, welche durch die beiden Reihen von Rollen erhalten wird. Wo die Belastungskapazität für die Querlast, welche nur durch die beiden Reihen von Kugeln aufgenommen wird, auf im wesentlichen die Hälfte der inversen Radiallast begrenzt ist, kann eine Struktur bereitgestellt werden, in welcher die Lasten in die vier Richtungen, d. h. die radiale Richtung, die inverse radiale Richtung, und die rechten und linken Querrichtungen, ungefähr gleich zueinander gehalten werden können. Der Linearführungsapparat hat daher exzellente Haltbarkeitseigenschaften gegen Lasten in jegliche Richtungen, und kann unter jeglichen Bedingungen verwendet werden, um für verschiedene Zwecke eingesetzt zu werden. Wenn der Linearführungsapparat als ein Tischführungsapparat für eine Werkzeugmaschine verwendet wird, ist es möglich, eine einfache Berechnung für Festigkeit und Lebensdauer durchzuführen, die nützlich für das Bestimmen der mechanischen Struktur ist.

Wenn jede der Kugellaufnuten und der Kugellaufgegennuten einen Krümmungsradius aufweist, der geringer ist als der Wert von 52% des Durchmessers der Kugeln, kann Differenzialschlupf leicht auftreten, wodurch die Dämpfungskapazität verbessert wird.

Die Kraft, die die Funktion des Ausdehnens des Flügelbauteiles des beweglichen Blockes aufweist, wie z. B. die Vorspannung, die auf die Kugeln aufgebracht wird, die inverse Radiallast oder die Querlast, welche auf den beweglichen Block aufgebracht wird, verursacht das simultane Erzeugen des Zugmomentes des mittigen Abschnittes des horizontalen Bauteiles des beweglichen Blockes weg von einem zuführenden Bauteil, wie z. B. ein Bearbeitungstisch. Ein mittiger Abschnitt des horizontalen Bauteiles ist fest mit dem zu führenden Bauteil verbunden durch Bolzen, und es ist daher möglich, das Deformieren des horizontalen Bauteils zu verhindern, so daß ein guter Zustand beibehalten werden kann, in welchem die Rolle mit einem linearen Abschnitt an ihrem Rand in Kontakt mit der Rollenlaufgegenoberfläche kommt, die auf der unteren Oberfläche des horizontalen Bauteils des beweglichen Blockes ausgebildet ist, wodurch eine gute Festigkeit und eine gleichmäßige Rolleigenschaft der Rolle beibehalten wird.

Patentansprüche

1. Ein Linearführungsapparat mit:
einer Führungsschiene, die mit zwei Rollenlaufoberflächen, die an einer oberen Oberfläche der Führungsschiene ausgebildet sind und mit zwei Kugellaufnuten vorgesehen ist, die auf jeder der Seitenoberflächen der Führungsschiene ausgebildet sind;
einem beweglichen Block, der mit einem horizontalen Bauteil versehen ist, welches der oberen Oberfläche der Führungsschiene gegenüberliegt, und mit einem Paar von Flügelbauteilen, die jeweils den Seitenoberflächen der Führungsschiene gegenüberliegen, wobei das horizontale Bauteil auf seiner unteren Oberfläche zwei Rollenlaufgegenoberflächen entsprechend den beiden Rollenlaufoberflächen der Führungsschiene aufweist, und jedes der Flügelbauteile auf einer ihrer inneren Oberflächen zwei Kugellaufgegennuten aufweisen, die den beiden Kugellaufnuten der Führungsschiene entsprechen;
zwei Reihen von Rollen, die zwischen den beiden Rollenlaufoberflächen der oberen Oberfläche der Führungsschiene und den beiden Rollenlaufgegenoberflächen des horizontalen Bauteiles des bewegten Blockes jeweils gegenüberliegen, um rollbar zu sein;
zwei Reihen von Kugeln, die zwischen den beiden Kugellaufnuten der Seitenoberflächen der Führungsschiene und den beiden Kugellaufgegennuten auf den inneren Oberflächen des Flügelbauteiles angeordnet sind, in jeder der Lücken zwischen den Seitenoberflächen der Führungsschiene und den inneren Oberflächen der Flügelbauteile, um rollbar zu sein.
2. Ein Apparat nach Anspruch 1, bei dem:
jede der Kugeln an zwei einander gegenüberliegenden Punkten jeweils mit der Kugellaufnut der Führungsschiene und der Kugellaufgegennut des beweglichen Blockes in Kontakt gelangen, und wobei eine Kontaktlinie, die die beiden einander gegenüberliegenden Punkte miteinander verbindet, nach oben in Richtung zur Führungsschiene geneigt ist.
3. Ein Apparat nach Anspruch 2, bei dem:
Kontaktwinkellinie eine horizontale Linie schneidet, die sich durch eine Mitte der Kugel mit einem Winkel von 45 Grad hindurch erstreckt.
4. Ein Apparat nach einem der Ansprüche 1 bis 3, bei dem:
das horizontale Bauteil des beweglichen Blockes Bolzenlöcher aufweist, welche jeweils zwischen den beiden Reihen von Rollen und außerhalb der beiden Reihen von Rollen angeordnet sind.
5. Ein Apparat nach einem der Ansprüche 1 bis 4, bei dem:
jede der Kugellaufnuten und der Kugellaufgegennuten einen Krümmungsradius aufweist, der kleiner ist als ein Wert von 52% des Durchmessers der Kugel.

Hierzu 5 Seite(n) Zeichnungen

Nummer: **DE 198 30 578 A1**
Int. Cl.[6]: **F 16 C 29/04**
Offenlegungstag: 4. Februar 1999

FIG. 1(a)

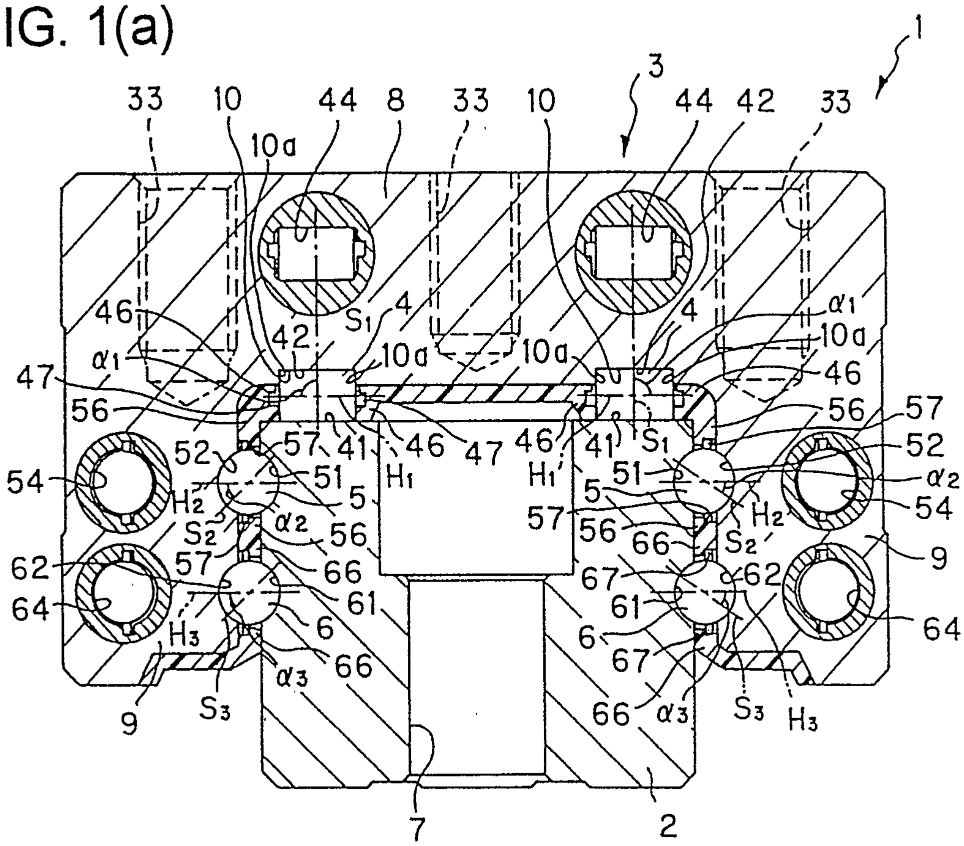


FIG. 1(b)

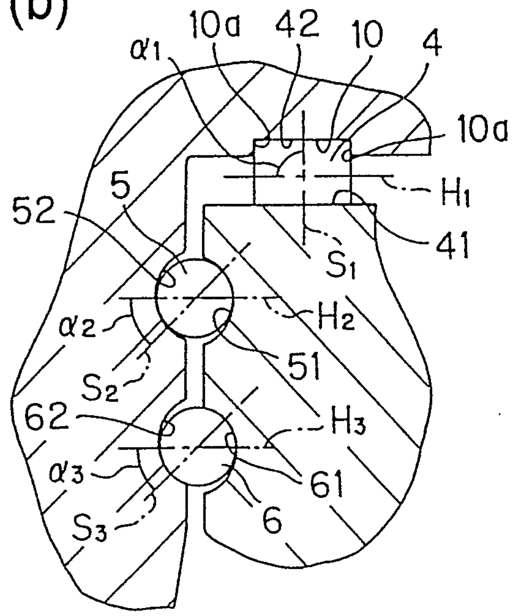


FIG. 2(a)

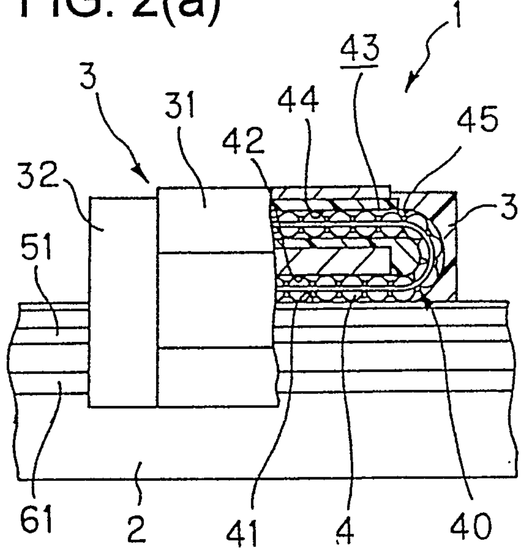


FIG. 2(b)

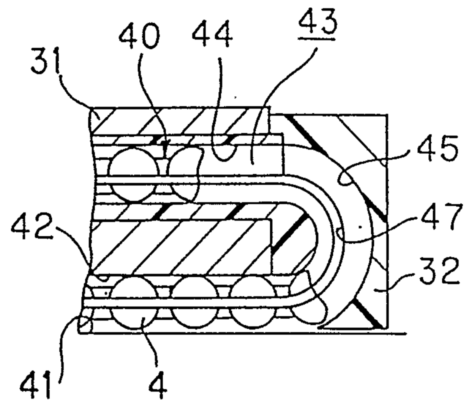


FIG. 2(c)

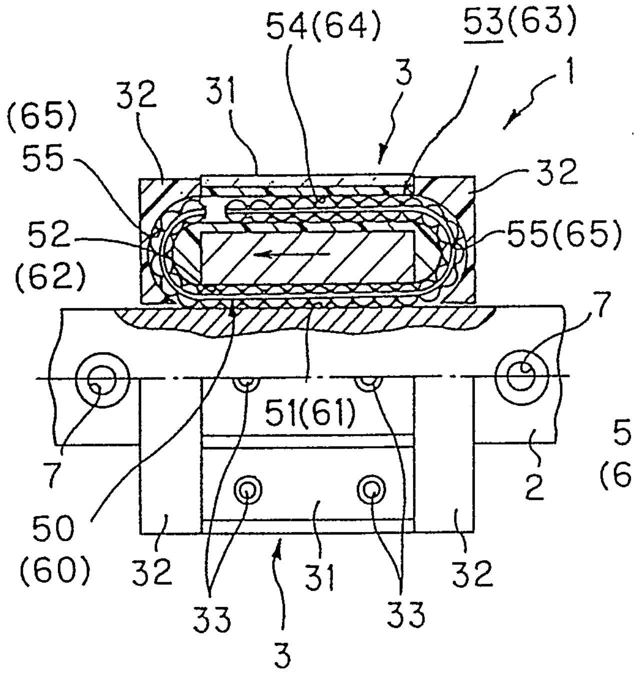


FIG. 2(d)

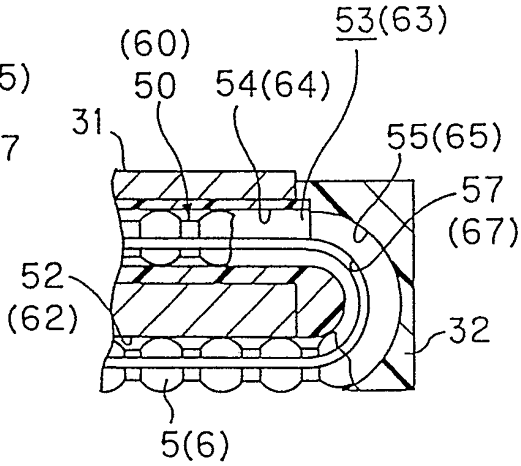


FIG. 3(a)

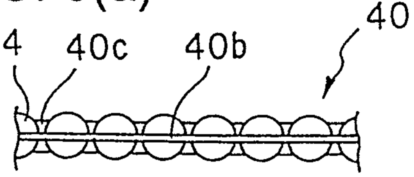


FIG. 3(b)

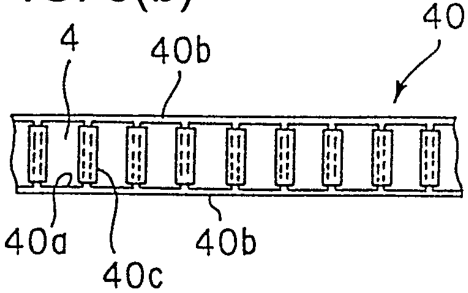


FIG. 3(c)

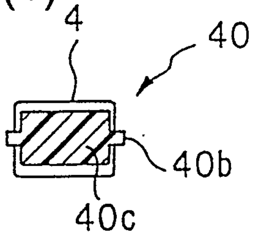


FIG. 3(d)

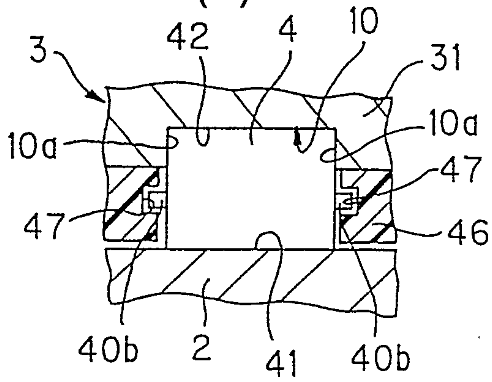


FIG. 3(e)

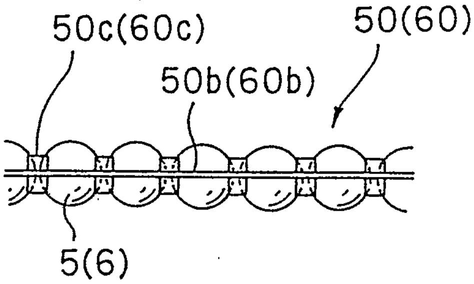


FIG. 3(f)

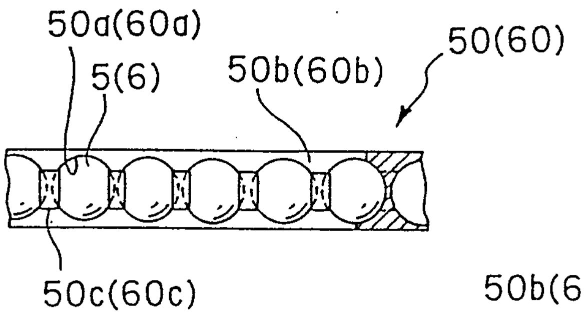


FIG. 3(g)

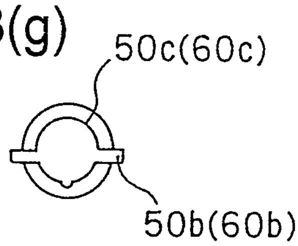
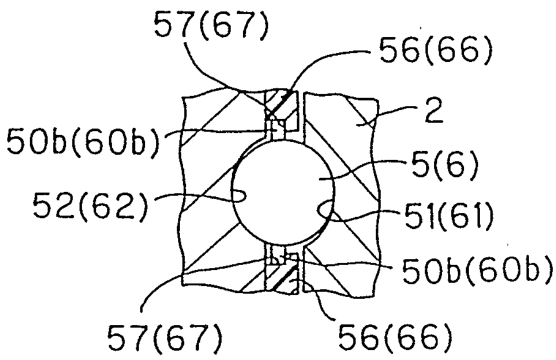


FIG. 3(h)



Nummer: DE 198 30 578 A1
Int. Cl.[6]: F 16 C 29/04
Offenlegungstag: 4. Februar 1999

FIG. 4(a)

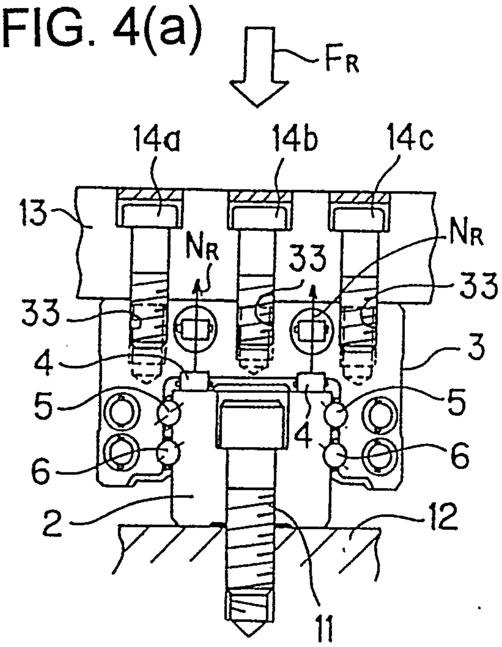


FIG. 4(b)

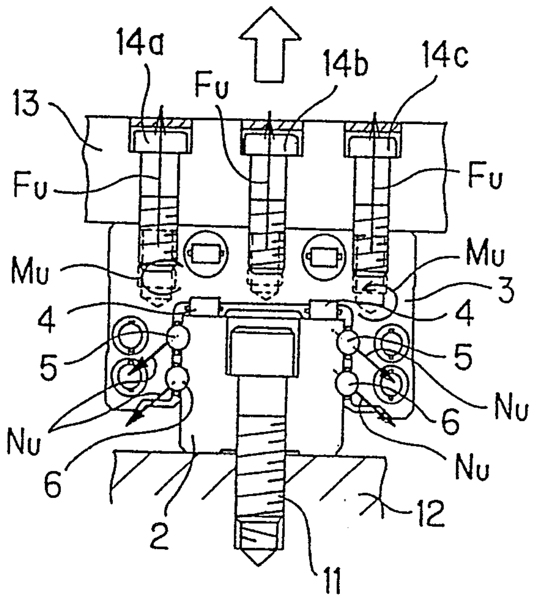


FIG. 4(c)

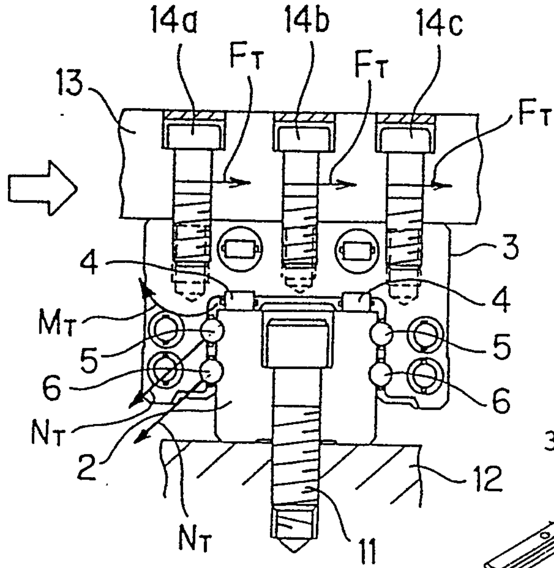


FIG. 4(d)

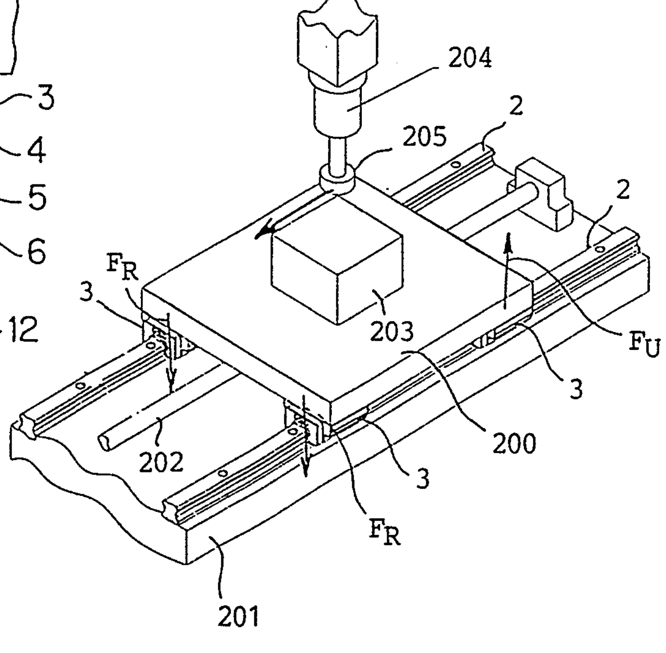


FIG. 5(a)

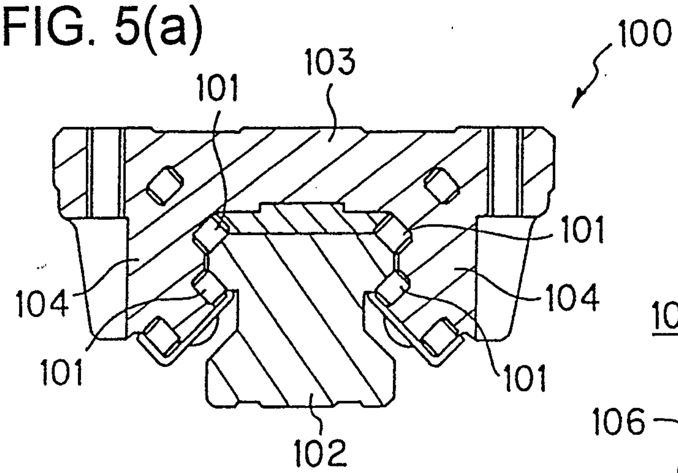


FIG. 5(b)

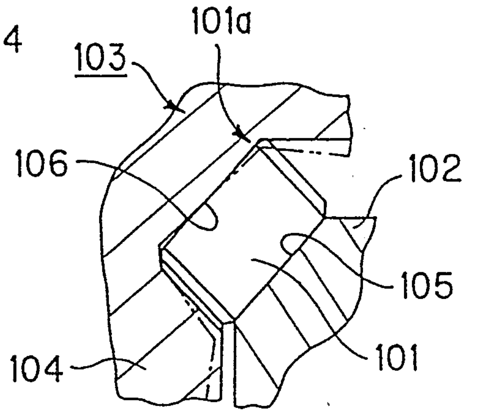


FIG. 5(c)

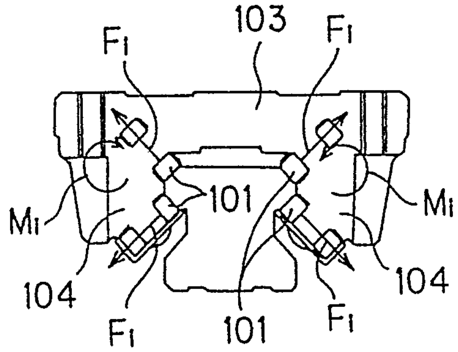


FIG. 5(d)

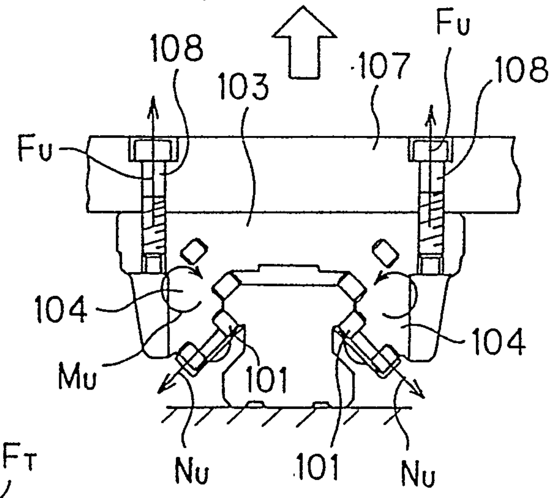
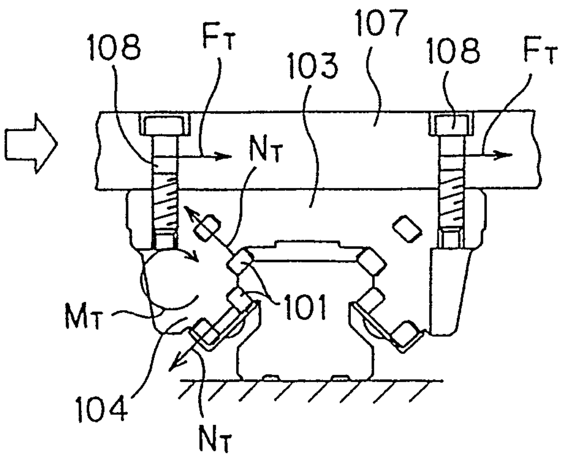


FIG. 5(e)



(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 198 28 587 A 1**

(51) Int. Cl.^{6}:
F 16 C 33/66
F 16 C 29/06
B 23 Q 1/01
B 23 Q 1/40

(21) Aktenzeichen: 198 28 587.6
(22) Anmeldetag: 26. 6. 98
(43) Offenlegungstag: 7. 1. 99

DE 198 28 587 A 1

(30) Unionspriorität:
175729 01. 07. 97 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Vossius & Partner GbR, 81675 München

(72) Erfinder:
Shirai, Takeki, Tokio/Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Linearführungsvorrichtung

(57) Die Erfindung stellt eine Linearführungsvorrichtung bereit, mit der es möglich ist, Austritt von in ein Gleitstück eingeleitetem Schmiermittel zu verhindern und dadurch eine Schmiermittelverbrauchsmenge zu reduzieren sowie Wälzelemente und einen endlosen Umlaufgang für sie sicher zu schmieren, und mit der dies zudem durch einen einfachen Aufbau erreicht werden kann. Erfindungsgemäß ist bei einer Linearführungsvorrichtung aus einer Spurschiene mit einer Wälzfläche aus Wälzelementen und einem Gleitstück, das eine zur Wälzfläche der Spurschiene weisende Lastwälzfläche mit den Wälzelementen dazwischen und einen Wälzelementrücklaufgang hat, der parallel zu dieser Lastwälzfläche ist, sowie bogenförmige Richtungsumkehrgänge zum Führen von Wälzelementen zwischen der Lastwälzfläche und dem Wälzelementrücklaufgang hat und sich entlang der Spurschiene bei endlosem Umlauf der Wälzelemente bewegen kann, ein Schmiermittelzufuhrloch in Verbindung mit einem der Richtungsumkehrgänge in einer Vorder- und/oder Rükkendfläche des Gleitstücks vorgesehen, die Endfläche, in der dieses Schmiermittelzufuhrloch vorgesehen ist, ist mit einem plattenartigen Teil abgedeckt, eine Schmiermittelzufuhrrinne in Verbindung mit dem Schmiermittelzufuhrloch ist in dieser Endfläche und/oder der Innenfläche des diese Endfläche abdeckenden plattenartigen Teils gebildet, und ein Schmiermittelzufuhrgang ist durch das am Gleitstück befestigte plattenartige Teil gebildet.

DE 198 28 587 A 1

Beschreibung

Die Erfindung betrifft eine Linearführungsvorrichtung, bei der sich ein Gleitstück, das einen bewegbaren Körper, z. B. einen Tisch, stützt, entlang einer Spurschiene auf Roll- oder Wälzelementen, z. B. Kugeln oder Rollen, die durch das Gleitstück umlaufen, bewegt, und insbesondere eine Aufbauverbesserung zum sicheren Zuführen von Schmiermittel zu den Rollelementen.

Zu bekannten Linearführungsvorrichtungen dieser Art gehören jene, die aus einer Spurschiene, die darauf gebildete Rollflächen hat und an einem feststehenden Teil, z. B. einem Bett, angeordnet ist, und aus einem Gleitstück bestehen, das auf dieser Spurschiene mit mehreren Kugeln dazwischen angeordnet ist und sich entlang der Spurschiene bewegt, während es einen bewegbaren Körper, z. B. einen Tisch, stützt.

Das Gleitstück besteht aus einem beweglichen Block und einem Paar Abdeckteilen. Der bewegliche Block hat Lastrollflächen, die zu den Rollflächen der Spurschiene mit Kugeln dazwischen weisen, und Kugelrücklaufgänge, die parallel zu diesen Lastrollflächen sind, und kann sich entlang der Spurschiene auf den Kugeln bewegen. Die Abdeckteile haben bogenförmige Richtungsumkehrgänge zum Führen der Kugeln zwischen den Lastrollflächen und den Kugelrücklaufgängen des beweglichen Blocks. Indem die Abdeckteile an der Vorder- und Rückendfläche des beweglichen Blocks befestigt sind, sind die Enden der Lastrollflächen und der Kugelrücklaufgänge verbunden, und endlose Kugelumlaufgänge sind im Gleitstück vervollständigt.

Um ferner zu verhindern, daß an der Spurschiene haftender Staub u.ä. in das Innere des Gleitstücks bei Bewegung des Gleitstücks eintritt, sind normalerweise plattenartige Abdichtungsteile aus einem weichen elastischen Material, z. B. Gummi, an diesen Vorder- und Rückendflächen befestigt, und das Gleitstück bewegt sich mit diesen Abdichtungsteilen in eng anliegender Berührung mit der Oberfläche der Spur.

Beim Einsatz dieser Linearführungsvorrichtung muß zwecks Unterdrückung von Verschleiß der Kugeln selbst sowie Verschleiß der Rollflächen der Spurschiene und der Lastrollflächen des Gleitstücks, auf denen sie rollen und dadurch eine sehr genaue Bewegung des Gleitstücks lange Zeit beibehalten, ein Schmiermittel, z. B. Schmierfett, diesen Kugeln und den Lastrollflächen periodisch oder kontinuierlich zugeführt werden.

Dazu ist in der zuvor beschriebenen Linearführungsvorrichtung der verwandten Technik ein als Schmiermittelzufuhrgang vorgesehener Kanal in der Rückfläche eines Abdeckteils des Gleitstücks gebildet, d. h., der an den beweglichen Block anstoßenden Fläche, und ein Schmiermittelzufuhrgang in Verbindung mit dem endlosen Kugelumlaufgang von außerhalb des Gleitstücks ist vervollständigt, wenn das Abdeckteil am beweglichen Block befestigt ist.

Da aber dieses Abdeckteil durch Spritzgießen eines relativ harten Kunstharzes hergestellt ist und sich bei selbst geringer Verzerrung im geformten Abdeckteil ein Spalt zwischen dem Abdeckteil und der Endfläche des beweglichen Blocks bildet, an dem es befestigt ist, bestand das Problem, daß in das Gleitstück eingeleitetes Schmiermittel zwischen dem Abdeckteil und dem beweglichen Block austritt und nicht ausreichend Schmiermittel im gesamten endlosen Kugelumlaufgang verteilt werden kann.

Da eingeleitetes Schmiermittel auf diese Weise austritt, bestand zudem das Problem, daß entsprechend mehr Schmiermittel eingeleitet werden muß, damit es die Kugeln und die Lastrollfläche ausreichend schmieren kann, wodurch Schmiermittel vergeudet wird.

Problematisch war außerdem, daß bei Schmierfettzufuhr in den Schmiermittelzufuhrgang mit vorbestimmtem Druck unter Verwendung einer Schmierpresse o. ä. im Fall eines Spalts, der sich zwischen dem Abdeckteil und dem beweglichen Block gebildet hat, der Fülldruck des Schmierfetts durch diesen Spalt nach außen austritt, weshalb Schmierfett nicht ausreichend bis zum Ende des Schmiermittelzufuhrgangs, d. h. zum endlosen Kugelumlaufgang, geführt werden kann.

Eine Linearführungsvorrichtung, bei der versucht wurde, diese Art von Schmiermittelaustritt zu verhindern, ist in der japanischen ungeprüften Gebrauchsmusterveröffentlichung Nr. H.5-71442 offenbart. Insbesondere ist ein Schmiermittelzufuhrloch in einem Abdeckteil mit einem Kugelrichtungsumkehrgang gebildet, und Schmiermittel wird direkt in den Kugelrichtungsumkehrgang durch dieses Zufuhrloch aus einem Schmiermittelzufuhrrohr eingeleitet, das an der Außenfläche des Abdeckteils vorgesehen ist.

Obwohl bei Einsatz dieses Aufbaus der Schmiermittelaustritt zwischen dem beweglichen Block und dem Abdeckteil verhindert werden kann, wird aber ein Rohr an der Außenfläche des Abdeckteils zum Einleiten von Schmiermittel in den Richtungsumkehrgang notwendig, und außerdem wird unter Berücksichtigung der Anordnung des Abdichtungsteils an der Außenfläche des Abdeckteils eine Aussparung in der Außenfläche des Abdeckteils zum Aufnehmen dieses Rohrs ebenfalls notwendig, weshalb das Problem bestand, daß die Anzahl von Teilen steigt und die Struktur des Abdeckteils komplizierter wird.

Daher besteht eine Aufgabe der Erfindung darin, eine Linearführungsvorrichtung bereitzustellen, mit der es möglich ist, den Austritt von in ein Gleitstück eingeleitetem Schmiermittel zu verhindern und dadurch die Schmiermittelverbrauchsmenge zu reduzieren sowie ferner Rollelemente und einen endlosen Rollelementumlaufgang sicher zu schmieren, und mit der sich dies mit einem einfachen Aufbau erreichen läßt. Diese Aufgabe wird mit den Merkmalen der Ansprüche gelöst.

Ist erfindungsgemäß das plattenartige Teil an der Endfläche des Gleitstücks befestigt, ist die in der Endfläche des Gleitstücks oder in der Innenfläche des plattenartigen Teils gebildete Zufuhrrinne abgedeckt, und ein Schmiermittelzufuhrgang ist durch das Gleitstück und das plattenartige Teil vervollständigt. Dann kann Schmiermittel dem Rollelementrichtungsumkehrgang durch diesen Schmiermittelzufuhrgang und das in der Endfläche des Gleitstücks gebildete Schmiermittelzufuhrloch zugeführt werden.

Ist hierbei ein Teil des an das Gleitstück anstoßenden plattenartigen Teils aus einem viskoelastischen Material hergestellt, stellt das am Gleitstück dicht befestigte plattenartige Teil eine eng anliegende Berührung mit der Endfläche des Gleitstücks her, und es bilden sich keine Spalte zwischen dem Plattenartigen Teil und dem Gleitstück. Dadurch läßt sich wirksam verhindern, daß Schmiermittel aus dem durch das Gleitstück und das plattenartige Teil vervollständigten Schmiermittelzufuhrgang austritt, und die Rollelemente sowie ihr endloser Umlaufgang lassen sich mit geringem Schmiermittelverbrauch sicher schmieren.

Da auf diese Weise wirksam verhindert werden kann, daß Schmiermittel aus dem Schmiermittelzufuhrgang austritt, kann auch beim Einspritzen von Schmierfett in den Schmiermittelzufuhrgang unter Verwendung einer Schmierpresse o.a. aufgrund der Tatsache, daß der Fülldruck bei diesem Einspritzen vollständig über dem gesamten Weg bis zum Ende des Schmiermittelzufuhrgangs wirkt, Schmierfett sicher in den Rollelementrichtungsumkehrgang des Gleitstücks eingeleitet werden.

Da bei einer erfindungsgemäßen Linearführungsvorrichtung ein Schmiermittelzufuhrgang durch das Gleitstück und das plattenartige Teil gebildet ist, die dicht aneinanderstoßen, kann somit sicher verhindert werden, daß Schmiermittel zwischen dem Gleitstück und dem plattenartigen Teil austritt, die Schmiermittelverbrauchsmenge läßt sich reduzieren, und die Rollelemente sowie der endlose Umlaufgang können sicher geschmiert werden.

Da ferner bei einem auch als plattenartiges Teil dienenden Abdichtungsteil das Abdichtungsteil selbst ein in Linearführungsvorrichtungen der verwandten Technik verwendeter konstituierender Bestandteil ist, kommt es bei Ausbilden des Schmiermittelzufuhrgangs durch das Gleitstück und das Abdichtungsteil zu keinerlei zusätzlichen Sonderteilen, und der Schmiermittelzufuhrgang kann dadurch mit einem einfachen Aufbau realisiert sein.

Hierbei ist zwecks noch sicherer Verhinderung des Schmiermittelaustritts aus dem Schmiermittelzufuhrgang vorzugsweise ein streifenförmiger Vorsprung, der an die Endfläche des Gleitstücks anstößt, am plattenartigen Teil um den gesamten Umfangsweg der Schmiermittelzufuhrrinne gebildet, die in der Endfläche des Gleitstücks und/oder der Innenfläche des die Endfläche abdeckenden plattenartigen Teils gebildet ist. Geschieht dies, stellt bei Befestigung des plattenartigen Teils am Gleitstück der streifenartige Vorsprung eine noch dichtere eng anliegende Berührung mit der Endfläche des Gleitstücks her, und der Schmiermittelzufuhrgang kann noch vollständiger ausgebildet sein. Ist das plattenartige Teil durch Vulkanisationsformen von Gummi hergestellt, läßt sich zudem der streifenartige Vorsprung leicht in einem Stück mit dem plattenartigen Teil formen.

Zwecks Zufuhr der minimalen notwendigen Schmiermittelmenge zu den im Gleitstück endlos umlaufenden Rollelementen ist vorzugsweise ein Halte- und Zufuhrmaterial zum Halten von Schmiermittel und seinem allmählichen Zuführen zu den Rollelementen im Richtungsumkehrgang in das Schmiermittelzufuhrloch und die Schmiermittelzufuhrrinne gestopft. Beispielsweise kann Harz, Gummi oder Filz für dieses Halte- und Zufuhrmaterial verwendet werden. In diesem Fall fließt überschüssiges Schmiermittel nicht in den Richtungsumkehrgang aus, und nur eine als Ergebnis des Umlaufs der Rollelemente verbrauchte Schmiermittelmenge fließt durch das Halte- und Zufuhrmaterial aus der Schmiermittelzufuhrrinne zum Schmiermittelzufuhrloch, weshalb sich das Gleitstück lange Zeit mit einer extrem kleinen Schmiermittelmenge betreiben läßt. Wird die als Schmiermittelzufuhrgang vorgesehene Schmiermittelzufuhrrinne auf der Gleitstückseite gebildet und etwas groß gestaltet, läßt sich die Schmiermittelmenge, mit der das Halte- und Zufuhrmaterial getränkt werden kann, groß einstellen, wodurch die Häufigkeit reduziert werden kann, mit der die Arbeiten zum Einleiten von Schmiermittel in das Gleitstück durchgeführt werden müssen.

Da in einem Halte- und Zufuhrmaterial, z. B. Filz, gehaltenes Schmiermittel als Ergebnis von Kapillarwirkung gegen die Schwerkraft fließen kann, läßt sich bei Stopfen dieses Halte- und Zufuhrmaterials in die Schmiermittelzufuhrrinne und das Schmiermittelzufuhrloch Schmiermittel auch einem Richtungsumkehrgang sicher zuführen, zu dem eine Schmiermittelzufuhr infolge eines Einflusses der Arbeitshöhe des Gleitstücks relativ schwierig ist.

Zu den "Rollelementen" in der Erfindung gehören Kugeln und Rollen, und die Erfindung kann wirksam die zuvor beschriebenen Effekte in einer Linearführungsvorrichtung bereitstellen, in der entweder Kugeln oder Rollen zum Einsatz kommen.

Fig. 1 ist eine Perspektivansicht einer ersten bevorzugten Ausführungsform einer Linearführungsvorrichtung, in der die Erfindung angewendet wurde;

Fig. 2 ist eine Schnittansicht der gleichen Linearführungsvorrichtung;

Fig. 3 ist eine Perspektivansicht eines Abdeckteils der ersten bevorzugten Ausführungsform im Blick von der Seite einer Fläche davon, die an einem beweglichen Block anzuordnen ist;

Fig. 4 ist eine Schnittansicht eines Kugelrichtungsumkehrgangs, der in einem Abdeckteil gemäß der ersten bevorzugten Ausführungsform gebildet ist;

Fig. 5 ist eine Perspektivansicht eines Abdichtungsteils gemäß der ersten bevorzugten Ausführungsform im Blick von der Seite einer Fläche davon, die an einem Abdeckteil anzuordnen ist;

Fig. 6 ist eine Schnittansicht einer im Abdichtungsteil gebildeten Schmiermittelzufuhrrinne;

Fig. 7 ist eine Perspektivansicht eines Abdeckteils einer Linearführungsvorrichtung einer zweiten bevorzugten Ausführungsform im Blick von der Seite einer Fläche davon, an der ein Abdichtungsteil zu befestigen ist; und

Fig. 8 ist eine Schnittansicht eines Kugelrichtungsumkehrgangs, der in einem Abdeckteil gemäß der zweiten bevorzugten Ausführungsform gebildet ist.

Im folgenden wird eine Linearführungsvorrichtung anhand der beigefügten Zeichnungen näher beschrieben.

Fig. 1 und **Fig.** 2 zeigen eine erste bevorzugte Ausführungsform einer erfindungsgemäßen Linearführungsvorrichtung. In diesen Darstellungen hat eine Spurschiene **1** Führungsfedern **11**, die in Axialrichtung in ihrem linken und rechten Schulterteil vorgesehen sind. Kugelrollflächen **12**, auf denen Kugeln **2** rollen, sind in einem oberen und unteren Teil jeder der Führungsfedern **11** gebildet, und jede der Kugelrollflächen **12** bildet einen Winkel von 45° zu einer Querrichtung und einer Schubrichtung. Diese Spurschiene **1** ist durch (nicht gezeigte) Befestigungsbolzen an einem feststehenden Teil, z. B. einem (nicht gezeigten) Bett, befestigt. In **Fig.** 1 bezeichnet die Bezugszahl **13** Bolzenlöcher, durch die diese Befestigungsbolzen geführt werden.

Die Bezugszahl **3** bezeichnet ein Gleitstück, das sich entlang der Spurschiene **1** bewegt und aus einem beweglichen Block **4**, der zusammen mit der Spurschiene **1** die Kugeln **2** dazwischen aufnimmt, einem Paar Abdeckteilen **5**, die an einer Vorder- und Rückendfläche dieses beweglichen Blocks befestigt sind, und einem Paar Abdichtungsteilen (plattenartigen Teilen) **6**, die an den Außenflächen dieser Abdeckteile **5** befestigt sind, hergestellt ist.

Gemäß **Fig.** 2 ist der bewegliche Block **4** in Form eines Sattels ausgebildet, der die Spurschiene **1** überspannt und ein waagerechtes Teil **4**a sowie ein Paar Hülsenteile **4**b hat, die von den Seiten dieses waagerechten Teils **4**a herabhängen, und vier Lastrollflächen **41**, die zusammen mit den Kugelrollflächen **12** der Spurschiene **1** die Kugeln **2** dazwischen aufnehmen, sind auf den Innenflächen dieser Hülsenteile **4**b gebildet. Außerdem durchlaufen Kugelrücklaufgänge **42**, die den Lastrollflächen **41** entsprechen und parallel dazu sind, die Hülsenteile **4**b. Anordnungsteile **44** mit Bolzenlöchern **43** sind von den Seitenflächen des beweglichen Blocks **4** vorspringend vorgesehen, und der bewegliche Block **4** ist an einem bewegbaren Körper, z. B. einem (nicht gezeigten) Tisch, durch (nicht gezeigte) Befestigungsbolzen befestigt, die durch die vorgenannten Bolzenlöcher **43** von unterhalb dieser Anordnungsteile **44** verlaufen.

Kugelhalteplatten **45**, **46** sind an den unteren Enden der Hülsenteile **4**b des beweglichen Blocks **4** bzw. an der Unterseite des waagerechten Teils **4**a befestigt. Hergestellt sind diese Kugelhalteplatten **45**, **46** z. B. durch Preßformen von Blech oder Spritzgießen eines harten Kunstharzes, und sie verhindern, daß die auf den Lastrollflächen **41** rollenden Kugeln **2** herausfallen, wenn das Gleitstück **3** von der Spurschiene **1** entfernt wird.

Fig. 3 ist eine Perspektivansicht eines der Abdeckteile **5** im Blick von der Rückflächenseite. Jedes der Abdeckteile **5** ist in Form eines Sattels mit einem waagerechten Teil **5**a und einem Paar Hülsenteile **5**b ausgebildet, die von den Seiten dieses waagerechten Teils **5**a wie beim beweglichen Block **4** herabhängen, und Kugelrichtungsumkehrgänge **51**, die einzeln die Lastrollflächen **41** und die Kugelrücklaufgänge **42** der Blockseite verbinden, sind in den Rückflächenseiten der Hülsenteile **5**b vorgesehen.

In **Fig.** 4 ist einer dieser Kugelrichtungsumkehrgänge **51** näher dargestellt. Eine im wesentlichen halbkreisförmige Außenführungsfläche **52** ist im Abdeckteil **5** gebildet und führt die Kugeln **2** in einem Kreisbogen zwischen der Kugelrollfläche **12** der Spurschiene **1** und dem Kugelrücklaufgang **42**. Ein Schaufelteil **53** zum Hochschaufeln der Kugeln **2** von der Kugelrollfläche **12** der Spurschiene **1** ist am Ende dieser Außenführungsfläche **52** gebildet. Ein Kugelführungsteil **7** paßt sich gegenüber dieser Außenführungsfläche **52** ein, und eine Innenführungsfläche **71** zum Führen der Kugeln **2** zwischen dem Kugelrücklaufgang **42** und der Lastrollfläche **41** ist auf diesem Kugelführungsteil **7** gebildet. Das heißt, durch das Einpassen des Kugelführungsteils **7** in das Abdeckteil **5** gemäß **Fig.** 4 liegen die Außenführungsfläche **52** und die Innenführungsfläche **71** einander gegenüber, und ein Kugelrichtungsumkehrgang **51** ist vervollständigt.

Schmiermittelzufuhrlöcher **56** sind einzeln vorgesehen und erstrecken sich zwischen der Außenfläche des Abdeckteils **5**, an dem das Abdichtungsteil **6** befestigt ist, und den Kugelrichtungsumkehrgängen **51**, und ein Schmiermittel, z. B. Schmierfett, kann in die Kugelrichtungsumkehrgänge **51** durch diese Schmiermittelzufuhrlöcher **56** eingeleitet werden, um die durch das Innere der Kugelrichtungsumkehrgänge **51** rollenden Kugeln **2** zu schmieren.

Diese Abdeckteile **5** sind an den Enden des beweglichen Blocks **4** mittels Innensechskantbolzen befestigt, die durch Anordnungslöcher **54** laufen. Vorsprünge **55** zum Positionieren sind von der Rückfläche jedes der Abdeckteile **5** um die Anordnungslöcher **54** vorragend vorgesehen, und durch Einpassen dieser Vorsprünge **55** in (nicht gezeigte) Aussparungen in den Endflächen des beweglichen Blocks **4** sind die Abdeckteile **5** gegenüber dem beweglichen Block **4** genau positioniert. Bei einer solchen Befestigung der Abdeckteile **5** am beweglichen Block **4** sind die Kugelrichtungsumkehrgänge **51** der Abdeckteile **5** und die Kugelrücklaufgänge **42** des beweglichen Blocks **4** verbunden, und endlose Kugelumlaufgänge zum Umwälzen der Kugeln **2** von einem Ende jeder der Lastrollflächen **41** zum anderen sind vervollständigt.

Gemäß **Fig.** 4 und **Fig.** 5 erfolgt die Herstellung jedes der Abdichtungsteile **6** durch Überziehen der Rückflächenseite, d. h. der Seite, die an das jeweilige Abdeckteil **5** anstoßen soll, einer als Kern dienenden Platte **61** mit einem Gummiformteil **62** durch Vulkanisationsformen, und die Gesamtheit ist in Form einer Platte gebildet, die im wesentlichen die gleiche Außenform wie der Querschnitt des Abdeckteils **5** hat. Ein Lippenteil **63**, das eine Gleitberührung mit der Spurschiene **1** herstellt, ist einstückig mit dem Gummiformteil **62** entlang der zur Spurschiene **1** weisenden Seite des Abdichtungsteils **6** gebildet und verhindert, daß Staub, Schmiermittel usw., die an der Spurschiene **1** haften, in das Innere des Gleitstücks **3** bei Bewegung des Gleitstücks **3** eintreten. In **Fig.** 5 bezeichnet die Bezugszahl **64** Schraubenlöcher zum Befestigen des Abdichtungsteils **6** am Abdeckteil **5**.

Ein Schmierspeicher **57** ist in der Endfläche des Abdeckteils **5** gebildet, an dem dieses Abdichtungsteil **6** befestigt ist (siehe **Fig.** 1), und ein (nicht gezeigter) Schmiernippel kann in diesen Schmierspeicher **57** durch eine im Abdichtungsteil **6** gebildete Ölzufuhröffnung **65** eingeschraubt sein.

Eine den Schmierspeicher **57** mit den Schmiermittelzufuhrlöchern **56** verbindende Schmiermittelzufuhrrinne **66** ist im Gummiformteil **62** des an die Endfläche des Abdeckteils **5** anstoßenden Abdichtungsteils **6** gebildet, und durch die Befestigung dieses Abdichtungsteils **6** an der Endfläche des Abdeckteils **5** ist ein Schmiermittelzufuhrgang vervollständigt, der sich vom Schmierspeicher **57** zu den Kugelrichtungsumkehrgängen **51** erstreckt.

Außerdem ist gemäß **Fig.** 6 ein streifenförmiger Vorsprung **67** über den gesamten Weg entlang den Seiten der Schmiermittelzufuhrrinne **66** gebildet, und bei Befestigung des Abdichtungsteils **6** am Abdeckteil **5** stellt der streifenförmige Vorsprung **67** eine dichte, eng anliegende Berührung mit der Endfläche des Abdeckteils **5** her und verhindert sicher, daß Schmiermittel aus dem Inneren der Schmiermittelzufuhrrinne **66** austritt.

Wird bei einer Linearführungsvorrichtung dieser bevorzugten Ausführungsform mit dem zuvor beschriebenen Aufbau Schmierfett aus einem am Abdeckteil **5** befestigten Schmiernippel unter Verwendung einer Schmierpresse eingespritzt, tritt es in die Schmiermittelzufuhrrinne **66** des Abdichtungsteils **6** über den in der Endfläche des Abdeckteils **5** gebildeten Schmierspeicher **57** ein, läuft entlang dieser Schmiermittelzufuhrrinne **66** und spritzt durch die Schmiermittelzufuhrlöcher **56** in die Kugelrichtungsumkehrgänge **51** aus. Damit werden die durch diese Kugelrichtungsumkehrgänge **51** rollenden Kugeln **2** durch das Schmierfett geschmiert, und das Schmierfett breitet sich zu den Lastrollflächen **41** und den Kugelrücklaufgängen **42** beim Umlaufen der Kugeln **2** aus.

Da hierbei das Gummiformteil **62** des am Abdeckteil **5** befestigten Abdichtungsteils **6** an die Endfläche des Abdeckteils **5** anstößt und dieses Gummiformteil **62** durch die Platte **61** in eng anliegende Berührung mit dem Abdeckteil **5** gedrückt wird, bilden sich keine Spalte zwischen dem Abdichtungsteil **6** und dem Abdeckteil **5**. Daher tritt kein Schmierfett aus dem Schmierspeicher **57** oder der Schmiermittelzufuhrrinne **66** aus, und das unter Druck mittels Schmierpresse eingeleitete Schmierfett kann in die Richtungsumkehrgänge **51** sicher eingespritzt werden.

Obwohl in der zuvor beschriebenen bevorzugten Ausführungsform Schmierfett unter Verwendung einer Schmierpresse eingeleitet wird, kann alternativ ein Aufbau zum Einsatz kommen, bei dem ein Rohr kontinuierlich mit dem Gleitstück **3** verbunden ist und ein Schmiermittel in Nebelform in die Schmiermittelzufuhrrinne **66** unter Verwendung dieses Rohrs eingeblasen wird.

Obwohl ferner in dieser bevorzugten Ausführungsform ein ursprünglich zur Staubverhinderung vorgesehenes Abdichtungsteil **6** auch als plattenartiges Teil wirkt, das einen Schmiermittelzufuhrgang zwischen sich und dem Gleitstück **3** bildet, um eine Erhöhung der Anzahl von Teilen zu umgehen, die aus der Bereitstellung des plattenartigen Teils resultiert, kann alternativ ein Aufbau zum Einsatz kommen, bei dem z. B. ein plattenartiges Teil aus dem gleichen Material getrennt vom Abdichtungsteil hergestellt und an der Endfläche des Gleitstücks befestigt ist, um einen Schmiermittelzufuhrgang zu bilden.

Als nächstes wird eine zweite bevorzugte Ausführungsform einer erfindungsgemäßen Linearführungsvorrichtung beschrieben.

Während in der zuvor beschriebenen ersten bevorzugten Ausführungsform die Schmiermittelzufuhrrinne **66** in dem am Abdeckteil **5** befestigten Abdichtungsteil **6** gebildet war, ist in dieser zweiten bevorzugten Ausführungsform die

Schmiermittelzufuhrrinne **66** auf der Seite des Abdeckteils **5** gebildet, und ein Halte- und Zufuhrmaterial ist in diese Schmiermittelzufuhrrinne gestopft.

Fig. 7 ist eine Perspektivansicht eines Abdeckteils **5** dieser bevorzugten Ausführungsform im Blick von seiner Seite, an der ein Abdichtungsteil **6** zu befestigten ist. In dieser Seite des Abdeckteils **5** ist eine Aussparung **58** zum Halten von Schmiermittel im waagerechten Teil **5**a des Abdeckteils **5** gebildet, und Schmiermittelzufuhrrinnen **59** in Verbindung mit dieser Aussparung **58** sind in den Hülsenteilen **5**b gebildet. Außerdem sind wie bei der Beschreibung der ersten bevorzugten Ausführungsform Schmiermittelzufuhrlöcher **56** in Verbindung mit Kugelrichtungsumkehrgängen **51** in diesem Abdeckteil **5** vorgesehen, und die Schmiermittelzufuhrrinnen **59** sind ebenfalls mit diesen Schmiermittelzufuhrlöchern **56** verbunden. Mit einem Schmiermittel getränkter Filz **60** ist in die Aussparung **58**, die Schmiermittelzufuhrrinnen **59** und die Schmiermittelzufuhrlöcher **56** gestopft.

Fig. 8 ist eine Schnittansicht dieses Abdeckteils **5** der zweiten bevorzugten Ausführungsform, das am zuvor beschriebenen beweglichen Block **4** mit einem Abdichtungsteil **6** befestigt ist, das am Abdeckteil **5** befestigt ist. Bei Befestigung dieses Abdeckteils **5** am beweglichen Block **4** gemäß der vorstehenden Beschreibung ist jeder der Kugelrichtungsumkehrgänge **51** des Abdeckteils **5** mit einem Kugelrücklaufgang **42** des beweglichen Blocks **4** verbunden und komplettiert einen endlosen Umlaufgang für umlaufende Kugeln **2** von einem Ende einer Lastrollfläche **41** zum anderen, wobei Spitzen des in die Schmiermittelzufuhrlöcher **56** gestopften Filzes **60** etwas in die Kugelrichtungsumkehrgänge **51** vorragen.

Der übrige Aufbau des Abdeckteils **5**, d. h. die Spurschiene **1**, der bewegliche Block **4** usw., entspricht exakt dem der zuvor beschriebenen ersten bevorzugten Ausführungsform und wird daher hier nicht beschrieben.

Bei Befestigung des Abdichtungsteils **6** am Abdeckteil **5** sind auch bei der Linearführungsvorrichtung dieser bevorzugten Ausführungsform die im Abdeckteil **5** gebildete Aussparung **58** und die Schmiermittelzufuhrrinne **59** durch das Abdichtungsteil **6** abgedeckt, und ein Schmiermittelzufuhrgang, der sich von der Aussparung **58** zu den Kugelrichtungsumkehrgängen **51** erstreckt, ist vervollständigt. Da hierbei das Gummiformteil **62** des Abdichtungsteils **6** dicht an das Abdeckteil **5** anstößt und kein Spalt zwischen beiden gebildet ist, ist auch in dieser bevorzugten Ausführungsform der Schmiermittelaustritt aus der Aussparung **58** oder der Schmiermittelzufuhrrinne **59** sicher verhindert.

Da ferner in dieser bevorzugten Ausführungsform Filz **60** in die Aussparung **58**, die Schmiermittelzufuhrrinnen **59** und die Schmiermittelzufuhrlöcher **56** gestopft ist, wird in die Aussparung **58** durch die Ölzufuhröffnung **65** im Abdichtungsteil **6** eingespritztes Schmiermittel vom Filz **60** aufgenommen und gehalten und durchläuft diesen Filz **60** zu den Kugelrichtungsumkehrgängen **51**. Da Schmiermittel direkt auf die Kugeln **2** aus dem etwas in die Kugelrichtungsumkehrgänge **51** vorragenden Filz **60** aufgetragen wird, fließt somit Schmiermittel nicht umsonst in die Kugelrichtungsumkehrgänge **51**, und die Kugeln **2** können mit der minimalen notwendigen Schmiermittelmenge sicher geschmiert werden.

Da zudem in dieser bevorzugten Ausführungsform die Aussparung **58** etwas größer als die Schmiermittelzufuhrrinnen **59** ausgebildet ist, so daß eine wesentliche Schmiermittelmenge im Filz **60** innerhalb dieser Aussparung **58** gehalten werden kann, wird durch die Ölzufuhröffnung **65** des Abdichtungsteils **6** eingespritztes Schmiermittel nicht schnell verbraucht, wodurch die Häufigkeit reduziert werden kann, mit der die Arbeiten zur erneuten Schmiermittelzufuhr zum Gleitstück durchzuführen sind, während die Linearführungsvorrichtung in Gebrauch ist.

Patentansprüche

1. Linearführungsvorrichtung mit: einer Spurschiene mit einer Wälzfläche aus Wälzelementen und einem Gleitstück, das eine zur Wälzfläche der Spurschiene weisende Lastwälzfläche mit den Wälzelementen dazwischen sowie einen Wälzelementrücklaufgang hat, der parallel zu dieser Lastwälzfläche ist, und bogenförmige Richtungsumkehrgänge zum Führen der Wälzelemente zwischen der Lastwälzfläche und dem Wälzelementrücklaufgang hat und sich entlang der Spurschiene bewegen kann, wobei die Wälzelemente endlos umlaufen,
wobei ein Schmiermittelzufuhrloch in Verbindung mit einem der Richtungsumkehrgänge in einer Vorder- und/oder Rückendfläche des Gleitstücks vorgesehen und die Endfläche, in der das Schmiermittelzufuhrloch vorgesehen ist, mit einem plattenartigen Teil abgedeckt ist, und eine Schmiermittelzufuhrrinne in Verbindung mit dem Schmiermittelzufuhrloch in dieser Endfläche und/oder der Innenfläche des diese Endfläche abdekkenden plattenartigen Teils vorgesehen und ein Schmiermittelzufuhrgang durch das am Gleitstück befestigte plattenartige Teil gebildet ist.
2. Vorrichtung nach Anspruch 1, wobei mindestens ein Teil des eine Berührung mit der Endfläche des Gleitstücks herstellenden plattenartigen Teils aus einem viskoelastischen Material besteht.
3. Vorrichtung nach Anspruch 1 oder 2, wobei das plattenartige Teil ein Abdichtungsteil ist, das eine Gleitberührung mit der Spurschiene herstellt.
4. Vorrichtung nach Anspruch 1, 2 oder 3, wobei ein streifenförmiger Vorsprung, der an die Endfläche des Gleitstücks anstößt, über den gesamten Umfangsweg der Schmiermittelzufuhrrinne gebildet ist.
5. Vorrichtung nach einem der Ansprüche 1 bis 4, wobei ein Halte- und Zufuhrmaterial zum Halten von Schmiermittel und zu seinem allmählichen Zuführen zu den Wälzelementen innerhalb des Richtungsumkehrgangs in das Schmiermittelzufuhrloch und die Schmiermittelzufuhrrinne gestopft ist.

Hierzu 8 Seite(n) Zeichnungen

- Leerseite -

Nummer: **DE 198 28 587 A1**
Int. Cl.[6]: **F 16 C 33/66**
Offenlegungstag: 7. Januar 1999

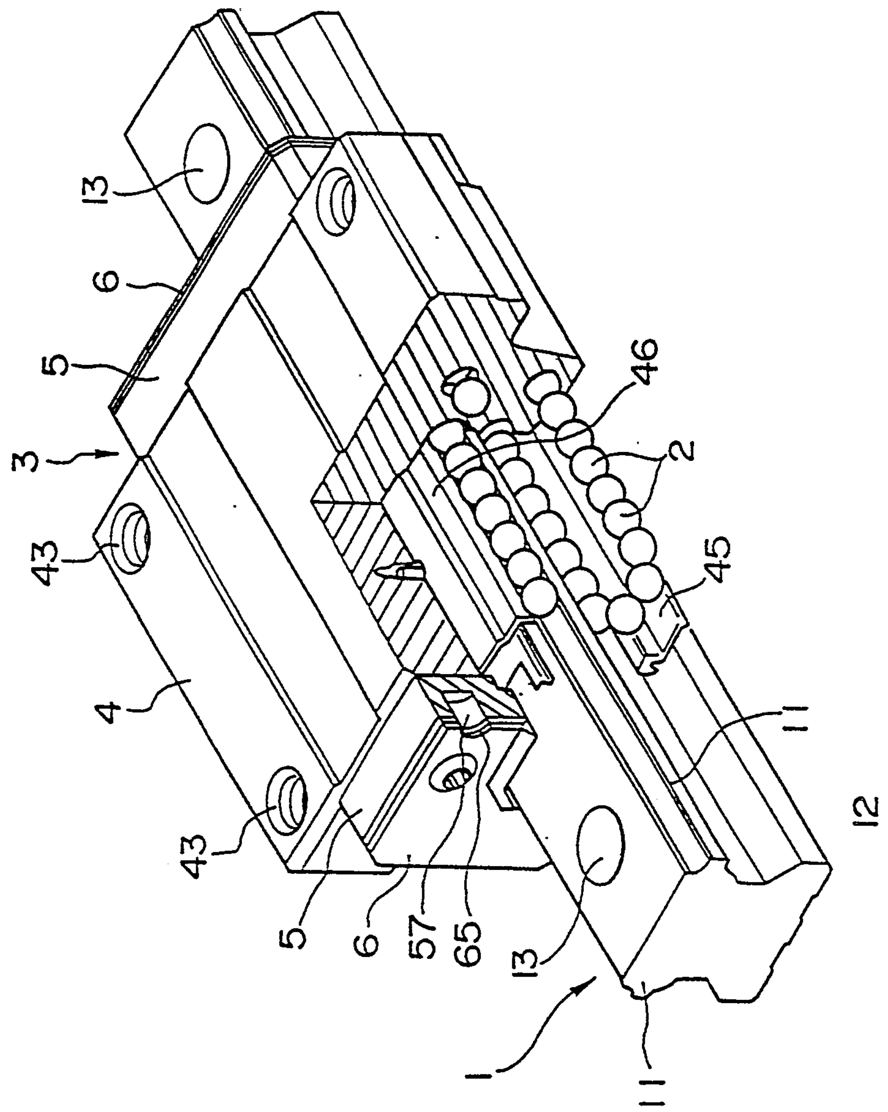
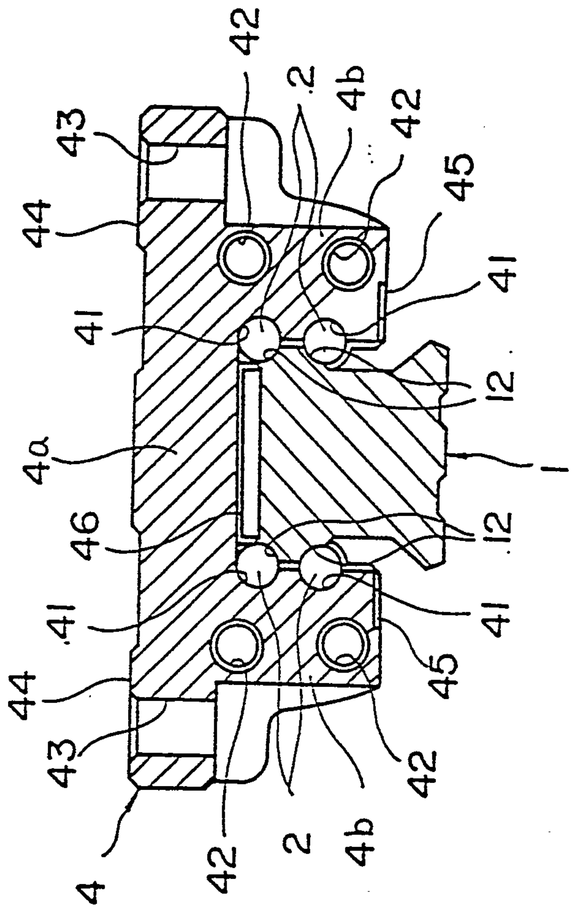


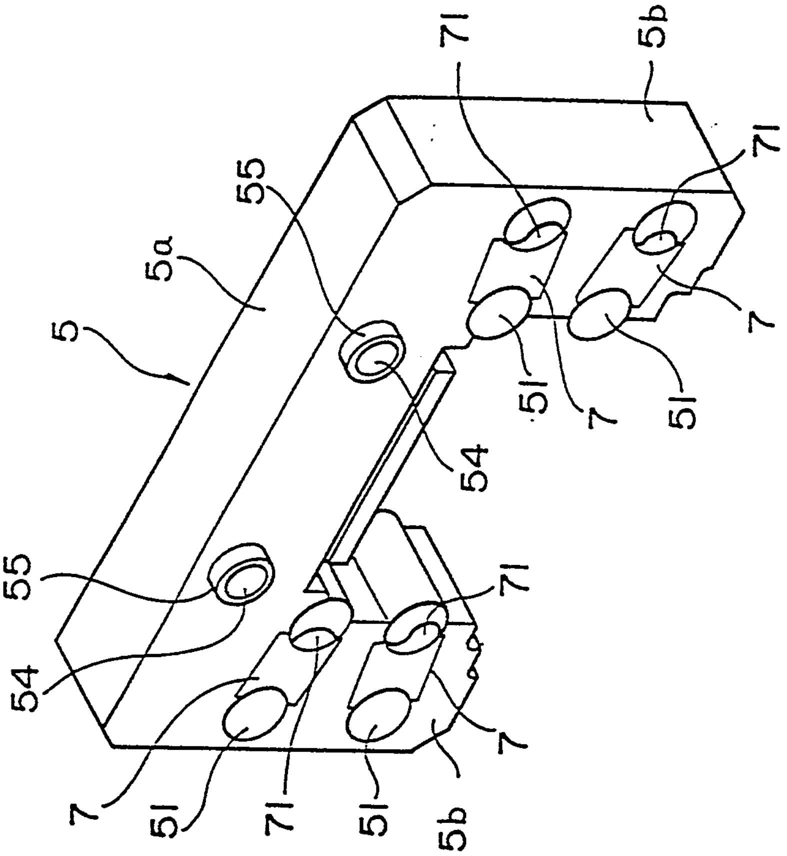
Fig. 1

Fig. 2



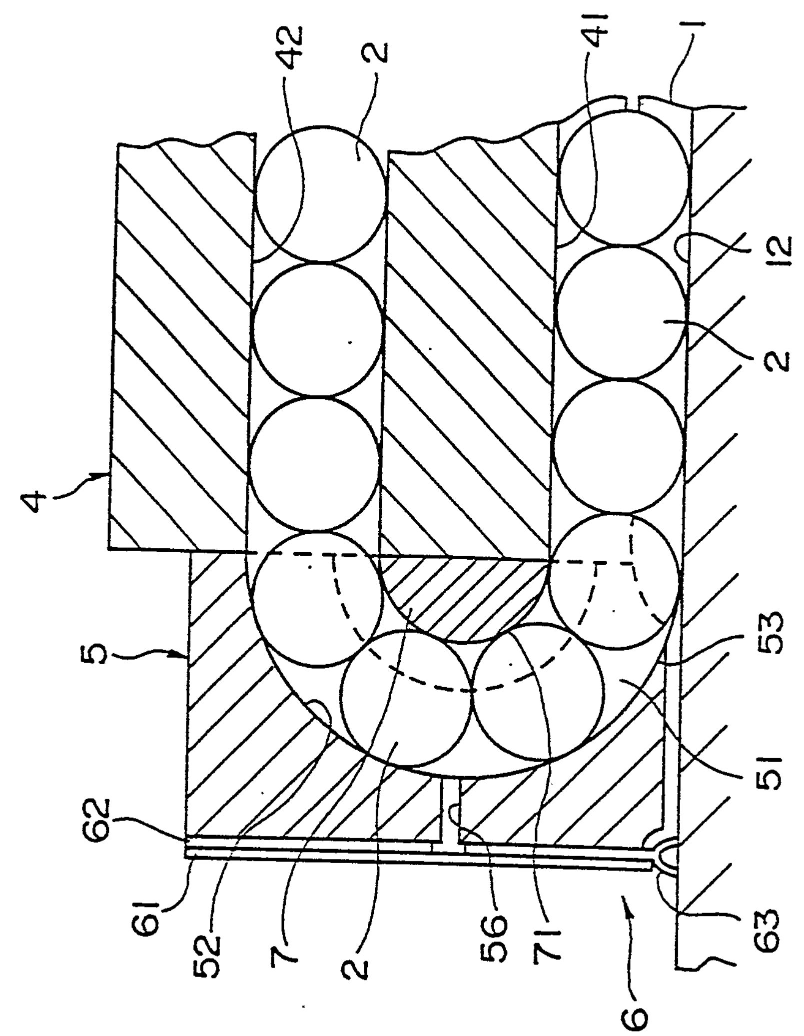
Nummer: DE 198 28 587 A1
Int. Cl.6: F 16 C 33/66
Offenlegungstag: 7. Januar 1999

Fig. 3



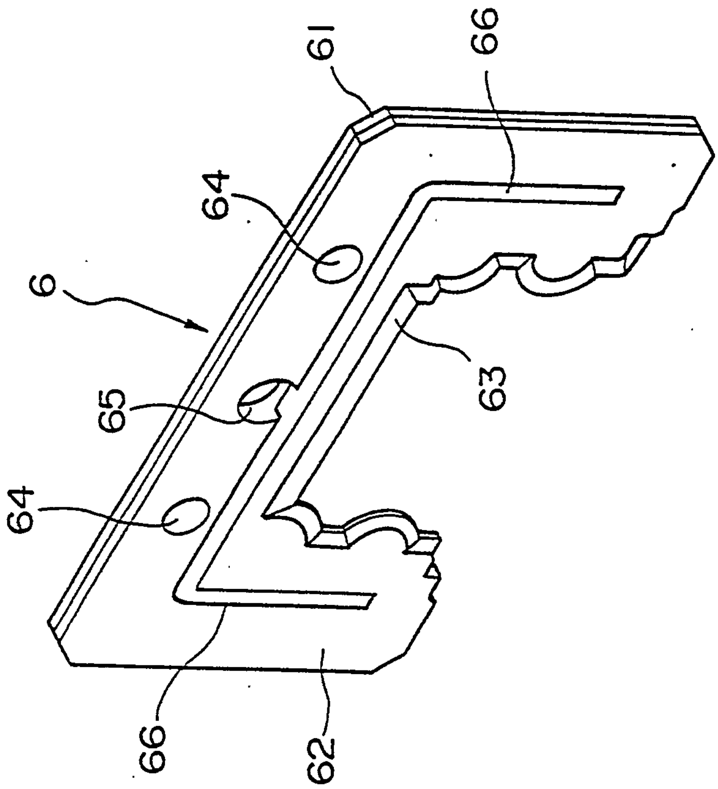
Nummer: DE 198 28 587 A1
Int. Cl.[6]: F 16 C 33/66
Offenlegungstag: 7. Januar 1999

Fig. 4



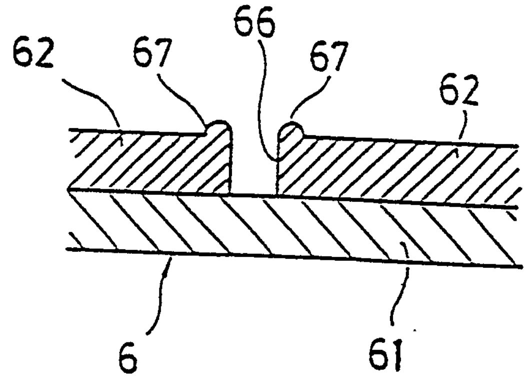
Nummer: DE 198 28 587 A1
Int. Cl.[6]: F 16 C 33/66
Offenlegungstag: 7. Januar 1999

Fig. 5



Nummer: DE 198 28 587 A1
Int. Cl.[6]: F 16 C 33/66
Offenlegungstag: 7. Januar 1999

Fig. 6



Nummer: DE 198 28 587 A1
Int. Cl.[6]: F 16 C 33/66
Offenlegungstag: 7. Januar 1999

Fig. 7

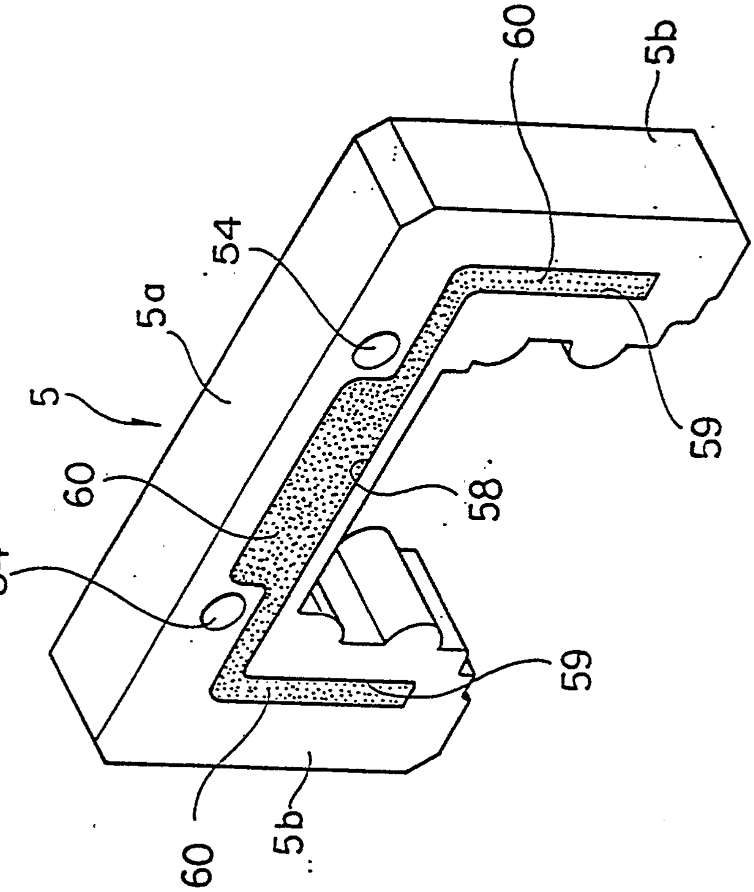
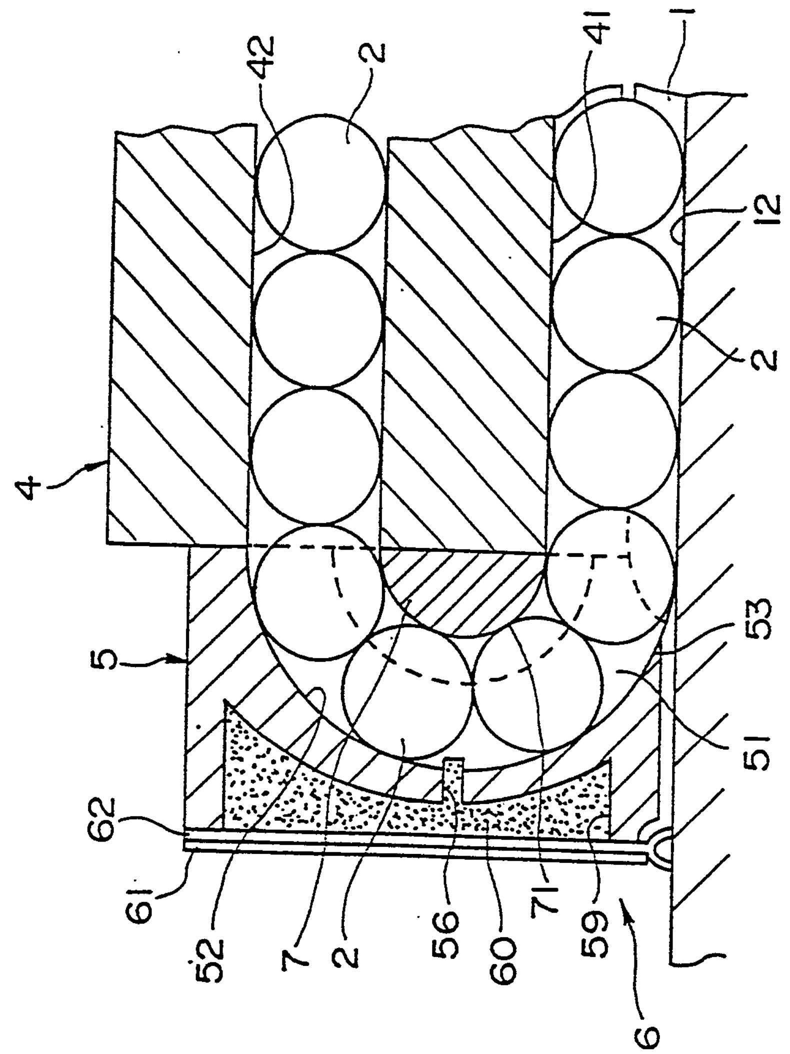


Fig. 8



(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 198 26 703 A 1**

(51) Int. Cl.^{6}:
F 16 C 29/04
B 23 Q 1/40

(21) Aktenzeichen: 198 26 703.7
(22) Anmeldetag: 16. 6. 98
(43) Offenlegungstag: 21. 1. 99

(30) Unionspriorität:
9-175336 16. 06. 97 JP
30. 04. 98 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Grünecker, Kinkeldey, Stockmair & Schwanhäusser, Anwaltssozietät, 80538 München

(72) Erfinder:
Michioka, Hidekazu, Tokio/Tokyo, JP; Iida, Katsuya, Tokio/Tokyo, JP; Yoshihashi, Masahiro, Tokio/Tokyo, JP; Mochizuki, Hiroaki, Tokio/Tokyo, JP; Hirokawa, Tadashi, Tokio/Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Führungseinrichtung für eine geradlinige Bewegung

(57) Eine Führungsvorrichtung für eine geradlinige Bewegung umfaßt eine mit einer Kugellaufrille versehene Führungsschiene und einen entlang der Führungsschiene über Kugeln beweglich angeordneten beweglichen Block. Der bewegliche Block ist mit einer Kugelgegenlaufrille, einem von der Kugelgegenlaufrille beabstandeten Kugelrücklauf und mit Richtungswechseldurchlässen, die diese Teile miteinander verbinden, versehen.
Ein aus Harz gebildeter Körper, der den Kugelumlauf bildet, weist ein Paar von einem Kugeldurchlaß bildenden Abschnitten, einen einen Rücklauf bildenden Abschnitt und ein Paar von einen Richtungswechseldurchlaß und innere Führung bildenden Abschnitten auf. Der aus Harz gebildete Körper ist getrennt von einem Körper des beweglichen Blocks ausgebildet. Zumindest zwei Abschnitte der (a) den Kugeldurchlaß bildenden Abschnitte, (b) des den Rücklauf bildenden Abschnittes, (c) einer der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte und (d) ein weiterer der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte sind durch einstückige Formgebung derart miteinander verbunden, daß der aus Harz gebildete Körper in den Körper des beweglichen Blocks eingebaut werden kann.

DE 198 26 703 A 1

DE 198 26 703 A 1

Beschreibung

HINTERGRUND DER ERFINDUNG

Gebiet der Erfindung

Die vorliegende Erfindung bezieht sich auf eine Führungsvorrichtung für eine geradlinige Bewegung, bei der ein einen Durchlaß ausbildendes Teil, das aus Harz ausgeformt ist, in einen Körper eines beweglichen Teils eingebaut ist.

Beschreibung der verwandten Technik

Der Anmelder hat bereits eine technische Erfindung vorgeschlagen, daß bei einem beweglichen Block einer Führungsvorrichtung für eine geradlinige Bewegung ein Paar von Abschnitten, die einen Kugeldurchlaß bilden und sich entlang den gegenüberliegenden, in Längsrichtung verlaufenden Seiten einer Tragkugellaufnut erstrecken, ein Abschnitt, der einen Kugelrücklauf ausbildet, und ein Paar von Abschnitten, die eine innere Führung und einen Richtungswechseldurchlaß bilden, einstückig in einem Körper des beweglichen Blocks aus Harz gefertigt sind (vgl. vorläufige japanische Patentveröffentlichung Nr. H7-317 762).

Wenn insbesondere die Formgebung aus Harz durchgeführt wird, wird der Körper des beweglichen Blockes in eine Form eingesetzt und die den Kugeldurchlaß bildenden Abschnitte, die einen Richtungswechseldurchlaß und innere Führung bildenden Abschnitte oder der den Ballrücklauf bildende Abschnitt sind im Blockkörper einstückig ausgebildet.

Bei dem herkömmlichen, beweglichen Block, der durch eine einstückige Ausbildung erhalten wird, wird der Blockkörper wie oben erwähnt in die Form eingesetzt. Wenn der Blockkörper groß ist, muß eine entsprechend große Form verwendet werden. Es ist zum einen nicht einfach, eine derartige große Form vorzubereiten und zum anderen gibt es hinsichtlich der Größe tatsächlich eine Beschränkung. Die den Kugeldurchlaß bildenden Abschnitte, die an den gegenüberliegenden, in Längsrichtung verlaufenden Seiten der Kugellaufnut angeordnet sind und sich in Längsrichtung des Blockkörpers erstrecken, sind schmal und lang, was zur Folge hat, daß flüssiges Harz nicht jeden Raumabschnitt zur Ausbildung der den Kugeldurchlaß bildenden Abschnitte während der Formgebung mit Harz erreichen kann.

Eine Erhöhung der Anzahl von Eingußstellen, die in der Form ausgebildet sind, kann das oben erwähnte Problem einer vom flüssigen Harz mangelhaft ausgefüllten Form lösen. Wenn jedoch der Blockkörper in die Form eingesetzt wird, kann der Blockkörper dem Lauf des flüssigen Harzes verschlechtern.

Wenn der bewegliche Block ein Paar von Schenkelabschnitten aufweist, die rechten und linken Seitenabschnitten der Führungsschiene gegenüberliegen, so daß die Führungsschiene zwischen den Schenkelabschnitten gehalten ist, und vier Kugelzüge zwischen den rechten und linken Seitenabschnitten der Führungsschiene und den rechten und linken Schenkelabschnitten des beweglichen Blockes vorgesehen sind und insbesondere die oberen und unteren Kugellaufbahnen jeweils an einer Lücke zwischen dem rechten Seitenabschnitt des Führungsabschnittes und dem entsprechenden rechten Schenkelabschnitt des beweglichen Blockes und an einer weiteren Lücke zwischen dem linken Seitenabschnitt der Führungsschiene und dem entsprechenden linken Schenkelabschnitt des beweglichen Blockes sich befinden, dann kann der in die Form eingesetzte Blockkörper den Lauf des flüssigen Harz in Breitenrichtung des beweglichen Blockes verschlechtern.

ZUSAMMENFASSUNG DER ERFINDUNG

Ein Ziel der vorliegenden Erfindung ist daher, eine Führungsvorrichtung für eine geradlinige Bewegung bereitzustellen, bei der ein aus Harz geformter Körper zur Ausbildung eines Rollkörperumlaufs getrennt von einem Körper eines beweglichen Teils ausgebildet ist, so daß eine leichte Formgebung des aus Harz gebildeten Körpers möglich ist und der derartig aus Harz gebildete Körper in den Körper des beweglichen Teils eingebaut werden kann, wodurch eine einstückige Formbarkeit der größtmöglichen Anzahl von Einheitsstücken zur Bestimmung des Rollkörperumlaufs sichergestellt wird.

Um das obengenannte Ziel zu erreichen, weist eine Führungsvorrichtung für eine geradlinige Bewegung die folgenden Merkmale auf:
ein Führungsteil, das mit einer Rollkörperlaufbahn versehen ist, und
ein bewegliches Teil, das derart angeordnet ist, daß es entlang des Führungsteils über eine große Anzahl von Rollkörpern beweglich ist, wobei das bewegliche Teil versehen ist mit (**1**) einer Rollkörpergegenlaufbahn, die der Rollkörperlaufbahn des Führungsteils entspricht, (ii) einem Rollkörperrücklauf, der in einem vorgegebenen Abstand von der Rollkörpergegenlaufbahn parallel zu dieser angeordnet ist und (iii) einem Paar von Richtungswechseldurchlässen, die die Rollkörpergegenlaufbahn und den Rollkörperrücklauf verbinden, um einen Umlauf der Rollkörper zu ermöglichen,
dadurch gekennzeichnet, daß:
ein aus Harz gebildeter Körper, der einen Rollkörperumlauf bildet, ein Paar von einen Rollkörperdurchlaß bildenden Abschnitten aufweist, die sich entlang der beiden in Längsrichtung verlaufenden Seiten der Rollkörpergegenlaufbahn erstrecken, einen einen Rücklauf bildenden Abschnitt, der einen Rollkörperrücklauf bildet, und ein Paar von einen Richtungswechseldurchlaß und innere Führung ausbildenden Abschnitten, die innere, in Umfangsrichtung verlaufende Führungsabschnitte der Richtungswechseldurchlässe bilden, wobei der aus Harz geformte Körper getrennt vom Körper des beweglichen Teils ausgebildet ist; und
zumindest zwei Abschnitte (a) des Paars der den Rollkörperdurchlaß bildenden Abschnitte (b) des den Rücklauf bildenden Abschnittes, (c) einer des Paars der den Richtungswechseldurchlaß und innere Führung ausbildenden Abschnitte und (d) ein weiteres Paar der den Richtungswechseldurchlaß und innere Führung ausbildenden Abschnitte miteinander einstückig verbunden sind, so daß der aus Harz gebildete Körper in den Körper des beweglichen Teils eingebaut werden kann.

Ausführungsbeispiele der Kombination dieser Abschnitte (a) bis (d) beim aus Harz gebildeten Körper können zur Ausbildung des Rollkörperumlaufs die folgenden drei Beispiele umfassen:
das erste Beispiel, bei dem der aus Harz geformte Körper (i) einen einstückig ausgebildeten Körper aus dem Paar von den den Rollkörperdurchlaß bildenden Abschnitten und dem Paars der den Richtungswechseldurchlaß und innere Führung ausbildenden Abschnitte und (ii) den den Rücklauf bildenden Abschnitt aufweist, die getrennt vom einstückigen Körper ausgebildet sind;
das zweite Beispiel, bei dem der aus Harz gebildete Körper (i) einen einstückig ausgebildeten Körper des Paars von den Rollkörperdurchlaß bildenden Abschnitten, den den Rücklauf ausbildenden Abschnitt und eines Paars der den Richtungswechseldurchlaß und innere Führung ausbildenden Abschnitte, und (ii) ein weiteres Paar der den Richtungswechseldurchlaß und innere Führung ausbildenden Ab-

schnitte aufweist, die getrennt vom einstückigen Körper ausgebildet sind; und

das dritte Beispiel, bei dem der aus Harz gebildete Körper dadurch hergestellt ist, daß ein einstückiger Körper aus dem Paar der den Rollkörperdurchlaß bildenden Abschnitte, dem den Rücklauf ausbildenden Abschnitt und dem Paar der den Richtungswechseldurchlaß und innere Führung ausbildenden Abschnitte vorbereitet wird, und dann das Paar von den Rollkörperdurchlaß ausbildenden Abschnitte und der den Rücklauf ausbildenden Abschnitt jeweils in zwei in Längsrichtung verlaufende, zwischenliegende Abschnitte geteilt ist.

Entsprechend der vorliegenden Erfindung ist der aus Harz gebildete Körper zur Ausbildung des Rollkörperumlaufs getrennt vom Körper des beweglichen Teils ausgebildet. Selbst wenn das bewegliche Teil groß ist, wird dadurch der Fluß des flüssigen Harzes nicht vom Körper des beweglichen Teils behindert wie im Stand der Technik, bei dem der Körper des beweglichen Teils und der aus Harz gebildete Körper einstückig miteinander ausgebildet sind. Dadurch ist es möglich, einen guten Lauf des flüssigen Harz durch eine Erhöhung der Anzahl von Eingußstellen in der Form sicherzustellen, was zu einer hervorragenden Formgebung führt. Im allgemeinen ist ein passender Lauf des flüssigen Harz insbesondere bei den den Rollkörperdurchlaß bildenden Abschnitten, die sich entlang den in Längsrichtung verlaufenden Seiten der Rollkörpergegenlaufbahn erstrecken, schwer zu erreichen und daher ist es von Vorteil, den aus Harz gebildeten Körper getrennt vom Körper des beweglichen Teils gemäß der vorliegenden Erfindung zu formen.

Der Rollkörperumlauf wird durch den aus Harz geformten Körper gebildet. Dadurch kann eine direkte Lagebestimmung in der relativen Lagebeziehung zwischen den den Richtungswechseldurchlaß und innere Führung ausbildenden Abschnitten und dem den Rollkörperdurchlaß bildenden Abschnitt sowie der relativen Lagebeziehung zwischen den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten und dem den Rücklauf bildenden Abschnitt erreicht werden und die Durchgängigkeit des Rollkörperumlaufs wird in vorteilhafter Weise sichergestellt und führt so zu einem glatten Lauf der Rollkörper.

Da die den Rollkörperdurchlaß bildenden Abschnitte entlang der beiden sich in Längsrichtung erstreckenden Seiten der Rollkörpergegenlaufbahn angeordnet sind, sind die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte, die in einer geeigneten relativen Lagebeziehung zu den den Rollkörperdurchlaß bildenden Abschnitten stehen, genau an den beiden Enden der Rollkörpergegenlauffläche gesetzt.

Die Beibehaltung einer geeigneten relativen Lagebeziehung der den Richtungswechseldurchlaß und innere Führung ausbildenden Abschnitte zum Rollkörperrücklauf bewirkt, daß die den Richtungswechseldurchlaß und innere Führung ausbildenden Abschnitte genau mit der inneren Oberfläche des Rollkörperrücklaufs verbunden sind.

Insbesondere findet der Wechsel einer Laufrichtung der Rollkörper in der Verbindungsfläche der den Rollkörperdurchlaß bildenden Abschnitte mit den den Richtungswechseldurchlaß und innere Führung ausbildenden Abschnitte sowie in der Verbindungsfläche der den Richtungswechseldurchlaß und innere Führung ausbildenden Abschnitte mit dem den Rücklauf ausbildendem Abschnitt statt. Wenn zwei Abschnitte in einer derartigen Verbindungsfläche miteinander durch einstückige Formgebung miteinander verbunden werden, ist ein Schritt zum Zusammenbauen dieser beiden Abschnitte nicht notwendig, wodurch es möglich ist, eine glatte Durchgängigkeit dieser beiden Abschnitte sicherzustellen, die durch die Genauigkeit beim Zusammenbau nicht beeinflußt wird.

Wenn die den Rollkörperdurchlaß bildenden Abschnitte und die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte einstückig miteinander ausgebildet sind, um auf diese Weise die glatte Verbindungsfläche zu bilden, ist es möglich, den glatten Lauf der Rollkörper in der Verbindungsfläche dieser Abschnitte zu erreichen und dadurch die Umlaufeigenschaften der Rollkörper zu verbessern, ohne einen aus Harz gefertigten, einen Rücklauf bildenden Abschnitt vorzusehen. Durch einen derartigen Aufbau ist eine leichte Herstellung der Vorrichtung aufgrund des fehlenden, den Rücklauf bildenden Abschnittes möglich.

Die vorliegende Erfindung kann die zusätzlichen Merkmale aufweisen, daß ein Rollkörperkäfig vorgesehen ist, der in der Lage ist, die Rollkörper in einem vorgegebenen Abstand zwischen zwei benachbarten Rollkörpern zu halten und der Seitenkantenabschnitte aufweist, die von beiden Seiten eines jeden Rollkörpers hervorragen; und Führungsnuten zum Führen der Seitenkantenabschnitte des Rollkörperkäfigs am gesamten Umfang des Rollkörperumlaufs ausgebildet sind.

Die vorliegende Erfindung kann die zusätzlichen Merkmale aufweisen, daß ein Halteabschnitt an dem den Rollkörperdurchlaß bildenden Abschnitt vorgesehen ist, um zu verhindern, daß der Rollkörperkäfig seine Lage verläßt, wenn das bewegliche Teil vom Führungsteil entfernt wird, und ein Führungsabschnitt durchgängig am gesamten Umfang des Rollkörperumlaufs ausgebildet ist, um die Seitenkantenabschnitte des Rollkörperkäfigs zu führen.

Ein derartiger Rollkörperkäfig ermöglicht den glatten Umlauf der Rollkörper aufgrund der Wahrung der Durchgängigkeit des Führungsabschnitts für den Rollkörperkäfig.

Da der Führungsabschnitt für den Rollkörperkäfig, der im übrigen eine kleine Dicke aufweist, nicht durch Einsetzen des Körpers des beweglichen Teils in eine Form und dem darauffolgenden Einspritzen von flüssigen Harz in die Form ausgebildet wird, sondern getrennt vom Körper des beweglichen Teils geformt wird, kann die Lage der Eingußstellen ohne Einschränkung durch den Körper des beweglichen Teils frei bestimmt werden, mit dem Ergebnis, daß das flüssige Harz während des Formens des Führungsabschnittes den gesamten, dafür vorgesehenen Raum ausfüllen kann, der in der Form ausgebildet ist.

Die vorliegende Erfindung kann die zusätzlichen Merkmale aufweisen, daß ein jeder der den Richtungswechseldurchlaß und innere Führung ausbildenden Abschnitte einen dünnen Plattenabschnitt aufweist, der mit der Endfläche des Körpers des beweglichen Teils in Kontakt gebracht wird, wobei ein jeder der den Richtungswechseldurchlaß und innere Führung ausbildenden Abschnitte mit den den Rollkörperdurchlaß bildenden Abschnitten oder dem den Rücklauf ausbildenden Abschnitt mittels dem dünnen Plattenabschnitt verbunden ist.

Wenn ein jeder der den Richtungswechseldurchlaß und innere Führung ausbildenden Abschnitte mit den den Rollkörperdurchlaß bildenden Abschnitte mittels dem dünnen Plattenabschnitt verbunden ist, kann eine Verformung des dünnen Plattenabschnitts eine Verschiebung ausgleichen, die zwischen dem den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt und dem den Rollkörperdurchlaß bildenden Abschnitt oder zwischen dem den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt und dem den Rücklauf bildenden Abschnitt auftritt. Dementsprechend ist es möglich, eine genaue Lagebeziehung zwischen dem Ende des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes und dem den Rollkörperdurchlaß bildenden Abschnitt oder zwischen dem den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt und dem den Rücklauf bildenden Abschnitt beizubehalten.

Der dünne Plattenabschnitt wird durch eine auf die seitliche Deckplatte wirkende Klemmkraft gegen das flache Ende des Körpers des beweglichen Teils gedrückt. Die Lage des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes kann dadurch über eine Verformung des dünnen Plattenabschnittes korrigiert werden, selbst wenn der dem Richtungswechseldurchlaß und innere Führung bildende Abschnitt gegenüber der Endfläche des Körpers des beweglichen Teils falsch positioniert ist. Zusätzlich kann der dünne Plattenabschnitt fest zwischen der seitlichen Deckplatte und dem Körper des beweglichen Teils durch die auf die seitliche Deckplatte wirkende Klemmkraft gesichert werden, wodurch eine falsche Plazierung des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes verhindert wird.

Die Vorrichtung der vorliegenden Erfindung kann derart aufgebaut sein, daß das Führungsteil eine Führungsschiene aufweist, das bewegliche Teil einen beweglichen Block aufweist, der mit einem waagerechten Abschnitt versehen ist, welcher einer oberen Fläche der Führungsschiene und einem Paar von Schenkelabschnitten gegenüberliegt, zwischen denen die Führungsschiene an deren rechten und linken Seitenflächen gehalten ist; zwei Rollkörperlaufbahnen in einer Lücke zwischen der oberen Fläche der Führungsschiene und einer unteren Fläche des beweglichen Blocks angeordnet sind und eine einzelne Rollkörperlaufbahn in einer jeden Lücke zwischen den rechten und linken Seitenflächen der Führungsschiene und den beiden Schenkelabschnitten angeordnet ist, so daß insgesamt vier Bahnen vorhanden sind.

Die Vorrichtung der vorliegenden Erfindung kann derart aufgebaut sein, daß das Führungsteil eine Führungsschiene aufweist, das bewegliche Bauteil einen beweglichen Block aufweist, der mit einem Paar von Schenkelabschnitten versehen ist, zwischen denen die Führungsschiene an deren rechten und linken Seitenflächen gehalten ist; und zwei Rollkörperlaufbahnen in einer jeden Lücke zwischen den rechten und linken Seitenflächen der Führungsschiene und den beiden Schenkelabschnitten angeordnet sind, so daß insgesamt vier Bahnen vorhanden sind.

In diesen Fällen können jeweils vier einen Richtungswechseldurchlaß und innere Führung ausbildende Abschnitte in einem einstückigen Körper ausgebildet sein oder die beiden jeweiligen Richtungswechseldurchlaß und innere Führung ausbildenden Ab-. schnitte an einer jeden rechten und linken Seite des beweglichen Blockes können als ein einstückiger Körper ausgebildet sein.

Die Vorrichtung der vorliegenden Erfindung kann derart aufgebaut sein, daß das Führungsteil eine Führungsschiene aufweist, das bewegliche Teil mit einem waagerechten Abschnitt versehen ist, der einer oberen Fläche der Führungsschiene und einem einzelnen Schenkelabschnitt gegenüberliegt, der wiederum einer Seitenfläche der Führungsschiene gegenüberliegt; eine einzelne Rollkörperlaufbahn in einer Lücke zwischen der einen Seitenfläche der Führungsschiene und dem einzelnen Schenkelabschnitt angeordnet ist und eine weitere, einzelne Rollkörperlaufbahn in einer Lücke zwischen der oberen Fläche der Führungsschiene und einer unteren Fläche des waagerechten Abschnitts in der Nähe einer Ecke der Führungsschiene angeordnet ist.

Die Vorrichtung der vorliegenden Erfindung kann derart aufgebaut sein, daß das Führungsteil eine Führungsschiene aufweist; das bewegliche Teil einen beweglichen Block aufweist, der mit einem Paar von Schenkelabschnitten versehen ist, zwischen denen die Führungsschiene an deren rechten und linken Seitenflächen gehalten ist; und eine einzelne Rollkörperlaufbahn in einer jeden Lücke zwischen den rechten und linken Seitenflächen der Führungsschiene und den beiden Schenkelabschnitten angeordnet ist, so daß insgesamt zwei Bahnen vorhanden sind.

Die Vorrichtung der vorliegenden Erfindung kann derart aufgebaut sein, daß das Führungsteil eine Führungsschiene aufweist; das bewegliche Teil einen beweglichen Block aufweist, der entlang einer Seitenfläche der Führungsschiene angeordnet ist; und zwei Rollkörperlaufbahnen in einer Lücke zwischen der einen Seitenfläche der Führungsschiene und dem beweglichen Block angeordnet ist.

Die Vorrichtung der vorliegenden Erfindung kann derart aufgebaut sein, daß das Führungsteil eine Keilwelle aufweist; und das bewegliche Teil ein äußeres Rohr aufweist, das an der Keilwelle über eine Vielzahl von Rollkörperlaufbahnen beweglich gehalten ist.

Zusätzlich ist entsprechend der vorliegenden Erfindung auch eine Führungsvorrichtung für eine geradlinige Bewegung vorgesehen, die folgende Merkmale aufweist:
eine Führungsschiene, die mit zwei Rollkörperlaufbahnen an einer jeden rechten und linken Seitenfläche der Führungsschiene versehen ist, so daß insgesamt vier Rollkörperlaufbahnen vorhanden sind; und
ein beweglicher Block, der mit einem Paar von Schenkelabschnitten versehen ist, zwischen denen die Führungsschiene an deren rechten und linken Seitenflächen gehalten ist, wobei ein jeder der Schenkelabschnitte an einer inneren Fläche zwei Rollkörpergegenlaufbahnen aufweist, die zwei Rollkörperlaufbahnen der Führungsschiene entsprechen, so daß insgesamt vier Rollkörpergegenlaufbahnen vorhanden sind, wobei ferner der bewegliche Block vier endlose Umläufe aufweist, die durch vier Rollkörperrückläufe gebildet sind, die jeweils parallel zu den vier Rollkörpergegenlaufbahnen angeordnet sind und die beiden Enden einer jeden der vier Rollkörpergegenlaufbahnen mit den beiden Enden einer jeden der vier Rollkörperlaufbahnen verbinden,
dadurch gekennzeichnet, daß:
ein aus Harz gebildeter Körper bei einem jeden der endlosen Umläufe ein Paar von einen Rollkörperdurchlaß bildenden Abschnitten aufweist, die sich entlang der beiden in Längsrichtung verlaufenden Seiten der Rollkörpergegenlaufbahn erstrecken, einen einen Rücklauf bildenden Abschnitt für den Rollkörperrücklauf und ein Paar von Richtungswechseldurchlaß und innere Führung ausbildenden Abschnitten aufweist, die innere, in Umfangsrichtung wirkende Führungsabschnitte der Richtungswechseldurchlässe bilden, wobei der aus Harz gebildete Körper getrennt von einem Körper des beweglichen Blockes ausgebildet ist;
der aus Harz gebildete Körper in zwei Teilkörper geteilt ist, die jeweils an den Schenkelabschnitten des beweglichen Blocks angeordnet sind, um so zwei endlose Umläufe an der Innenseite eines jeden der Schenkelabschnitte zu bilden; und
die Rollkörpergegenlaufbahn und das Paar von den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten bei einem jeden der zwei Körperteile als ein einstückiger Körper ausgebildet sind, wobei der den Rücklauf bildende Abschnitt getrennt vom einstückigen Körper geformt ist.

Gemäß der vorliegenden Erfindung ist der aus Harz gebildete Körper für den Rollkörperumlauf getrennt vom Körper des beweglichen Blockes ausgebildet. Selbst wenn der bewegliche Block groß ist, wird dadurch der Fluß des flüssigen Harzes nicht durch den Körper des beweglichen Blockes wie beim Stand der Technik behindert, bei dem der Körper des beweglichen Blockes und der aus Harz gebildete Körper einstückig miteinander ausgebildet sind, und es ist möglich, einen guten Fluß des flüssigen Harzes durch Vorsehen einer größeren Anzahl von Eingußstellen in der Form sicherzustellen, was somit zu einer hervorragenden Formgebung führt. Im allgemeinen ist es schwer, einen guten Fluß des flüssigen Harzes insbesondere an den den Rollkörperdurchlaß bildenden Abschnitten, die sich entlang der in Längsrichtung verlaufenden Seiten der Rollkörpergegenlaufbahn erstrecken, zu erreichen und daher ist es bedeutsam, den aus Harz gebildeten Körper getrennt vom Körper des beweglichen Blockes erfindungsgemäß zu formen.

Da insbesondere der aus Harz gebildete Körper in zwei Teilkörper unterteilt ist, von denen ein jeder zwei endlose Umläufe ausbildet, kann ein guter Lauf des flüssigen Harzes sichergestellt werden, selbst wenn der Block breiter ist.

Der Rollkörperumlauf wird durch den aus Harz gebildeten Körper gebildet. Dadurch kann eine direkte Lagebestimmung in der relativen Lagebeziehung zwischen den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten und dem den Rollkörperdurchlaß bildenden Abschnitt sowie der relativen Lagebeziehung zwischen den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten und dem den Rücklauf bildenden Abschnitt erreicht werden und die Durchgängigkeit des Rollkörperumlaufs wird auf vorteilhafte Weise sichergestellt, wodurch ein glatter Umlauf der Rollkörper erreicht wird.

Da die den Rollkörperdurchlaß bildenden Abschnitte entlang der beiden in Längsrichtung verlaufenden Seiten der Rollkörpergegenlaufbahn angeordnet sind, sind die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte, die in einer geeigneten relativen Lagebeziehung mit den den Rollkörperdurchlaß bildenden Abschnitten stehen, genau an den beiden Enden der Rollkörpergegenlaufbahn gesetzt.

Durch die Wahrung der geeigneten, relativen Lagebeziehung der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte mit dem Rollkörperrücklauf bewirkt, daß die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte genau mit der inneren Oberfläche des Rollkörperrücklaufs verbunden sind.

Insbesondere findet der Wechsel einer Laufrichtung der Rollkörper in der Verbindungsfläche der den Rollkörperdurchlaß bildenden Abschnitte mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten statt. Wenn diese beiden Abschnitte in einer solchen Verbindungsfläche miteinander durch einstückige Formgebung verbunden werden, ist ein Arbeitsschritt zum Zusammenbau dieser beiden Abschnitte nicht nötig, wodurch es möglich ist, eine glatte Durchgängigkeit dieser beiden Abschnitte sicherzustellen, ohne durch die Genauigkeit des Zusammenbaus beeinflußt zu werden.

Die vorliegende Erfindung kann die zusätzlichen Merkmale aufweisen, daß ein Rollkörperkäfig vorgesehen ist, der die Rollkörper hintereinander in einem vorgegebenen Abstand zwischen zwei benachbarten Rollkörpern halten kann und der Seitenkantenabschnitte aufweist, die von beiden Seiten eines jeden Rollkörpers vorspringen; und Führungsnuten zum Führen der Seitenkantenabschnitte des Rollkörperkäfigs am gesamten Umfang des Rollkörperumlaufs ausgebildet sind.

Eine derartiger Rollkörperkäfig ermöglicht aufgrund der guten Durchgängigkeit des Führungsabschnittes für den Rollkörperkäfig einen glatten Umlauf der Rollkörper.

Da der Führungsabschnitt für den Rollkörperkäfig, der im übrigen eine kleine Dicke aufweist, nicht durch Einsetzen des Körpers des beweglichen Blockes in eine Form und dem darauffolgenden Einspritzen von flüssigem Harz in die Form ausgeformt wird, sondern getrennt vom Körper des beweglichen Blocks gebildet wird, kann die Lage von Eingußstellen frei bestimmt werden, ohne durch den Körper des beweglichen Blockes behindert zu sein, mit dem Ergebnis, daß das flüssige Harz während der Bildung des Führungsabschnittes den gesamten dafür vorgesehenen Raum erreichen kann, der in der Form ausgebildet ist.

Die vorliegende Erfindung kann die zusätzlichen Merkmale aufweisen, daß ein jeder, der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte einen dünnen Plattenabschnitt aufweist, der in Kontakt mit der Endfläche des Körpers des beweglichen Blocks gebracht wird, und daß ein jeder der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte mit den den Rollkörperdurchlaß bildenden Abschnitten oder dem den Rücklauf bildenden Abschnitt durch den dünnen Plattenabschnitt verbunden ist.

Wenn ein jeder der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte mit den den Rollkörperdurchlaß bildenden Abschnitten durch den dünnen Plattenabschnitt verbunden ist, kann eine Verformung des dünnen Plattenabschnittes eine Verschiebung ausgleichen, die zwischen dem den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt und dem den Rollkörperdurchlaß bildenden Abschnitt oder zwischen dem den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt und dem den Rücklauf bildenden Abschnitt stattfindet. Entsprechend ist es möglich, eine genaue Lagebeziehung zwischen dem Ende des den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt und dem den Rollkörperdurchlaß bildenden Abschnitt oder zwischen dem den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt und dem den Rücklauf bildenden Abschnitt beizubehalten.

Der dünne Plattenabschnitt wird gegen die flache Endfläche des Körpers des beweglichen Teils durch eine Klemmkraft gedrückt, die auf die seitliche Deckplatte wirkt. Die Lage des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes kann dadurch über die Verformung des dünnen Plattenabschnittes korrigiert werden, selbst wenn der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt relativ zur Endfläche des Körpers des beweglichen Blocks falsch positioniert ist. Zusätzlich kann der dünne Plattenabschnitt fest zwischen der seitlichen Deckplatte und dem Körper des beweglichen Blocks durch die Klemmkraft gesichert werden, die auf die seitliche Deckplatte wirkt, wodurch eine falsche Plazierung des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes verhindert wird.

KURZE BESCHREIBUNG DER ZEICHNUNGEN

Fig. 1 zeigt eine schematische, auseinandergebaute Perspektivansicht, in der ein beweglicher Block einer Führungsvorrichtung für eine geradlinige Bewegung gemäß dem ersten Ausführungsbeispiel der vorliegenden Erfindung dargestellt ist;

Fig. 2 zeigt ein Rahmenteil aus Harz, wie es in **Fig.** 1 gezeigt ist, der einen der aus Harz gebildeten Körper zur Ausbildung eines Kugelumlaufs darstellt; insbesondere zeigt 2(a) eine Vorderansicht des Rahmenteils aus Harz,

Fig. 2(b) eine Seitenansicht des Rahmenteils aus Harz, **Fig.** 2(c) eine Schnittansicht entlang der Linie C-C der **Fig.** 2(a), **Fig.** 2(d) einen Querschnitt entlang der Linie D-D der **Fig.** 2(b), **Fig.** 2(e) einen vergrößerten Querschnitt entlang der Linie E-E der **Fig.** 2(a) und **Fig.** 2(f) einen vergrößerten Querschnitt entlang der Linie F-F der **Fig.** 2(a);

Fig. 3(a) zeigt eine Vorderansicht im Querschnitt, in der die Führungsvorrichtung für eine geradlinige Bewegung gemäß dem ersten Ausführungsbeispiel der vorliegenden Erfindung, wie es in der **Fig.** 1 gezeigt ist, dargestellt ist,

Fig. 3(b) zeigt eine Vorderansicht der Vorrichtung der **Fig.** 3(a), bei der in einer Hälfte ein Abschnitt einer seitlichen Deckplatte weggelassen ist und

Fig. 3(c) bis (f) sind ausschnittsweise Querschnitte, in denen Ausführungsbeispiele des Aufbaus eines den Kugeldurchlaß bildenden Abschnittes und dessen Umgebung dargestellt sind, wie in **Fig.** 3(a) gezeigt;

Fig. 4(a) zeigt eine Seitenansicht zusammen mit einem teilweisen Querschnitt der Führungsvorrichtung für eine geradlinige Bewegung gemäß dem ersten Ausführungsbeispiel der vorliegenden Erfindung, **Fig.** 4(b) zeigt einen Querschnitt eines Kugelumlaufs des beweglichen Blockes der **Fig.** 4(a), von dem ein Kugelkäfig entfernt ist, **Fig.** 4(c) ist eine ausschnittsweise Seitenansicht des Kugelkäfigs, **Fig.** 4(d) ist eine Draufsicht des Kugelkäfigs der **Fig.** 4(c) und **Fig.** 4(e) ist eine Ansicht des Kugelkäfigs in Richtung eines Pfeiles "a" der **Fig.** 4(d);

Fig. 5 zeigt eine seitliche Deckplatte des beweglichen Blocks und insbesondere zeigt **Fig.** 5(a) eine Vorderansicht der seitlichen Deckplatte, **Fig.** 5(b) zeigt eine Rückenansicht und **Fig.** 5(c) zeigt einen Querschnitt im Mittenabschnitt;

Fig. 6(a) bis 6(i) zeigen Ansichten zur Erläuterung der Arbeitsschritte zum Zusammenbau des beweglichen Blocks der **Fig.** 1;

Fig. 7(a) zeigt eine teilweise, vergrößerte Ansicht des Richtungswechseldurchlasses der **Fig.** 4(b), **Fig.** 7(b) zeigt eine ausschnittsweise Seitenansicht des Richtungswechseldurchlasses der **Fig.** 4(b), bei der die seitliche Deckplatte entfernt ist, **Fig.** 7(c) zeigt eine ausschnittsweise Seitenansicht, in der ein ausgesparter Abschnitt dargestellt ist, der den Richtungswechseldurchlaß in der seitlichen Deckplatte der **Fig.** 7(a) bildet, **Fig.** 7(d) zeigt einen ausschnittsweisen Querschnitt eines äußeren, umfangsseitigen Halbröhrenteils, der einen anderen Teil des Harzrohrs der **Fig.** 7(a) bildet,**Fig.** 7(g) zeigt eine Seitenansicht des inneren, umfangsseitigen Halbröhrenteils der **Fig.** 7(f);

Fig. 8 zeigt eine schematische, auseinandergebaute Perspektivansicht, in der die erste Abänderung des aus Harz gebildeten Körpers zur Ausbildung des Kugelumlaufs des ersten Ausführungsbeispiels der vorliegenden Erfindung dargestellt ist;

Fig. 9(a) zeigt eine auseinandergebaute Seitenansicht mit einem ausschnittsweisen Querschnitt, in der der aus Harz gebildete Körper des Kugelumlaufs der

Fig. 8 dargestellt ist, **Fig.** 9(b) zeigt eine Ansicht, in der der erste Harzrahmen des aus Harz gebildeten Körpers dargestellt ist, **Fig.** 9(c) zeigt eine Ansicht, in der dessen zweiter Harzrahmen dargestellt ist, **Fig.** 9(d) zeigt eine Rückansicht des ersten Harzrahmens und **Fig.** 9(e) zeigt eine Rückansicht des zweiten Harzrahmens.

Fig. 10 zeigt eine schematische, auseinandergebaute Perspektivansicht, in der die zweite Abänderung des aus Harz gebildeten Körpers zur Ausbildung des Kugelumlaufs des ersten Ausführungsbeispiels der vorliegenden Erfindung dargestellt ist;

Fig. 11(a) zeigt eine auseinandergebaute Seitenansicht mit einem ausschnittsweisen Querschnitt, in der der in **Fig.** 10 gezeigte, aus Harz gebildete Körper für den Kugelumlauf dargestellt ist, **Fig.** 11(b) zeigt eine Seitenansicht, in der das Verbindungsende eines der in **Fig.** 11(a) gezeigten, geteilten Harzrahmen dargestellt ist und **Fig.** 11(c) zeigt einen vergrößerten Querschnitt, in dem der Verbindungsabschnitt der Harzrahmen dargestellt ist;

Fig. 12 zeigt eine schematische, auseinandergebaute Perspektivansicht, in der die dritte Abänderung des aus Harz gebildeten Körpers zur Ausbildung des Kugelumlaufs gemäß dem ersten Ausführungsbeispiel der vorliegenden Erfindung dargestellt ist;

Fig. 13(a) zeigt eine Seitenansicht mit einem ausschnittsweisen Querschnitt, in der die Führungsvorrichtung für eine geradlinige Bewegung dargestellt ist, bei der der bewegliche Block der **Fig.** 12 verwendet wird, und **Fig.** 13(b) zeigt einen Querschnitt des aus Harz gebildeten Körpers zur Ausbildung des Kugelumlaufs der **Fig.** 13(a);

Fig. 14(a) zeigt einen ausschnittsweisen, vergrößerten Querschnitt des Richtungswechseldurchlasses der **Fig.** 13(b), der in der seitlichen Deckplatte ausgebildet ist, die von dem den Kugeldurchlaß bildenden Abschnitt entfernt ist,

Fig. 14(b) zeigt einen ausschnittsweisen Querschnitt, in dem die seitliche Deckplatte der **Fig.** 14(a) dargestellt ist, die mit dem den Kugeldurchlaß bildenden Abschnitt verbunden ist, **Fig.** 14(c) zeigt eine ausschnittsweise Seitenansicht, in der der den Kugeldurchlaß bildende Abschnitt dargestellt ist, bei dem die seitliche Deckplatte der **Fig.** 14(a) entfernt ist, und **Fig.**

14(d) zeigt eine ausschnittsweise Seitenansicht, in der ein ausgesparter Abschnitt dargestellt ist, der in der seitlichen Deckplatte der **Fig.** 14(a) den Richtungswechseldurchlaß bildet;

Fig. 15 zeigt eine schematische, auseinandergebaute Perspektivansicht, in der die vierte Abänderung des aus Harz gebildeten Körpers zur Ausbildung des Kugelumlaufs gemäß dem ersten Ausführungsbeispiel der vorliegenden Erfindung dargestellt ist;

Fig. 16(a) bis 16(h) zeigen erläuternde Ansichten, in denen die weiteren Ausführungsbeispiele der Anordnung der Rollenbahnen bei der Führungsvorrichtung für eine geradlinige Bewegung gemäß dem ersten Ausführungsbeispiel der vorliegenden Erfindung dargestellt sind;

Fig. 17 zeigt eine Perspektivansicht, die die anderen Konstruktionselemente als den aus Harz gebildeten Körper zum Ausbilden des Kugelumlaufs der mit zwei Rollenbahnen an jeder der beiden Seiten versehenen Führungseinrichtung für eine geradlinige Bewegung der **Fig.** 16(a) darstellt;

Fig. 18 zeigt eine schematische, auseinandergebaute Perspektivansicht, die einen beweglichen Block einer Führungsvorrichtung für eine geradlinige Bewegung gemäß dem zweiten Ausführungsbeispiel der vorliegenden Erfindung darstellt;

Fig. 19(a) zeigt eine Vorderansicht, die die Führungsvorrichtung für eine geradlinige Bewegung gemäß dem zweiten Ausführungsbeispiel der vorliegenden Erfindung der **Fig.** 18 darstellt, **Fig.** 19(b) ist eine abschnittsweise Querschnittsansicht, die einen Kugelumlauf der Vorrichtung der **Fig.** 19(a) darstellt, **Fig.** 19(c) ist eine abschnittsweise Vorderansicht eines Kugelkäfigs der **Fig.** 19(b) und **Fig.** 19(d) ist eine Ansicht des Kugelkäfigs in Richtung des Pfeiles "d" der **Fig.** 19(c);

Fig. 20 zeigt den aus Harz gebildeten Körper zur Ausbildung des Kugelumlaufs der **Fig.** 18 und insbesondere zeigt **Fig.** 20 (a) einen Querschnitt entlang der Linie a-a der **Fig.** 20(b), **Fig.** 20(b) zeigt eine Vorderansicht des aus Harz geformten Körpers zur Ausbildung des Kugelumlaufs der **Fig.** 20(a),

Fig. 20(c) ist eine abschnittsweise Seitenansicht des aus Harz geformten Körpers zur Ausbildung des Kugelumlaufs, bei dem die aus Harz geformte Röhre der **Fig.** 20(a) entfernt ist, **Fig.** 20(d) zeigt einen Querschnitt einer äußeren, umfangsseitigen Halbröhre, die einen Teil einer Röhre aus Harz der **Fig.** 20(a) bildet, **Fig.** 20(e) zeigt eine Seitenansicht der äußeren, umfangsseitigen Halbröhre der **Fig.** 20(d), **Fig.** 20(f) zeigt einen Querschnitt einer inneren, umfangsseitigen Halbröhre zum Ausbilden eines weiteren Teils der Röhre aus Harz der **Fig.** 20(a), **Fig.** 20(g) zeigt eine Seitenansicht der inneren, umfangsseitigen Halbröhre der **Fig.** 20(f) und **Fig.** 20(h) zeigt einen abschnittsweisen Querschnitt, der den Aufbau des den Rollendurchlaß bildenden Abschnittes beispielhaft darstellt, bei dem der Rollerkäfig nicht verwendet wird;

Fig. 21 zeigt eine schematische, auseinandergebaute Perspektivansicht, die die erste Abänderung des aus Harz gebildeten Körpers zur Ausbildung des Kugelumlaufs gemäß dem zweiten Ausführungsbeispiel der vorliegenden Erfindung darstellt;

Fig. 22(a) zeigt eine auseinandergebaute Seitenansicht mit einem abschnittsweisen Querschnitt, indem der aus Harz gebildete Körper für den Kugelumlauf der

Fig. 21 dargestellt ist, **Fig.** 22(b) zeigt eine Ansicht, in der der erste Rahmen aus Harz der **Fig.** 22(a) in einer Ansicht dargestellt ist, die an dessen geteilten Endseite liegt, und **Fig.** 22(c) ist eine Ansicht, in der der zweite Rahmen aus Harz der **Fig.** 22(a) in einer Ansicht, die an dessen geteilten Endseite liegt, dargestellt ist;

Fig. 23 zeigt eine schematische, auseinandergebaute Perspektivansicht, in der die zweite Abänderung des aus Harz gebildeten Körpers zur Ausbildung des Kugelumlaufs gemäß dem zweiten Ausführungsbeispiel der vorliegenden Erfindung dargestellt ist;

Fig. 24(a) zeigt eine auseinandergebaute Seitenansicht mit einem abschnittsweisen Querschnitt, in der der aus Harz gebildete Körper für den Kugelumlauf der

Fig. 23 dargestellt ist, **Fig.** 24(b) zeigt eine Ansicht, in der ein Rahmen aus Harz der **Fig.** 24(a) in einer Ansicht dargestellt ist, die an dessen geteilter Endseite liegt, und **Fig.** 24(c) zeigt eine Ansicht, in der der andere Rahmen aus Harz der **Fig.** 24(a) in einer Ansicht dargestellt ist, die an dessen geteilter Endseite liegt;

Fig. 25 zeigt eine schematische, auseinandergebaute Perspektivansicht, in der die dritte Abänderung des aus Harz gebildeten Körpers zur Ausbildung des Kugelumlaufs gemäß dem zweiten Ausführungsbeispiel der vorliegenden Erfindung dargestellt ist;

Fig. 26 zeigt eine schematische, auseinandergebaute Perspektivansicht, in der die vierte Abänderung des aus Harz gebildeten Körpers zur Ausbildung des Kugelumlaufs gemäß dem zweiten Ausführungsbeispiel der vorliegenden Erfindung dargestellt ist;

Fig. 27 zeigt eine Vorderansicht, bei der eine Hälfte als Querschnitt dargestellt ist, wobei ein weiteres Ausführungsbeispiel einer Anordnung der Kugellaufbahnen der Führungsvorrichtung für eine geradlinige Bewegung gemäß dem zweiten Ausführungsbeispiel der vorliegenden Erfindung dargestellt ist;

Fig. 28 zeigt eine schematische, auseinandergebaute Perspektivansicht einer äußeren Röhre einer Kugelrille als eine Führungsvorrichtung für eine geradlinige Bewegung gemäß dem dritten Ausführungsbeispiel der vorliegenden Erfindung;

Fig. 29(a) zeigt eine Vorderansicht mit einem Querschnitt, in der die Kugelrille des dritten Ausführungsbeispiels der vorliegenden Erfindung dargestellt ist, bei der die Hülse der **Fig.** 28 verwendet ist, **Fig.** 29(b) zeigt einen abschnittsweisen Querschnitt, in der ein Kugelumlauf der Vorrichtung der **Fig.** 29(a) dargestellt ist, und **Fig.** 29(c) ist ein auseinandergebauter Querschnitt, in dem der Aufbau des Kugeldurchlasses dargestellt ist, bei dem der Rollenkäfig der **Fig.** 29(b) entfernt ist;

Fig. 30 zeigt den aus Harz gebildeten Körper zur Ausbildung des Kugelumlaufs der **Fig.** 29 und insbesondere zeigt **Fig.** 30(a) einen Querschnitt entlang der Linie a-a der **Fig.** 30(b), **Fig.** 30(b) zeigt eine Vorderansicht des aus Harz gebildeten Körpers zur Ausbildung des Kugelumlaufs der **Fig.** 30(a),

Fig. 30(c) zeigt eine abschnittsweise Seitenansicht des aus Harz gebildeten Körpers zur Ausbildung des Kugelumlaufs, bei dem das Rohr aus Harz der **Fig.** 30(a) entfernt ist, **Fig.** 30(d) zeigt einen Querschnitt einer äußeren, umfangsseitigen Halbröhre zur Ausbildung eines Teils der Röhre aus Harz der **Fig.** 30(a), **Fig.** 30(e) zeigt eine Seitenansicht der äußeren, umfangsseitigen Halbröhre der **Fig.** 30(d), **Fig.** 30(f) zeigt eine Querschnittansicht einer inneren, umfangsseitigen Halbröhre zur Ausbildung eines weiteren Teils der Röhre aus Harz der **Fig.** 30(a) und **Fig.** 30(g) zeigt eine Seitenansicht der inneren, umfangsseitigen Halbröhre der **Fig.** 30(f);

Fig. 31 zeigt eine schematische, auseinandergebaute Perspektivansicht, in der die erste Abänderung des aus Harz gebildeten Körpers zur Ausbildung des Kugelumlaufs gemäß dem dritten Ausführungsbeispiel der vorliegenden Erfindung dargestellt ist;

Fig. 32(a) zeigt eine auseinandergebaute Seitenansicht mit einem abschnittsweisen Querschnitt, in dem der aus Harz gebildete Körper für den Kugelumlauf der **Fig.** 31 dargestellt ist, **Fig.** 32(b) zeigt eine Ansicht, in der der erste Rahmen aus Harz der **Fig.** 32(a) in einer Ansicht dargestellt ist, die an dessen geteilten Endseite liegt, und **Fig.** 32(c) zeigt eine Ansicht, in der der zweite Rahmen aus Harz der **Fig.** 32(a) in einer Ansicht dargestellt ist, die an dessen geteilten Ende liegt;

Fig. 33 zeigt eine schematische, auseinandergebaute Perspektivansicht, in der die zweite Abänderung des aus Harz gebildeten Körpers zur Ausbildung des Kugelumlaufs gemäß dem dritten Ausführungsbeispiel der vorliegenden Erfindung dargestellt ist;

Fig. 34(a) zeigt eine auseinandergebaute Seitenansicht mit einem abschnittsweisen Querschnitt, in dem der aus Harz gebildete Körper für den Kugelumlauf der **Fig.** 33 dargestellt ist, **Fig.** 34(b) zeigt eine Ansicht, in der ein Rahmen aus Harz der **Fig.** 34(a) in einer Ansicht dargestellt ist, die an dessen geteilten Ende liegt, und **Fig.** 34(c) ist eine Ansicht, in der der andere Rahmen aus Harz der **Fig.** 34(a) in einer Ansicht dargestellt ist, die an dessen geteilten Endseite liegt;

Fig. 35 zeigt eine schematische, auseinandergebaute Perspektivansicht, in der die dritte Abänderung des aus Harz gebildeten Körpers zur Ausbildung des Kugelumlaufs gemäß dem dritten Ausführungsbeispiel der vorliegenden Erfindung dargestellt ist;

Fig. 36 zeigt eine schematische, auseinandergebaute Perspektivansicht, in der die vierte Abänderung des aus Harz gebildeten Körpers dargestellt ist, der den Kugelumlauf gemäß dem dritten Ausführungsbeispiel der vorliegenden Erfindung bildet;

Fig. 37 zeigt eine Vorderansicht mit einem abschnittsweisen Querschnitt, in dem ein weiteres Ausführungsbeispiel eine Anordnung der Kugellaufbahnen bei der Kugelrille der Führungsvorrichtung für eine geradlinige Bewegung gemäß dem dritten Ausführungsbeispiel der vorliegenden Erfindung dargestellt ist;

Fig. 38(a) zeigt eine Vorderansicht mit einem abschnittsweisen Querschnitt, in dem eine Rollennut als Führungsvorrichtung für eine geradlinige Bewegung gemäß dem vierten Ausführungsbeispiel der vorliegenden Erfindung, bei der eine seitliche Deckplatte entfernt ist, dargestellt ist und **Fig.** 38(b) zeigt einen abschnittsweisen, in Längsrichtung verlaufenden Querschnitt eines Rollenumlaufs der **Fig.** 38(b);

Fig. 39(a) zeigt einen abschnittsweisen Querschnitt, in dem der Aufbau des aus Harz gebildeten Körpers zur Ausbildung des Rollenumlaufs der Rollennut der

Fig. 38 beispielhaft dargestellt ist und **Fig.** 39(b) bis 39(e) zeigen Ansichten, in denen die erste bis vierte Abänderung des aus Harz gebildeten Körpers zur Ausbildung des Rollenumlaufs dargestellt ist;

Fig. 40(a) zeigt eine Vorderansicht des beweglichen Blocks der Führungsvorrichtung für eine geradlinige Bewegung gemäß dem vierten Ausführungsbeispiel der vorliegenden Erfindung, bei dem die seitliche Deckplatte entfernt ist und **Fig.** 40(b) zeigt eine Perspektivansicht des beweglichen Blocks der **Fig.** 40(a);

Fig. 41 zeigt eine schematische, auseinandergebaute Perspektivansicht der aus Harz geformten Körper zur Ausbildung des Kugelumlaufs der **Fig.** 40;

Fig. 42 zeigt eine Vorderansicht des Rahmens aus Harz, der Teil des aus Harz geformten Körpers zur Ausbildung des Kugelumlaufs der **Fig.** 41 ist, **Fig.** 42(b) zeigt eine linke Seitenansicht des aus Harz geformten Körpers der

Fig. 42(a) und **Fig.** 42(c) zeigt eine rechte Seitenansicht des aus Harz geformten Körpers der **Fig.** 42(a);

Fig. 43 zeigt eine Röhre aus Harz, die einen Teil des aus Harz geformten Körpers der **Fig.** 41 darstellt, der wiederum den Kugelumlauf bildet, und insbesondere zeigt **Fig.** 43(a) eine Vorderansicht einer äußeren, umfangsseitigen Halbröhre, **Fig.** 43(b) zeigt eine Seitenansicht der äußeren, umfangsseitigen Halbröhre der **Fig.** 43(a), **Fig.** 43(c) zeigt eine Vorderansicht einer inneren, umfangsseitigen Halbröhre, **Fig.** 43(d) zeigt eine Seitenansicht der inneren, umfangsseitigen Halbröhre der **Fig.** 43(c); und

Fig. 44(a) zeigt einen Querschnitt eines Kugelumlaufs, bei dem der Kugelkäfig vom beweglichen Block der **Fig.** 40(a) entfernt ist, **Fig.** 44(b) zeigt eine abschnittsweise, vergrößerte Ansicht des Richtungswechseldurchlasses der **Fig.** 44(a), **Fig.** 44(c) zeigt eine abschnittsweise Seitenansicht des Kugelkäfigs, **Fig.** 44(d) zeigt eine Draufsicht des Kugelkäfigs der **Fig.** 44(c), **Fig.** 44(e) zeigt eine Ansicht des Kugelkäfigs in Richtung eines Pfeiles "a" der **Fig.** 44(d), **Fig.** 44(f) zeigt eine abschnittsweise Seitenansicht des Richtungswechseldurchlasses der **Fig.** 44(b), bei dem die seitliche Deckplatte entfernt ist, und **Fig.** 44(g) zeigt eine abschnittsweise Seitenansicht, in der ein ausgesparter Abschnitt dargestellt ist, der in der seitlichen Deckplatte der **Fig.** 44(b) den Richtungswechseldurchlaß bildet.

GENAUE BESCHREIBUNG DER BEVORZUGTEN AUSFÜHRUNGSBEISPIELE

Im folgenden werden nun Ausführungsbeispiele einer Führungsvorrichtung für eine geradlinige Bewegung gemäß der vorliegenden Erfindung unter Bezugnahme auf die Zeichnungen beschrieben.

[ERSTES AUSFÜHRUNGSBEISPIEL]

Die **Fig.** 1 bis 7 zeigen eine Führungsvorrichtung für eine geradlinige Bewegung gemäß dem ersten Ausführungsbeispiel der vorliegenden Erfindung.

Die Führungsvorrichtung **1** für eine geradlinige Bewegung ist mit einer Führungsschiene **2** als einem sich geradlinig erstreckenden Führungsteil und einem beweglichen Block **4** als einem beweglichen Teil versehen, der derart angeordnet ist, daß er entlang der Führungsschiene **2** über eine große Anzahl von Kugeln **3** als Rollkörper beweglich ist.

Die Führungsschiene **2** hat die Form eines langen Balkens mit einem rechteckigen Querschnitt. Zwei Kugellaufrillen **5**, **5** als Rollkörperlaufbahnen sind an der waagerechten oberen Oberfläche der Führungsschiene **2** ausgebildet und eine einzelne Kugellaufrille **5** als Rollkörperlaufbahn ist an jeder der rechten und linken senkrechten Oberflächen der Führungsschiene **2** ausgebildet, so daß eine Gesamtzahl von vier Rillen **5** vorgesehen ist.

Der bewegliche Block **4** ist als ein Blockkörper mit einem Querschnitt in Form eines umgekehrten U's ausgebildet, dessen sich öffnendes Ende nach unten gerichtet ist. Der Blockkörper ist mit einem waagerechten Abschnitt **6** versehen, der der oberen Oberfläche der Führungsschiene **2** gegenüberliegt, und mit einem Paar von Schenkelabschnitten **7**, **7** versehen, die sich von den rechten und linken Enden des waagerechten Abschnittes **6** nach unten erstrecken und den rechten und linken Seitenflächen der Führungsschiene **2** jeweils gegenüberliegen. Der waagerechte Abschnitt **6** weist an seiner unteren Oberfläche zwei Kugelgegenlaufrillen **8**, **8** als Rollkörpergegenlaufbahnen auf, die den Kugellaufrillen **5**, **5** entsprechen, die an der oberen Oberfläche der Führungsschiene **2** ausgebildet sind. Ein jeder der Schenkelabschnitte **7**, **7** weist an seiner inneren Oberfläche eine einzelne Kugelgegenlaufrille **8** als Rollkörpergegenlaufbahn auf, die den jeweiligen Kugellaufrillen **5**, **5** entsprechen, die an den rechten und linken Seitenflächen der Führungsschiene **2** ausgebildet sind.

Zusätzlich sind am beweglichen Block **4** vier Kugelrückläufe **9**, **9**, **9**, **9** als Rollkörperrückläufe ausgebildet, die parallel zu den vier Kugelgegenlaufrillen **8**, **8**, **8**, **8** jeweils vorgesehen sind sowie vier Paare von Richtungswechseldurchlässen **10**, **10**, **10**, **10**, die jeweils U-förmig ausgebildet sind und die jeweiligen beiden Enden der Kugelgegenlaufrillen **8**, **8**, **8**, **8** mit den jeweiligen beiden Enden der Kugelrückläufe **9**, **9**, **9**, **9** verbinden und auf diese Weise vier endlose Umläufe bilden. Die Kugelrückläufe **9**, **9**, die jeweils den auf der oberen Seite der Führungsschiene **2** ausgebildeten Kugellaufrillen **5**, **5** entsprechen, sind im waagerechten Abschnitt **6** ausgebildet. Die anderen Kugelrückläufe **9**, **9**, die jeweils den an den rechten und linken senkrechten Oberflächen der Führungsschiene **2** ausgebildeten Kugellaufrillen **5**, **5** entsprechen, sind jeweils in den Schenkelabschnitten **7**, **7** des beweglichen Blockes **4** ausgebildet.

Bei jedem der vier endlosen Umläufe gemäß diesem Ausführungsbeispiel sind die Kugeln **3** in Form einer Reihe mittels eines Kugelkäfigs **12** als einen Rollkörperkäfig gehalten, wie in der **Fig.** 4 gezeigt ist, so daß die Kugeln **3** umlaufen können, während sie durch den Kugelkäfig **12** geführt sind.

Der Kugelkäfig **12** umfaßt einen biegsamen Gurtabschnitt **12**b, der mit Kugellöchern **12**a zur jeweiligen Aufnahme der Kugeln **3** und mit zwischen zwei aufeinanderfolgenden Kugeln **3**, **3** angeordneten Abstandsabschnitten **12**c versehen ist. Der Gurtabschnitt **12**b hat eine Weite, die größer ist als der Durchmesser einer Kugel **3**, so daß die beiden Seitenkanten des Gurtabschnittes **12**b von einer Kugel **3** nach außen erstrecken.

Der Abstandsabschnitt **12**c ist mit einer kugelförmigen Aussparung **12**d zur Aufnahme einer Kugel versehen, die der Kugeloberfläche einer Kugel **3** entspricht. Die Kugel **3** ist an ihren beiden Seiten durch ein Paar von stützenden, kugelförmigen Aussparungen **12**d gestützt, so daß verhindert wird, daß eine Kugel **3** vom Gurtabschnitt **12**b loskommen kann. Bei diesem Ausführungsbeispiel ist das eine Ende des Gurtabschnittes **12**b nicht mit dessen anderen Ende verbunden, so daß ein streifenförmiger Gurt mit zwei Enden gebildet wird. Das eine Ende des Gurtabschnittes **12**b kann mit dessen anderen Ende verbunden werden, um einen endlosen Gurt zu bilden.

Der bewegliche Block **4** weist einen Blockkörper **13** mit Kugelgegenlaufrillen **8**, **8**, **8**, **8**, einen aus Harz geformten Körper **20** zur Ausbildung der Kugelumläufe, der in den Blockkörper **13** eingesetzt ist, und ein Paar von seitlichen Deckplatten **40**, **40** auf, die an den beiden Endflächen des Blockkörpers **13** befestigt sind, in dem der aus Harz gebildete Körper **20** eingesetzt ist.

Ein jeder der Kugelumläufe des aus Harz geformten Körpers **20** weist ein Paar von einen Kugeldurchlaß bildenden Abschnitten **21, 21** auf, die sich entlang der beiden in Längsrichtung erstreckenden Seiten der Kugelgegenlaufrille **8** erstrecken, des weiteren ein Paar von einen Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **22, 22**, die an den beiden Seitenflächen des Blockkörpers **13** vorgesehen sind, und eine Röhre aus Harz **23** als einen einen Rücklauf bildenden Abschnitt, der in eine im Blockkörper **13** gebildete Durchgangsöffnung eingesetzt ist. Bei diesem Ausführungsbeispiel sind die den Kugeldurchlaß bildenden Abschnitte **21, 21** und das Paar der einen Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **22, 22** einstückig miteinander als ein einheitlicher Körper ausgebildet und die Röhre **23** aus Harz ist getrennt vom oben erwähnten einheitlichen Körper ausgebildet. Insbesondere wird der Aufbau verwendet, daß die den Kugeldurchlaß bildenden Abschnitte **21, 21** und das Paar von den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **22, 22** miteinander einstückig über eine einstückige Formgebung verbunden sind, um einen einstückigen Rahmen **24** aus Harz zu bilden, und die vier Röhren **23** aus Harz können jeweils in den Blockkörper **13** eingesetzt werden.

Die den Kugeldurchlaß bildenden Abschnitte **21, 21** sind mit Führungsrillen zum Führen der beiden Seitenkanten des Gurtabschnittes **12**b des Kugelkäfigs **12** in einem belasteten Bereich ausgestattet. Die Führungsrillen können nicht nur verhindern, daß der Kugelkäfig **12** während des Laufs an der Kugel schwingt, sondern auch daß er durchhängt, wenn der bewegliche Block **4** von der Führungsschiene **2** entfernt wird, indem die Seitenkanten des Gurtabschnittes **12**b in die Führungsrille **21**a eingreifen. Die Kugeln **3** werden durch den Kugelkäfig **12** abgestützt. Insbesondere ist der Kugelkäfig **12** durch den Backenabschnitt der Führungsrille **21**a mit dem Ergebnis abgestützt, daß die Kugeln **3** in der richtigen Lage gehalten werden und nicht vom beweglichen Block **4** abfallen.

Bei diesem Ausführungsbeispiel ist ein Abstand zwischen dem Paar der den Kugeldurchlaß bildenden Abschnitt **21, 21**, das parallel zueinander an einen beiden in Längsrichtung verlaufenden Seiten der Kugelgegenlaufrille **8** angeordnet sind, etwas größer als ein Durchmesser einer Kugel **3**. Die Kugeln **3** fallen aus der Kugelgegenlaufrille **8**, wenn der Kugelkäfig **12** nicht verwendet wird. Wenn eine Länge des Vorsprungs des Backenabschnittes **21**b derart bestimmt ist, daß ein Abstand zwischen dem Paar der den Kugeldurchlaß bildenden Abschnitte **21, 21** etwas größer ist als der Durchmesser einer Kugel **3**, wie in der **Fig.** 3(d) gezeigt ist, ist es jedoch möglich zu verhindern, daß die Kugeln **3** auch ohne Verwendung des Kugelkäfigs **12** aus der Kugelgegenlaufrille **8** herausfallen. Ein derartiger Aufbau kann nicht nur in dem Fall verwendet werden, in welchem die Kugeln **3** in den Kugelumlauf unter Verwendung des Kugelkäfigs **12** eingesetzt werden, sondern auch in dem Fall, in welchem die Kugeln darin ohne den Kugelkäfig **12** eingesetztwerden. Der Abstand zwischen dem Paar von den den Kugeldurchlaß bildenden Abschnitten **21, 21** kann etwas kleiner sein als der Durchmesser einer Kugel **3**, so daß die den Kugeldurchlaß bildenden Abschnitte **21, 21** eine Kugel **3** ohne Verwendung des Kugelkäfigs **12** direkt halten, wie in der **Fig.** 3(e) gezeigt ist.

Außerdem sind Führungsrillen **9**c, **10**c im Kugelrücklauf **9** und im Richtungswechseldurchlaß **10** als nicht belastete Flächen ausgebildet, um die Seitenkanten des Gurtabschnittes **12**b zu führen. Die Führungsrillen **9**c, **10**c sind mit der obengenannten Führungsrille **21**a im belasteten Bereich verbunden, so daß eine endlose Rille am gesamten Umfang gebildet wird.

Wenn der Kugelkäfig **12**, wie in der **Fig.** 3(f) gezeigt, nicht verwendet wird, dann kann der Abstand zwischen dem Paar der den Kugeldurchlaß bildenden Abschnitte **21, 21**, die an den beiden in Längsrichtung verlaufenden Seiten der Kugelgegenlaufrille **8** angeordnet sind, wobei diese Abschnitte keine Backenabschnitte **21** aufweisen, etwas kleiner sein als der Durchmesser einer Kugel **3**, wodurch verhindert wird, daß die Kugeln **3** von der Kugelgegenlaufrille **8** herausfallen können.

Die vier Teile der den Kugeldurchlaß bildenden Abschnitte **21, 21** sind aus einem ersten, dünnen Verbindungsplattenabschnitt **25**, der sich in Längsrichtung entlang der Unterfläche des waagerechten Abschnittes **6** des Blockkörpers **13** erstreckt, einem Paar von zweiten Verbindungsplattenabschnitten **26, 26**, die einen L-förmigen Querschnitt aufweisen und sich in Längsrichtung des Blockkörpers **13** entlang den Eckenabschnitten zwischen dem waagerechten Abschnitt **6** und den Schenkelabschnitten **7, 7** des Blockkörpers **13** erstrecken, und ein Paar von dritten Verbindungsplattenabschnitten **27, 27**, die sich in der Längsrichtung des Blockkörpers **13** entlang der Unterflächen der Schenkelabschnitte **7, 7** des Blockkörpers **13** erstrecken, aufgebaut.

Insbesondere sind die rechten und linken Seitenkanten des ersten Verbindungsplattenabschnittes **25** und die oberen Kanten des Paares der rechten und linken zweiten Verbindungsplattenabschnitte **26, 26** an den beiden Seiten der jeweiligen Kugelgegenlaufrillen **8, 8** angeordnet, die an den Unterflächen des waagerechten Abschnittes **6** vorgesehen sind, so daß sie die den Kugeldurchlaß bildenden Abschnitte **21, 21; 21, 21** bilden. Die Unterkanten der zweiten Verbindungsplattenabschnitte **26, 26**, die Innenkanten der dritten Verbindungsplattenabschnitte **26, 26** sowie die Innenkanten der dritten Verbindungsplattenabschnitte **27, 27** sind an den beiden Seiten der jeweiligen Kugelgegenlaufrillen **8, 8** angeordnet, die an der jeweiligen Innenfläche der Schenkelabschnitte **7, 7** vorgesehen sind, so daß sie die anderen, den Kugeldurchlaß bildenden Abschnitte **21, 21; 21, 21** bilden.

Der den Richtungswechseldurchlaß und innere Führung bildende Abschnitt **22** weist einen dünnen Plattenabschnitt **29** auf, der mit der Endfläche des Blockkörpers **13** verbunden wird. Die den Kugeldurchlaß bildenden Abschnitt **21, 21** und die Röhre **23** aus Harz sind miteinander durch den obengenannten, dünnen Plattenabschnitt **29** verbunden. Bei dieses Ausführungsbeispiels sind die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **22, 22** und die den Kugeldurchlaß bildenden Abschnitte **21, 21** über den dünnen Plattenabschnitt **29** durch einstückige Formgebung verbunden. Die Röhre **23** aus Harz wird in eine Öffnung **34** eingesetzt, das am dünnen Plattenabschnitt **29** ausgebildet ist, um so eine Randverbindung herzustellen, und ist am dünnen Plattenabschnitt **29** befestigt.

Der dünne Plattenabschnitt **29** weist einen ersten Endplattenabschnitt **30** auf, der der Endfläche des waagerechten Abschnittes **6** des Blockkörpers **13** entspricht, des weiteren ein Paar von dritten Endplattenabschnitten **32, 32**, die den Endflächen der Schenkelabschnitte **7, 7** entsprechen, sowie zweite Endplattenabschnitte **31, 31**, um den ersten Endplattenabschnitt **30** und die jeweiligen dritten Endplattenabschnitte **32, 32** miteinander zu verbinden. Der erste Endplattenabschnitt **30** weist die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **22, 22** auf, die derart ausgebildet sind, daß sie entsprechend den zwei Kugellaufbahnen **3, 3** an der Oberflächenseite der Führungsschiene **2** vorspringen. Ein jeder der dritten Endplattenabschnitte **32, 32** weist den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt **22** auf, der derart ausgebildet ist, daß er entsprechend der einzelnen Kugellaufbahn **3** an der Seitenfläche der Führungsschiene **2** hervorspringt.

Die ersten Endplattenabschnitte **30**, **30**, die jeweils an den beiden Enden des Blockkörpers **13** plaziert werden, sind mit ihrem unteren Abschnitt mit den beiden Enden des ersten Verbindungsplattenabschnittes **25** verbunden, der sich in Längsrichtung zwischen den ersten Endplattenabschnitten **30**, **30** erstreckt. Die zweiten Endplattenabschnitte **31**, **31**, die jeweils an den beiden Enden des Blockkörpers **13** plaziert werden, sind an ihrem inneren Kantenabschnitt mit den beiden Enden des zweiten Verbindungsplattenabschnittes **26** verbunden, der sich in Längsrichtung zwischen den zweiten Endplattenabschnitten **31**, **31** erstreckt. Die anderen, zweiten Endplattenabschnitte **31**, **31** weisen denselben Verbindungsaufbau auf. Die dritten Endplattenabschnitte **32**, **32**, die jeweils an den beiden Enden des Blockkörpers **13** plaziert werden, sind an ihrem inneren Kantenabschnitt mit den beiden Enden des dritten Verbindungsplattenabschnittes **27** verbunden, der sich in Längsrichtung zwischen den dritten Endplattenabschnitten **32**, **32** erstreckt. Die anderen dritten Endplattenabschnitte **32**, **32** weisen denselben Verbindungsaufbau auf. Auf diese Weise wird ein einzelner Rahmen **24** aus Harz gebildet.

Ein jeder der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **22** weist eine halbzylinderförmige Form auf. Am äußeren Umfang des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **22** ist eine innere Führungsrille **10**a mit einem halbkreisförmigen Querschnitt ausgebildet, um den inneren Führungsabschnitt für den Richtungswechseldurchlaß **10** zu bilden. Das eine Ende der inneren Führungsrille **10**a ist mit dem Ende der Kugelgegenlaufrille **8** verbunden. Dementsprechend hat das eine Ende der inneren Führungsrille **10**a dieselbe Querschnittsform wie die Kugelgegenlaufrille **8**, so daß das eine Ende der inneren Führungsrille **10**a mit dem Ende der Kugelgegenlaufrille **8** ausgerichtet ist. Das andere Ende der inneren Führungsrille **10**a des Richtungswechseldurchlasses **10** ist mit dem Ende des Kugelrücklaufs **9** verbunden. Dementsprechend weist das andere Ende der inneren Führungsrille **10**a dieselbe Querschnittsform auf wie der Kugelrücklauf **9**, um so das andere Ende der inneren Führungsrille **10**a mit dem Ende des Kugelrücklaufs **9** auszurichten.

An den beiden Enden der inneren Führungsrille **10**a sind zylindrische Flanschabschnitte **33**, **33** ausgebildet. Der Abstand zwischen den jeweiligen Außenflächen der zylindrischen Flanschabschnitte **33**, **33** ist größer als die Weite des Gurtabschnittes **12**b. Die zylindrischen Flanschabschnitte **33**, **33** bilden eine Käfigführungsrille für den Kugelkäfig **12** zusammen mit einem halbkreisförmigen, ausgesparten Abschnitt, der Aussparungen aufweist und am inneren Umfang der Aussparung der weiter unten beschriebenen seitlichen Deckplatte **40** ausgebildet ist.

Die beiden Enden der inneren Führungsrille **10**a für den Richtungswechseldurchlaß **10** erstrecken sich bis zur Berührungsfläche der ersten und dritten Endplattenabschnitte **30**, **32** mit der Endfläche des Blockkörpers **13**, um so mit den jeweiligen Enden der Kugelgegenlaufrille **8** und dem Kugelrücklauf **9** verbunden zu sein. Löcher **34**, **34**, **34**, **34** von halbkreisförmiger Form zum Einsetzen der Röhre, in welche die Enden der Röhren **23** aus Harz eingesetzt werden, sind an den ersten und dritten Endplattenabschnitten **30**, **32** ausgebildet.

Wie in der **Fig.** 7 gezeigt, besteht die Röhre **23** aus Harz aus einem inneren, umfangsseitigen Halbröhrenteil **23**a, das an der inneren Umfangsseite des Kugelumlaufs angeordnet ist, die durchgängig mit der inneren Führungsrille **10**a des Richtungswechseldurchlasses verbunden ist, sowie ein äußeres umfangsseitiges Halbröhrenteil **23**b, das an der äußeren Umfangsseite des Kugelumlaufes angeordnet ist, der durchgängig mit einer äußeren Führungsrille **10**b für den Richtungswechseldurchlaß **10** verbunden ist, der an der seitlichen Deckplatte **40** angeordnet ist. Das innere, umfangsseitige Halbröhrenteil **23**a weist einen Rillenabschnitt **9**a von halbkreisförmigem Querschnitt und Seitenkantenabschnitte **23**c auf, die sich in Längsrichtung entlang des Rillenabschnittes **9**a erstrecken.

Das äußere, umfangsseitige Halbröhrenteil **23**b ist als ein geradliniges Teil mit demselben kreisförmigen Querschnitt wie die äußere Führungsrille **10**b des Richtungswechseldurchlasses ausgebildet, der an der seitlichen Deckplatte **40** ausgebildet ist. Das äußere umfangsseitige Halbröhrenteil **23**b weist einen Rillenabschnitt **9**b auf, der durchgängig mit der äußeren Führungsrille **10**b verbunden ist, sowie Seitenkantenabschnitte **23**d, die sich in Längsrichtung entlang des Rillenabschnittes **9**b erstrecken. Die Seitenkantenabschnitte **23**d sind an ihren äußeren Kanten mit Vorsprüngen **23**e versehen, die mit den äußeren Kanten der Seitenkantenabschnitte **23**c des inneren, umfangsseitigen Halbröhrenteil **23**a in Kontakt gebracht werden, um die Käfigführungsrille **9**c des Kugelkäfigs **12** zu bilden.

Das innere, umfangsseitige Halbröhrenteil **23**a der Röhre **23** aus Harz weist dieselbe Länge wie der Blockkörper **13** auf. Das innere umfangsseitige Halbröhrenteil **23**a wird derart positioniert, daß es in Kontakt mit der Rückfläche des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **22** gebracht wird.

Das äußere umfangsseitige Halbröhrenteil **23**b der Röhre **23** aus Harz ist andererseits um einen Betrag, der der Dicke des dünnen Plattenabschnittes **29** entspricht, länger als der Blockkörper **13**. Die äußeren umfangsseitigen Halbröhrenteile **23**b sind in die Einsetzlöcher **34** der ersten und dritten Endplattenabschnitte **30**, **32** eingesetzt. Eine Lagebestimmung des äußeren, umfangsseitigen Halbröhrenteils **23**b in Längsrichtung wird dadurch gemacht, daß die beiden Enden des äußeren, umfangsseitigen Halbröhrenteils **23**b, die in die Einsetzlöcher **34** eingesetzt sind, in Kontakt mit der Umfangskante des Endabschnittes der äußeren Führungsrillen **10**b des Richtungswechseldurchlasses gebracht werden, die an der seitlichen Deckplatte **40** angebracht sind. Die an den beiden Seitenkanten des äußeren umfangsseitigen Halbröhrenteils **23**b angeformten Vorsprünge **23**e berühren die äußeren Kanten der zylindrischen Flanschabschnitte **33**, die an dem den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt **22** ausgestaltet sind, um einen Teil der Führungsrille **10**c zu bilden, und das äußere umfangsseitige Halbröhrenteil **23**b und das innere umfangsseitige Halbröhrenteil **23**a können in der Einsetzöffnung **14** nicht drehen.

Die Röhre aus Harz **23** und die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **22** werden über die Einsetzlöcher **34**, die an den ersten und dritten Endplattenabschnitten **30**, **32** des dünnen Plattenabschnittes **29** ausgebildet sind, genau positioniert. Auf diese Weise kann ein korrekter Zusammenbau ausgeführt werden.

Wie in der **Fig.** 5 gezeigt, ist die seitliche Deckplatte **40** mit einem ausgesparten Einsetzabschnitt **40**a versehen, in die der dünne Plattenabschnitt **29** eingesetzt wird, sowie mit vier ausgesparten Abschnitten **41** mit äußeren Führungsrillen **10**b des Richtungswechselsdurchlasses, in die Abschnitte der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **22** eingesetzt sind, sowie ferner mit Abschnitten für Schrauben, um die seitliche Deckplatte **40** am Blockkörper **13** zu befestigen. Durch die Einschraubabschnitte wird die seitliche Deckplatte **40** am Blockkörper **13** durch Einsetzen von Schrauben **44** in Löcher **43** befestigt, die an der seitlichen Deckplatte **40** ausgebildet sind und die Schrauben mit Gewindelöcher **45**, die an der Endfläche des Blockkörpers **13** ausgebildet sind, in Eingriff bringen. Die Löcher **43** sind zwischen den ersten und dritten Endplattenabschnitten **30**, **32** des dünnen Plattenabschnittes **29** angeordnet.

Wie in der **Fig.** 7 gezeigt, weist die äußere Führungsrille **10**b des Richtungswechselsdurchlasses im ausgesparten Absatz **41** an ihren Seitenkanten bogenförmige Aussparungen **46** mit größerem Durchmesser, die zusammen mit den zylindrischen Flanschabschnitten **33** der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **22** die Käfigführungsrillen **10**c bilden, sowie bogenförmige Aussparungen **47** mit kleinerem Durchmesser auf, in die die zylindrischen Flanschabschnitte **33** eingesetzt werden. Der den Richtungswechseldurchlaß und innere Führung bildende Abschnitt **22**, der an der inneren Führungsrille **10**a des Richtungswechselsdurchlasses vorgesehen ist, ist in den ausgesparten Abschnitt **41** der seitlichen Deckplatte **40** eingesetzt und der dünne Plattenabschnitt **29** ist vom ausgesparten Einsetzabschnitt **40**a der seitlichen Deckplatte **40** aufgenommen. Der dünne Plattenabschnitt **29** ist zwischen der seitlichen Deckplatte **40** und der Endfläche des Blockkörpers **13** durch eine Klemmkraft gehalten, so daß er dazwischen fest befestigt ist.

Die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **22** und der den Kugeldurchlaß bildende Abschnitt **21** sind durch den dünnen Plattenabschnitt **29** verbunden, wodurch es möglich ist, eine genaue Lagebeziehung des Endes der inneren Führungsrille **10**a des Richtungswechselsdurchlasses, der in dem den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt **22** ausgebildet ist, relativ zu den den Kugeldurchlaß bildenden Abschnitte **21**, **21** sowie eine genaue Lagebeziehung der inneren Führungsrille **10**a des Richtungswechselsdurchlasses relativ zum Kugelrücklauf **9** zu wahren.

Der dünne Plattenabschnitt **29**, der in der Umgebung des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **22** gelegen ist, wird durch eine auf die seitliche Deckplatte **40** (vgl. **Fig.** 7) wirkende Klemmkraft gleichmäßig gegen die flache Endfläche des Blockkörpers **13** gedrückt. Selbst wenn der den Richtungswechseldurchlaß und innere Führung bildende Abschnitt **22** sich nicht in einer korrekten Lage befindet, dann ändert der dünne Plattenabschnitt **22** seine Form an der Endfläche des Blockkörpers **13**, wodurch die korrekte Lage des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **22** ermöglicht wird. Der dünne Plattenabschnitt **29** wird durch eine Klemmkraft, die an der seitlichen Deckplatte **40** wirkt, festgeklemmt und befestigt und die durch eine derartige Klemmung erzeugte Reibkraft kann eine ungünstige Bewegung der inneren Führungsrille **10**a des Richtungswechselsdurchlasses verhindern.

Die seitliche Deckplatte **40** ist am Blockkörper **13** derart befestigt, daß der mit dem Blockkörper **13** zusammengebaute, den Richtungswechseldurchlaß und innere Führung bildende Abschnitt **22** in den ausgesparten Abschnitt **41** der seitlichen Deckplatte **40** eingesetzt ist. Dieser Arbeitsschritt des Einsetzens erlaubt es, eine genaue Lage der seitlichen Deckplatte **40** relativ zum Bockkörper **13** zu erhalten.

Fig. 6 zeigt die Arbeitsschritte beim Zusammenbau des oben beschriebenen, aus Harz geformten Körpers zur Ausbildung des Kugelumlaufs.

Zunächst wird das innere, umfangsseitige Halbröhrenteil **23**a der Röhre **23** aus Harz in die Durchgangsöffnung **14** des Blockkörpers **13** eingesetzt (vgl. **Fig.** 6(a) und 8(b).

Dann wird der durch einstückige Formgebung erhaltene Rahmen **24** aus Harz in die Aussparung des Blockkörpers **13** eingesetzt, wobei die dünnen Plattenabschnitte **29** an den beiden Enden des Rahmens **24** aus Harz an den jeweiligen Endflächen des Blockkörpers **13** gleiten (vgl. **Fig.** 6(c) und 6(d)). Der erste Verbindungsplattenabschnitt **25** des Rahmens **24** aus Harz kommt in Kontakt mit der Unterfläche des waagerechten Abschnittes **6**, wodurch eine Lagebestimmung in senkrechter Richtung des Rahmens **24** aus Harz stattfindet. Der zweite Verbindungsplattenabschnitt **26** und der dritte Verbindungsplattenabschnitt **27** des Rahmens **24** aus Harz kommen mit den jeweiligen Innenflächen der Schenkelabschnitte **7**, **7** des Blockkörpers **13** in Kontakt, wodurch eine Lagebestimmung der den Kugeldurchlaß bildenden Abschnitte **21**, **21** und des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **22** stattfindet (vgl. **Fig.** 6(e) und 6(f)). Zu diesem Zeitpunkt ist die Einsetzöffnung **34** des dünnen Plattenabschnittes **29** mit der Durchgangsöffnung **14** des Blockkörpers **13** ausgerichtet.

Dann wird das äußere, umfangsseitige Halbröhrenteil **23**b in die Durchgangsöffnung **14** von der Einsetzöffnung **34** eingesetzt, wodurch der Zusammenbau des aus Harz geformten Körpers **20** zur Ausbildung des Kugelumlaufs vervollständigt ist (vgl. **Fig.** 6(g) und 6(h)).

Dann wird die eine seitliche Deckplatte **40** mit der einen Endfläche des Blockkörpers **13** in einem weiteren Arbeitsschritt durch Klemmen befestigt, der die Kugeln haltende Kugelkäfig **12** wird eingesetzt und die andere seitliche Deckplatte **40** wird mit der anderen Endfläche des Blockkörpers **13** durch denselben Arbeitsvorgang durch Klemmen befestigt, wodurch der Zusammenbau des beweglichen Blocks **4** vollendet ist.

Gemäß der folgenden Erfindung ist der aus Harz geformte Körper **20**, der den Kugelumlauf bildet, getrennt vom Blockkörper **13** geformt. Selbst wenn der bewegliche Block **4** größer ist, wird der Fluß des flüssigen Harzes durch den Blockkörper **13** nicht behindert, wie in dem Fall, in dem der Blockkörper **13** einstückig mit dem aus Harz geformten Körper **20** ausgebildet ist. Eine Erhöhung der Anzahl von Eingußstellen, die in einer Form ausgebildet sind, kann einen korrekten Lauf des flüssigen Harzes sicherstellen, wodurch die Formgebung verbessert wird. Insbesondere sind die den Kugeldurchlaß bildenden Abschnitte **21**, **21**, die an den gegenüberliegenden, sich in Längsrichtung erstreckenden Seiten der Kugellaufrille **8** angeordnet sind, dünn, was bewirkt, daß das flüssige Harz nicht jeden Abschnitt des Raumes zur Ausbildung der den Kugeldurchlaß bildenden Abschnitte **21**, **21** erreichen kann. Daher wird in effektiver Weise der aus Harz geformte Körper **20** getrennt vom Blockkörper **13** entsprechend dem Ausführungsbeispiel der vorliegenden Erfindung ausgebildet.

Der durchgängige Umlauf wird durch den aus Harz geformten Körper **20** gebildet und es ist dadurch möglich, eine Lagebestimmung der inneren Führungsrille **10**a des Richtungswechselsdurchlasses relativ zu den den Kugeldurchlaß bildenden Abschnitten **21**, **21** sowie eine Lagebestimmung der inneren Führungsrille **10**a des Richtungswechselsdurchlasses relativ zum Kugelrücklauf **9** durchzuführen, wodurch die Durchgängigkeit des Umlaufs sichergestellt wird, um einen glatten Umlauf der Kugeln **3** zu ermöglichen.

Wenn die richtige Lagebeziehung der inneren Führungsrille **10**a des Richtungswechselsdurchlasses relativ zu den den Kugeldurchlaß bildenden Abschnitte **21**, **21** gewahrt ist, sind die den Kugeldurchlaß bildenden Abschnitte **21**, **21** an den beiden in Längsrichtung verlaufenden Seiten der Kugellaufrille **8** angeordnet, so daß sie mit den Enden der inneren Führungsrille **10**a des Richtungswechselsdurchlasses ausgerichtet sind.

Wenn die richtige Lagebeziehung der inneren Führungsrille **10**a des Richtungswechselsdurchlasses relativ zum Kugelrücklauf **9** gewahrt ist, dann kann die innere Führungsrille **10**a des Richtungswechselsdurchlasses mit der inneren Rille **23**a des Kugelrücklaufs **9** ausgerichtet werden.

Der Verbindungsabschnitt der den Kugeldurchlaß bildenden Abschnitte **21**, **21** und des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **22** wird durch einstückige Formgebung erhalten, wodurch auf einen Arbeitsschritt zum Zusammenbauen des Verbindungsabschnittes verzichtet werden kann. Obwohl die Laufrichtung der Kugeln **3** in einem derartigen Verbindungsabschnitt wechselt, kann der obengenannte, einstückige Aufbau eine Durchgängigkeit des Umlaufs sicherstellen, ohne durch die Genauigkeit beim Zusammenbau beeinflußt zu werden. Daher ist es möglich, einen glatten Lauf der Kugeln **3** von der Kugellaufbahn zwischen der Kugellaufrille **5** und der Kugelgegenlaufrille **8** zum Richtungswechseldurchlaß **10** sowie vom Richtungswechseldurchlaß **10** zum Kugelrücklauf **9** sicherzustellen.

Im folgenden werden Abänderungen des aus Harz geformten Körpers **20**, der den Kugelumlauf bildet und in weitere Teile unterteilt ist, beschrieben. Bei der Beschreibung dieser Abänderungen werden geänderte Merkmale nur im Vergleich zum ersten Ausführungsbeispiel der vorliegenden Erfindung erläutert. Für die gleichen Merkmale wie die des ersten Ausführungsbeispiels der vorliegenden Erfindung werden dieselben Bezugszeichen verwendet und auf ihre Beschreibung wird verzichtet.

[Erste Abänderung]

Die **Fig.** 8 und 9 zeigen die erste Abänderung des aus Harz geformten Körpers **20**, der den Kugelumlauf bildet, wie er beim ersten Ausführungsbeispiel beschrieben ist.

Bei der ersten Abänderung ist der aus Harz geformte Körper, der den Kugelumlauf bildet, aus dem ersten aus Harz geformten Rahmen **20**A gebildet, der durch einstückige Verbindung sowohl der den Kugeldurchlaß bildenden Abschnitte **21**, **21** als auch der Röhren **23** aus Harz an ihren Enden mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **22**A für die eine Seite und den zweiten aus Harz geformten Rahmen **20**B, der mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **22**B für die andere Seite versehen ist und getrennt vom ersten aus Harz geformten Rahmen **20**A ausgebildet ist.

In diesem Fall sind die den Kugeldurchlaß bildenden Abschnitte **21**, **21** einstückig mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **22**A über den dünnen Plattenabschnitt **29**A wie bei dem ersten Ausführungsbeispiel verbunden.

Die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **22**A sind außerdem über den dünnen Plattenabschnitt **29**A einstückig mit den Röhren **23** aus Harz verbunden. In diesem Fall ist die Röhre **23** aus Harz als ein röhrenförmiger, einstückiger Körper ausgebildet, obwohl die Halbröhrenteile des ersten Ausführungsbeispiels verwendet werden. Dementsprechend gibt es keine Einsetzöffnung **34** im dünnen Plattenabschnitt **29**A und der Kugelrücklauf **9** ist am dünnen Plattenabschnitt **29**A offengelegt.

Der erste, aus Harz geformte Rahmen **20**A und der zweite, aus Harz geformte Rahmen **20**B sind, wie in der **Fig.** 9 gezeigt, mittels einer Verbindung miteinander verbunden, bei der eine Kombination einer Aussparung und eines darin eingesetzten Vorsprungs verwendet wird, wie beispielsweise einer Randverbindung. Bei dem dargestellten Beispiel ist ein ausgesparter Abschnitt **36** einer Schwalbenschwanznut im zweiten aus Harz geformten Rahmen **20**B ausgebildet und ein Eingriffsvorsprung **35**, der in den ausgesparten Abschnitt **36** eingreifen soll, ist andererseits an den den Kugeldurchlaß bildenden Abschnitten **21**, **21** ausgebildet.

In diesem Fall wird die Röhre **23** aus Harz des ersten aus Harz geformten Rahmens **20**A in die Durchgangsöffnung **14** des Blockkörpers **13** eingesetzt und die ersten, zweiten und dritten Verbindungsplattenabschnitte **25**, **26**, **27** werden entlang der Unterfläche des waagerechten Abschnittes **6** des Blockkörpers **13** und den Innenflächen der Schenkelabschnitte **7**, **7** eingesetzt.

Dann werden die Eingriffsvorsprünge **35**, die an den jeweiligen freien Endabschnitten der ersten, zweiten und dritten Verbindungsplattenabschnitte **25**, **26**, **27** angeformt sind, mit den ausgesparten Abschnitten **36** in Eingriff gebracht, die am dünnen Plattenabschnitt **29**B des zweiten, aus Harz geformten Rahmens **24**B ausgebildet sind, der an der anderen Endfläche des Blockkörpers **13** angeordnet ist.

Die ausgesparten Abschnitte **36** können am ersten, aus Harz geformten Rahmen **20**A angeformt sein und die Eingriffsabschnitte **35** können am zweiten, aus Harz geformten Rahmen **20**B angeformt sein. Die Verbindung ist nicht auf die oben beschriebene Art beschränkt, sondern es kann jedwede herkömmliche Verbindungsmethode verwendet werden, bei denen die Enden der getrennten Teile in einer geeigneten Verbindungslage gehalten und verbunden werden können.

[Zweite Abänderung]

Die **Fig.** 10 und 11 zeigen die zweite Abänderung des aus Harz geformten Körpers **20**, der den Kugelumlauf bildet, wie er beim ersten Ausführungsbeispiel beschrieben ist.

Bei der zweiten Abänderung ist der aus Harz geformte Körper **20**, der den Kugelumlauf bildet und der durch einstückige Formgebung der beiden den Kugeldurchlaß bildenden Abschnitte **21**, **21** und der Röhren **23** aus Harz als einen den Rücklauf bildenden Abschnitt zusammen mit einem Paar von den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **22**, **22** geformt ist, am Mittelabschnitt eines jeden, den Kugeldurchlaß bildenden Abschnittes **21**, **21** und der Röhren **23** aus Harz in zwei Teile geteilt. Insbesondere sind die den Kugeldurchlaß bildenden Abschnitte **21**, **21** und die Röhren **23** aus Harz an ihrem Mittelabschnitt in jeweils zwei Hälften geteilt und eine jede der beiden dermaßen geteilten Hälften ist einstückig mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **22**, **22** ausgebildet, wodurch zwei aus Harz geformte Rahmen **20**C, **20**D mit im wesentlichen derselben Form gebildet werden.

Vier den Kugeldurchlaß bildende Abschnitte **21**, **21** sind an den ersten, zweiten und dritten Verbindungsplattenabschnitten **25**, **26**, **27** ausgebildet. Ausgesparte Abschnitte **38** und darin einzusetzende Eingriffsvorsprünge **37** sind an den geteilten Enden der ersten, zweiten und dritten Verbindungsplattenabschnitte **25**, **27** und den geteilten Enden der Röhren **23** aus Harz angeformt.

[Dritte Abänderung]

Die **Fig.** 12 bis 14 zeigen die dritte Abänderung des aus Harz geformten Körpers **20**, der den Kugelumlauf bildet, wie er beim ersten Ausführungsbeispiel beschrieben ist.

Bei der dritten Abänderung wird die Röhre **23** aus Harz als ein den Rücklauf bildender Abschnitt, wie sie beim ersten Ausführungsbeispiel beschrieben ist, nicht verwendet und ein aus Harz geformter Rahmen **20**E wird durch einstückige Formgebung der ersten, zweiten und dritten Verbindungsplattenabschnitte **25**, **26**, **27** erhalten, die die den Kugeldurchlaß bildende Abschnitte **21**, **21** mit den dünnen Plattenabschnitten **29**, **29** aufweisen, die jeweils das Paar der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **22**, **22** aufweisen. Der Kugelrücklauf **9** ist als eine im Blockkörper **13** ausgebildete Durchgangsöffnung aufgebaut.

In diesem Fall kann ein Eingriffsvorsprung **39**a, der mit einem sich verjüngenden, im Öffnungsende des Kugelrücklaufs **9** ausgebildeten Abschnitt **15** in Eingriff bringbar ist, im Öffnungsende der Kugelöffnung **39** des dünnen Plattenabschnittes **29** angeformt sein. Ein derartiger Aufbau erlaubt es, eine korrekte Verbindung des Endes des Kugelrücklaufs **9** mit dem den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt **22** herzustellen.

Bei dem dargestellten Beispiel ist zusätzlich ein gebogener Eingriffsvorsprung **48** am Verbindungsabschnitt der äußeren Führungsrille **10**b des Richtungswechseldurchlasses mit dem Kugelrücklauf **9** ausgebildet. Der Eingriffsvorsprung **48** kann in die Kugelöffnung **39** des dünnen Plattenabschnittes **29** eingesetzt werden und greift in den sich verjüngenden Abschnitt **15** des Öffnungsendes des Kugelrücklaufs **9** ein.

[Vierte Abänderung]

Fig. 15 zeigt die vierte Abänderung des aus Harz geformten Körpers **20**, der den Kugelumlauf bildet, wie er beim ersten Ausführungsbeispiel beschrieben ist.

Bei der vierten Abänderung wird die bei der dritten Abänderung beschriebene Röhre **23** aus Harz nicht verwendet und ein aus Harz geformter Rahmen **24**B wird durch einstückige Formgebung der den Kugeldurchlaß bildenden Abschnitte **21** zusammen mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **22** bei der einen Seite erhalten, der andere aus Harz geformte Rahmen **24**C, der mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **22** für die andere Seite versehen ist, ist getrennt vom oben erwähnten aus Harz geformten Rahmen **24**B ausgestaltet, und die aus Harz geformten Rahmen **24**B, **24**C sind miteinander durch den Eingriff des Eingriffsvorsprung **35** in die Aussparung **36** verbunden. Abgesehen davon ist der restliche Aufbau derselbe wie der der dritten Abänderung.

[Abänderungen der Kugellaufbahn]

Beim ersten Ausführungsbeispiel und den ersten bis vierten Abänderungen wurde beschrieben, daß zwei Laufbahnen für die Kugeln an der Oberfläche der Führungsschiene **2** und eine einzelne Kugellaufbahn an einer jeden Seitenfläche der Führungsschiene **2** vorgesehen ist, so daß eine Gesamtzahl von vier Kugellaufbahnen vorgesehen ist. Bei der vorliegenden Erfindung können jedoch andere Bauformen von Kugellaufbahnen verwendet werden, wie dies in der **Fig.** 16 gezeigt ist. Bezüglich der Teilung des aus Harz geformten Körpers **20**, der den Kugelumlauf bildet, basieren sämtliche, in der **Fig.** 16 gezeigten Abänderungen auf dem Teilungsschema des ersten Ausführungsbeispiels. Es können jedoch sämtliche Teilungsschemata der ersten bis vierten Abänderungen bei den Abänderungen der Kugellaufbahn, wie sie in der **Fig.** 16 gezeigt sind, verwendet werden.

Bei dem Beispiel, das in den **Fig.** 16(a) und 16(b) gezeigt ist, sind zwei untere und obere Kugellaufbahnen als Rollkörper an einer jeden Lücke zwischen den rechten und linken Seitenflächen der Führungsschiene **2** und den inneren Flächen der rechten und linken Schenkelabschnitte **7**, **7** des beweglichen Blockes **13** vorgesehen, so daß insgesamt vier Kugellaufbahnen vorhanden sind.

Fig. 16(b) zeigt die aus Harz geformten Körper **20**, bei dem sämtliche, den Kugeldurchlaß bildenden Abschnitte der vier Kugellaufbahnen einstückig miteinander ausgebildet sind. Der aus Harz gebildete Körper **20** kann jedoch auch in zwei aus Harz geformte Körper **20**, **20** geteilt sein, die zwei Kugellaufbahnen für eine jede der rechten und linken Seiten der Führungsschiene **2**, wie in der **Fig.** 18 gezeigt ist, entsprechen.

Im Beispiel der **Fig.** 16(c) und 16(d) ist der bewegliche Block **4** mit dem horizontalen Abschnitt **6**, der der Oberfläche der Führungsschiene **2** gegenüberliegt, und mit einem einzigen Schenkelabschnitt **7** versehen, der der einen Seitenfläche der Führungsschiene **2** gegenüberliegt. Die einzelne Kugellaufbahn **3** als Rollkörper ist zwischen der einen Seitenfläche der Führungsschiene **2** und dem einzelnen Schenkelabschnitt **7** des beweglichen Blockes **7** vorgesehen und die andere, einzelne Kugellaufbahn **3** ist zwischen der Oberfläche der Führungsschiene **2** und der Unterfläche des waagerechten Abschnittes in der Nähe der Kante der Führungsschiene **2** vorgesehen, um so insgesamt zwei Kugellaufbahnen vorzusehen.

Bei dem in **Fig.** 16(e) und 16(f) gezeigten Beispielen ist der bewegliche Block **4** mit einem Paar von Schenkelabschnitten **7**, **7** versehen, zwischen denen die Führungsschiene **2** an ihren rechten und linken Flächen gehalten ist. Die einzelne Kugellaufbahn **3** ist in einer jeden Lücke zwischen den rechten und linken Oberflächen der Führungsschiene **2** und den inneren Flächen der rechten und linken Schenkelabschnitte **7**, **7** des beweglichen Blockes **4** vorgesehen, so daß insgesamt zwei Kugellaufbahnen vorhanden sind.

Beim Beispiel der **Fig.** 16(g) und 16(h) ist der bewegliche Block **4** entlang der einen Seitenfläche der Führungsschiene **2** angeordnet. Zwei obere und untere Kugellaufbahnen sind zwischen der einen Seitenfläche der Führungsschiene **2** und des beweglichen Blockes **4** vorgesehen.

[Zweites Ausführungsbeispiel]

Die **Fig.** 18 bis 20 zeigen eine Führungsvorrichtung für eine geradlinige Bewegung gemäß dem zweiten Ausführungsbeispiel der vorliegenden Erfindung.

Beim zweiten Ausführungsbeispiel werden Rollen als Rollkörper verwendet. Insbesondere weist die Führungsvorrichtung für eine geradlinige Bewegung eine Führungsschiene **202** als ein Führungsteil auf, welches sich geradlinig erstreckt, und ein beweglicher Block **104** ist derart angeordnet, daß er über eine große Anzahl von Rollen **203** als Rollkörper entlang der Führungsschiene **202** beweglich ist.

Die Führungsschiene **202** ist in der Form eines langen Balkens mit rechteckigem Querschnitt ausgestaltet. Zwei Rollenlaufflächen **205**, **205** sind als Rollkörperlaufflächen an der waagerechte, oberen Fläche der Führungsschiene **2** ausgebildet und eine einzelne Rollenlauffläche **205** als Rollkörperlauffläche ist an jeder der rechten und linken senkrechten Flächen der Führungsschiene **2** ausgebildet, so daß insgesamt vier Oberflächen **5** vorhanden sind.

Der bewegliche Block **204** ist als ein Blockkörper ausgestaltet, der einen Querschnitt in Form eines umgekehrten U's aufweist, dessen sich öffnende Enden nach unten gerichtet sind. Der Blockkörper ist mit einem waagerechten Abschnitt **206** versehen, der der oberen Fläche der Führungsschiene **202** gegenüberliegt, sowie mit einem Paar von Schenkelabschnitten **207**, **207**, die sich von den rechten und linken Enden des waagerechten Abschnittes **206** nach unten erstrecken und den rechten und linken Seitenflächen der Führungsschiene **202** jeweils gegenüberliegen. Der waagerechte Abschnitt **206** weist an seiner unteren Fläche zwei Rollengegenlaufflächen **208**, **208** als Rollkörpergegenlaufbahnen auf, die den auf der oberen Fläche der Führungsschiene **202** ausgebildeten Rollenlaufflächen **205**, **205** entsprechen. Ein jeder der Schenkelabschnitte **207**, **207** weist an seiner Innenfläche eine einzelne Rollengegenlauffläche **208** als Rollkörpergegenlaufbahn auf, die der jeweiligen Rollenlauffläche **205**, **205** entspricht, die an den rechten und linken Seitenflächen der Führungsschiene **202** ausgebildet sind.

Zusätzlich sind beim beweglichen Block **204** vier Rollenrückläufe **209**, **209**, **209**, **209** als Rollkörperrückläufe ausgebildet, die jeweils parallel zu den vier Rollengegenlaufflächen **208**, **208**, **208**, **208** ausgestaltet sind, sowie vier Paare von Richtungswechseldurchlässen **210**, **210**, **210**, **210**, die jeweils U-förmig ausgestaltet sind, um die beiden jeweiligen Enden der Rollengegenlaufflächen **208**, **208**, **208**, **208** mit den beiden jeweiligen Enden der Rollenrückläufe **209**, **209**, **209**, **209** zu verbinden, um auf diese Weise vier endlose Umläufe zu bilden.

Die Rollenrückläufe **209**, **209**, die jeweils den Rollenlaufflächen **205**, **205** entsprechen, die an der oberen Seite der Führungsschiene **202** ausgebildet sind, sind im waagerechten Abschnitt **206** ausgebildet. Die anderen Rollenrückläufe **209**, **209**, die jeweils den Rollenlaufflächen **205**, **205** entsprechen, die an den rechten und linken senkrechten Flächen der Führungsschiene **202** ausgeformt sind, sind an den Schenkelabschnitten **207**, **207** des beweglichen Blockes **204** jeweils ausgebildet.

Bei jedem der endlosen Umläufe dieses Ausführungsbeispiels sind die Rollen **3** in Form einer Kette mittels eines Rollenkäfigs **212** als Rollkörperkäfig gehalten, so daß die Rollen **203** umlaufen können, während sie durch den Rollenkäfig **212** geführt werden.

Wie in den **Fig.** 19(b) bis 19(d) gezeigt ist, weist der Rollenkäfig **212** einen biegsamen Gurtabschnitt **212**b, der mit Rollenöffnungen **212**a zur jeweiligen Aufnahme der Rollen **203** versehen ist, sowie Abstandsabschnitte **212**c auf, die wiederum zwischen zwei benachbarten Rollen **203**, **203** angeordnet sind. Der Gurtabschnitt **212**b hat eine Weite, die größer ist als der Durchmesser einer Rolle **203**, so daß die beiden Seitenkanten des Gurtabschnittes **212**b sich von einer Rolle **203** nach außen erstrecken.

Der Abstandsabschnitt **212**c ist mit einer Aussparung **212**d zum Abstützen einer Rolle versehen, die der zylindrischen Oberfläche einer Rolle **203** entspricht. Die Rolle **203** ist an ihren beiden Seiten durch ein Paar von stützenden Aussparungen **212**d abgestützt, so daß verhindert wird, daß die Rollen **203** vom Gurtabschnitt **212**b herausfallen können. Bei diesem Ausführungsbeispiel ist das eine Ende des Gurtabschnittes **212**b nicht mit dessen anderen Ende verbunden, wodurch ein streifenförmiger Gurt mit zwei Enden entsteht. Das eine Ende des Gurtabschnittes **212**b kann mit dem anderen Ende verbunden werden, so daß ein endloser Gurt gebildet wird.

Wie in den **Fig.** 18 und 20 gezeigt ist, besteht der bewegliche Block **204** aus einem Blockkörper **213** aus Metall mit Rollengegenlaufflächen **208**, **208**, **208**, **208**, aus einem aus Harz geformten Körper **220**, der die Rollenumläufe bildet und der in den Blockkörper **213** eingesetzt ist, sowie aus einem Paar von seitlichen Deckplatten **214**, **214**, die an den beiden Endflächen des Blockkörpers **213** befestigt sind, in welchen der aus Harz geformte Körper **220** eingesetzt wird.

Beim zweiten Ausführungsbeispiel sind vier Umläufe durch zwei aus Harz geformte Körper **220**, **220** gebildet, welche wiederum den Rollenumlauf bilden und welche an den rechten und linken Seiten angeordnet sind.

Ein jeder der Rollenumläufe der aus Harz geformten Körper **220** weist ein Paar von einem Rollendurchlaß bildenden Abschnitten **221**, **221** auf, die sich entlang der beiden in Längsrichtung erstreckenden Seiten der Rollengegenlaufflächen **208** erstrecken, sowie ein Paar von einen Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **222**, **222**, die an den beiden Seitenflächen des Blockkörpers **213** vorgesehen ist, sowie ferner einer Röhre **223** aus Harz als einen den Rücklauf ausbildenden Abschnitt, der in eine im Blockkörper **213** gebildete Durchgangsöffnung eingesetzt ist.

Die den Rollendurchlaß bildenden Abschnitte **221**, **221** sind mit Führungsflächen versehen, die die beiden Seitenkanten des Gurtabschnittes **212**b des Rollenkäfigs **212** in einem belasteten Bereich führen, wie im Detail in der **Fig.** 20 dargestellt ist. Die Führungsrillen können nicht nur verhindern, daß der Rollenkäfig **212** während des Laufs der Rollen schwingt, sondern auch, daß er durchhängt, indem die Seitenkanten des Gurtabschnittes **212**b in die Führungsrille **221**a eingreifen. Die Rollen **203** werden durch den Rollenkäfig **212** abgestützt. Insbesondere wird der Rollenkäfig **212** durch einen Backenabschnitt der Führungsrille **221**a abgestützt, was zum Ergebnis hat, daß die Rollen **203** in ihrer korrekten Lage gehalten werden und nicht vom beweglichen Block **204** abfallen.

Bei diesem Ausführungsbeispiel ist das eine Ende des Gurtabschnittes **212**b nicht mit dessen anderem Ende verbunden, wodurch ein streifenförmiger Gurt mit zwei Enden entsteht. Das eine Ende des Gurtabschnittes **212**b kann mit dessen anderem Ende verbunden sein, so daß ein endloser Gurt gebildet wird.

Im Rollenrücklauf **209** und im Richtungswechseldurchlaß **210** als nicht belastete Bereiche sind außerdem Führungsrillen **209**c, **210**c ausgebildet, um die Seitenkanten des Gurtabschnittes **212**b zu führen. Die Führungsrillen **209**c, **210**c sind mit der oben erwähnten Führungsrille **221**a im belasteten Bereich verbunden, um so eine endlose Rille am gesamten Umfang zu bilden.

Bei einem jeden der aus Harz geformten Körper **220**, **220**, die den Rollenumlauf bilden, sind die den Rollendurchlaß bildenden Abschnitte **221**, **221** und das Paar der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **222**, **222** einstückig miteinander ausgebildet. Die Röhre **223** aus Harz, die den Rollenrücklauf **209** bildet, ist getrennt von den aus Harz geformten Körpern **220**, **220** gebildet. Insbesondere sind die einen Enden der beiden Paare der den Rollendurchlaß bildenden Abschnitte **221**, **221** einstückig mit den Enden des Paares der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **222**, **222** verbunden, um einen einzelnen Rahmen **220A** aus Harz zu bilden, so daß der dermaßen gebildete Rahmen **220A** aus Harz in den Blockkörper **213** eingesetzt werden kann. Der andere Rahmen **220A** aus Harz weist denselben Aufbau auf.

Die den Rollendurchlaß bildenden Abschnitte **221**, **221**, die an der oberen Fläche der Führungsschiene **202** angeordnet sind, sind einstückig mit den anderen, den Rollendurchlaß bildenden Abschnitten **221**, **221** verbunden, die an der Seitenfläche der Führungsschiene **202** mittels eines dünnen Verbindungsplattenabschnittes **226** angeordnet sind.

Der den Richtungswechseldurchlaß und innere Führung bildende Abschnitt **222** ist einstückig mit einem dünnen Plattenabschnitt **229** ausgeformt, der mit der Endfläche des Blockkörpers **213** in Kontakt gebracht wird.

Der dünne Plattenabschnitt **229** weist den ersten Endplattenabschnitt **230** auf, der in Kontakt mit der Endfläche des waagerechten Abschnittes **206** des Blockkörpers **213** gebracht werden soll, sowie den dritten Endplattenabschnitt **232**, der mit der Endfläche des Schenkelabschnitts **207** in Kontakt gebracht werden soll, sowie ferner den zweiten Endplattenabschnitt **231**, der an der Ecke zwischen dem waagerechten Abschnitt **206** und dem Schenkelabschnitt **207** an der Endfläche des Blockkörpers **213** angeordnet ist und den ersten Endplattenabschnitt **230** mit dem dritten Endplattenabschnitt **232** verbindet.

Das Paar der den Richtungswechseldurchlaß bildenden Abschnitte **221**, **221**, die an den beiden sich in Längsrichtung erstreckenden Seiten der Rollenlauffläche **208** angeordnet sind, sind an der inneren Kante des ersten Endplattenabschnittes **230** und der Innenkante des dritten Endplattenabschnittes **232** jeweils einstückig angeformt. Die beiden Enden des Verbindungsplattenabschnittes **226** sind einstükkig mit den Innenkanten der zweiten Plattenabschnitte **231**, **231** verbunden.

Ein jeder der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **222** ist von halbzylindrischer Form. Am äußeren Umfang des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **222** ist eine innere Führungsrille **210**a mit einem rechteckigen Querschnitt ausgeformt, so daß der innere Führungsabschnitt des Richtungswechseldurchlasses **210** entsteht. Das eine Ende des Grundes der inneren Führungsrille **210**a ist mit dem Ende der Rollengegenlauffläche **208** verbunden. Dementsprechend hat das eine Ende der inneren Führungsrille **210**a im Querschnitt dieselbe Form wie die Rollengegenlauffläche **208**, so daß das eine Ende der inneren Führungsrille **210**a mit dem Ende der Rollengegenlauffläche **208** ausgerichtet ist. Das andere Ende der inneren Führungsrille **210**a des Richtungswechseldurchlasses **210** ist mit dem Ende des Rollenrücklaufs **229** verbunden. Dementsprechend hat das andere Ende der inneren Führungsrille **210**a im Querschnitt dieselbe Form wie der Rollenrücklauf **209**, so daß das andere Ende der inneren Führungsrille **210**a mit dem Ende des Rollenrücklaufs **209** ausgerichtet ist.

Zylindrische Flanschabschnitte **233**, **233** sind an den beiden Enden der inneren Führungsrille **210**a ausgeformt. Der Abstand zwischen den jeweiligen äußeren Flächen der zylindrischen Flanschabschnitte **233**, **233** ist größer als die Weite des Gurtabschnittes **212**b. Die zylindrischen Flanschabschnitte **233**, **233** bilden zusammen mit der seitlichen Deckplatte **240**, die weiter unten beschrieben ist, eine Führungsrille **210**c für den Rollenkäfig **212**.

Das eine Ende der inneren Führungsrille **210**a des Richtungswechseldurchlasses **210** erstreckt sich bis zur Berührungsfläche des ersten und dritten Endplattenabschnittes **230**, **232** mit der Endfläche des Blockkörpers **213**, und ist so mit dem Ende der Rollengegenlauffläche **208** verbunden. Das andere Ende der inneren Führungsrille **210**a des Richtungswechseldurchlasses **210** erstreckt sich bis zur Endfläche des dünnen Plattenabschnittes **229**, der vom Blockkörper **213** beabstandet ist. Ein Absatzabschnitt **222**a, dessen Tiefe identisch der Wandstärke des dünnen Plattenabschnittes **229** ist, ist am anderen Ende der inneren Führungsrille **210**a ausgebildet. Das innere, umfangsseitige Halbröhrenteil der Röhre **223** aus Harz steht von der Endfläche des Blockkörpers **13** um eine Länge hervor, die identisch der Dicke des dünnen Plattenabschnittes **229** ist. Das vorspringende Ende des Halbröhrenteils **223**a ist in den Absatzabschnitt **222**a des dünnen Plattenabschnittes **229** eingepaßt.

An den ersten und dritten Endplattenabschnitten **230**, **232** des dünnen Plattenabschnittes **229** sind halbkreisförmige Öffnungen **234**, **234** zum Einsetzen der Röhre angeformt, in die die Enden des äußeren, umfangsseitigen Halbröhrenteils **223**a der Röhre **223**a eingesetzt werden, die den Rollenrücklauf **209** bildet. Die Röhre **223** aus Harz wird in die kreisförmige Durchgangsöffnung **214** eingesetzt, die im Blockkörper **213** ausgebildet ist, so daß die innere Umfläche der Röhre **223** aus Harz den Rollenrücklauf **209** bildet.

Wie in der **Fig.** 20 gezeigt ist, besteht die Röhre **223** aus Harz aus dem inneren, umfangsseitigen Halbröhrenteil **223**a, welches durchgängig mit der inneren Führungsrille **210**a des Richtungswechseldurchlasses verbunden ist, und aus dem äußeren umfangsseitigen Halbröhrenteil **323**b, welches durchgängig mit der äußeren Führungsrille **210**b des Richtungswechseldurchlasses **210** verbunden ist, welcher an der seitlichen Deckplatte **240** ausgebildet ist. Das innere, umfangsseitige Röhrenteil **223**a weist einen inneren Rillenabschnitt **209**a mit rechteckigem Querschnitt auf sowie Seitenkantenabschnitte **223**b, die sich entlang dem inneren Rillenabschnitt **209**a in Längsrichtung erstrecken. Die in Längsrichtung verlaufenden Kantenabschnitte **223**c des inneren, umfangsseitigen Halbröhrenteils **223**a weisen dieselbe Weite auf wie der Flanschabschnitt **232** des Abschnittes **228**.

Das äußere, umfangsseitige Halbröhrenteil **223**b ist als ein geradliniges Teil mit demselben rechteckigen Querschnitt wie die äußere Führungsrille **210**b des Richtungswechseldurchlasses ausgebildet, der an der seitlichen Deckplatte **240** ausgeformt ist. Das äußere, umfangsseitige Halbröhrenteil **223**b weist einen äußeren Rillenabschnitt **209**b auf, der durchgängig mit der äußeren Führungsrille **210**b verbunden ist, sowie Seitenkantenabschnitte 223d, die sich in Längsrichtung entlang dem äußeren Rillenabschnitt **209**b erstrecken. Die Seitenkantenabschnitte **223**d sind an ihren äußeren Kanten mit Vorsprüngen **223**e versehen, die in Kontakt mit den Seitenkantenabschnitten **223**c des inneren, umfangsseitigen Halbröhrenteils **223**a gebracht werden, um die Führungsrille des Gurtabschnittes **212** des Rollenkäfigs **212** zu bilden.

Das innere, umfangsseitige Halbröhrenteil **223**a der Röhre **223** aus Harz weist dieselbe Länge wie der Blockkörper **213** auf. Das innere, umfangsseitige Halbröhrenteil **223**a ist derart angeordnet, daß es die Endfläche des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **222** berührt, der an der Seite des Blockkörpers **213** angeordnet ist.

Das äußere, umfangsseitige Halbröhrenteil **223**b der Röhre **223** aus Harz weist andererseits eine größere Länge als der Blockkörper **213** auf und ist um die Dicke der ersten und dritten Endplattenabschnitte des dünnen Plattenabschnittes **229** länger, der an den beiden Enden des Blockkörpers **213** angeordnet ist. Das äußere, umfangsseitige Halbröhrenteil **223**b ist in Einsetzöffnungen **234** der ersten und dritten Endplattenabschnitte **230**, **232** eingesetzt. Eine Lagebestimmung in Längsrichtung des äußeren, umfangsseitigen Halbröhrenteils **223**b findet dadurch statt, daß die beiden Enden des äußeren, umfangsseitigen Halbröhrenteils **223**b, die in die Einsetzöffnungen **234** eingesetzt sind, die im Umfangsrichtung verlaufende Kante des Endabschnitts der äußeren Führungsrillen **210** des Richtungswechseldurchlasses berühren, die an der seitlichen Deckplatte ausgebildet sind. Die Vorsprünge **223**e, die an den beiden, sich in Längsrichtung erstreckenden Seitenkanten **223** des äußeren, umfangsseitigen Halbröhrenteils **223** ausgebildet sind, berühren die zylindrischen Flanschabschnitte **233** an den Seitenkanten der inneren Führungsrille **210**a des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **222** und das äußere, umfangsseitige Halbröhrenteil **223**b sowie das innere umfangsseitige Halbröhrenteil **223**a können sich in der Einsetzöffnung nicht drehen.

Die Röhren **223** aus Harz und die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **222** werden durch die Einsetzöffnungen **234**, die an den ersten und dritten Endplattenabschnitten **230**, **232** des dünnen Plattenabschnittes **229** angeformt sind, genau positioniert und auf diese Weise kann ein korrekter Zusammenbau stattfinden.

Die seitliche Deckplatte **240** ist mit vier ausgesparten Abschnitten **241** versehen, die äußere Führungsrillen **210**b für den Richtungswechseldurchlaß aufweisen, in welchen die

Abschnitte **228** der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **222** eingepaßt werden, sowie Einschraubabschnitte zum Befestigen der seitlichen Deckplatte **240** am Blockkörper **213**. Bei den Einschraubabschnitten wird die seitliche Deckplatte am Blockkörper **213** befestigt, indem Schrauben **244** in Öffnungen **243**, die an der seitlichen Deckplatte **240** ausgebildet sind, eingesetzt werden, wobei die Schrauben **244** mit Gewindeöffnungen **245**, die an der Endfläche des Körpers **213** ausgebildet sind, im Eingriff stehen. Die Öffnungen **243** befinden sich zwischen den ersten und dritten Endplattenabschnitten **230**, **232** des dünnen Plattenabschnittes **229**.

Der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt **222**, der mit der inneren Führungsrille **210**a des Richtungswechseldurchlasses versehen ist, ist in den ausgesparten Abschnitt **241** der seitlichen Deckplatte **240** eingepaßt. Der dünne Plattenabschnitt **229** ist zwischen der seitlichen Deckplatte **240** und der Endfläche des Blockkörpers **213** durch eine Klemmkraft gehalten, so daß er fest dazwischen befestigt ist.

Die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **222** und der den Rollendurchlaß bildende Abschnitt **221** sind über den dünnen Plattenabschnitt **229** verbunden, wodurch es möglich ist, eine genaue Lagebeziehung des Endes der inneren Führungsrille **210**a des Richtungswechseldurchlasses relativ zu den den Rollendurchlaß bildenden Abschnitte **221** sowie eine genaue Lagebeziehung der inneren Führungsrille **210**a des Richtungswechseldurchlasses relativ zum Rollenrücklauf **209** zu wahren.

Der dünne Plattenabschnitt **229** wird gleichmäßig gegen die ebene Endfläche des Blockkörpers **213** durch eine auf die seitliche Deckplatte **240** wirkende Klemmkraft gedrückt. Selbst wenn der den Richtungswechseldurchlaß und innere Führung bildende Abschnitt **222** sich nicht in einer korrekten Lage befindet, ändert der dünne Plattenabschnitt **229** seine Form, wodurch die korrekte Lage des den Richtungswechseldurchlaß und innere Führung bildenden Abschnitts **222** ermöglicht wird. Der dünne Plattenabschnitt **229** ist durch eine Klemmkraft festgeklemmt befestigt, die auf die seitliche Deckplatte **240** wirkt und die durch ein derartiges Klemmverfahren erzeugte Reibungskraft kann eine ungünstige Bewegung der inneren Führungsrille **210**a des Richtungswechseldurchlasses verhindern.

Im folgenden werden Abänderungen des aus Harz geformten Körpers **220**, der den Rollenumlauf bildet und in Teile unterteilt ist beschrieben. Bei der Beschreibung der Abänderungen werden abgeänderte Merkmale nur im Vergleich zum zweiten Ausführungsbeispiel der vorliegenden Erfindung erläutert. Dieselben Bauteile erhalten dieselben Bezugszeichen wie die beim zweiten Ausführungsbeispiel der vorliegenden Erfindung und auf ihre Beschreibung wird im folgenden verzichtet.

[Erste Abänderung]

Die **Fig.** 21 und 22 zeigen die erste Abänderung des aus Harz geformten Körpers **20**, der den Rollkörperumlauf bildet, wie er beim zweiten Ausführungsbeispiel beschrieben ist.

Bei der ersten Abänderung ist der aus Harz geformte Körper **220**, der den Rollkörperumlauf bildet, aus einem ersten aus Harz geformten Rahmen **220**A, der durch eine einstükkige Bindung der beiden den Rollendurchlaß bildenden Abschnitte **221**, **221** und den Röhren **223** aus Harz an ihren jeweiligen Enden mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **221** an der einen Seite erhalten wird, und aus dem zweiten aus Harz geformten Rahmen **220**B zusammengesetzt, der mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **222**B an der anderen Seite versehen ist und getrennt vom ersten aus Harz geformten Rahmen **220**A ausgebildet ist.

In diesem Fall sind die den Rollendurchlaß bildenden Abschnitte **221**, **221** mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **222**A über den dünnen Plattenabschnitt **229**A wie beim zweiten Ausführungsbeispiel einstückig verbunden.

Die den Richtungswechseldurchlaß und innere Führung bildende Abschnitte **222** sind außerdem über den dünnen Plattenabschnitt **229**A einstückig mit den Röhren **222** aus Harz verbunden. In diesem Fall ist die Röhre **223** aus Harz als ein röhrenförmiger einstückiger Körper ausgestaltet, obwohl die Halbröhrenteile beim zweiten Ausführungsbeispiel verwendet werden. Dementsprechend gibt es keine Einsetzöffnung **234** im dünnen Plattenabschnitt **229**A und der Rollenrücklauf **209** ist am dünnen Plattenabschnitt **229**A offengelegt.

Der erste, aus Harz geformte Rahmen **220**A und der zweite, aus Harz geformte Rahmen **220**B sind, wie in der **Fig.** 22 gezeigt, durch eine Verbindung miteinander verbunden, die eine Kombination einer Aussparung und eines darin einzusetzenden Vorsprungs umfaßt, wie beispielsweise eine Randverbindung. Beim dargestellten Beispiel ist ein ausgesparter Abschnitt **236** einer Schwalbenschwanznut im zweiten, aus Harz geformten Rahmen **120**B ausgebildet und ein Eingriffsvorsprung **235**, der in den ausgesparten Abschnitten **236** eingreift, ist außerdem an den den Rollendurchlaß bildenden Abschnitten **221**,**221** ausgebildet.

In diesem Fall ist die Röhre **223** aus Harz in den aus Harz geformten Rahmen **220**A in der Durchgangsöffnung des Blockkörpers **213** eingesetzt und die den Rollendurchlaß bildenden Abschnitte **221**, **221** und der Verbindungsplattenabschnitt **226** sind entlang der Unterfläche des waagerechten Abschnittes **206** des Blockkörpers **213** und den Innenflächen der Schenkelabschnitte **207**, **207** eingesetzt.

Dann greifen die Eingriffsvorsprünge **235**, die an den den Rollendurchlaß bildenden Abschnitten **221**, **221** und dem Verbindungsplattenabschnitt **226** ausgebildet sind, in die ausgesparten Abschnitte **236** ein, die am dünnen Plattenabschnitt **229**B des zweiten, aus Harz gebildeten Rahmens **224**B ausgebildet sind, der wiederum an der anderen Endfläche des Blockkörpers **213** angeordnet ist.

Die ausgesparten Abschnitte **236** können am ersten, aus Harz gebildeten Rahmen **220**A ausgebildet sein und die Eingriffsvorsprünge **235** können am zweiten aus Harz geformten Rahmen **220**B ausgebildet sein. Die Verbindung ist nicht auf die oben beschriebene Verbindung beschränkt, sondern es kann jedwede herkömmliche Verbindung verwendet werden, bei denen die Enden der geteilten Teile in einer geeigneten Verbindungslage gehalten und verbunden werden können.

[Zweite Abänderung]

Die **Fig.** 23 und 24 zeigen die zweite Abänderung des aus Harz geformten Körpers **220**, der den Rollkörperumlauf bildet, wie er beim zweiten Ausführungsbeispiel beschrieben ist.

Bei der zweiten Abänderung ist der aus Harz geformte Körper **220**, der den Rollenumlauf bildet und der durch einstückige Formgebung sowohl der den Rollendurchlaß bildenden Abschnitte **221**, **221** als auch der Röhren **223** aus Harz als einen den Rücklauf bildenden Abschnitt zusammen mit einem Paar von den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt **221**, **221** erhalten wurde, am Mittelabschnitt eines jeden der den Rollendurchlaß bildenden Abschnitte **221**, **221** und den Röhren **223** aus Harz in zwei Teile geteilt. Insbesondere sind die den Rollendurchlaß bildenden Abschnitte **221**, **221** und die Röhren **223** aus Harz an ihrem Mittelabschnitt in die jeweiligen zwei Hälften geteilt und eine jede der derartig geteilten Hälften ist einstükkig mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **221**, **221** ausgebildet, wodurch zwei aus Harz gebildete Rahmen **220**C, **220**D mit im wesentlichen derselben Form gebildet werden.

An den geteilten Enden der den Rollendurchlaß bildenden Abschnitte **221**, **221**, den geteilten Enden des Verbindungsplattenabschnittes **226** und den geteilten Enden der Röhren **223** aus Harz sind ausgesparte Abschnitte **238** und darin einzusetzende Eingriffsvorsprünge **237** angeformt.

[Dritte Abänderung]

Die **Fig.** 25 bis 26 zeigen die dritte Abänderung des aus Harz gebildeten Körpers **220**, der den Rollenumlauf bildet, wie er beim zweiten Ausführungsbeispiel beschrieben ist.

Bei der dritten Abänderung wird die Röhre **223** aus Harz, die den den Rücklauf bildenden Abschnitt darstellt, der beim zweiten Ausführungsbeispiel beschrieben ist, nicht verwendet und ein aus Harz gebildeter Rahmen **220**E entsteht durch einstückige Formgebung der den Rollendurchlaß bildenden Abschnitte sowie des Verbindungsplattenabschnittes **226** zusammen mit den dünnen Plattenabschnitten **229**, **229**, die jeweils das Paar der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **222**, **222** aufweisen. Der Rollenrücklauf **209** ist als eine im Blockkörper **213** ausgeformte Durchgangsöffnung ausgebildet.

In diesem Fall kann ein Eingriffsvorsprung **239**a, der mit einem sich verjüngenden Abschnitt **215** in Eingriff bringbar ist, der im Öffnungsende des Rollenrücklaufs **209** angeformt ist, im Öffnungsende der Rollenöffnung **239** des dünnen Plattenabschnittes **229** angeformt sein. Ein derartiger Aufbau ermöglicht eine korrekte Verbindung des Endes des Rollenrücklaufs **209** und des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **222**.

Beim dargestellten Beispiel ist ein bogenförmiger Eingriffsvorsprung **248** zusätzlich am Verbindungsabschnitt der äußeren Führungsrille **210**b des Richtungswechseldurchlasses mit dem Rollenrücklauf ausgebildet. Der Eingriffsvorsprung **248** kann in die Rollenöffnung **239** des dünnen Plattenabschnittes **229** eingepaßt werden und in den sich verjüngenden Abschnitt **215** des Öffnungsendes des Rollenrücklaufes **209** eingreifen.

[Vierte Abänderung]

Fig. 26 zeigt die vierte Abänderung des aus Harz gebildeten Körpers **220**, der den Rollenumlauf bildet, wie er beim zweiten Ausführungsbeispiel beschrieben ist.

Bei der vierten Abänderung wird die Röhre **223**, wie sie in der dritten Abänderung beschrieben ist, nicht verwendet und ein aus Harz geformter Rahmen **220**F wird durch einstückige Formgebung der den Rollendurchlaß bildenden Abschnitte **221** mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **222** an der einen Seite erhalten. Der andere aus Harz geformte Rahmen **220**F, der mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **222** der anderen Seite versehen ist, ist getrennt vom obengenannten, aus Harz gebildeten Rahmen **220**F ausgebildet und die aus Harz gebildeten Rahmen **220**F, **220**F sind miteinander durch den Eingriff der Eingriffsvorsprünge **235** in die Aussparung **236** verbunden. Der restliche Aufbau entspricht dem der dritten Abänderung.

[Abänderungen der Rollenbahn]

Beim zweiten Ausführungsbeispiel und den ersten bis vierten Abänderungen wurde beschrieben, daß zwei Rollenlaufbahnen an der Oberfläche der Führungsschiene **2** und eine einzelne Rollenlaufbahn an einer jeden Seitenfläche der Führungsschiene **2** vorgesehen sind, so daß insgesamt vier Rollenlaufbahnen vorhanden sind. Wie in den Figuren gezeigt ist, können jedoch auch andere Bauformen von Rollenlaufbahnen verwendet werden. Alle Abänderungen basieren bezüglich der Teilung des aus Harz gebildeten Körpers **220**, der den Rollenumlauf bildet, auf dem Teilungsschema des ersten Ausführungsbeispiels. Bei den Abänderungen der Rollenlaufbahn können jedoch alle Teilungsschemata der ersten bis vierten Abänderung verwendet werden.

Beim Beispiel der **Fig.** 27 sind zwei untere und obere Rollenlaufbahnen als Rollkörperlaufbahnen an einer jeden Lücke zwischen den rechten und linken Seitenflächen der Führungsschiene **202** und den inneren Flächen der rechten und linken Schenkelabschnitte **207**, **207** des beweglichen Blockes **204** vorgesehen, so daß insgesamt vier Rollenlaufbahnen vorhanden sind.

In diesem Fall sind vier innere Führungsabschnitte **210**a, die den vier Rollenlaufbahnen **203** entsprechen, einstückig miteinander in den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **222** ausgebildet.

Bei der obigen Beschreibung wird die vorliegende Erfindung bei einer Führungsvorrichtung für eine geradlinige Bewegung verwendet, bei der der bewegliche Block über Rollkörper auf der Führungsschiene als Spurstange angeordnet ist. Die vorliegende Erfindung kann jedoch auch bei einer sogenannten Kugelverzahnung verwendet werden, bei der eine äußere Hülse als bewegliches Teil auf eine Keilwelle als Spurstange gesetzt ist, wie unten beschrieben wird.

[Drittes Ausführungsbeispiel]

Eine Kugelkeilverzahnung **301**, wie sie in **Fig.** 28 bis 30 gezeigt ist, stellt eine sogenannte "Winkelkontakt"-Kugelkeilverzahnung dar und weist eine keilverzahnte Welle **302** als das sich geradlinig erstreckende Führungsteil und eine äußere Hülse **304** auf, die derart angeordnet ist, daß sie entlang der Keilwelle **302** über Kugeln **303** als der großen Anzahl von Rollkörpern beweglich ist.

Die keilverzahnte Welle **304** ist als ein langer Balken mit kreisförmigem Querschnitt ausgestaltet. Die keilverzahnte Welle **304** weist an ihrem äußeren Umfang drei Vorsprünge **306** auf. Zwei Kugellaufrillen **305**, **305** sind an den beiden Seiten eines jeden Vorsprunges **306** ausgebildet, um so insgesamt sechs Rillen vorzusehen.

Die äußere Hülse **304** weist an ihrem inneren Umfang drei Aussparungen **307** auf, die den Vorsprüngen **306** der keilverzahnten Welle **302** jeweils entsprechen. Kugelgegenlaufrillen **308**, **308** sind an den beiden Ecken einer jeden Aussparung **307** ausgebildet, um so den obengenannten Kugellaufrillen **305**, **305** zu entsprechen.

Zusätzlich weist die äußere Hülse **304** sechs Kugelrückläufe **309**, **309**; **309**, **309**; **309**, **309** auf, die parallel zu den sechs Kugelgegenlaufrillen **308**, **308**; **308**, **308**; **308**, **308** und sechs Richtungswechseldurchlässen **310**, **310**; **310**, **310**; **310**, **310** angeordnet sind, die als U-förmige Hülsen ausgebildet sind und die Enden der obengenannten Kugelgegenlaufrillen **308**, **308**; **308**, **308**; **308**, **308** mit den Enden der obengenannten Kugelrückläufe **309**, **309**; **309**, **309**; **309**, **309** verbinden. Die äußere Hülse **304** weist auf diese Weise sechs Umläufe auf.

Eine an den beiden Seitenflächen der Vorsprünge **306** der keilverzahnten Welle **302** berührt an gegenüberliegenden Punkten jeweils die Kugellaufrille **305** und die Kugelgegenlaufrille **308**. Eine die die obengenannten Kontaktpunkte verbindende Linie wird als die "Kontaktwinkellinie" bezeichnet. Ein Kontaktwinkel α, d. h. ein Winkel zwischen der Kontaktwinkellinie und dem Radius, der den Mittelpunkt der keilverzahnten Welle **302** und den Mittenabschnitt des Vorsprunges **306** verbindet, ist relativ groß. Der Kugelrücklauf **309** befindet sich auf dieser Kontaktwinkellinie.

Bei diesem dritten Ausführungsbeispiel sind die Kugeln **303**, die in einem jeden Umlauf eingesetzt sind, mittels eines Kugelkäfigs **312** miteinander verbunden, umso die Kette von Kugeln **303** zu bilden. Die Kugeln **303** werden durch den Kugelkäfig **312** geführt und laufen in jedem Umlauf um. Der Kugelkäfig **312** weist denselben Aufbau, wie in der **Fig.** 14 gezeigt ist, auf und daher wird auf dessen Beschreibung verzichtet.

Die äußere Hülse **304** besteht aus einem hülsenförmigen Körper **313**, der die Kugelgegenlaufrillen **308, 308; 308, 308; 308, 308** aufweist, aus drei aus Harz gebildeten Körpern **320, 320, 320**, die den Kugelumlauf bilden und in den Körper **313** eingesetzt sind, sowie ferner aus einem Paar von seitlichen Deckplatten **314, 314**, die an den beiden Enden des Körpers **313** befestigtwerden, nachdem die aus Harz gebildeten Körper **320, 320, 320** in den Körper **313** eingesetzt wurden.

Beim dritten Ausführungsbeispiel sind die sechs Umläufe durch die drei aus Harz gebildeten Körper **320, 320, 320** gebildet.

Ein jeder der Umläufe **311** der aus Harz gebildeten Körper **320**, die den Kugelumlauf bilden, weist ein Paar von den Kugelumlauf bildenden Abschnitten **321, 321** auf, die sich entlang der in Längsrichtung verlaufenden Seitenkanten der Kugelgegenlaufrillen **308** erstrecken, sowie ein Paar der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **322, 322**, die an den beiden Enden des Körpers **313** vorgesehen sind, sowie ferner Röhren **323** aus Harz als einen den Rücklauf bildenden Abschnitt, die in im Körper **313** ausgeformten Durchgangsöffnungen eingesetzt sind.

Die den Kugeldurchlaß bildenden Abschnitte **321, 321** sind mit Führungsrillen zum Führen der beiden Seitenkanten des Gurtabschnittes **312**b des Kugelkäfigs **312** in einem belasteten Bereich versehen. Die Führungsrillen können nicht nur verhindern, daß der Kugelkäfig **312** während des Umlaufs der Kugeln schwingt, sondern auch daß er durchhängt, indem die Seitenkanten des Gurtabschnittes **312**b in die Führungsrillen **321**a eingreifen, wenn die äußere Hülse **304** von der keilverzahnten Welle **302** entfernt wird. Die Kugeln **303** sind durch den Kugelkäfig **312** gehalten. Insbesondere wird der Kugelkäfig **312** durch einen Backenabschnitt der Führungsrille **321**a abgestützt, was zum Ergebnis hat, daß die Kugeln **303** in ihrer korrekten Lage gehalten werden und nicht aus der äußeren Hülse **304** herausfallen.

Im Kugelrücklauf **309** und dem Richtungswechseldurchlaß **310** als den nicht belasteten Bereichen sind außerdem Führungsrillen **309**c, **310**c ausgeformt, um die Seitenkanten des Gurtabschnittes **312**b zu führen. Die Führungsrillen **309**c, **310**c sind mit der oben erwähnten Führungsrille **321**a im belasteten Bereich verbunden, so daß am gesamten Umfang eine endlose Rille gebildet wird.

Bei jedem aus Harz gebildeten Körper **320**, der einen Kugelumlauf bildet, sind die den Kugeldurchlaß bildenden Abschnitte **321, 321** und das Paar der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **322, 322** einstückig miteinander verbunden. Der aus Harz gebildete Körper **320** ist an den anderen Abschnitten in getrennte Teile geteilt, so daß er in den Körper **313** eingesetzt werden kann. Beim dritten Ausführungsbeispiel wird ein einzelner Rahmen **324** aus Harz dadurch erhalten, daß die Enden der vier den Kugeldurchlaß bildenden Abschnitte **321, 321** mit dem Ende des Paars der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **322, 322** einstückig verbunden werden und der dermaßen erhaltene Rahmen **324** aus Harz am Verbindungsabschnitt des den Rücklauf bildenden Abschnittes **323** mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **322, 322** in getrennte Teile unterteilt wird, so daß er in den Körper **313** eingesetzt werden kann.

Jeweils zwei benachbarte, den Rollendurchlaß bildende Abschnitte **321, 321, 321, 321** sind miteinander durch einen dünnen, verbindenden Plattenabschnitt **326** einstückig verbunden. Der den Richtungswechseldurchlaß und innere Führung bildende Abschnitt **322** ist mit dem dünnen Plattenabschnitt **329** einstückig ausgeformt, welcher wiederum mit der Endfläche des Körpers **313** in Kontakt gebracht wird.

Der dünne Plattenabschnitt **329** ist mit den ersten Endplattenabschnitten **330, 330** und den zweiten Endplattenabschnitten **231** versehen, um die ersten Endplattenabschnitte **330, 330** miteinander zu verbinden. Ein jeder der den Kugeldurchlaß bildenden Abschnitte **321, 321** ist einstückig mit der Innenkante des ersten Endplattenabschnittes **130** verbunden. Die beiden Enden des Verbindungsplattenabschnittes **326** sind mit der Innenkante des zweiten Endplattenabschnittes **331** einstückig verbunden.

Ein jeder der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte ist von halbzylinderförmiger Gestalt. Am äußeren Umfang des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **322** ist eine innere Führungsrille **310**a von halbkreisförmigem Querschnitt angeformt, um den inneren Führungsabschnitt des Richtungswechseldurchlaß **310** zu bilden. Das eine Ende der inneren Führungsrille **310**a ist mit dem Ende der Kugelgegenlaufrille **308** verbunden. Entsprechend weist das eine Ende der inneren Führungsrille **310**a im Querschnitt dieselbe Form auf wie die Kugelgegenlaufrille **308**, so daß das eine Ende der inneren Führungsrille **310**a mit dem Ende der Kugelgegenlaufrille **308** ausgerichtet ist. Das andere Ende der inneren Führungsrille **310**a des Richtungswechseldurchlasses **310** ist mit dem Ende des Kugelrücklaufes **309** verbunden. Dementsprechend weist das andere Ende der inneren Führungsrille **310**a im Querschnitt dieselbe Form auf wie der Kugelrücklauf **309**, so daß das andere Ende der inneren Führungsrille **310**a mit dem Ende des Kugelrücklaufs **309** ausgerichtet ist.

Zylindrische Flanschabschnitte **333, 333** sind an den beiden Enden der inneren Führungsrille **310**a ausgeformt. Der Abstand zwischen den jeweiligen Außenflächen der zylindrischen Flanschabschnitte **333, 333** ist größer als die Weite des Gurtabschnittes **312**b. Die zylindrischen Flanschabschnitte **333, 333** bilden zusammen mit der weiter unten beschriebenen seitlichen Deckplatte **340** eine Käfigführungsrille **310**c für den Kugelkäfig **312**.

Die beiden Enden der inneren Führungsrille **310**a des Richtungswechseldurchlasses **310** erstrecken sich bis an die Berührungsfläche des ersten Endplattenabschnittes **330** mit der Endfläche des Körpers **313**, so daß sie mit der jeweiligen Enden der Kugelgegenlaufrille **308** und dem Kugelrücklauf **309** verbunden sind.

Halbkreisförmige Einsetzlöcher **334, 334** für die Röhre, in die die Enden der beiden äußeren umfangsseitigen Halbröhrenteile **323**a der Röhren **323** aus Harz, die den Kugelrücklauf **309** bilden, eingesetzt werden, sind an den ersten und dritten Endplattenabschnitten **330, 332** des dünnen Plattenabschnittes **329** ausgeformt. Die Röhre **323** aus Harz wird in die kreisförmige Durchgangsöffnung **314** des Körpers **313** eingesetzt, so daß die innere Umfläche der Röhre **323** aus Harz den Kugelrücklauf **309** bildet.

Die Röhre **323** aus Harz besteht aus dem inneren, umfangsseitigen Halbröhrenteil **323**a, welches durchgängig mit der inneren Führungsrille **310**a des Richtungswechseldurchlasses verbunden ist, sowie aus dem äußeren, umfangsseitigen Halbröhrenteil **323**b, welches durchgängig mit der äußeren Führungsrille **310**b des Richtungswechseldurchlasses **310** verbunden ist, der wiederum an der seitlichen Deckplatte **340** angeformt ist. Das innere, umfangsseitige Halbröhrenteil **323**a weist einen inneren Rillenabschnitt **309**a von rechteckigem Querschnitt sowie Seitenkantenabschnitte **323**b auf, die sich in Längsrichtung entlang des inneren Rillenabschnittes **309**a erstrecken. Die sich in Längsrichtung erstreckenden Kantenabschnitte **323**c des inneren, umfangsseitigen Halbröhrenteils **323**a weisen dieselbe Weite auf wie der Flanschabschnitt **333** des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **322**.

Das äußere umfangsseitige Halbröhrenteil **323**b ist als ein geradliniges Teil ausgeformt, das denselben rechteckigen Querschnitt wie die äußere Führungsrille **310**b des Richtungswechseldurchlasses aufweist, welcher wiederum an der seitlichen Deckplatte **340** ausgebildet ist. Das äußere, umfangsseitige Halbröhrenteil **323**b weist einen äußeren Rillenabschnitt **309**b auf, der durchgängig mit der äußeren Führungsrille **310**b verbunden ist, sowie Seitenkantenabschnitte **323**d, die sich in Längsrichtung entlang des äußeren Rillenabschnittes **309**b erstrecken. Die Seitenkantenabschnitte **323**b sind an ihren äußeren Kanten mit ihren Vorsprüngen **323**e versehen, die in Kontakt mit den Seitenkantenabschnitten 323c des inneren, umfangsseitigen Halbröhrenteils **323**a gebracht werden, um die Führungsrille für den Gurtabschnitt **312** des Kugelkäfigs **312** zu bilden.

Das innere, umfangsseitige Halbröhrenteil **323**a der Röhre **323** aus Harz hat dieselbe Länge wie der Körper **313**, Das innere, umfangsseitige Halbröhrenteil **323**a ist derart positioniert, daß es mit der Endfläche des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **322** gebracht wird, der an der Seite des Körpers **313** angeordnet ist.

Das äußere, umfangsseitige Halbröhrenteil **323**b der Röhre **323** aus Harz ist andererseits um eine Länge, die der Dicke der ersten Endplattenabschnitte **330**, **330** des dünnen Plattenabschnittes **329** entspricht, länger als der Körper **313**, wobei die ersten Endplattenabschnitte **330**, **330** an den beiden Enden des Körpers **313** angeordnet sind. Die äußeren, umfangsseitigen Halbröhrenteile **323**b werden in die Einsetzöffnungen **334** der ersten Endplattenabschnitte **330**, **332** eingesetzt. Eine Lagebestimmung des äußeren, umfangsseitigen Halbröhrenteils **323**b in Längsrichtung findet dadurch statt, daß die beiden Enden des äußeren, umfangsseitigen Halbröhrenteils **323**b, die in die Einsetzöffnungen **334** eingesetzt sind, in Kontakt mit der Umfangskante des Endabschnittes der äußeren Führungsrillen **310**b des Richtungswechseldurchlasses gebracht werden, die an der seitlichen Deckplatte **340** ausgeformt sind. Die Vorsprünge **323**e, die an den beiden sich in Längsrichtung erstreckenden Seitenkanten **323** des äußeren, umfangsseitigen Halbröhrenteils **323**b ausgeformt sind, berühren die äußeren Kanten der zylindrischen Flanschabschnitte des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **322**, um so eine Führungsrille zu bilden, und das äußere, umfangsseitige Halbröhrenteil **323**b und das innere, umfangsseitige Halbröhrenteil **323**a können sich in der Einsetzöffnung **314** nicht drehen.

Die Röhren **323** aus Harz und die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **322** als die den Kugelrücklauf bildenden Abschnitte sind über die Einsetzöffnungen **334**, die an den ersten Endplattenabschnitten **330**, **330** des dünnen Plattenabschnittes **329** angeformt sind, genau positioniert und auf diese Weise kann ein korrekter Zusammenbau stattfinden.

Die seitliche Deckplatte **340** ist mit vier ausgesparten Abschnitten **341** versehen, an denen die äußeren Führungsrillen **310**b des Richtungswechseldurchlasses angeordnet sind, in die die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **322** eingepaßt werden, sowie Anschraubabschnitte, um die seitliche Deckplatte **340** am Körper **313** zu befestigen. An den Anschraubabschnitten wird die seitliche Deckplatte **340** am Körper **313** befestigt, in dem Schrauben **344** in an der seitlichen Deckplatte **340** ausgeformten Löcher **343** eingesetzt werden und die Schrauben **344** in die Gewindelöcher **345** eingreifen, die an der Endfläche des Körpers **313** ausgebildet sind. Die Öffnungen **343** sind zwischen den ersten Endplattenabschnitten **330**, **330** des dünnen Plattenabschnittes **329** angeordnet.

Der den Richtungswechseldurchlaß und innere Führung bildende Abschnitt **322** wird in den ausgesparten Abschnitt **341** der seitlichen Deckplatte **340** eingepaßt. Der dünne Plattenabschnitt **329** wird zwischen der seitlichen Deckplatte **340** und der Endfläche des Körpers **313** durch eine Klemmkraft fest gehalten, so daß er dazwischen befestigt ist.

Die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **322** und der den Kugeldurchlaß bildende Abschnitt **321** sind über den dünnen Plattenabschnitt **329** verbunden, wodurch es möglich wird, eine genaue Lagebeziehung des Endes der inneren Führungsrille **310**a des Richtungswechseldurchlasses relativ zu den den Kugeldurchlaß bildenden Abschnitten **321** sowie eine genaue Lagebeziehung der inneren Führungsrille **310**a des Richtungswechseldurchlasses relativ zum Kugelrücklauf **309** zu wahren.

Der dünne Plattenabschnitt **329** wird durch eine auf die seitliche Deckplatte **340** wirkende Klemmkraft gleichmäßig gegen die flache Endfläche des Körpers **313** gedrückt. Selbst wenn der den Richtungswechseldurchlaß und innere Führung bildende Abschnitt **322** sich nicht in einer korrekten Lage befindet, ändert der dünne Plattenabschnitt **329** seine Form, wodurch die korrekte Lage des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **322** ermöglicht wird. Der dünne Plattenabschnitt **329** wird durch eine Klemmkraft, die auf die seitliche Deckplatte **340** wirkt, festgeklemmt und befestigt und eine durch eine derartige Klemmung bewirkte Reibungskraft kann eine ungünstige Bewegung der inneren Führungsrille **310**a des Richtungswechseldurchlasses verhindern.

Entsprechend der vorliegenden Erfindung ist nur die Kugelgegenlaufrille **308** des Umlaufes **311** am Körper **313** mit hochfest ausgebildet und die anderen Abschnitte werden von den aus Harz geformten Körpern **320**, die den Kugelumlauf darstellen, gebildet. Eine präzise Bearbeitung nur der Kugelgegenlaufrille **308** des Körpers **313** ist ausreichend, wodurch die Anzahl der Arbeitsschritte und die Produktionskosten gesenkt werden kann.

Der aus Harz geformte Körper **320**, der den Kugelumlauf bildet, ist getrennt vom Körper **313** ausgebildet. Selbst wenn die äußere Hülse **304** größer ist, gibt es keine Beschränkung der Strömung des flüssigen Harzes durch den Körper **313**, in dem Fall, in dem der Körper **313** einstückig mit dem aus Harz geformten Körper **320** ausgebildet ist. Eine Erhöhung der Anzahl von Eingußstellen, die in einer Gußform ausgebildet sind, kann einen korrekten Fluß des flüssigen Harzes sicherstellen, wodurch die Formgebung verbessert wird. Insbesondere weisen die den Kugeldurchlaß bildenden Abschnitte **321**, **321**, die an den gegenüberliegenden, sich in

Längsrichtung erstreckenden Seiten der Kugellaufrille **308** angeordnet sind, eine niedrige Wandstärke auf, was zum Ergebnis hat, daß das flüssige Harz nicht jeden Teil des zur Ausbildung der den Kugeldurchlaß bildenden Abschnitt **321**, **321** vorgesehenen Raum erreichen kann. Daher ist es günstig, den aus Harz gebildeten Körper **320** getrennt vom Körper **313** entsprechend dem Ausführungsbeispiel der vorliegenden Erfindung auszubilden.

Die den Kugeldurchlaß bildenden Abschnitte **321**, **321** sind durchgängig und einstückig mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **322** verbunden und die geteilten Teile sind derart ausgerichtet verbunden, daß eine Randverbindung entsteht. Es ist daher möglich, eine günstige Durchgängigkeit des Verbindungsabschnittes des Umlaufs zu erzielen und einen glatten Umlauf der Kugeln **303** vom Kugeldurchlaß zwischen der Kugellaufrille **305** und der Kugelgegenlaufrille **308** zum Richtungswechseldurchlaß **310** sowie vom Richtungswechseldurchlaß **310** zum Kugelrücklauf **309** zu ermöglichen.

Im folgenden werden Abänderungen des aus Harz gebildeten Körpers **320**, die einen Kugelumlauf bildet und der in Teile unterteilt ist, beschrieben. Bei der Beschreibung der Abänderungen werden abgeänderte Merkmale nur im Vergleich zum dritten Ausführungsbeispiel der vorliegenden Erfindung beschrieben. Dieselben Bauteile erhalten dieselben Bezugszeichen wie die des dritten Ausführungsbeispiels der vorliegenden Erfindung und auf ihre Beschreibung wird im folgenden verzichtet.

[Erste Abänderung]

Die **Fig.** 31 und 32 zeigen die erste Abänderung des aus Harz gebildeten Körpers **320**, der den beim dritten Ausführungsbeispiel beschriebenen Kugelumlauf bildet.

Bei der ersten Änderung besteht der aus Harz gebildete Körper **320**, der den Kugelumlauf bildet, aus einem ersten, aus Harz gebildeten Rahmen **320**A, der dadurch erhalten wird, daß die den Kugeldurchlaß bildenden Abschnitte **321**, **321** und die Röhren **323** aus Harz an der einen Seite an ihren Enden mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **322**A verbunden werden, sowie aus einem zweiten, aus Harz gebildeten Rahmen **320**B, der mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **322**B der anderen Seite versehen und getrennt vom ersten, aus Harz gebildeten Rahmen **320** ausgestaltet ist.

In diesem Fall sind die den Kugeldurchlaß bildenden Abschnitte **321**, **321** einstückig mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **322**A über den dünnen Plattenabschnitt **329**A wie beim ersten Ausführungsbeispiel verbunden.

Die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **322**A sind ebenfalls einstückig mit den Röhren **323** aus Harz über den dünnen Plattenabschnitt **329**A verbunden. In diesem Fall ist die Röhre **323** aus Harz als ein einstückiger hülsenförmiger Körper ausgestaltet, obwohl die Halbröhrenteile beim dritten Ausführungsbeispiel verwendet werden. Entsprechend gibt es keine Einsetzöffnung **334** im dünnen Plattenabschnitt **329**A und der Kugelrücklauf **309** ist am dünnen Plattenabschnitt **329**A offengelegt.

Der erste, aus Harz gebildete Rahmen **320**A und der zweite, aus Harz gebildete Rahmen **320**B sind, wie in der **Fig.** 32 gezeigt, mittels einer Verbindung miteinander verbunden, die eine Kombination einer Aussparung und eines darin einzusetzenden Vorsprungs, wie beispielsweise eine Randverbindung, umfaßt. Beim dargestellten Beispiel ist ein ausgesparter Abschnitt **336** einer Schwalbenschwanznut im zweiten, aus Harz geformten Rahmen **320**B angeformt und ein Eingriffsvorsprung **335**, der in den ausgesparten Abschnitt **336** eingreift, ist andererseits in den den Kugeldurchlaß bildenden Abschnitten **321**, **321** ausgebildet.

In diesem Fall ist die Röhre **323** aus Harz des ersten, aus Harz geformten Rahmens **320**A in die Durchgangsöffnung **314** des Körpers **313** eingesetzt und die den Kugeldurchlaß bildenden Abschnitte **321**, **321** und der Verbindungsplattenabschnitt **236** sind entlang der Innenfläche der Aussparung **307** des Körpers **313** eingesetzt.

Dann werden die Eingriffsvorsprünge **335**, die an den jeweiligen freien Endabschnitten der den Kugeldurchlaß bildenden Abschnitte **321**, **321** und des Verbindungsplattenabschnittes **326** angeformt sind, mit den ausgesparten Abschnitten **336** in Eingriff gebracht, die am dünnen Plattenabschnitt **329**B des zweiten, aus Harz geformten Rahmens **324**B angeformt ist, welcher wiederum an der anderen Endfläche des Körpers **313** angeordnet ist.

Die ausgesparten Abschnitte **336** können am ersten, aus Harz geformten Rahmen **320**A und die Eingriffsvorsprünge **335** können am zweiten aus Harz geformten Rahmen **320**B angeformt sein. Die Verbindung ist nicht auf die oben beschriebene Verbindung beschränkt, sondern es kann jedwede herkömmliche Verbindung verwendet werden bei der die Enden der getrennten Teile in einer geeigneten Verbindungslage gehalten und verbunden werden können.

[Zweite Abänderung]

Die **Fig.** 33 und 34 zeigen die zweite Abänderung des aus Harz gebildeten Körpers **320**, der den Kugelumlauf bildet, wie er im dritten Ausführungsbeispiel beschrieben ist.

Bei der zweiten Abänderung ist der aus Harz gebildete Körper **320**, der den Kugelumlauf bildet und der durch einstückige Formgebung der den Kugeldurchlaß bildenden Abschnitte **321**, **321** und der Röhren **323** aus Harz als ein den Rücklauf bildender Abschnitt mit einem Paar von einen Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **322**, **322** erhalten wurde, am Mittelabschnitt eines jeden, den Kugelrücklauf bildenden Abschnittes **321**, **321** und der den Kugelrücklauf bildenden Abschnitte **323** in zwei Teile geteilt. Insbesondere sind die den Kugeldurchlaß bildenden Abschnitte **321**, **321** und die den Kugelrücklauf bildenden Abschnitte **323** an ihrem Mittelabschnitt in die jeweiligen zwei Hälften geteilt und eine jede der derart getrennten Hälften ist einstückig mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **322**, **322** ausgeformt, wodurch zwei aus Harz gebildete Rahmen **320**C, **320**D mit im wesentlichen der gleichen Form ausgebildet sind.

An den geteilten Enden der den Kugeldurchlaß bildenden Abschnitte **321**, **321**, den geteilten Enden des mittleren Verbindungsplattenabschnittes **326** und den geteilten Enden der Röhren **323** aus Harz sind ausgesparte Abschnitte **338** und darin einzusetzende Eingriffsvorsprünge **337** ausgebildet.

[Dritte Abänderung]

Fig. 35 zeigt die dritte Abänderung des aus Harz gebildeten Körpers **320**, der den Kugelumlauf bildet, wie er beim dritten Ausführungsbeispiel beschrieben ist.

Bei der dritten Abänderung wird die Röhre **323** aus Harz, die einen den Rücklauf bildenden Abschnitt darstellt, wie beim ersten Ausführungsbeispiel beschrieben, nicht verwendet, und ein aus Harz geformter Rahmen **320**E wird durch einstückige Formgebung der den Kugeldurchlaß bildenden Abschnitte **320**, der Verbindungsplattenabschnitte **326** mit den dünnen Plattenabschnitten **329**, **329** erhalten, die jeweils das Paar von den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **322**, **322** aufweisen. Der Kugelrücklauf **309** ist als eine im Körper **313** ausgebildete Durchgangsöffnung ausgestaltet.

In diesem Fall kann am Öffnungsende der Kugelöffnung **339** des dünnen Plattenabschnittes **329** ein Eingriffsvorsprung **339**a ausgeformt sein, der mit einem sich verjüngenden Abschnitt **315** in Eingriff bringbar ist, der im Öffnungsende des Kugelrücklaufs **309** ausgestaltet ist. Ein derartiger Aufbau erlaubt es, eine günstige Verbindung des Endes des Kugelrücklaufs **309** und des den Richtungswechseldurchlaß und innere Führung bildenden Abschnitts **323** herzustellen.

Beim dargestellten Beispiel ist zusätzlich ein gebogener Eingriffsvorsprung **348** am Verbindungsabschnitt der äußeren Führungsrille **310**b ausgestaltet, die an der seitlichen Deckplatte **340** zusammen mit dem Kugelrücklauf **309** ausgebildet ist. Der Eingriffsvorsprung **348** kann in den dünnen Plattenabschnitt **329** eingreifen.

[Vierte Abänderung]

Fig. 36 zeigt die vierte Abänderung des aus Harz geformten Körpers **320**, der den Kugelumlauf bildet, wie er beim dritten Ausführungsbeispiel beschrieben ist.

Bei der vierten Abänderung wird die Röhre **323** aus Harz, wie sie bei der dritten Abänderung beschrieben ist, nicht verwendet und ein aus Harz gebildeter Rahmen **320**F wird durch einstückige Formgebung der den Kugeldurchlaß bildenden Abschnitte **321** mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **322** an der einen Seite erhalten, der andere aus Harz geformte Rahmen **320**G, der mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **322** der anderen Seite versehen ist, ist vom oben erwähnten, aus Harz gebildeten Rahmen **320**F getrennt ausgebildet und die aus Harz geformten Rahmen **320**F, **320**G sind miteinander durch den Eingriff des Eingriffvorsprungs **335** in die Aussparung **336** verbunden. Der restliche Aufbau ist derselbe wie der der dritten Abänderung.

Beim oben beschriebenen dritten Ausführungsbeispiel werden drei aus Harz geformte Körper zur Bildung des Kugelumlaufs verwendet, von denen ein jeder in zwei Teile geteilt ist. Es können jedoch auch sechs aus Harz geformte Körper für die jeweiligen Umläufe verwendet werden. Es kann aber auch ein einzelner aus Harz geformter Körper verwendet werden. In diesem Fall sollte die Art der Teilung des aus Harz geformten Körpers auf den ersten, zweiten und vierten Abänderungen beruhen, wie sie oben beschrieben wurden, wobei die Schwierigkeit des Einsetzens des aus Harz geformten Körpers in den Körper der äußeren Hülse in Betracht gezogen werden sollte.

[Abänderungen der Kugellaufbahn]

Beim dritten Ausführungsbeispiel und bei dessen ersten bis vierten Abänderung ist die Kugelverzahnung von der Bauart einer Kugellaufbahn mit abgewinkelten Berührungslinien. Die vorliegende Erfindung kann jedoch auch bei einer Kugelverzahnung von der Bauart mit einer Kugellaufbahn mit radialen Berührungslinien verwendet werden, wie dies in der **Fig.** 37 gezeigt ist. Bei einer derartigen Kugellaufbahn mit einer radial verlaufenden Berührungslinie weist die Spurstange keinerlei Vorsprünge am äußeren Umfang auf, so daß ein kreisförmiger Querschnitt entsteht und die äußere Hülse hat am inneren Umfang keinerlei Aussparungen, so daß sie eine hohlzylindrische Form aufweist. Die Kugellaufbahn mit radialen Berührungslinien hat einen kleineren Kontaktwinkel -als die Kugellaufbahn von der Bauart mit winkelförmiger Kontaktlinie. Bezüglich der Art der Teilung des aus Harz geformten Körpers **320**, der den Kugelumlauf bildet, können sämtliche, beim dritten Ausführungsbeispiel und den ersten bis vierten Abänderungen beschriebenen Schemata verwendet werden.

Beim Beispiel, das in der **Fig.** 37 dargestellt ist, sind sechs aus Harz geformte Körner **320**, die den Kugelumlauf bilden, getrennt voneinander jeweils für die sechs Kugellaufbahnen vorgesehen. Die oben erwähnten zwei Bausätze der aus Harz geformten Körper **320** können einstückig miteinander ausgebildet sein, so daß sie drei Bausätze von aus Harz geformten Körper **320** bilden, die die sechs Kugelumläufe umfassen. Es kann aber auch der einzelne, aus Harz geformte Körper mit den sechs Kugelumläufen verwendet werden.

[Viertes Ausführungsbeispiel]

Die **Fig.** 38 und 39 stellen das vierte Ausführungsbeispiel dar. Beim vierten Ausführungsbeispiel wird die vorliegende Erfindung bei einer Rollenverzahnung verwendet bei der Rollen als Rollkörper verwendet werden.

Die in **Fig.** 38 gezeigte Rollenverzahnung **401** besteht aus einer Spurstange **402** als einem sich geradlinig erstreckenden Führungsteil und einer äußeren Hülse **404**, die derart angeordnet ist, daß sie entlang der Spurstange **402** über die Rollen **403** als Rollkörper beweglich ist.

Die Spurstange **402** ist in Form eines langen Balkens ausgebildet, der einen abgeänderten Querschnitt aufweist. Die Spurstange **402** weist an ihrem äußeren Umfang drei Vorsprünge **406** auf. An den beiden Seiten eines jeden Vorsprungs **406** sind zwei Rollenlaufflächen **405**, **405** angeordnet, so daß insgesamt sechs Laufflächen vorhanden sind.

Die äußere Hülse **404** weist an ihrem inneren Umfang drei Aussparungen **407** auf, die den Vorsprüngen **406** der Spurstange **402** jeweils entsprechen. An den beiden Ecken eines jeden Vorsprungs **407** sind Rollengegenlaufflächen **408**, **408** ausgebildet, die den oben erwähnten Rollenlaufflächen **405**, **405** entsprechen.

Zusätzlich weist die äußere Hülse **404** sechs Rollenrückläufe **409**, **409**; **409**, **409**; **409**, **409** auf, die parallel zu den sechs Rollengegenlaufflächen **408**, **408**; **408**, **408**; **408**, **408** und den sechs Richtungswechseldurchlässen **410**, **410**; **410**, **410**; **410**, **410** in Gestalt eines U-förmigen Rohres verlaufen, welches die Enden der oben erwähnten Rollengegenlaufflächen **408**, **408**; **408**, **408**; **408**, **408** mit den Enden der oben erwähnten Rollenrückläufe **409**, **409**; **409**, **409**; **409**, **409** verbindet. Die äußere Hülse **404** weist auf diese Weise sechs Umläufe auf.

Die Rollen **403**, die in einen jeden Umlauf eingesetzt sind, sind miteinander durch den gleichen Rollenkäfig **412** verbunden, wie der Rollenkäfig **212** der **Fig.** 19, so daß eine Kette von Rollen **403** gebildet wird. Die Rollen **403** werden durch den Rollenkäfig **412** geführt und laufen in einem jeden Umlauf um.

Die äußere Hülse **404** besteht aus einem hülsenförmigen Körper **413** mit den Rollengegenlaufflächen **408**, **408**; **408**, **408**; **408**, **408** drei aus Harz geformten Körpern **420**, **420**; **420**, die den Rollkörperumlauf bilden und in den Körper **413** eingesetzt sind, sowie ein Paar von seitlichen Deckplatten **440**, **440**, die an den beiden Enden des Körpers **413** nach dem Einsetzen der aus Harz geformten Körper **420**, **420**, **420** im Körper **413** befestigt werden.

Beim vierten Ausführungsbeispiel werden sechs Umläufe durch die drei aus Harz geformten Körper **420**, **420**, **420** wie beim dritten Ausführungsbeispiel gebildet.

Ein jeder der aus Harz gebildeten Körper **420**, die den Rollkörperumlauf bilden, weist ein Paar von den Rollendurchlaß bildenden Abschnitten **421**, **421** auf, die sich entlang der in Längsrichtung verlaufenden Seitenkanten der Rollengegenlaufflächen **408** erstrecken, sowie ein Paar von den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **422**, **422**, die an den beiden Enden des Körpers **413** vorgesehen sind, sowie ferner Röhren **423** aus Harz als einen den Rücklauf bildenden Abschnitt, die in im Körper **413** ausgebildeten Durchgangsöffnungen eingesetzt sind.

Die den Rollendurchlaß bildenden Abschnitte **421**, **421** sind mit Führungsrillen versehen, die die beiden Seitenkanten des Gurtabschnittes **412**b des Rollenkäfigs **412** in einem belasteten Bereich führen. Die Führungsrillen können nicht nur verhindern, daß der Rollenkäfig **412** während des Umlaufs der Rollen schwingt, sondern auch, daß der Rollenkäfig **412** durchhängt, indem die Seitenkanten des Gurtabschnittes **412**b in die Führungsrille **421**a eingreifen, wenn die äußere Hülse **404** von der Spurstange **402** entfernt wird. Die Rollen **403** werden durch den Rollenkäfig **412** gehalten. Insbesondere wird der Rollenkäfig **412** durch einen Backenabschnitt der Führungsrille **421**a gehalten, was zum Ergebnis hat, daß die Rollkörper **403** in ihrer richtigen Lage gehalten werden und nicht aus der äußeren Hülse **404** herausfallen können.

Außerdem sind im Rollenrücklauf **409** und dem Richtungswechseldurchlaß **410** im Rollenrücklauf **409** und dem Richtungswechseldurchlaß **410** als nicht belasteten Bereichen Führungsrillen **409**c, **410**c ausgebildet, um die Seitenkanten des Gurtabschnittes **412**b zu führen. Die Führungsrillen **409**c, **410**c sind mit der oben erwähnten Führungsrille **421**a im belasteten Bereich verbunden, um so eine endlose Rille am gesamten Umfang zu bilden.

Wenn der Rollenkäfig **412** nicht verwendet wird, werden die Führungsrillen **421**a, **410**a, **409**a nicht benötigt und die in den **Fig.** 20(h) gezeigten Backenabschnitte zum Abstützen der Rollenenden sind in den den Rollendurchlaß bildenden Abschnitten **421** ausgebildet.

In jedem der aus Harz gebildeten Körner **420**, die den Rollenumlauf bilden, sind zumindest vier Verbindungsabschnitte der den Rollendurchlaß bildenden Abschnitte **421**, **421** mit dem Paar der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **422**, **422** miteinander einstückig verbunden. Der aus Harz geformte Körper **420** ist an den anderen Abschnitten in einzelne Teile geteilt, so daß er in den Körper **413** eingesetztwerden kann.

Das grundsätzliche Ausführungsbeispiel des aus Harz gebildeten Körpers, der den Rollenumlauf bildet, der bei der keilverzahnten Vorrichtung verwendet wird, ist im Detail im dritten Ausführungsbeispiel beschrieben. Der Aufbau des aus Harz geformten Körpers, der den Rollenumlauf bildet, ist genauer beim zweiten Ausführungsbeispiel beschrieben. An dieser Stelle wird nur das grundsätzliche Teilungsschema des aus Harz gebildeten Körpers **420**, der den Rollenumlauf bildet, unter Bezugnahme auf die **Fig.** 39 im folgenden kurz beschrieben.

In der **Fig.** 39(a) sind die beiden Bausätze der den Rollendurchlaß bildenden Abschnitte **421**, **421** mit dem jeweiligen einen Ende des Paars der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **422**, **422** einstückig verbunden, um einen einzelnen Rahmen **424** aus Harz zu bilden, und die beiden Enden eines jeden der den Rücklauf bildenden Abschnitte **423** sind nicht mit dem anderen Ende des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **422** verbunden, so daß diese Teile in den Körper **418** eingebaut werden können.

In der **Fig.** 39(b) besteht der aus Harz geformte Körper **420**, der den Rollenumlauf bildet, aus dem ersten, aus Harz gebildeten Rahmen **420**A, der durch einstückige Verbindung der den Rollendurchlaß bildenden Abschnitte **421**, **421** und der Röhren **423** aus Harz als einen Rücklauf bildenden Abschnitt an deren Enden mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **422**A an der einen Seite gebildet ist, und aus dem zweiten, aus Harz gebildeten Rahmen **420**B, der mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **422**B an der anderen Seite versehen und getrennt vom ersten aus Harz geformten Rahmen **420**A ausgebildet ist.

In der **Fig.** 39(c) ist der aus Harz gebildete Körper **420**, der den Rollenumlauf bildet, der durch einstückige Verbindung der den Rollendurchlaß bildenden Abschnitte **421**, **421** und den Röhren **423** aus Harz als einen Rücklauf bildenden Abschnitt mit einem Paar von einen Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **422**, **422** erhalten wird, am Mittelabschnitt eines jeden einen Rollendurchlaß bildenden Abschnittes **421**, **421** und an dem den Rollenrücklauf bildenden Abschnitten **423** in zwei Teile geteilt. Insbesondere sind die den Rollenrücklauf bildenden Abschnitte **421**, **421** und die Röhren **423** aus Harz an ihrem Mittelabschnitt in jeweils zwei Hälften geteilt und eine jede der derartig geteilten zwei Hälften ist einstückig mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **422**, **422** ausgebildet, wodurch zwei aus Harz geformte Rahmen **420**C, **420**D mit im wesentlichen derselben Form gebildet werden.

In **Fig.** 39(d) wird die in der **Fig.** 39(a) gezeigte Röhre **423** aus Harz nicht verwendet und ein aus Harz geformter Rahmen **420**E wird durch einstückige Formgebung der den Rollendurchlaß bildenden Abschnitte und dem Verbindungsplattenabschnitt **326** zusammen mit den dünnen Plattenabschnitten **429**, **429** erhalten, von denen ein jeder das Paar von den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **422**, **422** aufweist. Der Rollenrücklauf **409** wird von einer im Körper **413** angeformten Durchgangsöffnung gebildet.

In der **Fig.** 39(e) wird die in der **Fig.** 39(b) verwendete Röhre **423** aus Harz nicht verwendet und ein aus Harz gebildeter Rahmen **420**F wird durch einstückige Formgebung der den Rollendurchlaß bildenden Abschnitte **421** zusammen mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **422** an der einen Seite erhalten, der andere aus Harz geformte Rahmen **420**G, der mit den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **422** an der anderen Seite versehen ist, ist getrennt vom oben erwähnten, aus Harz geformten Rahmen **420**F gebildet.

In den **Fig.** 39(a) bis 39(e) sind die aus Harz geformten Rahmen miteinander mittels einer herkömmlichen Verbindung, wie beispielsweise eine Randverbindung, miteinander verbunden, welche durch den Eingriff eines Eingriffsvorsprungs in eine Aussparung zustande kommt.

[Fünftes Ausführungsbeispiel]

Die **Fig.** 40 bis 44 zeigen eine Führungsvorrichtung für eine geradlinige Bewegung gemäß dem fünften Ausführungsbeispiel der vorliegenden Erfindung.

Die Führungsvorrichtung **501** für eine geradlinige Bewegung ist mit einer Führungsschiene **502** als einem Führungsteil versehen, welche sich geradlinig erstreckt, und weist einen beweglichen Block **504** als ein bewegliches Teil auf, das derart angeordnet ist, daß es entlang der Führungsschiene **502** über eine große Anzahl von Kugeln **503** als Rollenkörper beweglich ist.

Die Führungsschiene **502** hat die Form eines langen Balkens mit rechteckigem Querschnitt. Zwei Kugellaufrillen **505**, **505** als Rollkörperlaufbahnen sind an den rechten und linken Seitenflächen der Führungsschiene **502** angeformt, so daß insgesamt vier Rillen **505** vorgesehen sind. Die Führungsschiene **502** weist an einer jeden Seitenfläche einen Vorsprung **502**a auf, an dessen oberen und unteren Stellen die Kugellaufrillen **505**, **505** angeordnet sind.

Der bewegliche Block **504** ist als ein Blockkörper mit einem Querschnitt in Form eines umgedrehten U's ausgebildet, dessen Öffnungsende nach unten gerichtet ist. Der Blockkörper ist mit einem waagerechten Abschnitt **506** versehen, der der Oberfläche der Führungsschiene **502** gegenüberliegt, sowie mit einem Paar von Schenkelabschnitten **507**, **507**, die sich von den rechten und linken Enden des waagerechten Abschnittes **506** nach unten erstrecken und den rechten und linken Seitenflächen der Führungsschiene **502** jeweils gegenüberliegen. Ein jeder der Schenkelabschnitte **507**, **507** weist an seiner Innenfläche zwei Kugelgegenlaufrillen **508**, **508** als Rollkörpergegenlaufbahnen auf, die den jeweiligen Kugellaufrillen **505**, **505** entsprechen, die an den rechten und linken Seitenflächen der Führungsschiene **502** ausgebildet sind.

Ein jeder der rechten und linken Schenkelabschnitte **507**, **507** des beweglichen Blocks **504** weist zwei Kugelrückläufe bildende Abschnitte **509**, **509** auf, die darin ausgeformt sind und sich parallel zu den Kugelgegenlaufrillen **508**, **508** erstrecken. An den beiden in Längsrichtung liegenden Enden eines jeden Schenkelabschnittes **507**, **507** sind Richtungswechseldurchlässe **510**, **510**; **510**, **510** angeordnet, die die Enden der Kugelgegenlaufrillen **508**, **508**; **508**, **508** mit den Enden der Kugelrückläufe **509**, **509**; **509**, **509** verbinden. Alles in allem weist ein jeder der Schenkelabschnitte **507**, **507** des beweglichen Blocks **504** zwei endlose Umläufe auf, in denen die Kugeln **503** umlaufen, um so insgesamt vier Umläufe vorzusehen.

In einem jeden der vier endlosen Umläufe dieses Ausführungsbeispiels sind die Kugeln **503** kettenartig durch einen Kugelkäfig **512** als Rollkörperkäfig gehalten, so daß die Kugeln **503** umlaufen können, während sie vom Kugelkäfig **512** geführt werden.

Wie in den **Fig.** 44(c) bis 44(e) gezeigt ist, weist der Kugelkäfig **512** einen flexiblen Gurtabschnitt **512**b auf, der mit Kugelöffnungen **512**e zur jeweiligen Aufnahme der Kugel **503** sowie mit Abstandsabschnitten **512**c versehen ist, die zwischen zwei aufeinanderfolgenden Kugeln **503**, **503** angeordnet sind. Der Gurtabschnitt **512**b hat eine größere Weite als der Durchmesser einer Kugel **503**, so daß die beiden Seitenkanten des Gurtabschnittes **512**b sich von einer Kugel **503** nach außen erstrecken.

Der Abstandsabschnitt **512**c ist mit einer eine Kugel abstützenden, kugelförmigen Aussparung **512**d versehen, die der kugelförmigen Oberfläche einer Kugel **503** entspricht. Eine Kugel **503** wird an ihren beiden Seiten durch ein Paar von stützenden, kugelförmigen Aussparungen **512**d gehalten, so daß verhindert wird, daß eine Kugel **503** vom Gurtabschnitt **512**b herausfallen kann. Bei diesem Ausführungsbeispiel ist das eine Ende des Gurtabschnitts **512**b nicht mit dessen anderen Ende verbunden, wodurch ein streifenförmiger Gurt mit zwei Enden entsteht. Das eine Ende des Gurtabschnitts **512**b kann mit dessen anderem Ende verbunden sein, so daß ein endloser Gurt entsteht.

Wie in der **Fig.** 41 gezeigt ist, besteht der bewegliche Block **504** aus einem Blockkörper **513** mit Kugelgegenlaufrillen **508**, **508**, **508**, **508**, einem Paar von rechten und linken, aus Harz gebildeten Körpern **520**, **520**, die den Kugelumlauf bilden, der in den Blockkörper **513** eingesetzt ist, und einem Paar von seitlichen Deckplatten **540** (nur eine Deckplatte **540** ist gezeigt), die an den beiden Endflächen des Blockkörpers **513** befestigt sind, in den die aus Harz geformten Körper **520**, **520** eingesetzt sind.

Bei einem jeden der rechten und linken aus Harz geformten Körper **520**, **520**, die den Kugelumlauf bilden, sind zwei endlose Umläufe ausgebildet. Die rechten und linken aus Harz geformten Körper **520**, **520** sind symmetrisch. Einer dieser beiden Körper wird im folgenden beschrieben, auf die Beschreibung des anderen Körpers wird verzichtet.

Insbesondere besteht der aus Harz geformte Körper **520**, der den Kugelumlauf bildet, aus einem Rahmen **524** aus Harz, der durch einstückige Formgebung der den Kugelumlauf bildenden Abschnitte **521**, **521**, die sich entlang der beiden, in Längsrichtung erstreckenden Seiten der Kugelgegenlaufrille **508** erstrecken, mit dem Paar der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **522**, **522** (vgl. **Fig.** 42) sowie einem Paar von Röhren **523**, **523** aus Harz erhalten wird, die einen den Rücklauf bildenden Abschnitt darstellen und in Durchgangsöffnungen **514**, **514** eingesetzt sind, die im Blockkörper **513** (vgl. **Fig.** 43) gebildet sind. Die den Kugeldurchlaß bildenden Abschnitte **521**, **521** sind mit dem Paar der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **522**, **522** einstückig ausgebildet, um den Rahmen **524** aus Harz als einen einstückigen Körper zu bilden, und das Paar der Röhren **523**, **523** aus Harz ist getrennt von diesem einstückigen Körper ausgebildet, so daß diese Teile als Blockkörper **513** zusammengebaut werden können.

Wie in der **Fig.** 42 gezeigt ist, sind die den Kugeldurchlaß bildenden Abschnitte **521**, **521** mit Führungsrillen zum Führen der beiden Seitenkanten des Gurtabschnittes **512**b des Kugelkäfigs **512** in einem belasteten Bereich versehen. Diese Führungsrillen können nicht nur verhindern, daß der Kugelkäfig während des Umlaufs der Kugeln schwingt, sondern auch daß er durchhängt, indem die Seitenkanten des Gurtabschnittes **512**b in die Führungsrille **521**e eingreifen, wenn der bewegliche Block **504** von der Führungsschiene **502** entfernt wird. Die Kugeln **503** werden vom Kugelkäfig **512** gehalten. Insbesondere wird der Kugelkäfig **512** durch einen Backenabschnitt der Führungsrille **521**a abgestützt, was zur Folge hat, daß die Kugeln **503** in ihrer korrekten Lage gehalten werden und nicht aus dem beweglichen Block **504** herausfahren können.

Der Abstand zwischen dem Paar der den Kugeldurchlaß bildenden Abschnitte **521**, **521**, die parallel zueinander an den beiden in Längsrichtung verlaufenden Seiten der Kugelgegenlaufrille **508** angeordnet sind, ist etwas kleiner als der Durchmesser einer Kugel **503**. Bei einem derartigen Aufbau ist es möglich zu verhindern, daß die Kugeln **503** aus den den Kugeldurchlaß bildenden Abschnitten **521**, **521** herausfallen, selbst wenn der Kugelkäfig **512** nicht verwendet wird.

Außerdem sind beim Kugelrücklauf **509**, **509** und dem Richtungswechseldurchlässen **510**, **510** als nicht belasteten Bereichen Führungsrillen **509**c, **510**c ausgebildet, wie n den **Fig.** 44(a) und 44(b) gezeigt ist, um die Seitenkanten des Gurtabschnittes **512**(b) zu führen. Die Führungsrillen **509**(c), 510(c) sind mit der oben erwähnten Führungsrille **521**(a) im belasteten Bereich verbunden, um so eine endlose Rille am gesamten Umfang zu bilden.

Die den Kugeldurchlaß bildenden Abschnitte **521**, **521**; **521**, **521** sind, wie in der **Fig.** 42(a) gezeigt ist, aus dem ersten Verbindungsplattenabschnitt **525**, der sich in Längsrichtung entlang der Kante zwischen dem waagerechten Abschnitt **506** und dem Schenkelabschnitt **507** des Blockkörpers **513** in Längsrichtung des Blockkörpers **513** erstreckt, dem zweiten Verbindungsplattenabschnitt **526**, der sich in Längsrichtung zwischen der Kugelgegenlaufrille **508**, **508** an der Innenfläche eines jeden Schenkelabschnittes **507** des Blockes **513** erstreckt, und aus einem Paar von dritten Verbindungsplattenabschnitten **527** gebildet, die sich entlang der Unterfläche des Schenkelabschnitts **507** des Blockkörpers **513** in dessen Längsrichtung erstrecken.

Die obere Kante des ersten Verbindungsplattenabschnittes **525** und die untere Kante des zweiten Verbindungsabschnittes **526**, die einander gegenüberliegen, sind an den entgegengesetzten der oberen Kugelgegenlaufrille **508** plaziert, die im Schenkelabschnitt **507** angeordnet ist, um so die den Kugeldurchlaß bildenden Abschnitte **521**, **521** zu bilden. Die Unterkante des zweiten Verbindungsplattenabschnittes **526** und die Oberkante des dritten Verbindungsplattenabschnittes **527**, die einander gegenüberliegen, sind an entgegengesetzten Längsseiten der unteren Kugelgegenlaufrille **508** angeordnet, die im Schenkelabschnitt **507** vorgesehen ist, um so die den Kugeldurchlaß bildenden Abschnitte **521**, **521** zu bilden.

Wie in den **Fig.** 44(a), 44(b) und 44(c) gezeigt ist, sind die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **522** und die den Kugeldurchlaß bildenden Abschnitte **521**, **521** durch den dünnen Plattenabschnitt **529** durch einstückige Formgebung miteinander verbunden. Die Röhre **523** aus Harz ist in eine Öffnung **534** eingesetzt, die im dünnen Plattenabschnitt **529** ausgeformt ist, um so eine Randverbindung herzustellen, und am dünnen Plattenabschnitt **529** befestigt.

Der dünne Plattenabschnitt **529** weist die den Richtungswechseldurchlaß und innere Führung bildende Abschnitte **522**, **522** auf, die derart ausgestaltet sind, daß sie entsprechend den zwei Kugellaufbahnen **503**, **503** an der Seitenfläche der Führungsschiene **502** hervorstehen. Die beiden Enden der ersten, zweiten und dritten Verbindungsplattenabschnitte **525–527** sind mit dem dünnen Plattenabschnitt **529** verbunden, um am Ende des Blockkörpers **513** angeordnet zu sein und so den einen Rahmen **524** aus Harz zu bilden.

Ein jeder der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **522** ist von halbzylindrischer Gestalt. Am äußeren Umfang der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **522** ist eine innere Führungsrille **510**a mit halbkreisförmigem Querschnitt ausgeformt, um so den inneren Führungsabschnitt des Richtungswechseldurchlasses **510** zu bilden. Das eine Ende der inneren Führungsrille **510**a ist mit dem Ende der Kugelgegenlaufrille **508** verbunden. Dementsprechend weist das eine Ende der inneren Führungsrille **510**a denselben Querschnitt auf wie die Kugelgegenlaufrille **508**, um auf diese Weise das eine Ende der inneren Führungsrille **510**a mit dem Ende der Kugelgegenlaufrille **508** auszurichten. Das andere Ende der inneren Führungsrille **510**a des Richtungswechseldurchlasses **510** ist mit dem Ende des Kugelrücklaufes **509** verbunden. Dementsprechend weist das andere Ende der inneren Führungsrille **510**a denselben Querschnitt auf, wie der Kugelrücklauf **509**, um auf diese Weise das andere Ende der inneren Führungsrille **510**a mit dem Ende des Kugelrücklaufes **509** auszurichten.

Zylinderförmige Flanschabschnitte **533**, **533** sind an den beiden Enden der inneren Führungsrille **510**a ausgestaltet. Der Abstand zwischen den jeweiligen äußeren Flächen der zylindrischen Flanschabschnitte **533**, **533** ist größer als die Weite des Gurtabschnittes **512**b. Die zylindrischen Flanschabschnitte **533**, **533** bilden eine Käfigführungsrille **510**c für den Kugelkäfig **512** zusammen mit einem halbkreisförmigen, ausgesparten Abschnitt mit Aussparungen, der am inneren Umfang der Aussparung der seitlichen Deckplatte **540**, die weiter unten beschrieben ist, ausgebildet ist.

Die beiden Enden der inneren Führungsrille **510**a des Richtungswechseldurchlasses **510** erstrecken sich bis zur Kontaktfläche des dünnen Plattenabschnittes **529** mit der Endfläche des Blockkörpers **513**, um auf diese Weise mit den jeweiligen Enden der Kugelgegenlaufrille **508** und dem Kugelrücklauf **509** verbunden zu sein. Einsetzlöcher **534**, **534** für eine Röhre mit halbkreisförmigem Querschnitt, in welche die Enden der Röhren **523** aus Harz eingesetzt sind, sind am dünnen Plattenabschnitt **529** ausgeformt.

Wie in der **Fig.** 43 gezeigt ist, besteht die Röhre **523** aus einem äußeren umfangsseitigen Halbröhrenteil **523**b, das an der äußeren Umfangsseite des Kugelumlaufs angeordnet ist und durchgängig mit der äußeren Führungsrille **510**b des Richtungswechseldurchlasses **510** der seitlichen Deckplatte **540** verbunden ist, sowie aus einem inneren umfangsseitigen Halbröhrenteil **523**a, das an der inneren Umfangsseite des Kugelumlaufes angeordnet ist, der durchgängig mit einer inneren Führungsrille **510**a des Richtungswechseldurchlasses **510** der seitlichen Deckplatte **540** verbunden ist.

Das innere, umfangsseitige Halbröhrenteil **523**a weist einen Rillenabschnitt **509**a von halbkreisförmigem Querschnitt auf sowie Seitenkantenabschnitte **523**c, die sich in Längsrichtung entlang des Rillenabschnittes **509**a erstrekken, wie in den **Fig.** 43c und 43d gezeigt ist. Das äußere umfangsseitige Halbrillenteil **523**b ist als ein geradliniges Bauteil ausgebildet, das denselben kreisförmigen Querschnitt wie die äußere Führungsrille **510**b des Richtungswechseldurchlasses aufweist, der an der seitlichen Deckplatte **540** ausgebildet ist. Das äußere umfangsseitige Halbröhrenteil **523**b weist einen Rillenabschnitt **509**b auf, der durchgängig mit der äußeren Führungsrille **510**b verbunden ist, sowie Seitenkantenabschnitte **523**d, die sich in Längsrichtung entlang des Rillenabschnittes **509**b erstrecken. Die Seitenkantenabschnitte **523**d sind an ihren äußeren Kanten mit Vorsprüngen **523**e versehen, die in Kontakt mit den äußeren Kanten der Seitenkantenabschnitte **523**c des inneren umfangsseitigen Halbröhrenteils **523**a gebrachtwerden, um die Käfigführungsrille **509**d des Kugelkäfigs **512** zu bilden.

Das innere umfangsseitige Halbröhrenteil **523**a der Röhre **523** aus Harz weist dieselbe Länge wie der Blockkörper **513** auf. Das innere umfangsseitige Halbröhrenteil **523**a ist derart angeordnet, daß es in Kontakt mit der rückwärtigen Fläche des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **522** gebracht werden kann.

Das äußere umfangsseitige Halbröhrenteil **523**b der Röhre **523** aus Harz weist andererseits eine um die Dicke des dünnen Plattenabschnitts **529** größere Länge als der Blockkörper **513** auf. Die äußeren umfangsseitigen Halbröhrenteile **523**b werden in die Einsetzlöcher **534** eingesetzt. Eine Lagebestimmung des äußeren umfangsseitigen Halbröhrenteils **523**b findet in Längsrichtung dadurch statt, daß die beiden Enden des äußeren umfangsseitigen Halbröhrenteils **523**b, die in die Einsetzlöcher **534** eingesetzt sind, in Kontakt mit der in Umfangsrichtung verlaufenden Kante des Endabschnittes der äußeren Führungsrillen **510**b des Richtungswechseldurchlasses gebracht werden, die an der seitlichen Deckplatte **540** ausgeformt sind. Die an den beiden Seitenkanten des äußeren umfangsseitigen Halbröhrenteils **523**b angeformten Vorsprünge **523**e berühren die Außenkanten der zylindrischen Flanschabschnitte **533**, die an den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt **522** angeformt sind, um einen Teil der Führungsrille **510**c zu bilden, und das äußere umfangsseitigen Halbröhrenteil **523**b und das innere umfangsseitigen Halbröhrenteil **523**a können sich in der Einsetzöffnung **514** nicht drehen.

Die Röhren **523** aus Harz und die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **522** werden über die am dünnen Plattenabschnitt **529** ausgebildeten Einsetzlöcher **534** genau positioniert, so daß auf diese Weise ein korrekter Zusammenbau stattfinden kann.

Wie in den **Fig.** 44(f) und 44(g) gezeigt ist, ist die seitliche Deckplatte **540** mit einem ausgesparten Einsetzabschnitt **540**a versehen, in den der dünne Plattenabschnitt **529** eingesetzt wird, sowie mit ausgesparten Abschnitten **541**, die die äußeren Führungsrillen **510**b des Richtungswechseldurchlasses aufweisen, in die die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **522** eingepaßt werden, sowie ferner mit Abschnitten zur Befestigung von Schrauben, um die seitliche Deckplatte **540** am Blockkörper **513** zu befestigen. An den Abschnitten zum Befestigen von Schrauben wird die seitliche Deckplatte **540** am Blockkörper **513** befestigt, indem Schrauben (nicht gezeigt) in an der seitlichen Deckplatte **540** ausgebildete Öffnungen **543** eingesetzt werden und in Gewindelöcher **544**, die an der Endfläche des Blockkörpers **513** ausgeformt sind, eingreifen. Die Öffnungen **543** sind an vier Positionen angeordnet, d. h. der Position, die dem dünnen Plattenabschnitt **529** zwischen den den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten **522**, **522** eines jeden aus Harz gebildeten Körpers **520**, **520** entspricht und den Positionen in der Umgebung der dünnen Plattenabschnitte **529**, **529** am waagerechten Abschnitt **506**.

Wie in der **Fig.** 44(g) gezeigt ist, weist die äußere Führungsrille **510**b des Richtungswechseldurchlasses im ausgesparten Abschnitt **541** an ihren Seitenkanten gebogene Aussparungen **546** von einem größeren Durchmesser auf, die zusammen mit den zylindrischen Flanschabschnitten **533** der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **522**, wie in der **Fig.** 44(f) gezeigt, die Käfigführungsrille **510**c bilden, sowie bogenförmige Aussparungen **547** von kleinerem Durchmesser, in die die zylindrischen Flanschabschnitte **533** eingesetzt werden. Der den Richtungswechseldurchlaß und innere Führung bildende Abschnitt **522**, der mit der inneren Führungsrille **510**a des Richtungswechseldurchlasses versehen ist, ist in den ausgesparten Abschnitt **541** der seitlichen Deckplatte **540** eingepaßt und der dünne Plattenabschnitt **529** wird im ausgesparten Einsetzabschnitt **540**a der seitlichen Deckplatte **540** aufgenommen. Der dünne Plattenabschnitt **529** ist zwischen der seitlichen Deckplatte **540** und der Endfläche des Blockkörpers **513** durch eine Klemmkraft gehalten, so daß er fest dazwischen befestigt ist.

Die den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **522** und der den Kugeldurchlaß bildende Abschnitt **521** sind über den dünnen Plattenabschnitt **529** verbunden, wodurch es möglich ist, eine genaue Lagebeziehung des Endes der inneren Führungsrille **510**a des in dem den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt **522** ausgebildeten Richtungswechseldurchlaß relativ zu den den Kugeldurchlaß bildenden Abschnitten **521**, **521** als auch eine genaue Lagebeziehung der inneren Führungsrille **510**a des Richtungswechseldurchlasses relativ zum Kugelrücklauf **509**.

Der dünne Plattenabschnitt **529**, der in der Umgebung des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **522** angeordnet ist, wird gleichmäßig gegen die flache Endfläche des Blockkörpers **513** durch eine auf die seitliche Deckplatte **540** wirkende Klemmkraft gedrückt (vgl. **Fig.** 44). Selbst wenn der den Richtungswechseldurchlaß und innere Führung bildende Abschnitt **522** sich nicht in einer korrekten Lage befindet, ändert der dünne Plattenabschnitt **529** seine Form an der Endfläche des Blockkörpers **513**, wodurch die korrekte Positionierung des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes **522** ermöglicht wird. Der dünne Plattenabschnitt **529** wird durch eine Klemmkraft, die auf die seitliche Deckplatte **540** wirkt, festgeklemmt und befestigt und eine durch eine derartige Klemmung erzeugte Reibkraft kann eine ungünstige Bewegung der inneren Führungsrille **510**a des Richtungswechseldurchlasses verhindern.

Die seitliche Deckplatte **540** ist am Blockkörper **513** befestigt, so daß der den Richtungswechseldurchlaß und innere Führung bildende Abschnitt **522**, der am Blockkörper **513** angebaut ist, in den ausgesparten Abschnitt **541** der seitlichen Deckplatte **540** eingepaßt wird. Ein derartiges Einpassen ermöglicht eine genaue Positionierung der seitlichen Deckplatte **540** relativ zum Blockkörper **513**.

Im folgenden werden die Schritte zum Zusammenbau der oben erwähnten, aus Harz gebildeten Körper **520**, die den Kugelumlauf bilden, beschrieben.

Zunächst wird das innere umfangsseitige Halbröhrenteil **523**a der Röhre **523** aus Harz in die Durchgangsöffnung **514** des Schenkelabschnittes **507** des Blockkörpers **513** eingesetzt.

Dann wird der durch einstückige Formgebung erhaltene Rahmen **524** aus Harz in die Aussparung des Blockkörpers **513** eingesetzt, wodurch die dünnen Plattenabschnitte **529** an den beiden Enden des Rahmens **524** aus Harz an den jeweiligen Endflächen des Schenkelabschnittes **507** des Blockkörpers **513** entlanggleiten. Der erste Verbindungsplattenabschnitt **525** des Rahmens **524** aus Harz berührt den Eckenabschnitt zwischen dem waagerechten Abschnitt **506** und dem Schenkelabschnitt **507**, wodurch eine Lagebestimmung in senkrechter Richtung des Rahmens **524** aus Harz stattfindet. Der zweite Verbindungsplattenabschnitt **526** und der dritte Verbindungsplattenabschnitt **527** des Rahmens **524** aus Harz berühren die jeweiligen Innenflächen der Schenkelabschnitte **507** des Blockkörpers **513**, wodurch eine Lagebestimmung der den Kugeldurchlaß bildenden Abschnitte **521**, **521** und der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte **522**, **522** stattfindet. Zu diesem Zeitpunkt sind die Einsetzlöcher **534**, **534** des dünnen Plattenabschnittes **529** mit den Durchgangsöffnungen **514**, **514** des Blockkörpers **513** ausgerichtet.

Dann werden die äußeren umfangsseitigen Halbröhrenteile **523**b, **523**b in die Durchgangsöffnungen **514**, **514** von den Einsetzöffnungen **534**, **534** aus eingesetzt, wodurch der Zusammenbau einer der aus Harz geformten Körper **520**, **520**, die den Kugelumlauf bilden, fertiggestellt ist.

Der Zusammenbau des anderen aus Harz gebildeten Körpers **520**, **520** wird auf dieselbe Weise durchgeführt.

Dann wird die eine seitliche Deckplatte **540** an der einen Endfläche des Blockkörpers **513** durch Klemmen befestigt, der die Kugeln haltende Kugelkäfig **512** wird eingesetzt und die andere seitliche Deckplatte **540** wird an der anderen Endfläche des Blockkörpers **513** durch denselben Klemmvorgang befestigt, wodurch der Zusammenbau des beweglichen Blockes **504** fertig ist.

Entsprechend der vorliegenden Erfindung sind die aus Harz gebildeten Körper **520**, **520**, die den Kugelumlauf bilden, getrennt vom Blockkörper **513** ausgebildet. Selbst wenn der bewegliche Block **504** größer ist, gibt es keine Einschränkung des Flusses des flüssigen Harzes durch den Blockkörper **513** wie im Fall, in dem der Blockkörper **513** einstückig mit den aus Harz gebildeten Körpern **520**, **520** ausgebildet ist. Durch eine Erhöhung der Anzahl von Eingußstellen, die an einer Gußform ausgebildet sind, kann das korrekte Fließen des flüssigen Harzes sichergestellt werden und die Formgebung verbessert werden. Insbesondere sind die den Kugeldurchlaß bildenden Abschnitte **521**, **521**, die an den gegenüberliegenden Längsseiten der Kugelführungsrille **508** angeordnet sind, dünn, was zum Ergebnis hat, daß das flüssige Harz nicht jeden Teil des Raums erreichen kann, der die den Kugeldurchlaß bildenden Abschnitte **521**, **521** ausmacht. Daher ist es von Vorteil, die aus Harz gebildeten Körper **520**, **520** in Übereinstimmung mit dem Ausführungsbeispiel der vorliegenden Erfindung getrennt vom Blockkörper **513** auszubilden.

Da außerdem rechte und linke aus Harz gebildete Körper

520, **520**, die den Kugelumlauf bilden, ausgebildet sind, die jeweils Zwei endlose Umläufe aufweisen, kann ein korrektes Fließen des flüssigen Harzes selbst dann sichergestellt werden, wenn der bewegliche Block **513** relativ groß ist.

Der durchgängige Umlauf wird durch den aus Harz gebildeten Körper **520** gebildet und daher ist es möglich, eine Lagebestimmung der inneren Führungsrille **510**a des Richtungswechseldurchlasses relativ zu den den Kugeldurchlaß bildenden Abschnitten **521**, **521** sowie eine Lagebestimmung der inneren Führungsrille **510**a des Richtungswechseldurchlasses relativ zum Kugelrücklauf **509** durchzuführen, wodurch die Durchgängigkeit des Umlaufs sichergestellt wird, und ein glatter Umlauf der Kugeln **503** stattfinden kann.

Wenn die korrekte Lagebeziehung der inneren Führungsrille **510**a des Richtungswechseldurchlasses relativ zu den den Kugeldurchlaß bildenden Abschnitten **521**, **521** gewahrt ist, sind die den Kugeldurchlaß bildenden Abschnitte **521**, **521** an den beiden Längsseiten der Kugellaufrille **508** angeordnet und mit den Enden der inneren Führungsrille **510**a des Richtungswechseldurchlasses ausgerichtet.

Wenn die geeignete Lagebeziehung der inneren Führungsrille **510**a des Richtungswechseldurchlasses relativ zum Kugelrücklauf **509** gewahrt ist, kann die innere Führungsrille **510**a des Richtungswechseldurchlasses mit der inneren Rille **523**a des Kugelrücklaufs **509** ausgerichtet werden.

Der Verbindungsabschnitt der den Kugeldurchlaß bildenden Abschnitte **521**, **521** und der den Richtungswechseldurchlaß und innere Führung bildende Abschnitt **522** werden durch einstückige Formgebung erhalten, wodurch auf einen Arbeitsschritt verzichtet werden kann, in dem der Verbindungsabschnitt zusammengebaut wird. Obwohl die Laufrichtung der Kugeln **503** in einem derartigen Verbindungsabschnitt sich ändert, kann der oben erwähnte einteilige Aufbau die Durchgängigkeit des Umlaufs sicherstellen, ohne daß er durch die Genauigkeit des Zusammenbaus beeinflußt wird. Daher ist ein glatter Umlauf der Kugeln **503** vom Kugelrücklauf zum Richtungswechseldurchlaß **510** zwischen der Kugellaufrille **505** und der Kugelgegenlaufrille **508** sowie vom Richtungswechseldurchlaß **510** zum Kugelrücklauf **509** möglich.

Entsprechend der im Detail beschriebenen, vorliegenden Erfindung kann selbst bei einem größeren beweglichen Block durch eine Erhöhung der Anzahl von Eingußstellen an der Gußform ein korrekter Fluß des flüssigen Harzes sichergestellt werden und die Formgebung verbessert werden, da der aus Harz gebildete Körper, der den Rollkörperumlauf bildet, getrennt vom Blockkörper ausgebildet ist. Daher ist es von Vorteil, den aus Harz gebildeten Körper getrennt vom Blockkörper in Übereinstimmung mit der vorliegenden Erfindung auszubilden, wobei in Betracht gezogen wird, daß die den Rollkörperdurchlaß bildenden Abschnitte, die an den gegenüberliegenden Längsseiten der Rollkörperlaufbahn angeordnet sind, dünn sind, was wiederum zum Ergebnis hat, daß das flüssige Harz nicht jeden Teil des Raumes erreichen kann, der zur Formgebung der den Rollkörperdurchlaß bildenden Abschnitte vorgesehen ist.

Der durchgängige Umlauf wird durch den aus Harz gebildeten Körper gebildet, wodurch es möglich ist, eine Lagebestimmung der inneren Führungsrille des Richtungswechseldurchlasses relativ zu den den Rollkörperdurchlaß bildenden Abschnitte sowie eine Lagebestimmung der inneren Führungsrille des Richtungswechseldurchlasses relativ zum Rollkörperrücklauf durchzuführen, wodurch die Durchgängigkeit des Umlaufes und ein glatter Umlauf der Rollkörper sichergestellt wird.

Wenn der Verbindungsabschnitt der den Rollkörperdurchlaß bildenden Abschnitte und der den Richtungswechseldurchlaß und innere Führung bildende Abschnitt oder der Verbindungsabschnitt des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes und der den Rücklauf bildenden Abschnitt, indem sich die Laufrichtung der Rollkörper ändert, durch einstückige Formgebung erhalten wird, ist es möglich, auf einen Zusammenbau des Verbindungsabschnittes zu verzichten und die Durchgängigkeit des Umlaufs sicherzustellen, ohne durch eine Genauigkeit bei einem Zusammenbau betroffen zu sein.

Die einstückige Formgebung des Verbindungsabschnittes des den Rollkörperumlauf bildenden Abschnittes zusammen mit der den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes führt zu einem glatten Umlauf der Rollkörper zwischen der Rollkörperlaufbahn im belasteten Bereich und dem den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt, selbst wenn der den Rücklauf bildende Abschnitt aus Harz nicht verwendet wird.

Wenn der Rollkörperkäfig verwendet wird, ist es möglich, eine vorteilhafte Durchgängigkeit am gesamten Umfang des Umlaufs im Käfigführungsabschnitt, der den Rollkörperkäfig führt, zu wahren.

Der dünne Käfigführungsabschnitt wird ohne Einsetzen des Körpers des beweglichen Teils in eine Gußform ausgebildet und die Lage der Eingußstellen in der Form kann frei bestimmt werden, ohne durch den Körper des beweglichen Blocks behindert zu sein, was zum Ergebnis hat, daß das flüssige Harz während der Bildung des Führungsabschnittes den gesamten, dafür in der Gußform vorgesehenen Raum erreichen kann.

Zusätzlich kann die Ausbildung von rechten und linken aus Harz gebildeten Körpern, die den Rollkörperumlauf bilden und jeweils zwei endlose Umläufe aufweisen, einen korrekten Fluß des flüssigen Harzes sicherstellen, selbst wenn der Körper des beweglichen Teils relativ weit ist.

Die Verbindung des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes mit dem den Rollkörperdurchlaß bildenden Abschnitt über den dünnen Plattenabschnitt ermöglicht durch die Verformung des dünnen Plattenabschnitts das Einhalten einer korrekten Lagebeziehung zwischen dem den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt und dem den Rollkörperdurchlaß bildenden Abschnitt oder einer korrekten Lagebeziehung zwischen der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitt und dem den Rollkörperrücklauf bildenden Abschnitt, wodurch eine genaue Lagebestimmung des Endes des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes relativ zu dem den Rollkörperrücklauf bildenden Abschnitt und eine genaue Lagebestimmung des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes relativ zu dem den Rollkörperrücklauf bildenden Abschnitt stattfindet.

Der dünne Plattenabschnitt wird durch eine Klemmkraft, die auf die seitliche Deckplatte wirkt, gegen die flache Stirnfläche des Körpers des beweglichen Teils drückt. Daher ist es möglich, die Lage des den Richtungswechseldurchlaß und innere Führung bildenden Abschnittes über die Verformung des dünnen Plattenabschnittes zu korrigieren, selbst wenn der den Richtungswechseldurchlaß und innere Führung bildende Abschnitt nicht korrekt relativ zur Stirnfläche des Körpers des beweglichen Teils positioniert ist.

Zusätzlich kann der dünne Plattenabschnitt sicher zwischen der seitlichen Deckplatte und dem Körper des beweglichen Teils durch die Klemmkraft befestigt werden, die auf die seitliche Deckplatte wirkt, und daher ist es möglich zu verhindern, daß der den Richtungswechseldurchlaß und innere Führung bildende Abschnitt falsch plaziert wird.

Patentansprüche

1. Führungsvorrichtung für eine geradlinige Bewegung, die folgende Merkmale aufweist:
ein mit einer Rollkörperlaufbahn versehenes Führungsteil, und
ein bewegliches Teil, das derart angeordnet ist, daß entlang dem Führungsteil über eine große Anzahl von Rollkörpern beweglich ist, wobei das bewegliche Teil versehen ist mit (i) einer Rollkörpergegenlaufbahn, die der Rollkörperlaufbahn des Führungsteils entspricht (ii) einem Rollkörperrücklauf, der von der Rollkörpergegenlaufbahn in einem vorbestimmten Abstand parallel zu dieser angeordnet ist und (iii) ein Paar von Richtungswechseldurchlässen, die die Rollkörpergegenlaufbahn und den Rollkörperrücklauf verbinden und den Umlauf der Rollkörper ermöglichen,
dadurch gekennzeichnet, daß:
ein aus Harz gebildeter Körper, der den Rollkörperumlauf bildet, ein Paar von einen Rollkörperdurchlaß bildenden Abschnitten, die sich entlang der beiden in Längsrichtung verlaufenden Seiten der Rollkörpergegenlaufbahn erstrecken, einen den Rücklauf bildenden Abschnitt, der den Rollkörperrücklauf bildet, und ein Paar der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte aufweist, die innere, in Umfangsrichtung verlaufende Führungsabschnitte der Richtungswechseldurchlässe bilden, wobei der aus Harz gebildete Körper getrennt von einem Körper des beweglichen Teils ausgebildet ist; und
zumindest zwei von (a) einem Paar der den Rollkörperdurchlaß bildenden Abschnitte, (b) einem den Rücklauf bildenden Abschnitt (c) einem des Paars der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte und (d) einem weiteren des Paares der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte durch einstückige Formgebung derart miteinander verbunden sind, daß der aus Harz gebildete Körper in den Körper des beweglichen Teils eingebaut werden kann.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß:
der aus Harz gebildete Körper (i) einen einstückigen Körper des Paars der den Rollkörperdurchlaß bildenden Abschnitte und des Paars der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte und (ii) den den Rücklauf bildenden Abschnitt getrennt vom einstückigen Körper ausgebildet aufweist.

3. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß:
der aus Harz gebildete Körper (i) einen einstückigen Körper des Paars der den Rollkörperdurchlaß bildenden Abschnitte, den den Rücklauf bildenden Abschnitt und einen vom Paar des den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte sowie (ii) einen weiteren des Paares der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte getrennt vom einstückigen Körper ausgebildet aufweist.

4. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß:
der aus Harz gebildete Körper durch Herstellung eines einstückigen Körpers aus dem Paar der den Rollkörperdurchlaß bildenden Abschnitte, des den Rücklauf bildenden Abschnittes und des Paars der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte und nachfolgender Teilung des Paars der den Rollkörperdurchlaß bildenden Abschnitte und des den Rücklauf bildenden Abschnittes in in Längsrichtung verlaufende Zwischenabschnitte in jeweils zwei Teile gebildet ist.

5. Führungsvorrichtung für eine geradlinige Bewegung, die folgende Merkmale aufweist:
ein mit einer Rollkörperlaufbahn versehenes Führungsteil und
ein bewegliches Teil, das derart angeordnet ist, daß es entlang dem Führungsteil über eine große Anzahl von Rollkörpern beweglich ist, wobei das bewegliche Teil (i) eine Rollkörpergegenlaufbahn, die der Rollkörperlaufbahn des Führungsteils entspricht, (ii) einen Rollkörperrücklauf, der in einem vorgegebenen Abstand von der Rollkörpergegenlaufbahn parallel zu dieser angeordnet ist und (iii) ein Paar von Richtungswechseldurchlässen aufweist, die die Rollkörpergegenlaufbahn und den Rollkörperrücklauf miteinander verbinden und den Umlauf der Rollkörper ermöglichen,
dadurch gekennzeichnet, daß:
ein aus Harz gebildeter Körper, der den Rollkörperumlauf bildet, ein Paar von den Rollkörperdurchlaß bildenden Abschnitten aufweist, die sich entlang der beiden in Längsrichtung verlaufenden Seiten der Rollkörpergegenlaufbahnen erstrecken, sowie ein Paar von den Richtungswechseldurchlaß und innere Führung bildenden Abschnitten aufweist, die innere, in Umfangsrichtung verlaufende Führungsabschnitte der Richtungswechseldurchlässe bilden, wobei der aus Harz gebildete Körper getrennt von einem Körper des beweglichen Teils ausgebildet ist;
der Rollkörperrücklauf durch Ausformung einer Durchgangsöffnung im Körper des beweglichen Teils gebildet ist; und
ein Paar von den Rollkörperdurchlaß bildenden Abschnitten und zumindest einer des Paars der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte durch einstückige Formgebung miteinander verbunden sind.

6. Vorrichtung nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß:
ein Rollkörperkäfig vorgesehen ist, in dem die Rollkörper hintereinander in einem vorgegebenen Abstand zwischen Zwei benachbarten Rollkörpern aufnehmbar sind, wobei der Rollkörperkäfig Seitenkantenabschnitte aufweist, die von den beiden Seiten eines jeden Rollkörpers vorspringen; und
Führungsrillen, entlang derer die Seitenkantenabschnitte des Rollkörperkäfigs geführt sind, am gesamten Umfang des Rollkörperumlaufs ausgebildet sind.

7. Vorrichtung nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, daß:
ein jeder der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte einen dünnen Plattenabschnitt aufweist, der in Kontakt mit einer Stirnfläche des Körpers des beweglichen Teils bringbar ist, wobei jeder der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte mit den den Rollkörperdurchlaß bildenden Abschnitten oder dem in Rücklauf bildenden Abschnitt durch den dünnen Plattenabschnitt verbunden ist.

8. Vorrichtung nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß:
das Führungsteil eine Führungsschiene aufweist;
das bewegliche Teil einen beweglichen Block aufweist, der mit einem waagerechten Abschnitt versehen ist, welcher einer Oberfläche der Führungsschiene sowie einem Paar von Schenkelabschnitten gegenüberliegt, zwischen denen die Führungsschiene an deren rechten und linken Seitenflächen gehalten ist; und

zwei Rollkörperlaufbahnen in einer Lücke zwischen der Oberfläche der Führungsschiene und einer Unterfläche des beweglichen Blockes angeordnet sind und eine einzelne Rollkörperlaufbahn in einer jeden Lücke zwischen den rechten und linken Seitenflächen der Führungsschiene und den beiden Schenkelabschnitten angeordnet ist, so daß insgesamt vier Rollkörperlaufbahnen vorhanden sind.

9. Vorrichtung nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß:
das Führungsteil eine Führungsschiene aufweist;
das bewegliche Teil einen beweglichen Block aufweist, der mit einem Paar von Schenkelabschnitten versehen ist, zwischen denen die Führungsschiene an deren rechten und linken Seitenfläche gehalten ist; und
zwei Rollkörperlaufbahnen in jeder der Lücken zwischen den rechten und linken Seitenflächen der Führungsschiene und den beiden Schenkelabschnitten angeordnet sind, so daß insgesamt vier Rollkörperlaufbahnen vorhanden sind.

10. Vorrichtung nach Anspruch 9, dadurch gekennzeichnet, daß:
vier den Richtungswechseldurchlaß und innere Führung bildende Abschnitte jeweils entsprechend den vier Kegellaufbahnen ausgebildet sind und die vier den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte einstückig miteinander verbunden sind.

11. Vorrichtung nach Anspruch 9, dadurch gekennzeichnet, daß:
zwei der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte, die an einer Seite der rechten Seitenfläche der Führungsschiene angeordnet sind, einstückig miteinander verbunden sind und die anderen beiden den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte, die an einer Seite der linken Seitenfläche der Führungsschiene angeordnet sind, einstückig miteinander verbunden sind.

12. Vorrichtung nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß:
das Führungsteil eine Führungsschiene aufweist;
das bewegliche Teil mit einem waagerechten Abschnitt versehen ist, der einer Oberfläche der Führungsschiene gegenüberliegt, sowie mit einem einzelnen Schenkelabschnitt, der einer Seite der Führungsschiene gegenüberliegt; und
eine einzelne Rollkörperlaufbahn in einer Lücke zwischen einer Seitenfläche der Führungsschiene und dem einzelnen Schenkelabschnitt angeordnet ist und eine weitere Rollkörperlaufbahn in einer Lücke zwischen der Oberfläche der Führungsschiene und einer Unterfläche des waagerechten Abschnitts in der Umgebung einer Kante der Führungsschiene angeordnet ist.

13. Vorrichtung nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß:
das Führungsteil eine Führungsschiene aufweist;
das bewegliche Teil einen beweglichen Block aufweist, der mit einem Paar von Schenkelabschnitten versehen ist, zwischen denen die Führungsschiene an deren rechten und linken Seitenflächen gehalten ist; und
eine Rollkörperlaufbahn in einer jeden Lücke zwischen den rechten und linken Seitenflächen der Führungsschiene und den beiden Schenkelabschnitten angeordnet ist, so daß insgesamt zwei Rollkörperlaufbahnen vorhanden sind.

14. Vorrichtung nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß:
das Führungsteil eine Führungsschiene aufweist;
das bewegliche Teil einen beweglichen Block aufweist, der entlang einer Seitenfläche der Führungsschiene angeordnet ist; und
zwei Rollkörperlaufbahnen in einer Lücke zwischen der einen Seitenfläche der Führungsschiene und dem beweglichen Block angeordnet sind.

15. Vorrichtung nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß:
das Führungsteil eine Keilwelle aufweist; und
das bewegliche Teil eine äußere Hülse aufweist, die über eine Vielzahl von Rollkörperlaufbahnen beweglich auf der Keilwelle gelagert ist.

16. Führungsvorrichtung für eine geradlinige Bewegung, die folgende Merkmale aufweist:
eine Führungsschiene, die mit zwei Rollkörperlaufbahnen an jeder der rechten und linken Seitenflächen der Führungsschiene versehen ist, so daß insgesamt vier Rollkörperlaufbahnen vorhanden sind; und
einen beweglichen Block, der mit einem Paar von Schenkelabschnitten versehen ist, zwischen denen die Führungsschiene an deren rechten und linken Seitenflächen gehalten ist, wobei jeder Schenkelabschnitt an dessen Innenfläche zwei Rollkörpergegenlaufbahnen aufweist, die den zwei Rollkörperlaufbahnen der Führungsschiene entsprechen, so daß insgesamt vier Rollkörpergegenlaufbahnen vorhanden sind, und wobei ferner der bewegliche Block Rollkörperrückläufe sowie vier endlose Umläufe aufweist, die durch vier Rollkörperrückläufe gebildet sind, die jeweils parallel zu den vier Rollkörpergegenlaufbahnen angeordnet sind, wobei die Rollkörperrückläufe die beiden Enden einer jeden Rollkörperlaufbahn jeweils mit den beiden Enden eines jeden Rollkörperrücklaufes verbinden,
dadurch gekennzeichnet, daß:
ein aus Harz gebildeter Körper bei einem jeden der endlosen Umläufe ein Paar von einen Rollkörperdurchlaß bildenden Abschnitten aufweist, die sich entlang der beiden in Längsrichtung verlaufenden Seiten der Rollkörpergegenlaufbahn erstrecken, sowie einen einen Rücklauf bildenden Abschnitt, der den Rollkörperrücklauf bildet, und ein Paar von einen Richtungswechseldurchlaß und innere Führung bildenden Abschnitten, die innere, in Umfangsrichtung verlaufende Führungsabschnitte der Richtungswechseldurchlässe bilden, wobei der aus Harz gebildete Körper getrennt von einem Körper des beweglichen Blockes ausgebildet ist;
der aus Harz gebildete Körper in zwei Teilkörper unterteilt ist, die jeweils an den Schenkelabschnitten des beweglichen Blockes angeordnet sind, so daß sie zwei endlose Umläufe an den Innenseiten eines jeden Schenkelabschnittes bilden; und
bei einem jeden der zwei Teilkörper die Rollkörpergegenlaufbahn und das Paar der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte als ein einstückiger Körper ausgebildet sind und der den Rücklauf bildende Abschnitt getrennt vom einstückigen Körper ausgebildet ist.

17. Vorrichtung nach Anspruch 16, dadurch gekennzeichnet, daß:
ein Rollkörperkäfig vorgesehen ist, in welchem Rollkörper hintereinander in einem vorbestimmten Abstand zwischen zwei benachbarten Rollkörpern aufnehmbar sind und der Seitenkantenabschnitte aufweist, die von den beiden Seiten eines jeden Rollkörpers hervorspringen; und
Führungsrillen zum Führen der Seitenkantenabschnitte des Rollkörperkäfigs am gesamten Umfang des Rollkörperumlaufs angeformt sind.

18. Vorrichtung nach Anspruch 16e oder 17, dadurch gekennzeichnet, daß:
ein jeder der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte einen dünnen Plattenabschnitt aufweist, der eine Endfläche des Körpers des beweglichen Teils berührt, und wobei ein jeder der den Richtungswechseldurchlaß und innere Führung bildenden Abschnitte mit den den Rollkörperdurchlaß bildenden Abschnitten oder dem den Rücklauf bildenden Abschnitt durch den dünnen Plattenabschnitt verbunden ist

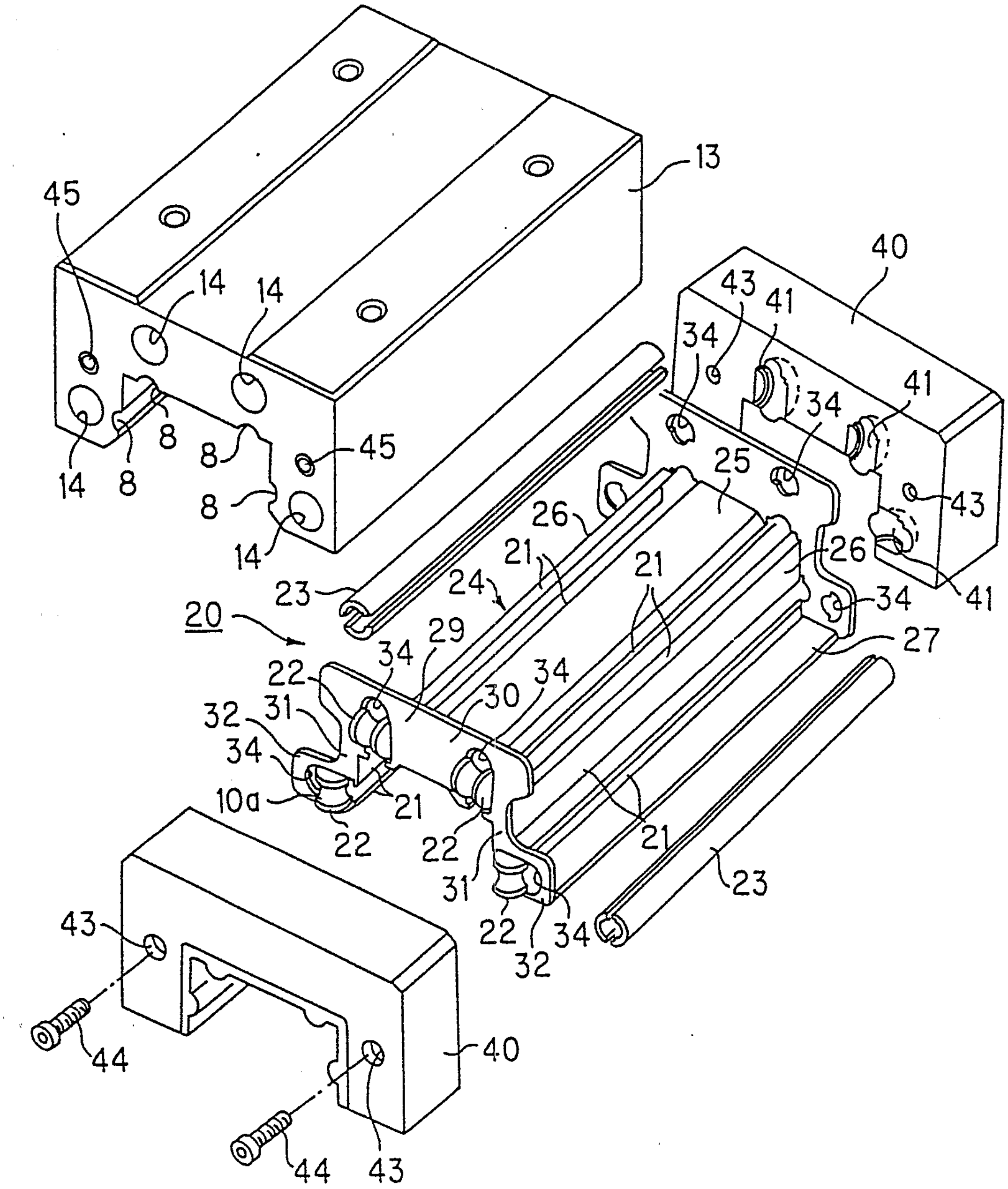
---

Hierzu 44 Seite(n) Zeichnungen

- Leerseite -

Nummer: **DE 198 26 703 A1**
Int. Cl.[6]: **F 16 C 29/04**
Offenlegungstag: 21. Januar 1999

FIG. 1



Nummer: DE 198 26 703 A1
Int. Cl.[6]: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

FIG. 2(a)

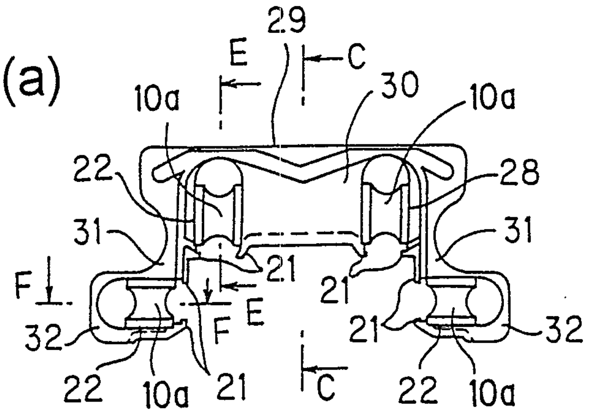


FIG. 2(b)

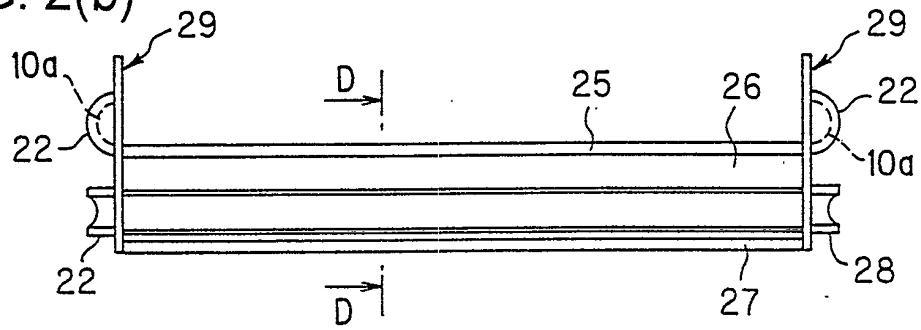


FIG. 2(c)

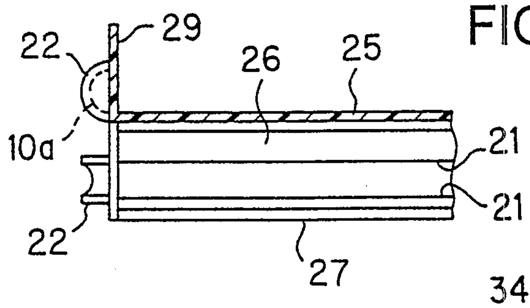


FIG. 2(d)

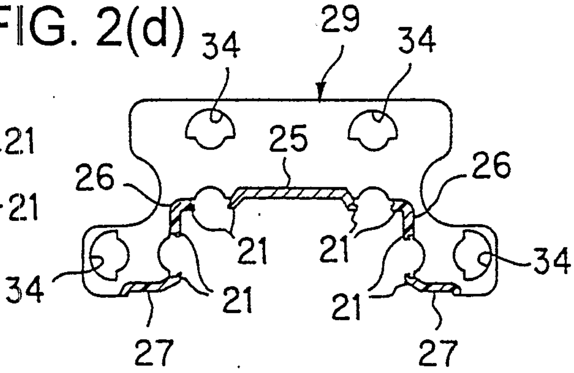


FIG. 2(e)

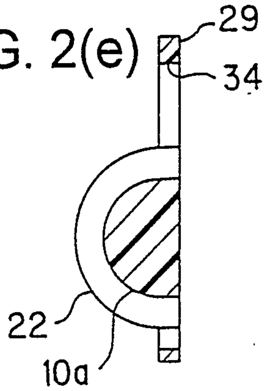
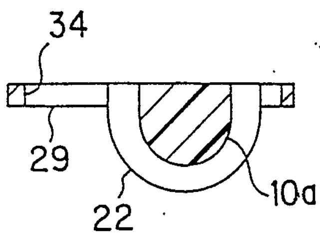


FIG. 2(f)



Nummer: DE 198 26 703 A1
Int. Cl.[6]: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

FIG. 3(a)

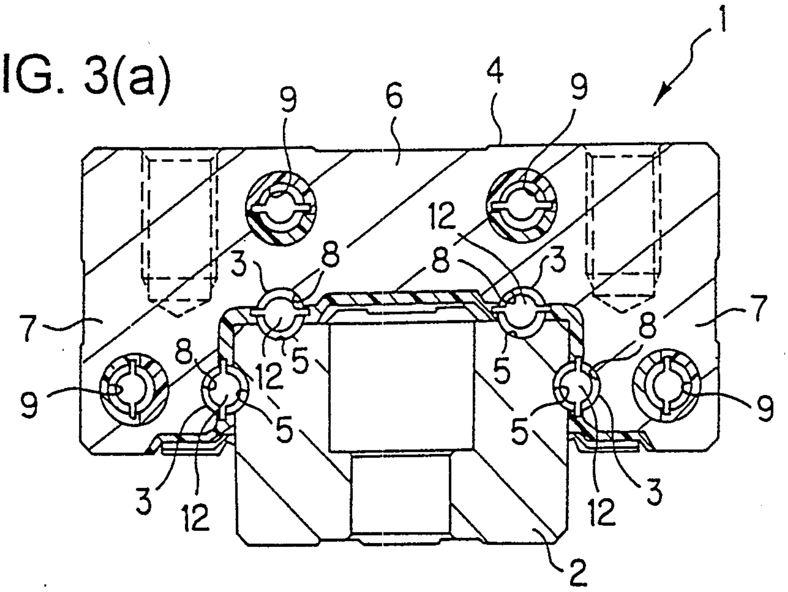


FIG. 3(b)

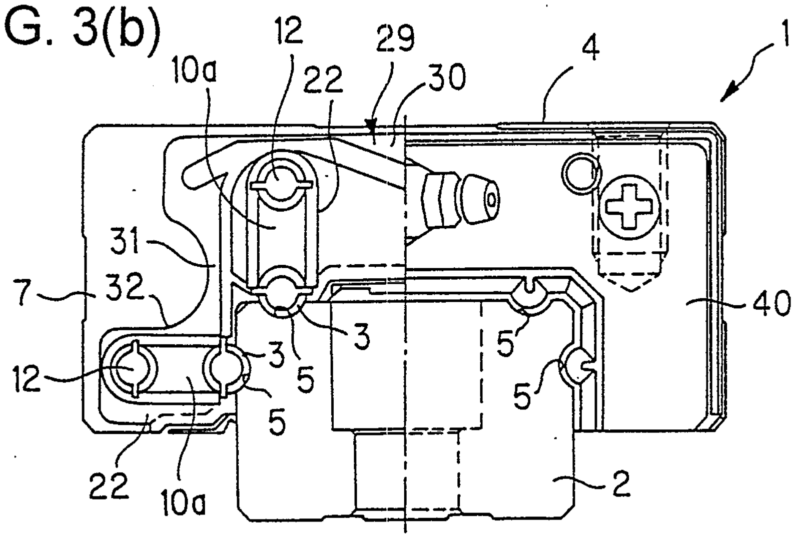


FIG. 3(c)

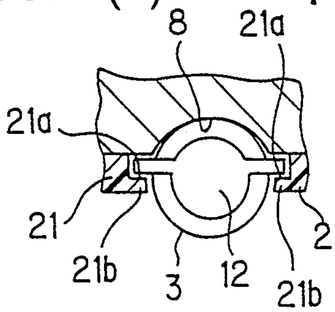


FIG. 3(d)

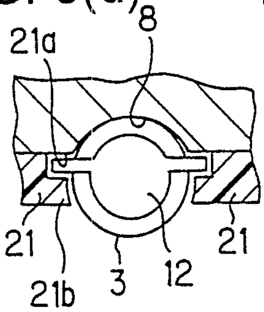


FIG. 3(e)

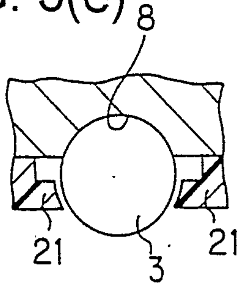
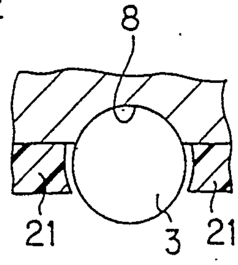


FIG. 3(f)



Nummer: **DE 198 26 703 A1**
Int. Cl.[6]: **F 16 C 29/04**
Offenlegungstag: 21. Januar 1999

FIG. 4(a)

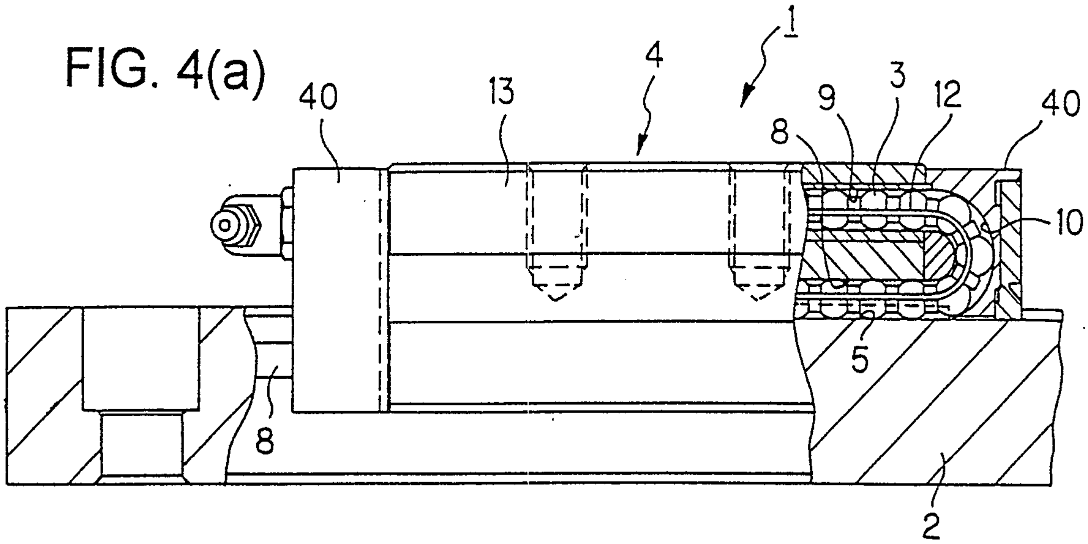


FIG. 4(b)

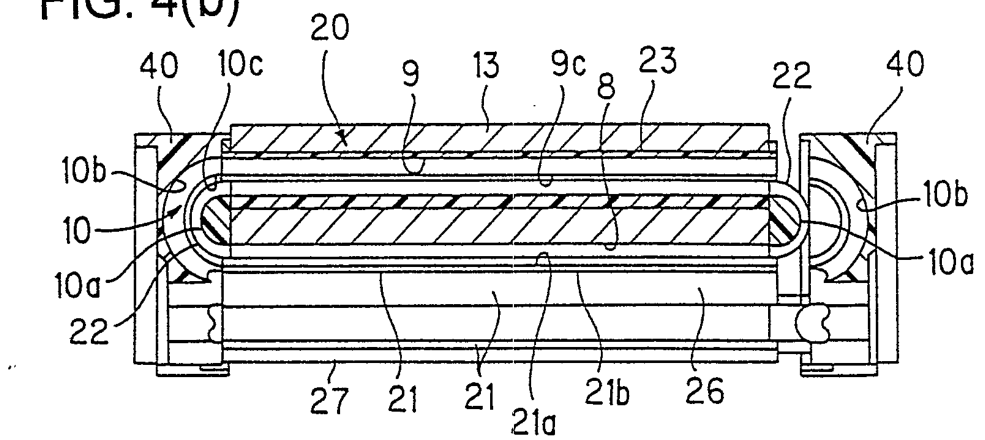


FIG. 4(c)

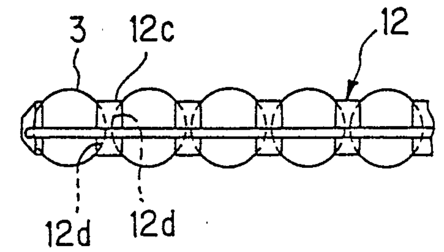


FIG. 4(d)

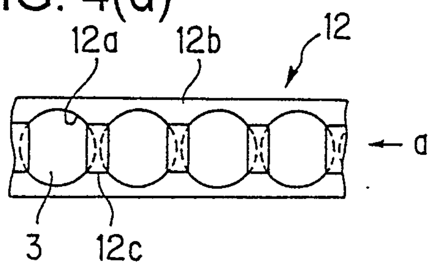
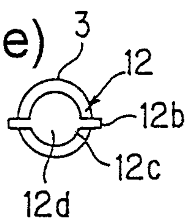


FIG. 4(e)



Nummer: **DE 198 26 703 A1**
Int. Cl.[6]: **F 16 C 29/04**
Offenlegungstag: 21. Januar 1999

FIG. 5(a)

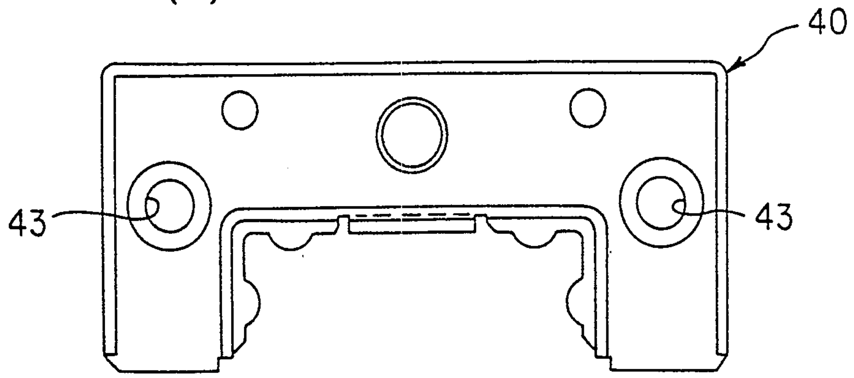


FIG. 5(b)

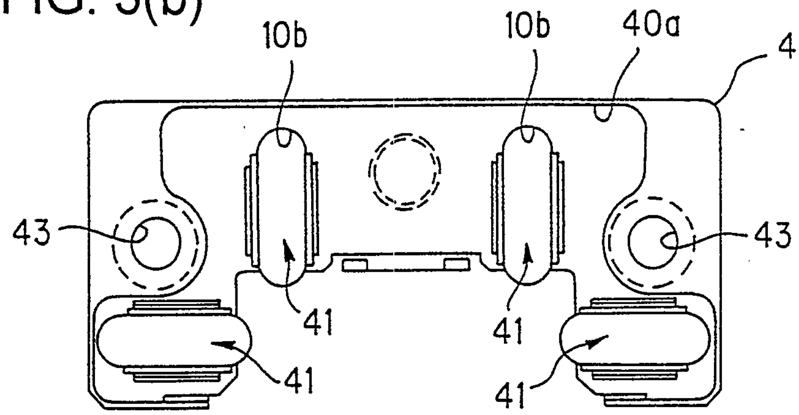
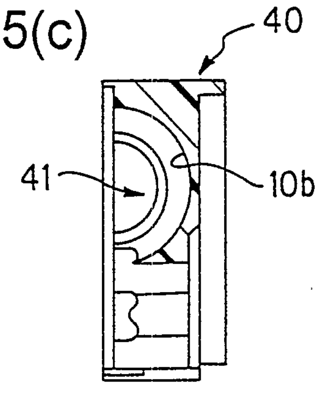


FIG. 5(c)



Nummer: DE 198 26 703 A1
Int. Cl.[6]: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

FIG. 6(a)

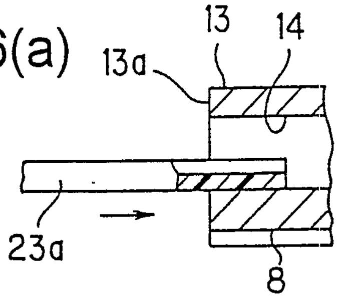


FIG. 6(b)

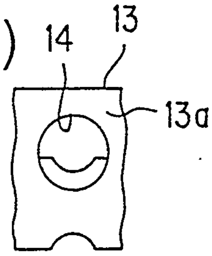


FIG. 6(c)

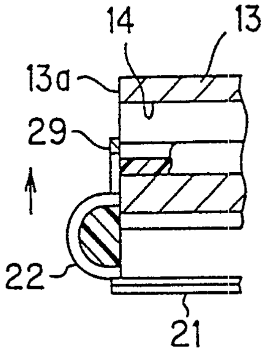


FIG. 6(d)

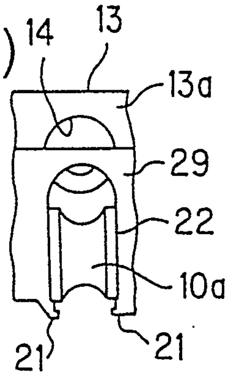


FIG. 6(e)

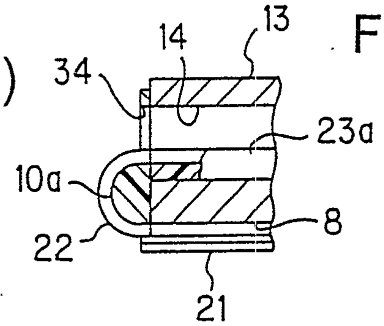


FIG. 6(f)

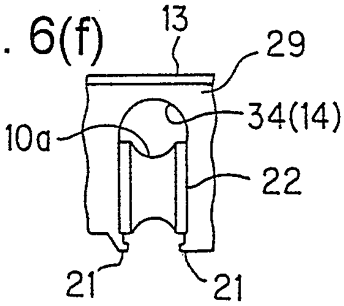


FIG. 6(g)

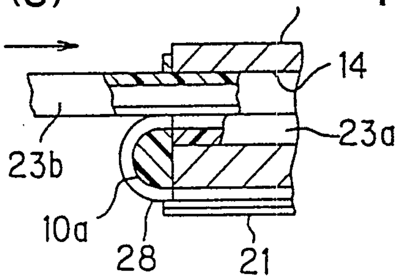


FIG. 6(h)

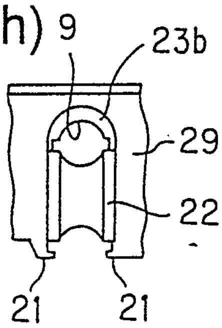


FIG. 6(i)

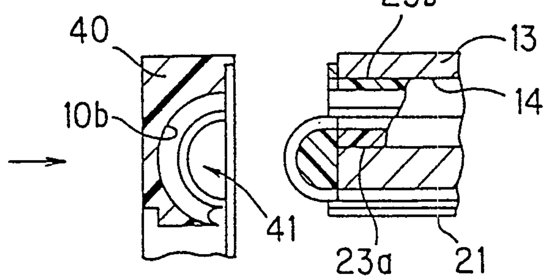


FIG. 7(a)

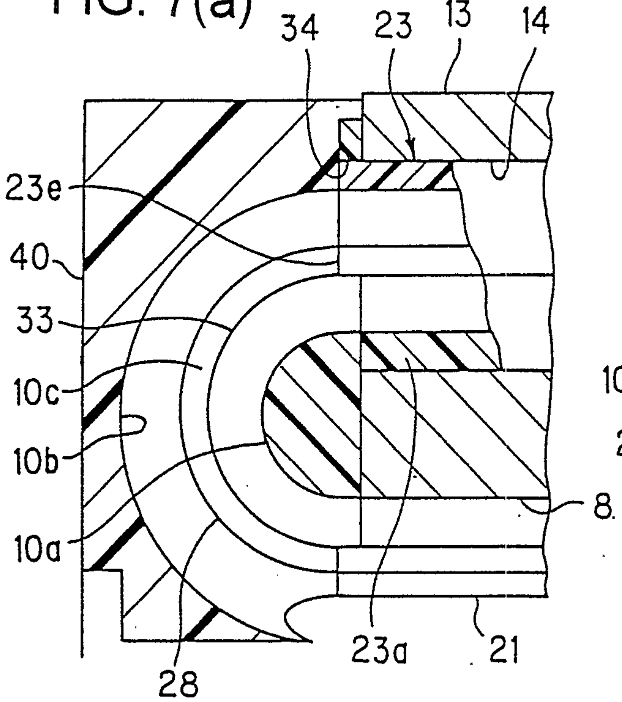


FIG. 7(b)

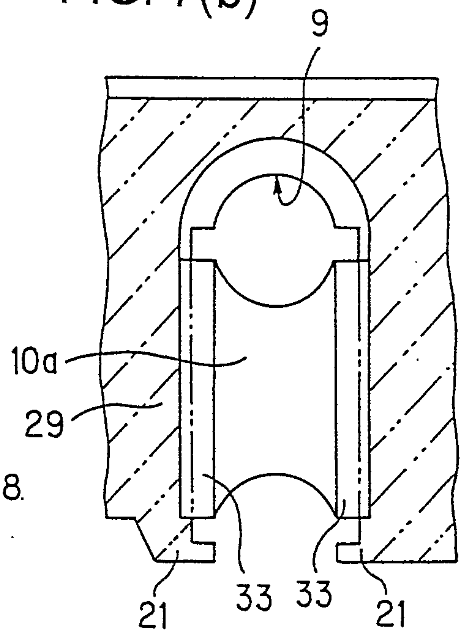


FIG. 7(c)

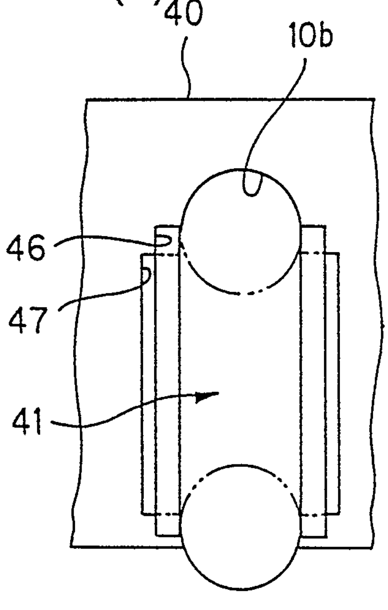


FIG. 7(e)

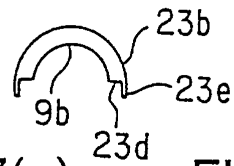


FIG. 7(d)

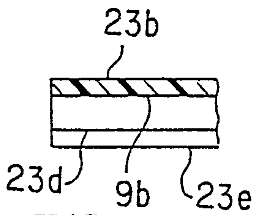


FIG. 7(g)

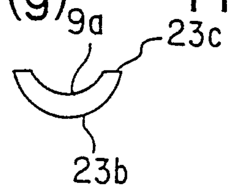
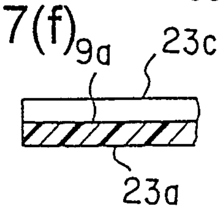


FIG. 7(f)



Nummer: **DE 198 26 703 A1**
Int. Cl.[6]: **F 16 C 29/04**
Offenlegungstag: 21. Januar 1999

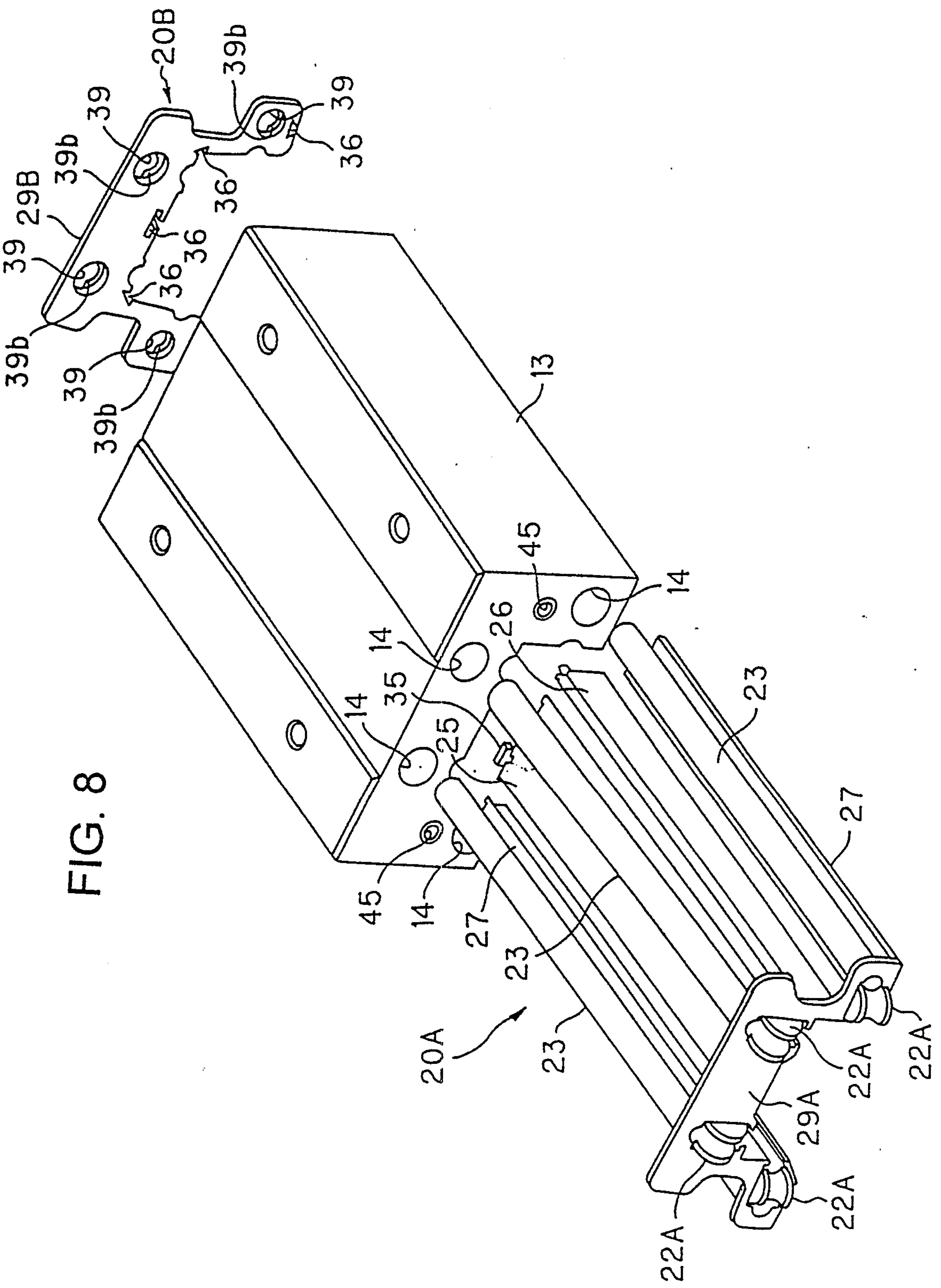


FIG. 8

FIG. 9(a)

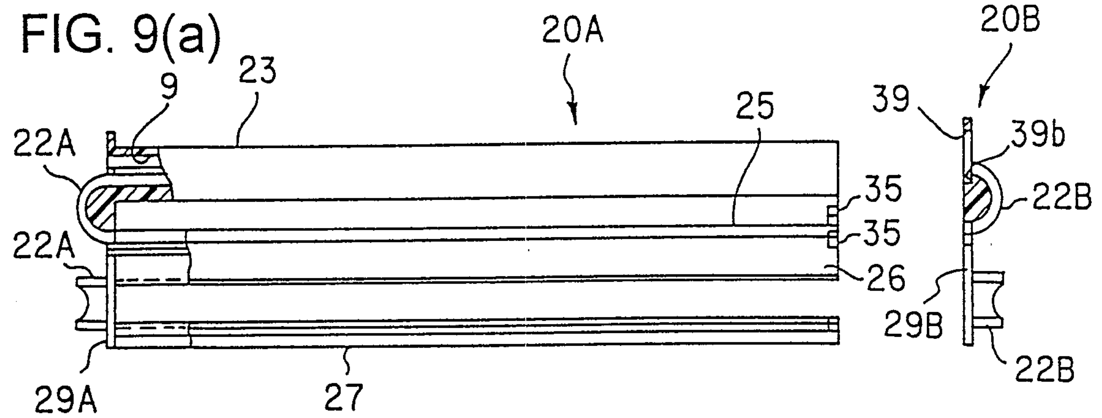


FIG. 9(b)

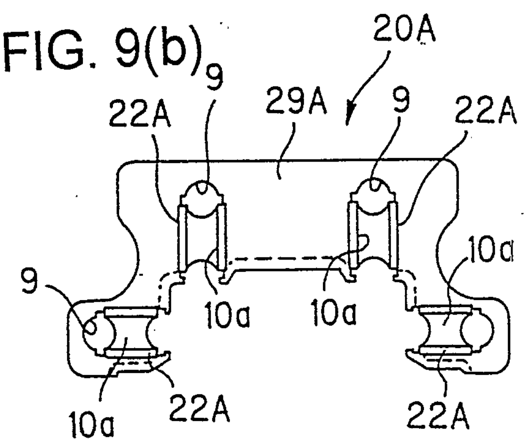


FIG. 9(c)

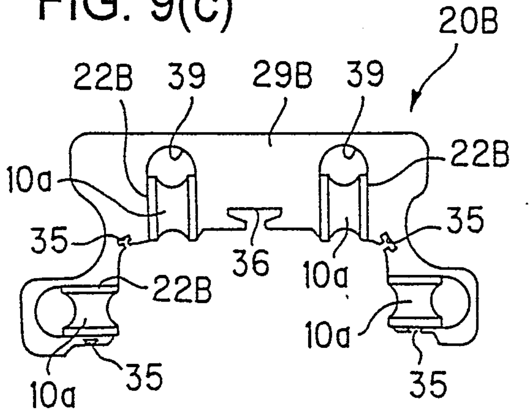


FIG. 9(d)

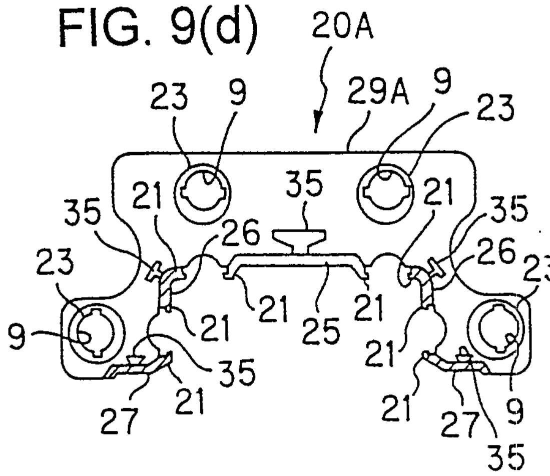
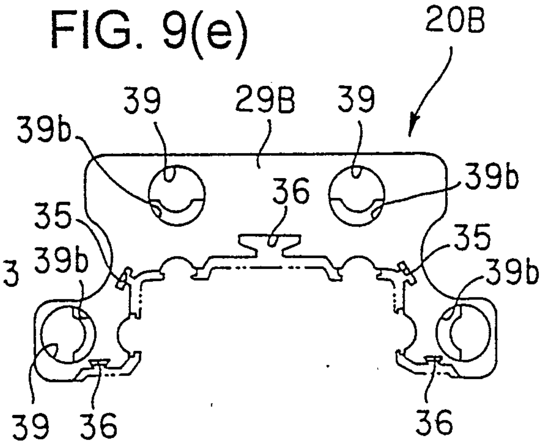


FIG. 9(e)



Nummer: **DE 198 26 703 A1**
Int. Cl.[6]: **F 16 C 29/04**
Offenlegungstag: 21. Januar 1999

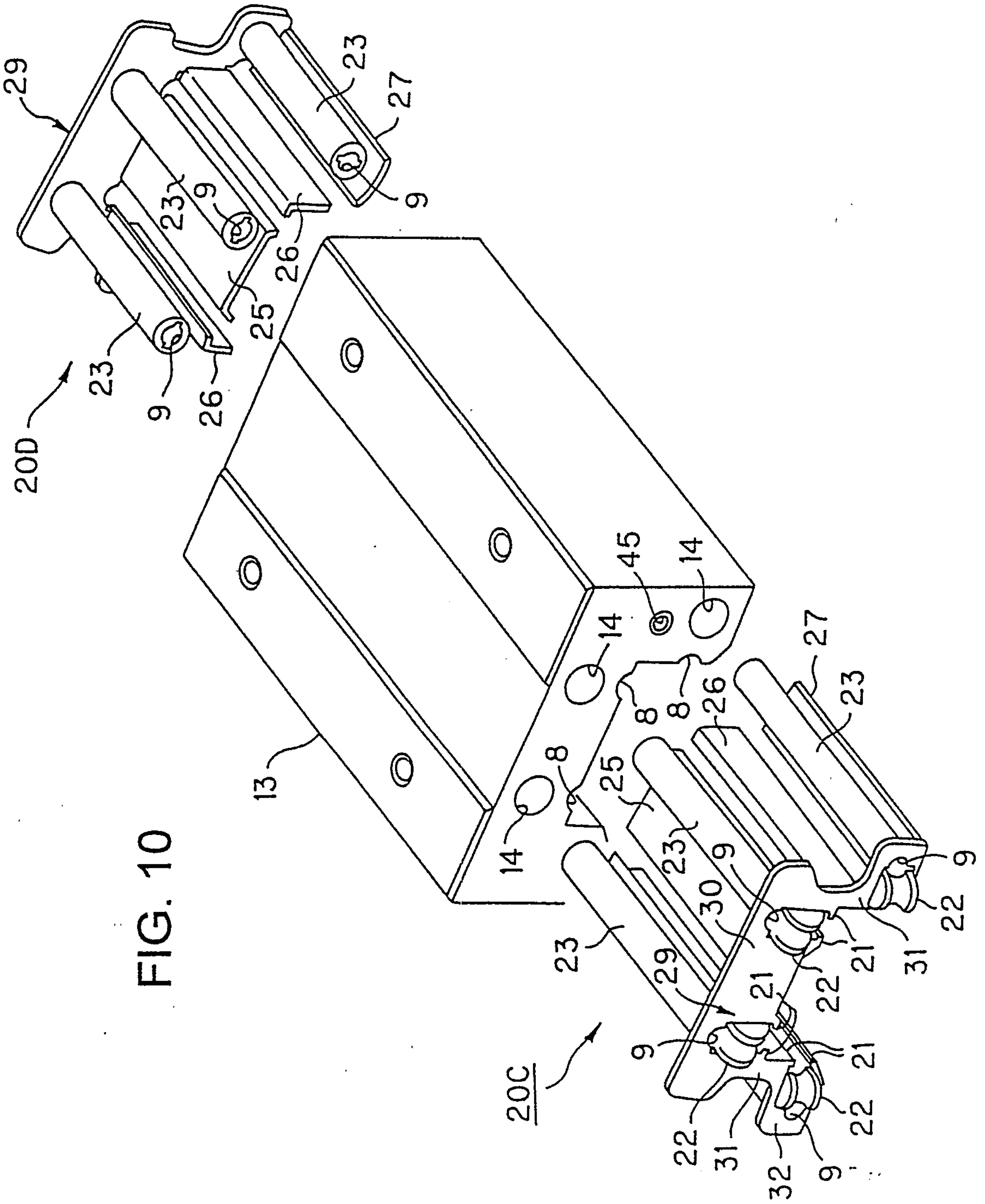


FIG. 10

Nummer: **DE 198 26 703 A1**
Int. Cl.[6]: **F 16 C 29/04**
Offenlegungstag: 21. Januar 1999

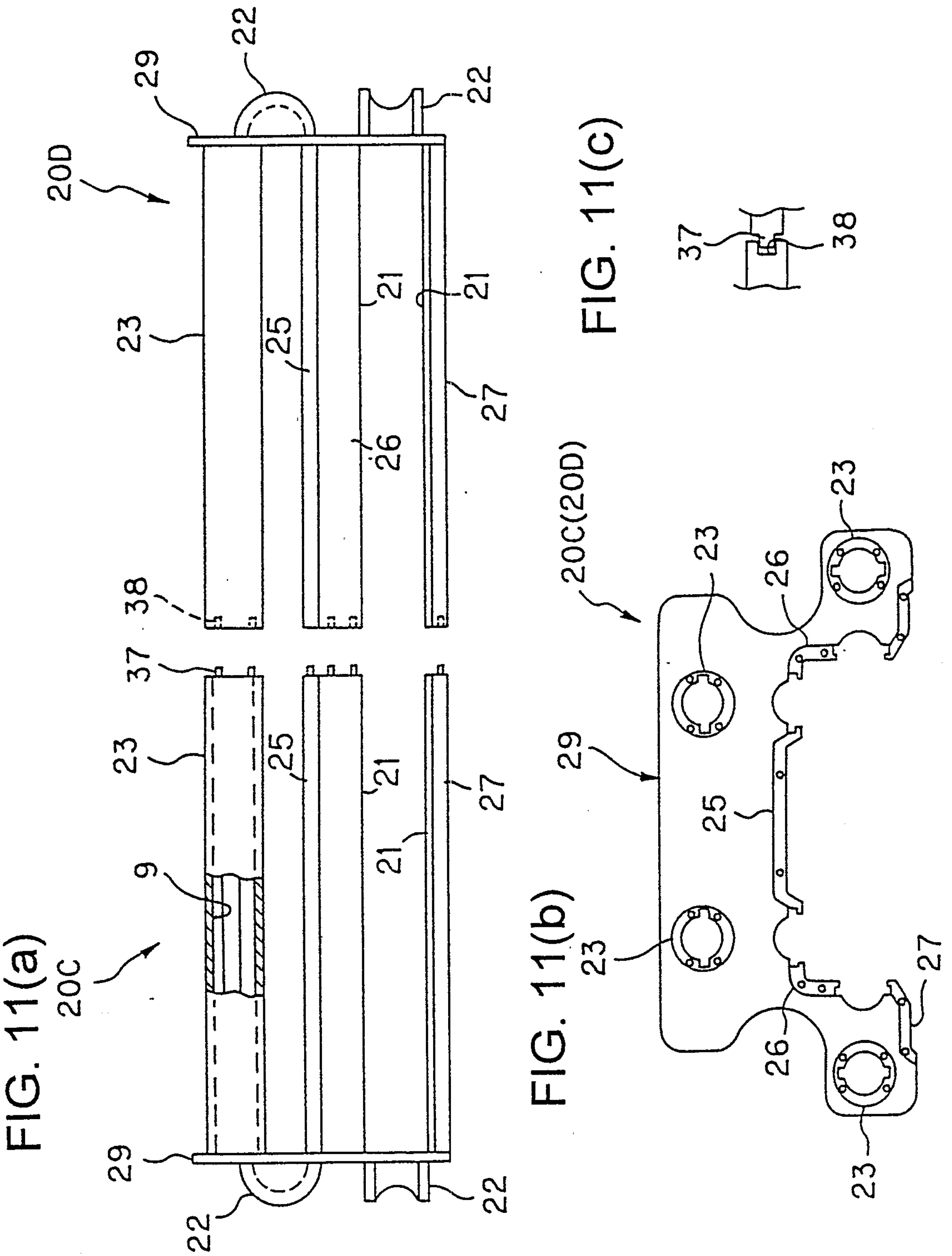


FIG. 11(a)

FIG. 11(b)

FIG. 11(c)

Nummer: DE 198 26 703 A1
Int. Cl.[6]: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

FIG. 12

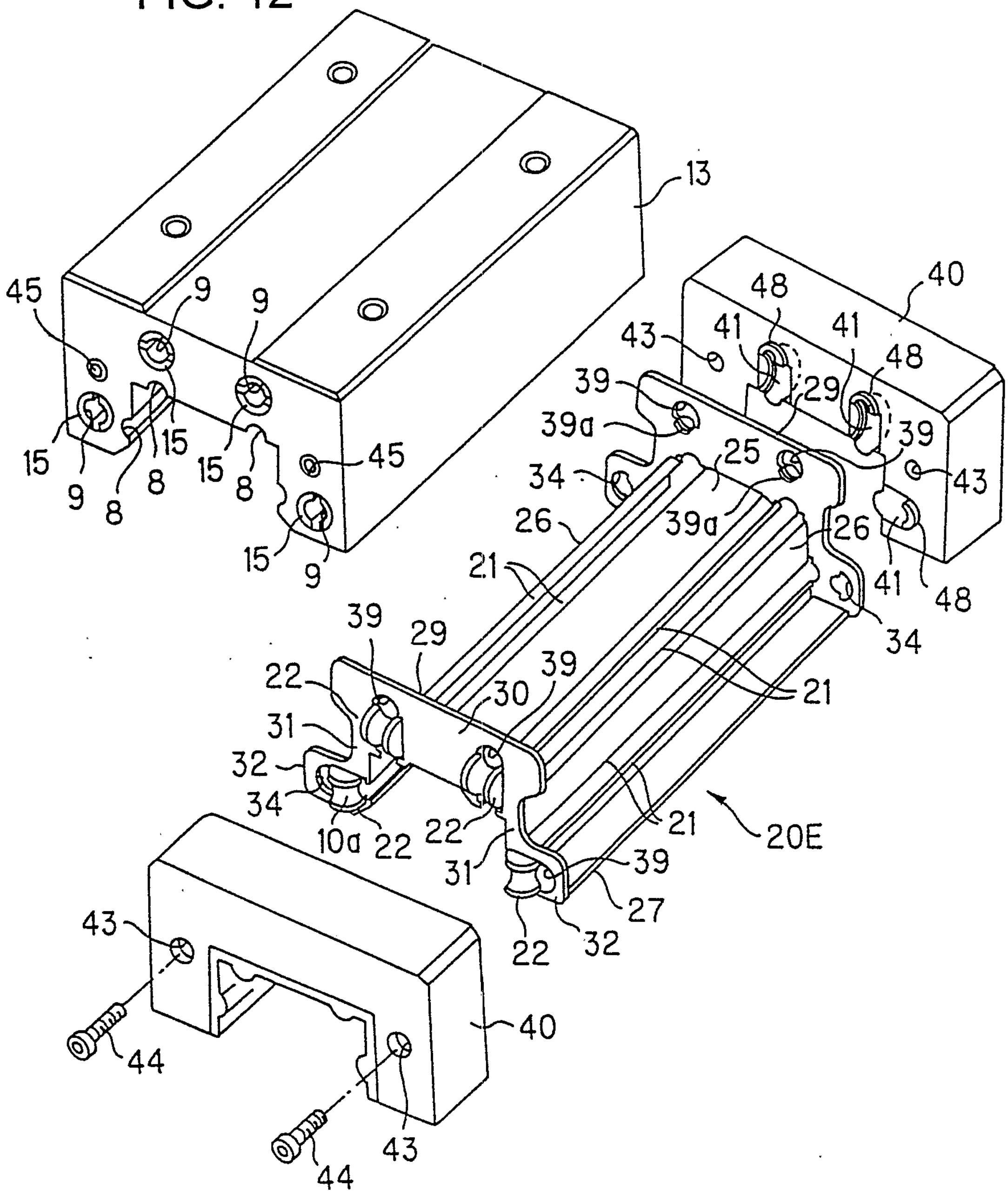


FIG. 13(a)

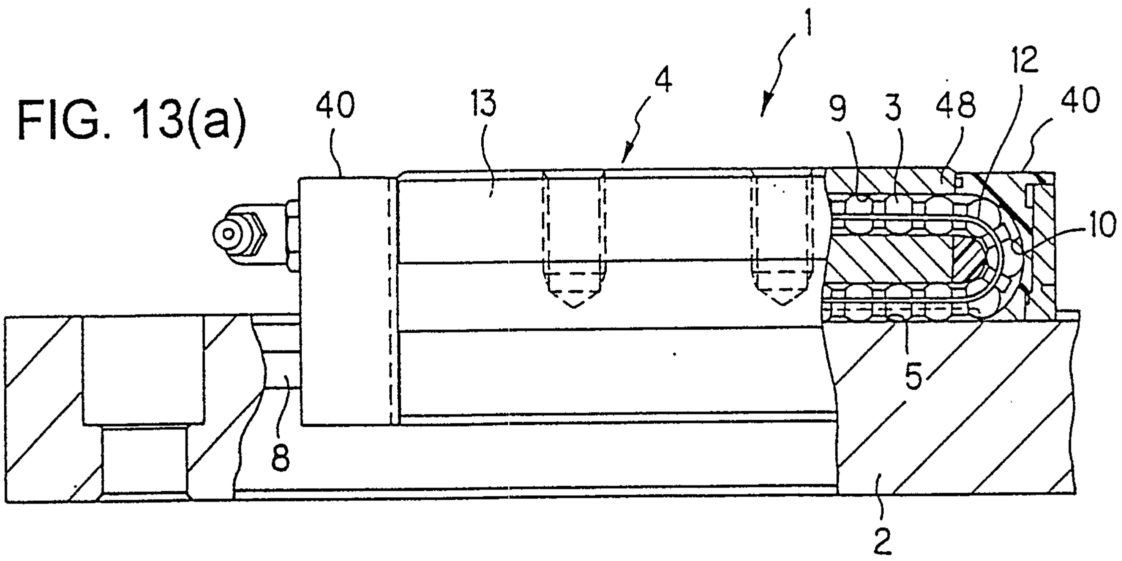


FIG. 13(b)

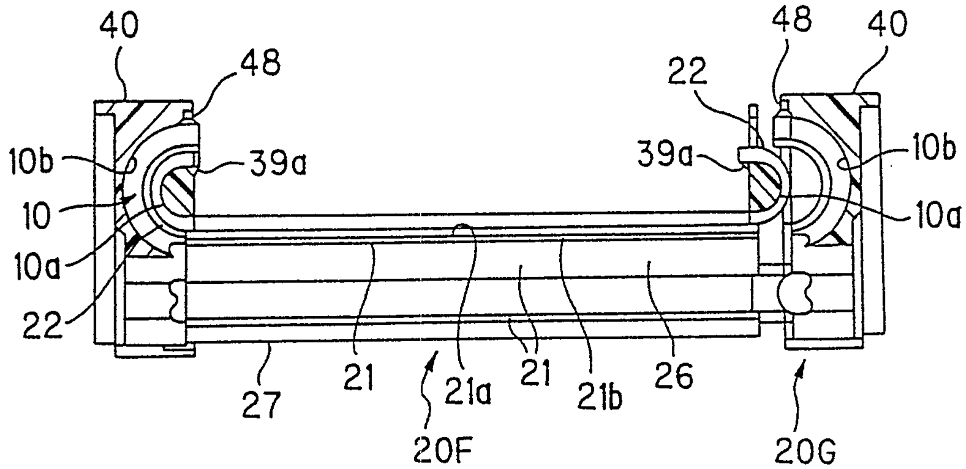


FIG. 14(a)

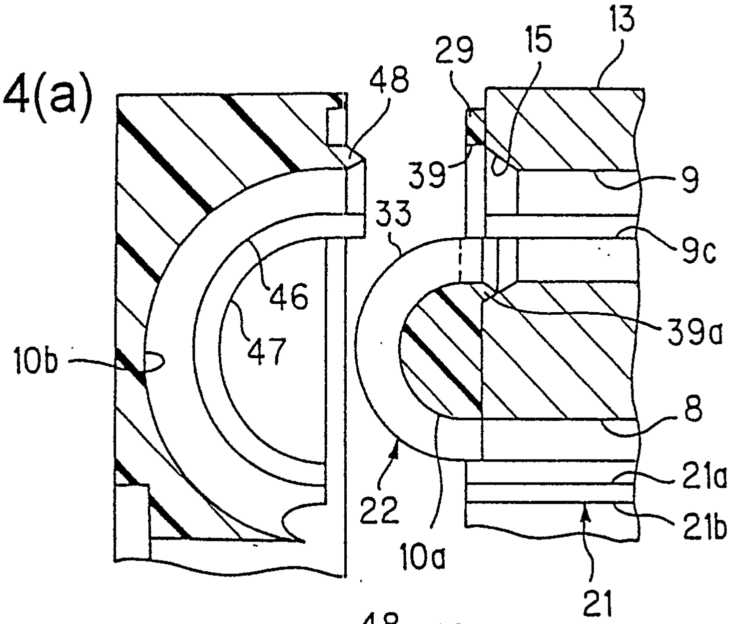


FIG. 14(b)

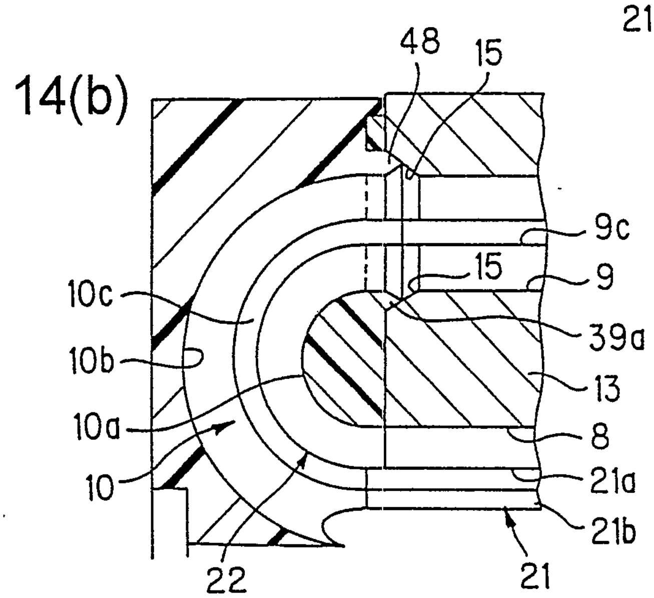


FIG. 14(c)

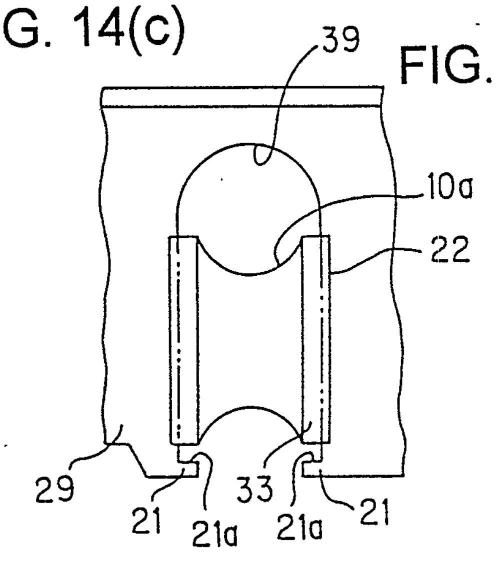


FIG. 14(d)

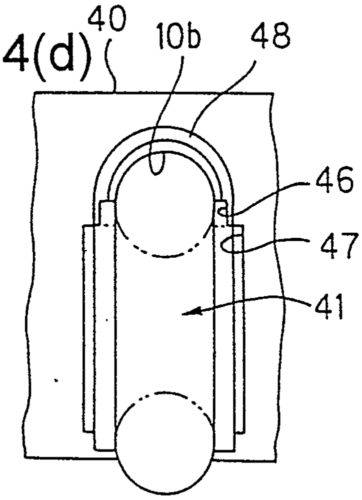
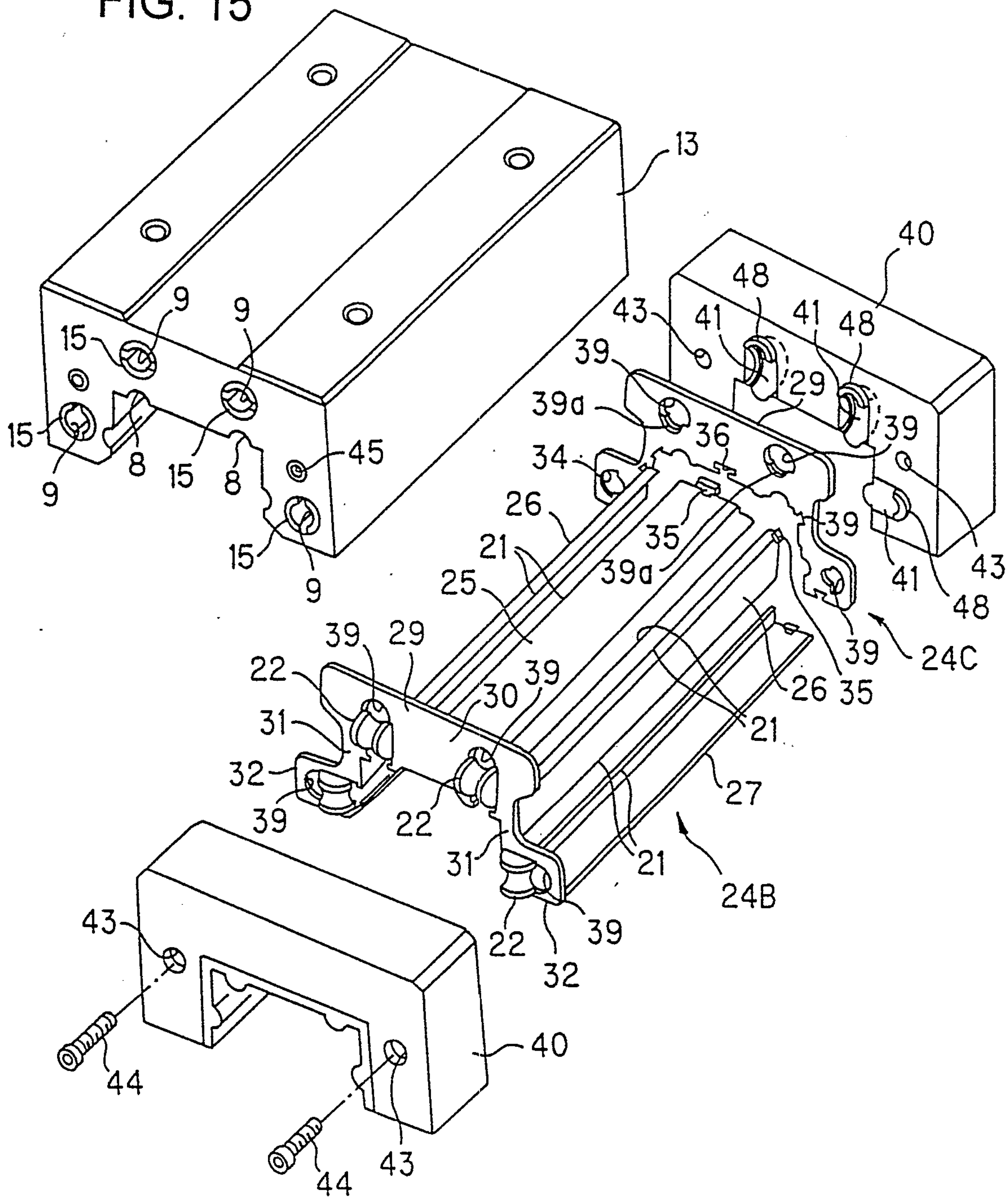


FIG. 15


13
40
48
43
41
41
48
39
29
39a
36
39
34
26
35
39
21
39a
25
39
24C
39
29
41
48
43
22
39
31
30
26
35
32
21
39
22
27
31
21
39
24B
22
32
43
40
44
44
43
15
9
9
15
45
8
15
9
8
9
15
9

Nummer: DE 198 26 703 A1
Int. Cl.^{6}: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

FIG. 16(a)

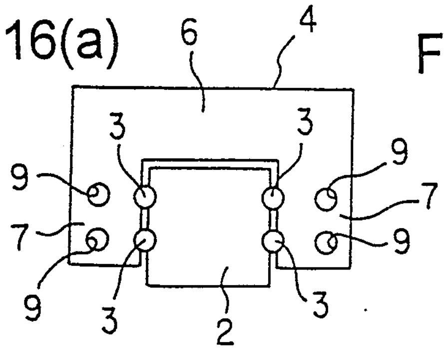


FIG. 16(b)

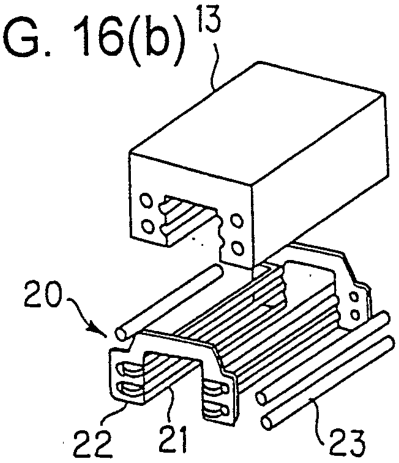


FIG. 16(c)

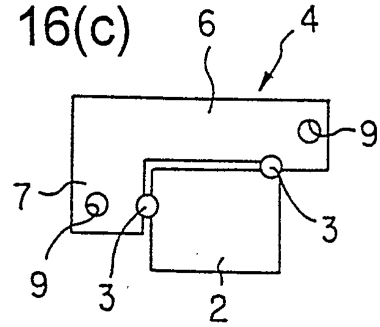


FIG. 16(d)

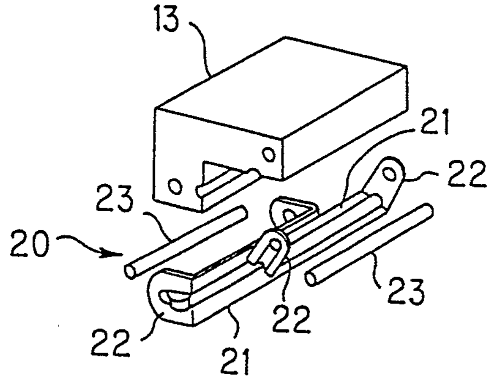


FIG. 16(e)

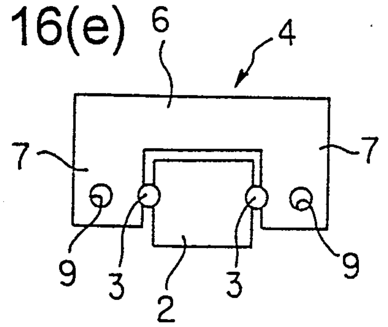


FIG. 16(f)

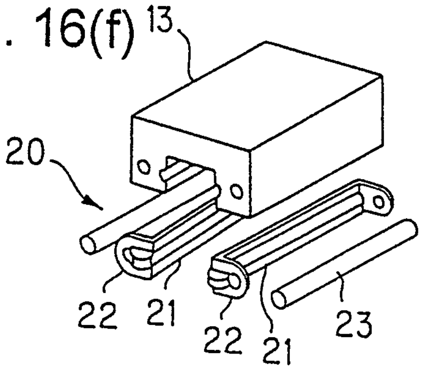


FIG. 16(g)

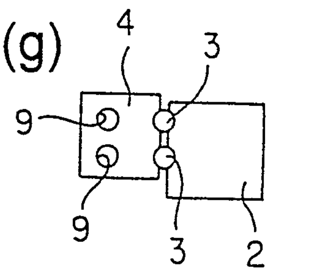


FIG. 16(h)

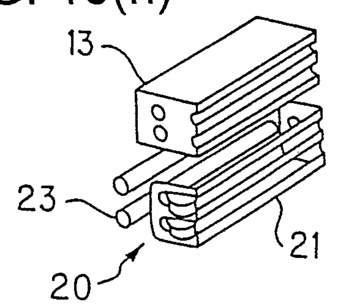


FIG. 17

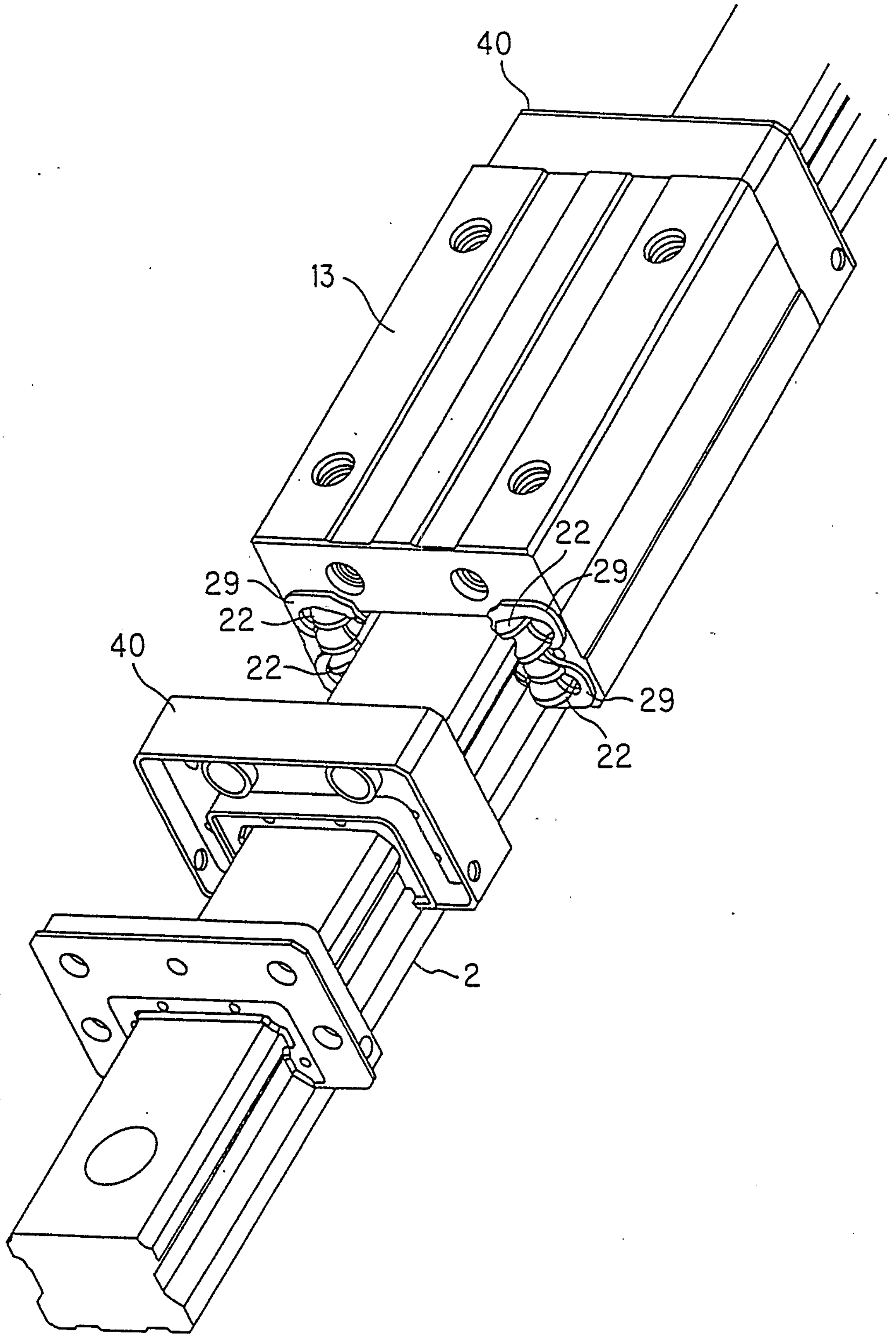
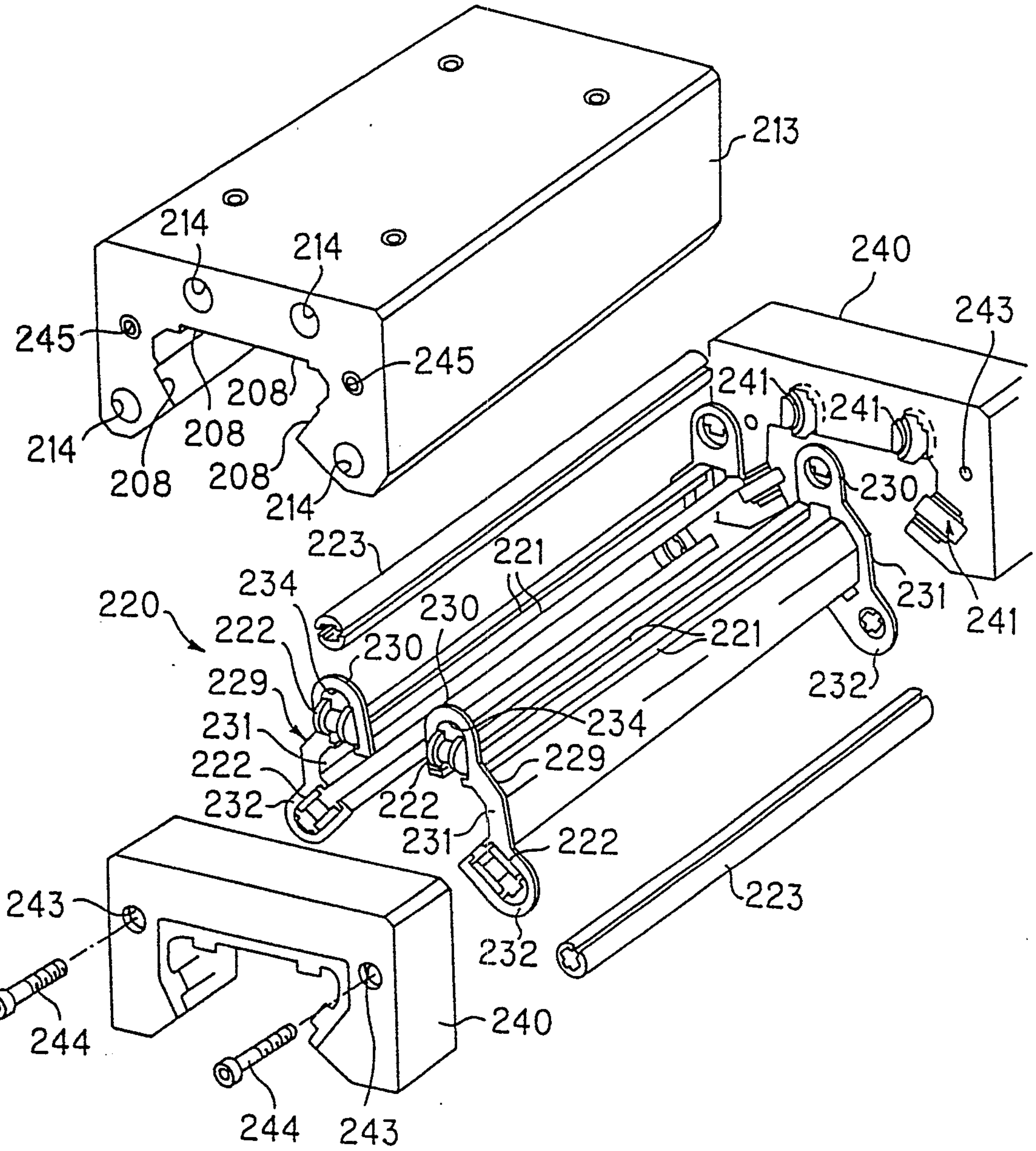


FIG. 18


213
214
214
245
245
208
208
208
208
214
214
240
243
241
241
230
241
223
221
221
220
234
222
230
230
229
231
222
232
234
229
222
231
222
231
232
232
223
243
244
240
244
243

Nummer: **DE 198 26 703 A1**
Int. Cl.[6]: **F 16 C 29/04**
Offenlegungstag: 21. Januar 1999

FIG. 19(a)

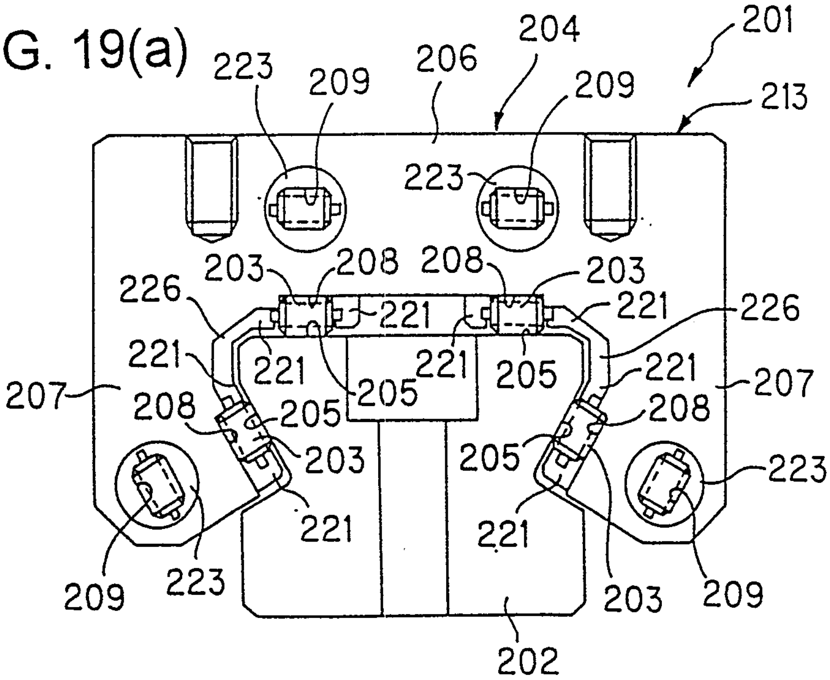


FIG. 19(b)

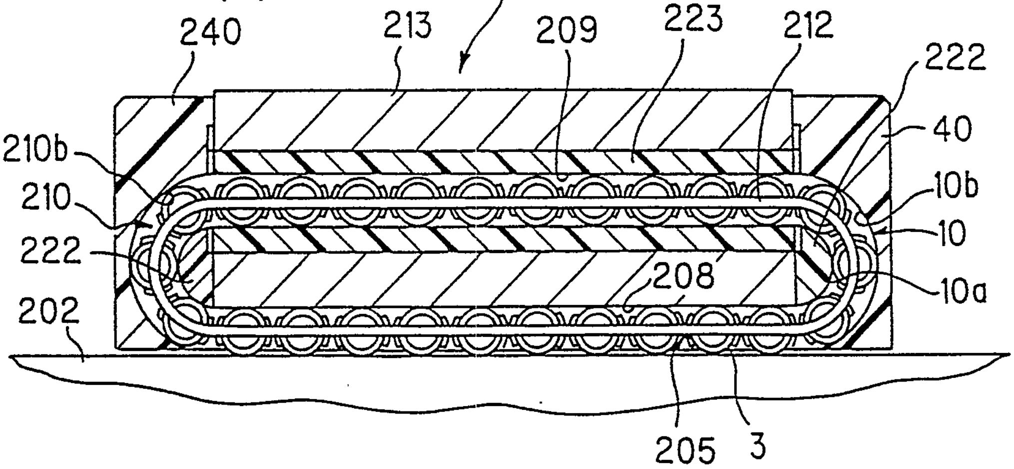


FIG. 19(d)

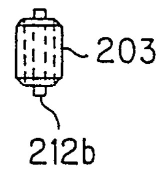
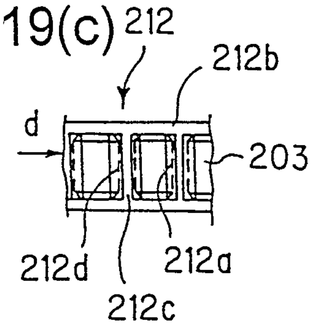


FIG. 19(c)



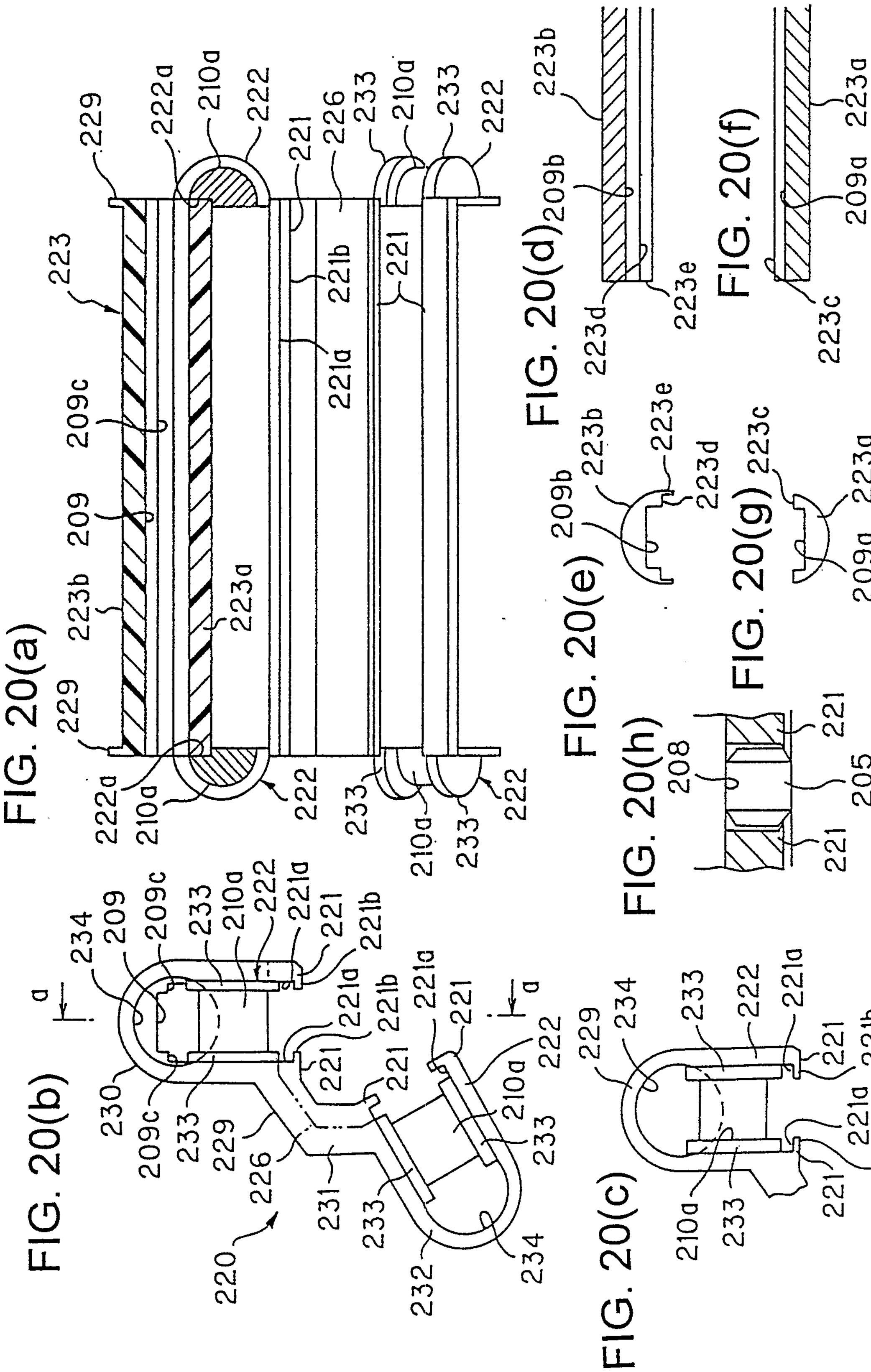


FIG. 20(a)

FIG. 20(b)

FIG. 20(c)

FIG. 20(d)

FIG. 20(e)

FIG. 20(f)

FIG. 20(g)

FIG. 20(h)

Nummer: **DE 198 26 703 A1**
Int. Cl.[6]: **F 16 C 29/04**
Offenlegungstag: 21. Januar 1999

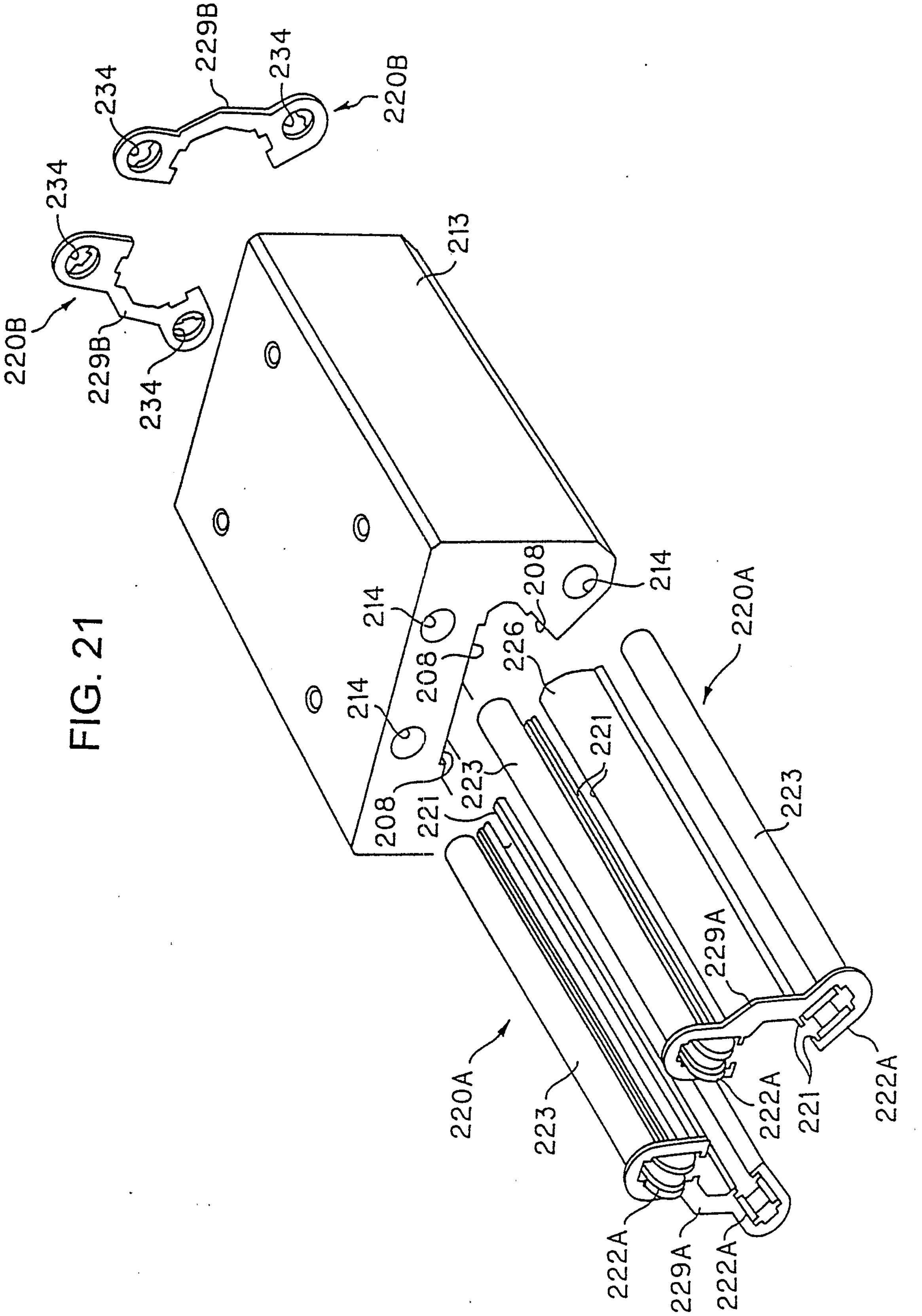


FIG. 21

FIG. 22(a)

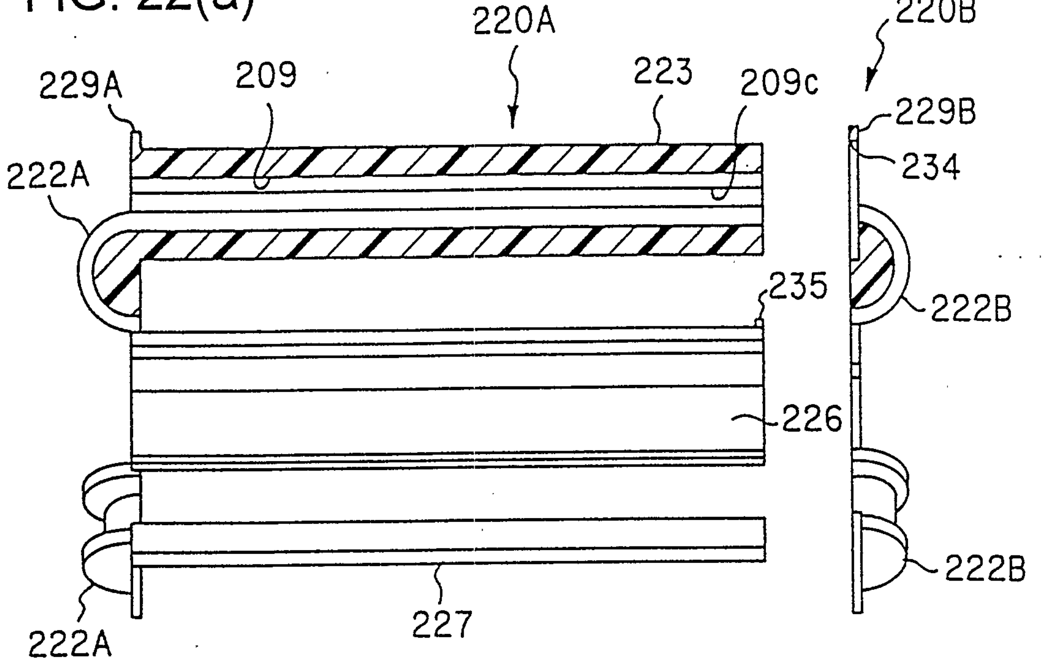


FIG. 22(b)

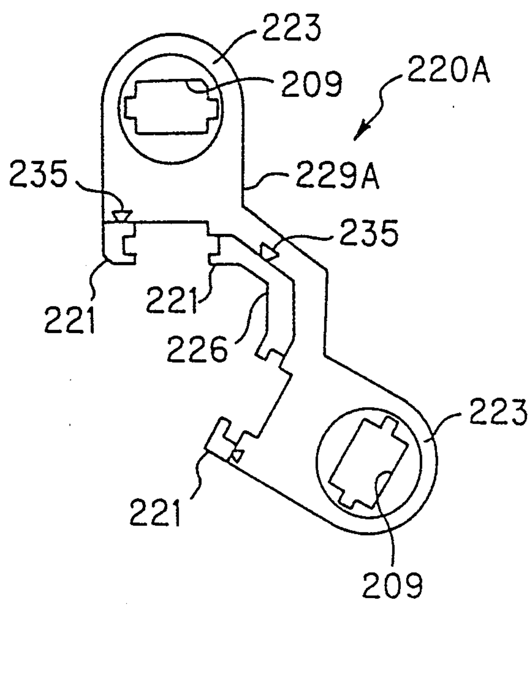
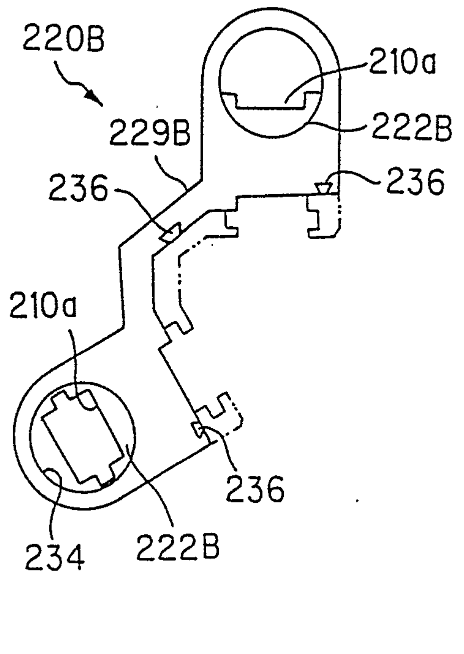


FIG. 22(c)



Nummer: **DE 198 26 703 A1**
Int. Cl.[6]: **F 16 C 29/04**
Offenlegungstag: 21. Januar 1999

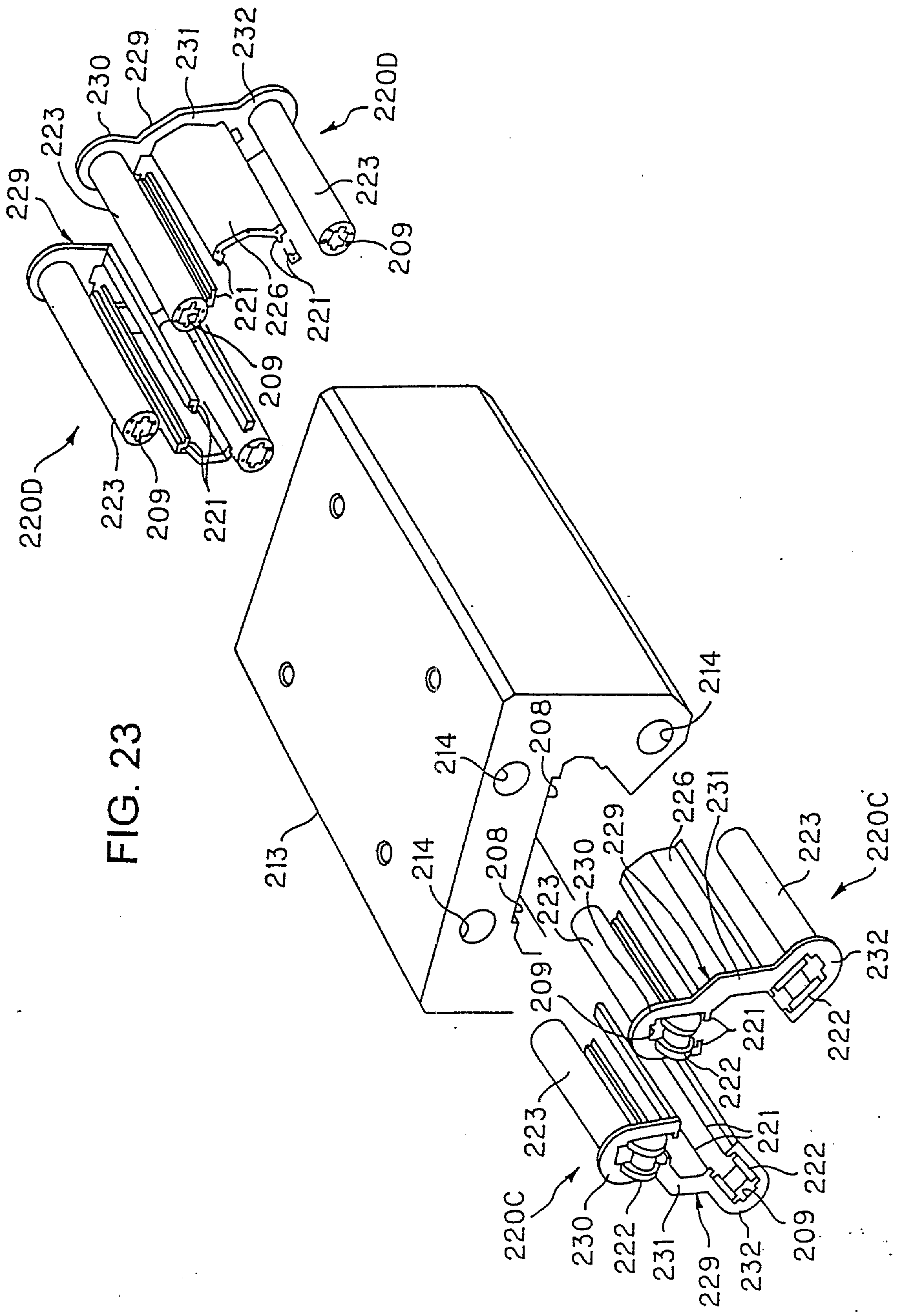


FIG. 23

Nummer: DE 198 26 703 A1
Int. Cl.[6]: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

FIG. 24(a)

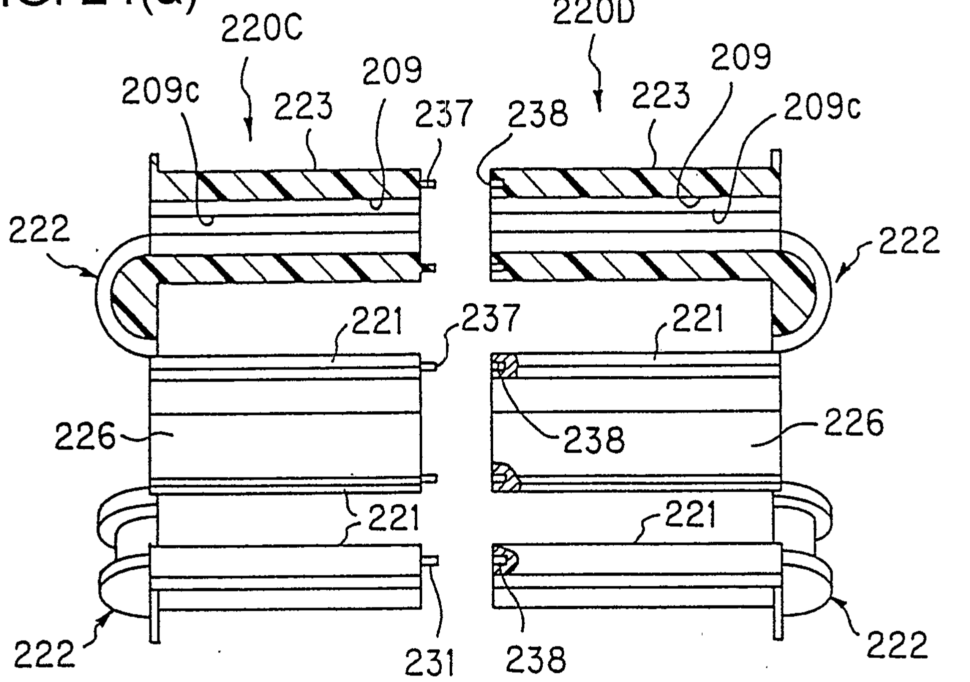


FIG. 24(b)

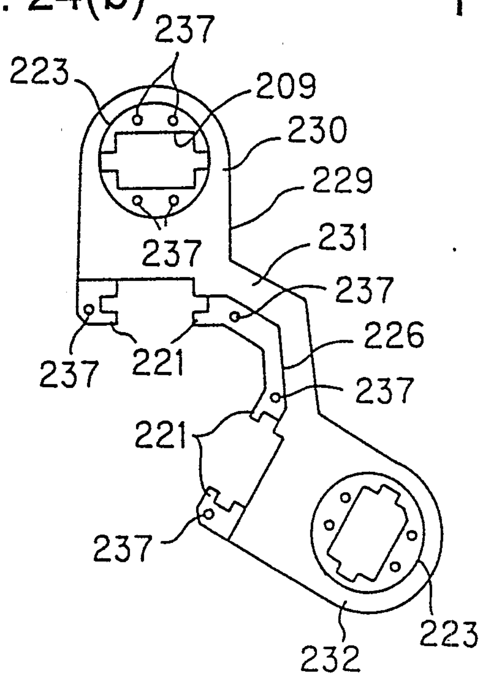
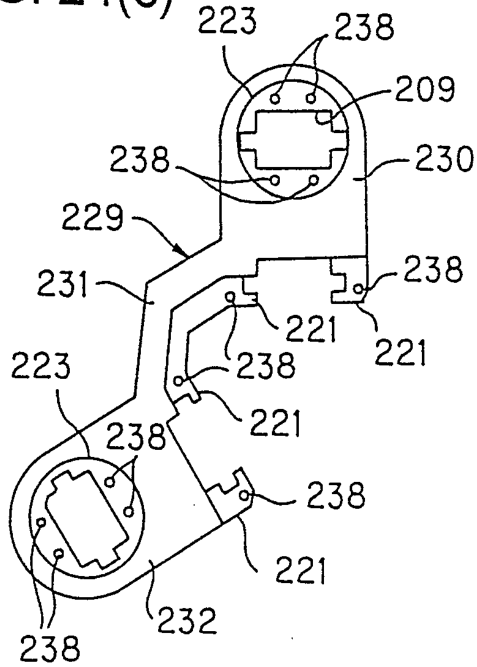
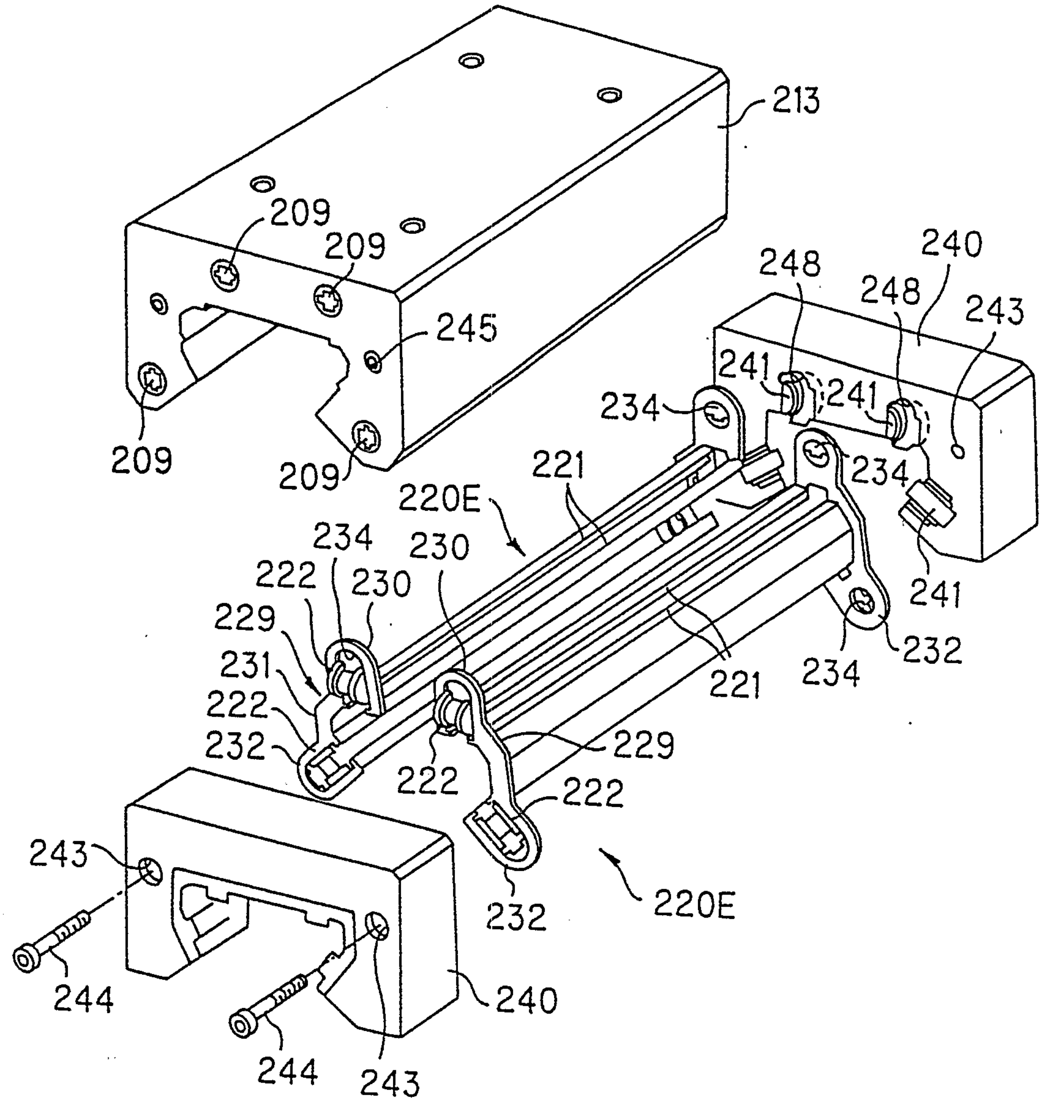


FIG. 24(c)



Nummer: DE 198 26 703 A1
Int. Cl.^{6}: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

FIG. 25



Nummer: DE 198 26 703 A1
Int. Cl.[6]: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

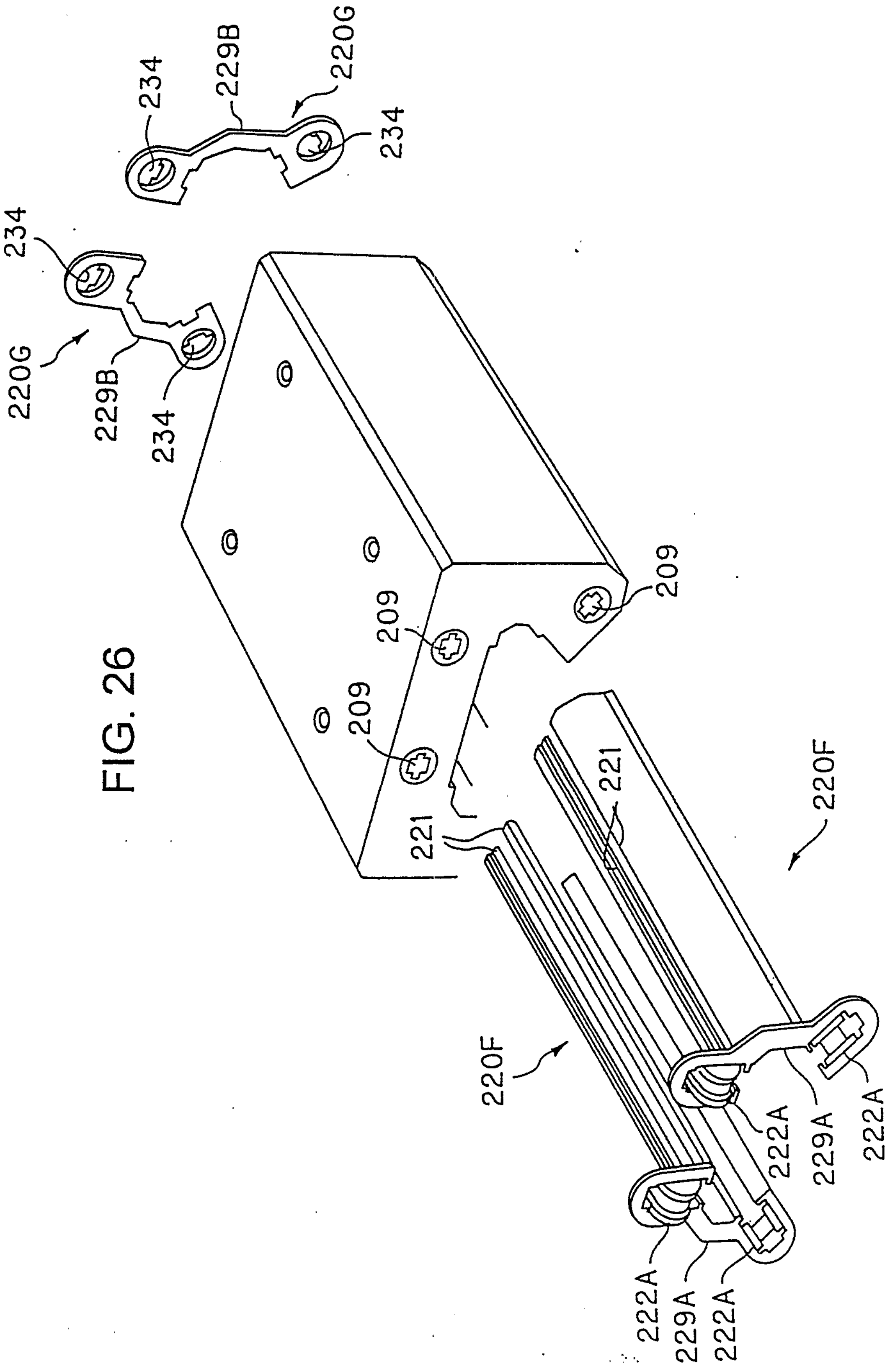
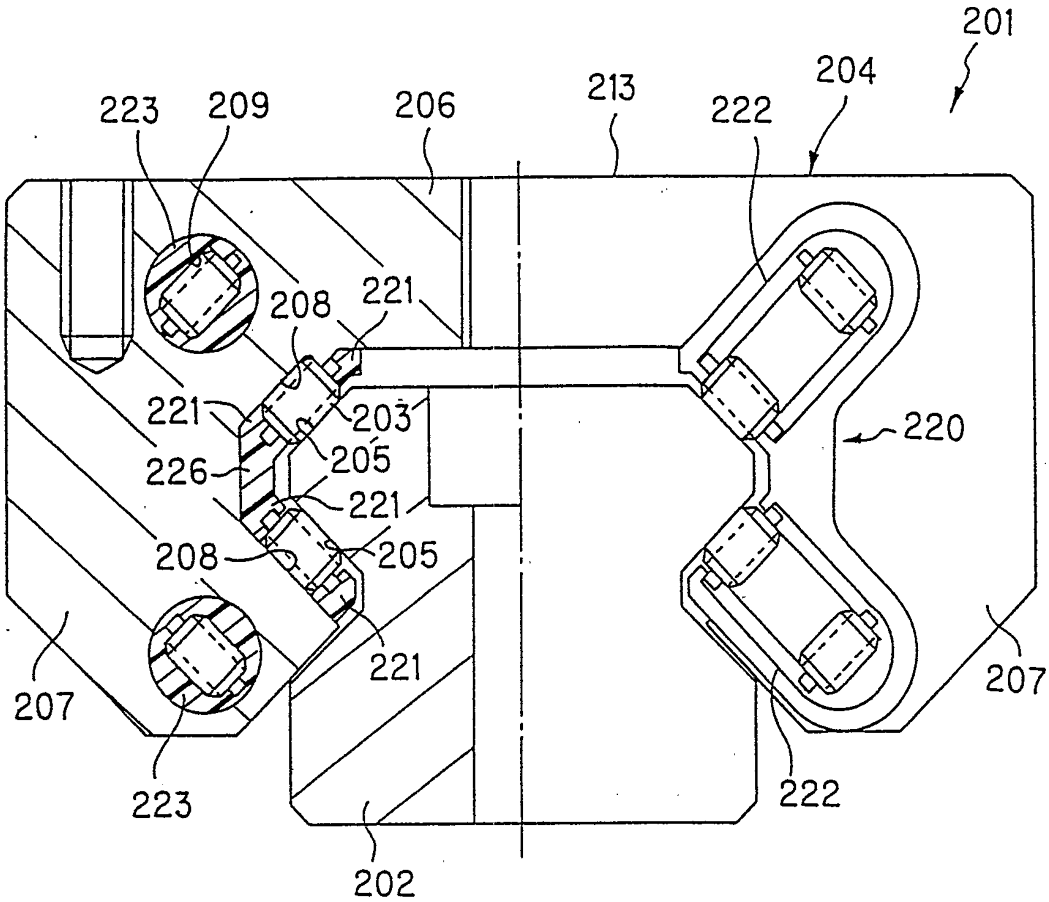


FIG. 26

Nummer: DE 198 26 703 A1
Int. Cl.[6]: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

FIG. 27



Nummer: **DE 198 26 703 A1**
Int. Cl.[6]: **F 16 C 29/04**
Offenlegungstag: 21. Januar 1999

FIG. 28

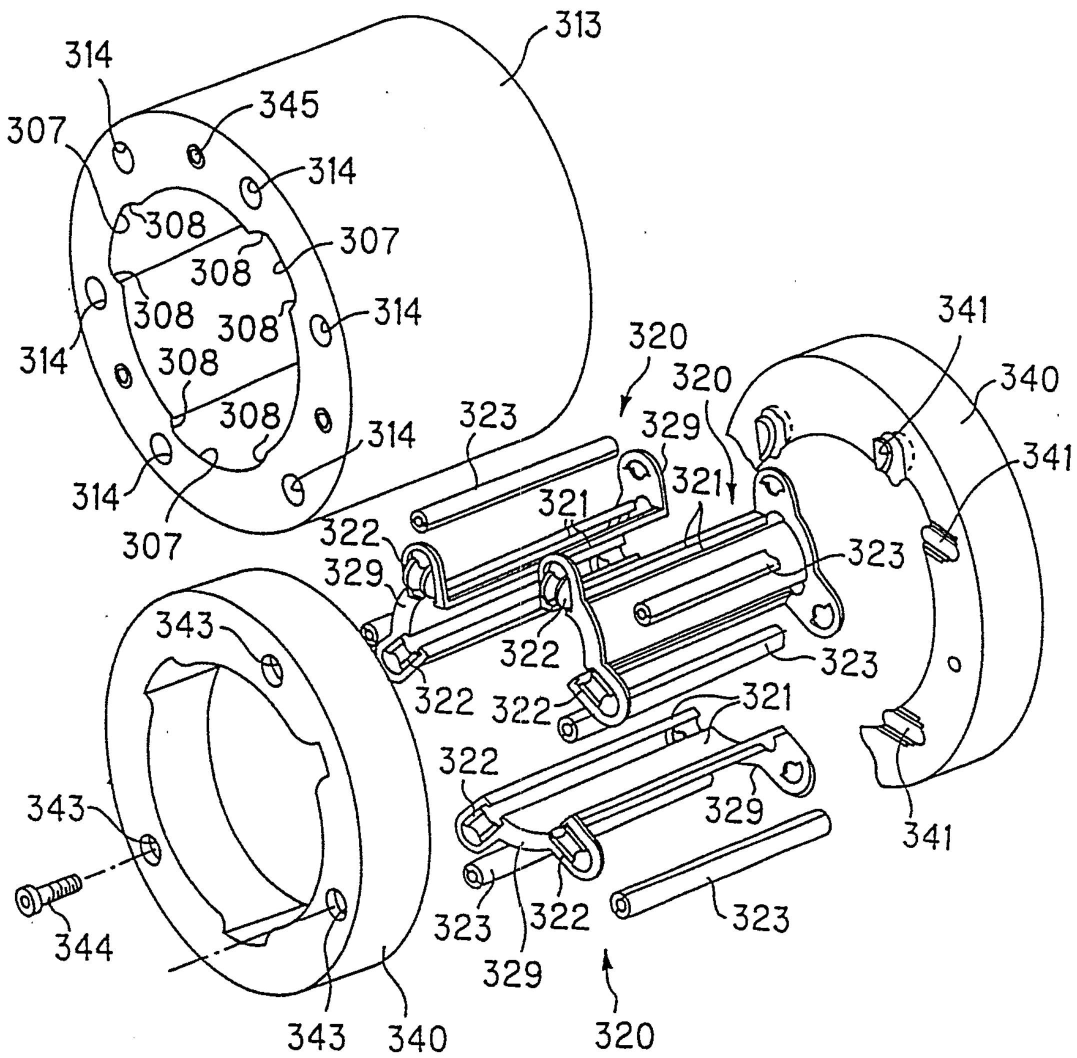


FIG. 29(a)

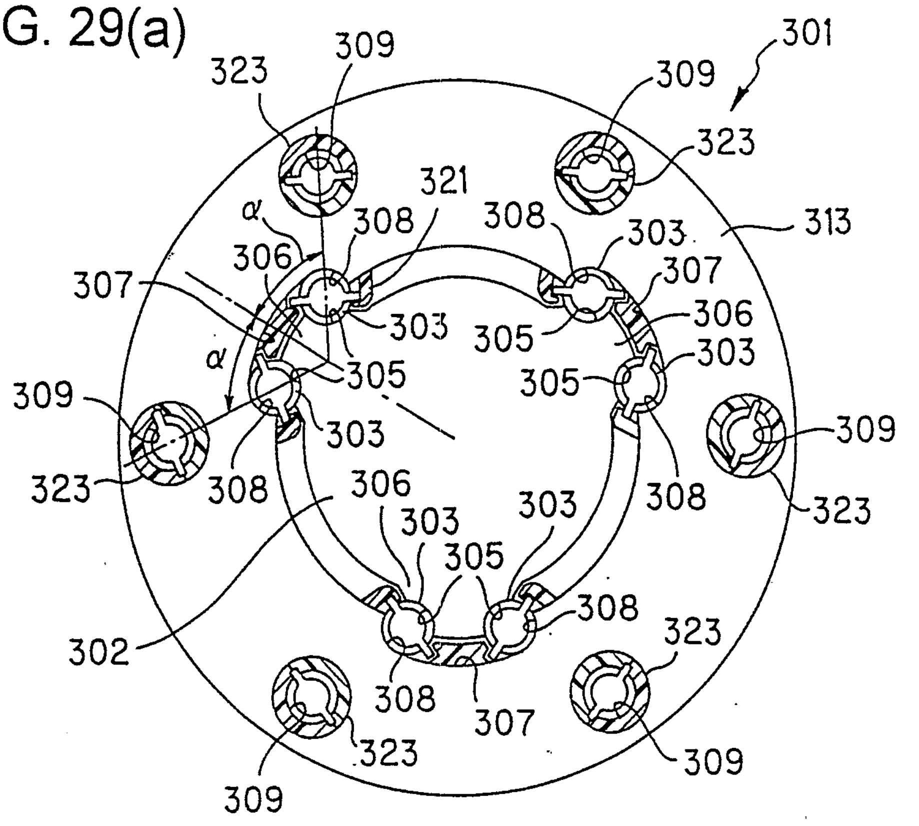


FIG. 29(b)

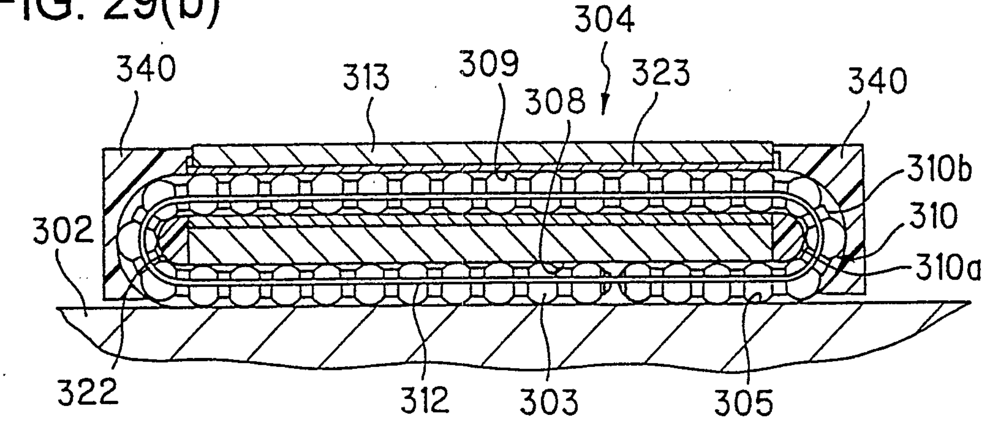
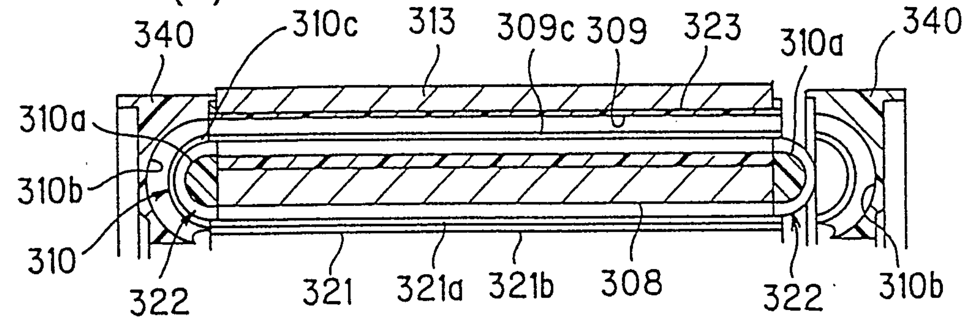


FIG. 29(c)



Nummer: DE 198 26 703 A1
Int. Cl.[6]: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

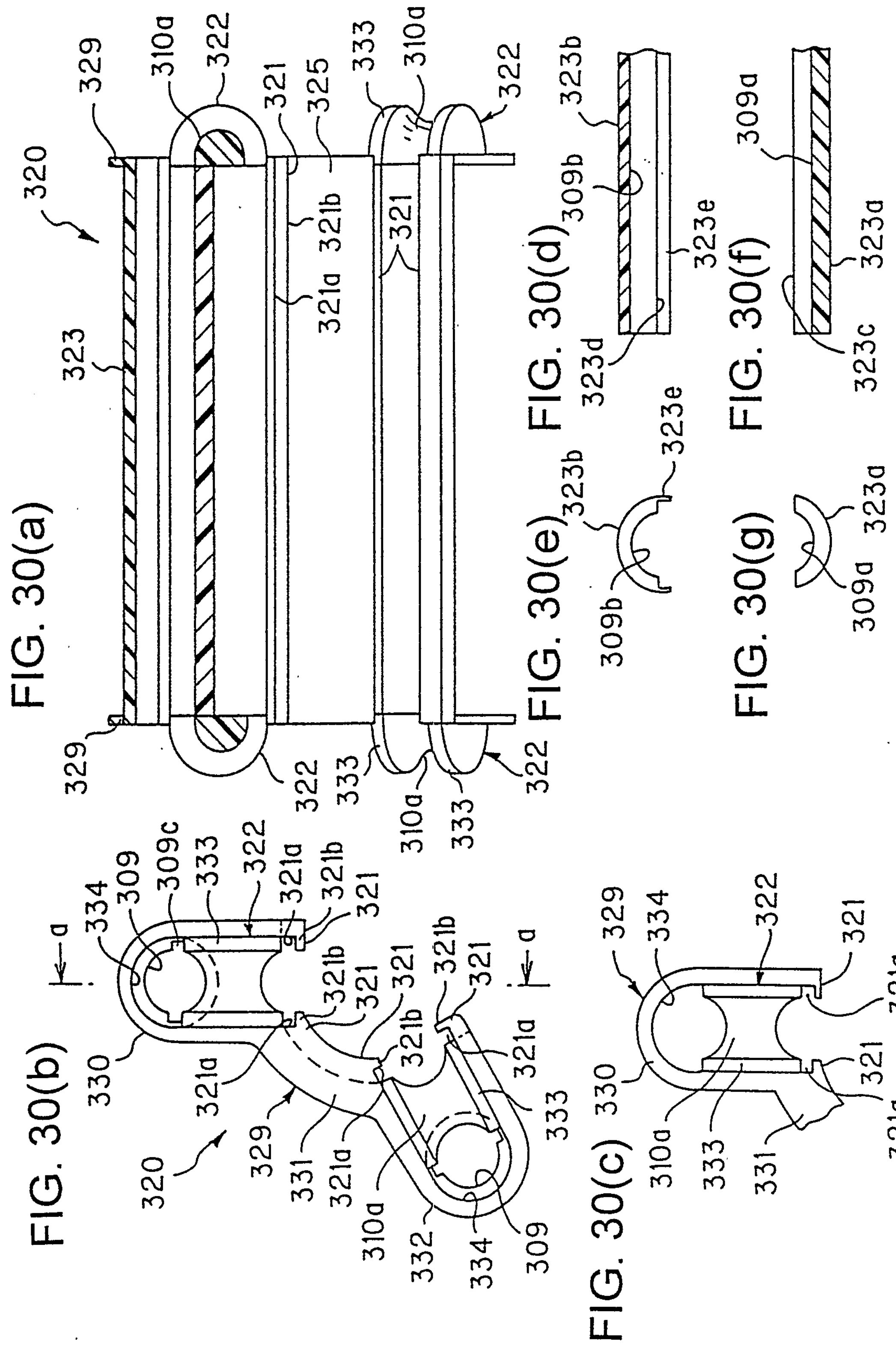


FIG. 30(a)
FIG. 30(b)
FIG. 30(c)
FIG. 30(d)
FIG. 30(e)
FIG. 30(f)
FIG. 30(g)

Nummer: DE 198 26 703 A1
Int. Cl.[6]: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

FIG. 31

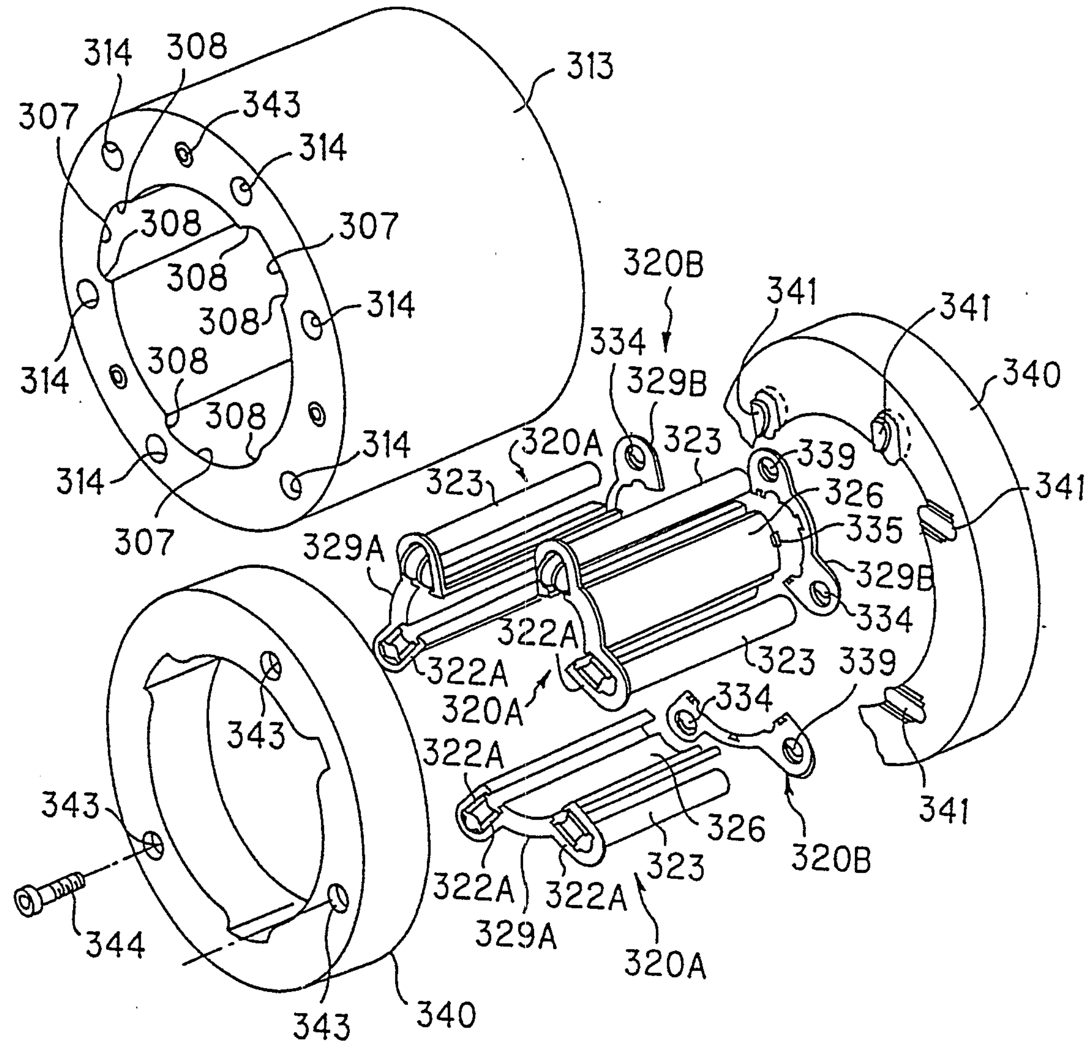


FIG. 32(a)

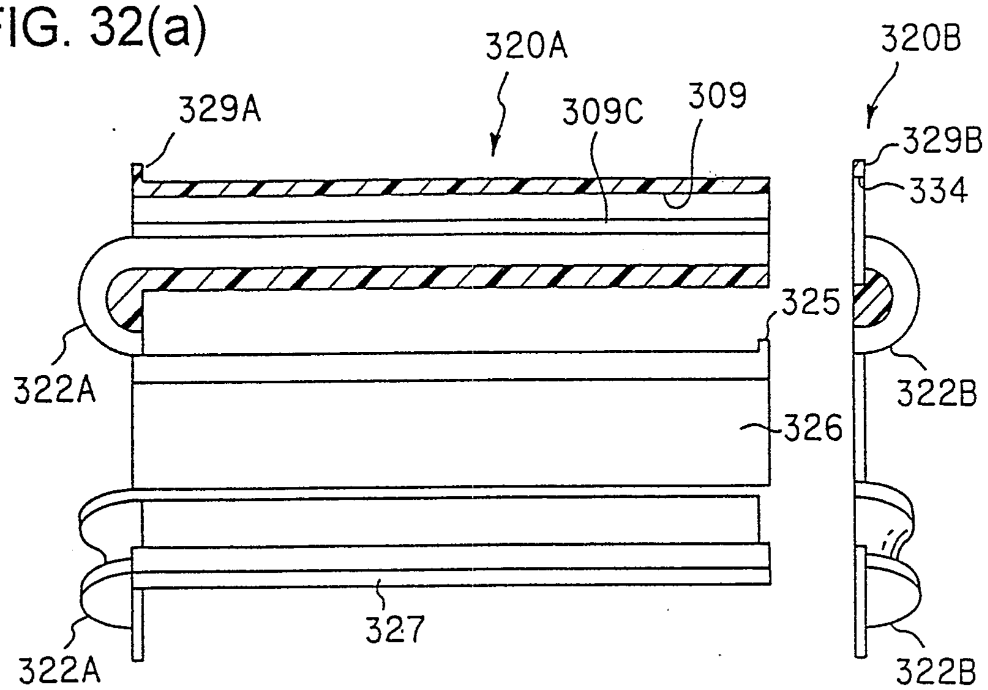


FIG. 32(b)

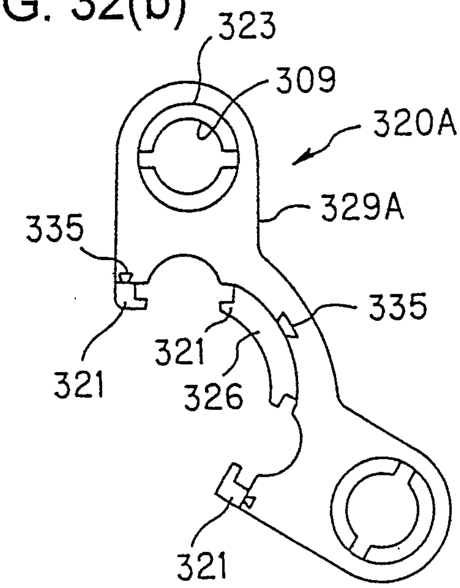
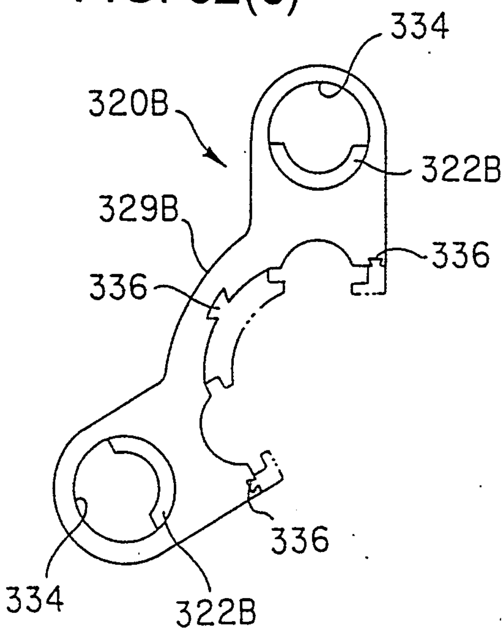


FIG. 32(c)



Nummer: **DE 198 26 703 A1**
Int. Cl.[6]: **F 16 C 29/04**
Offenlegungstag: 21. Januar 1999

FIG. 33

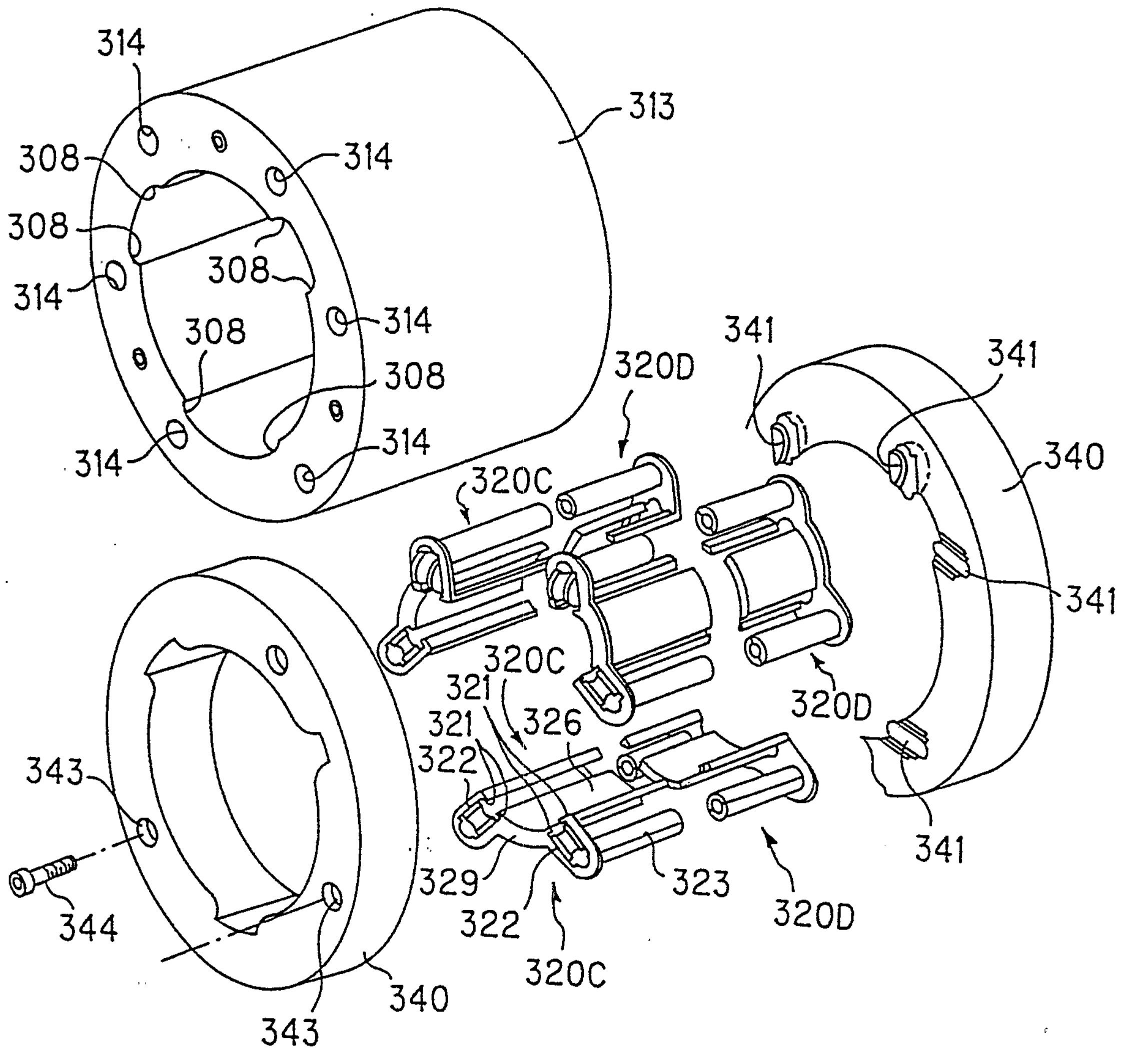


FIG. 34(a)

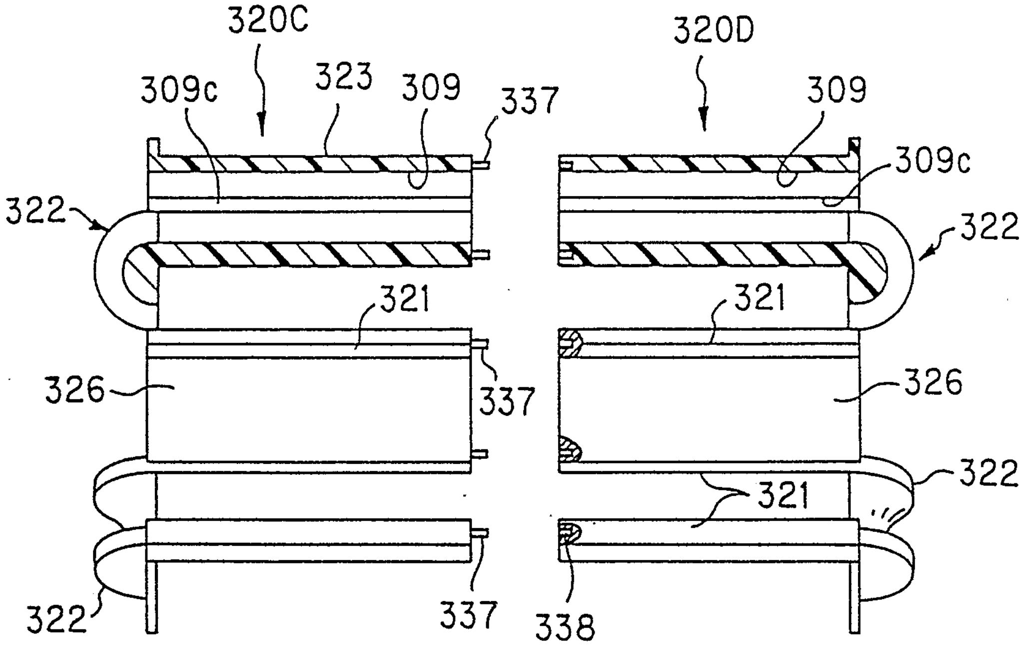


FIG. 34(b)

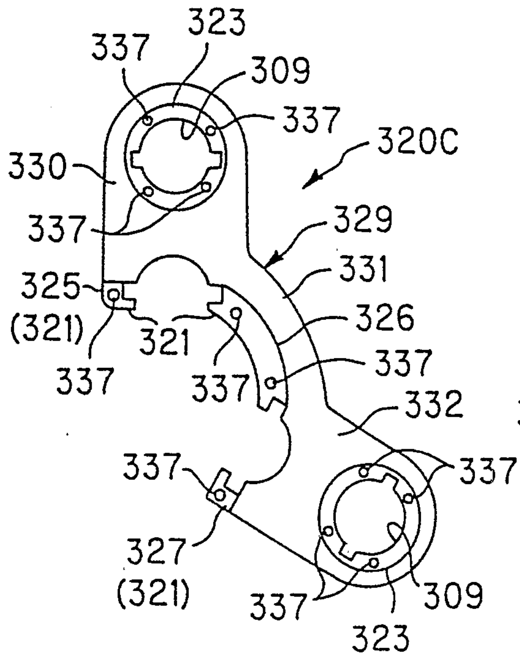
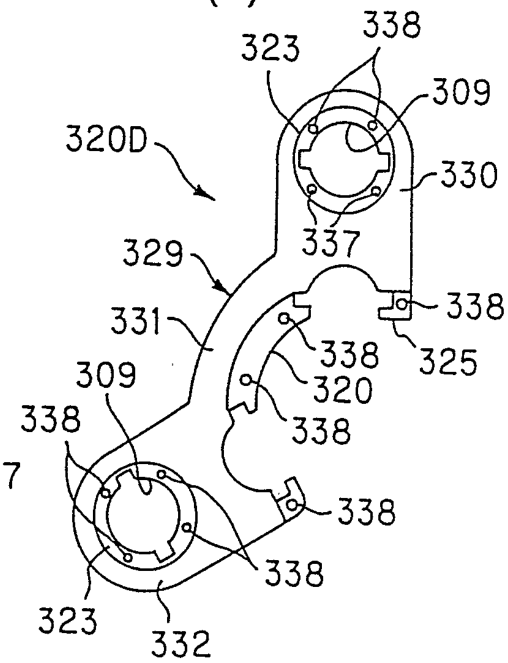
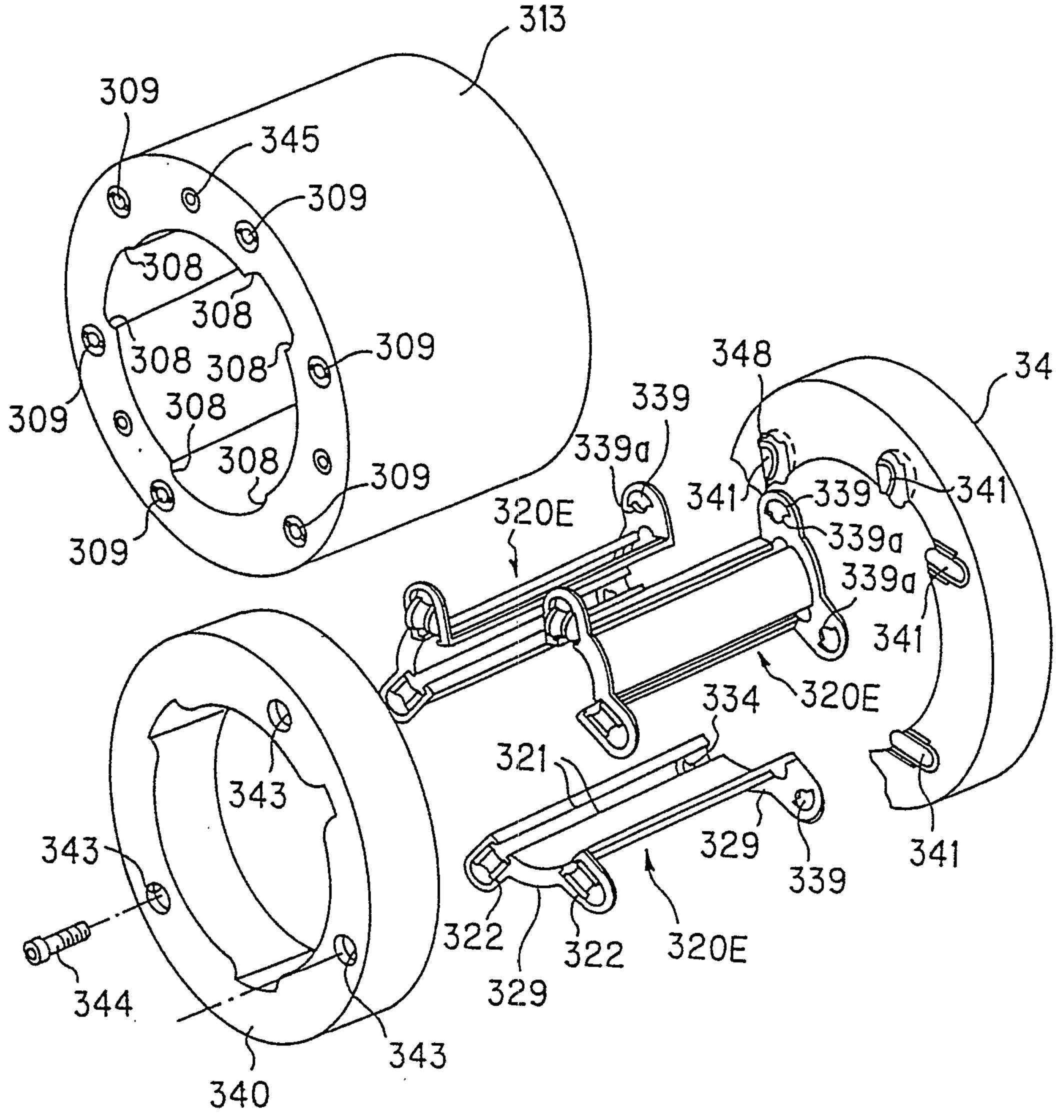


FIG. 34(c)



Nummer: DE 198 26 703 A1
Int. Cl.6: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

FIG. 35



Nummer: DE 198 26 703 A1
Int. Cl.[6]: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

FIG. 36

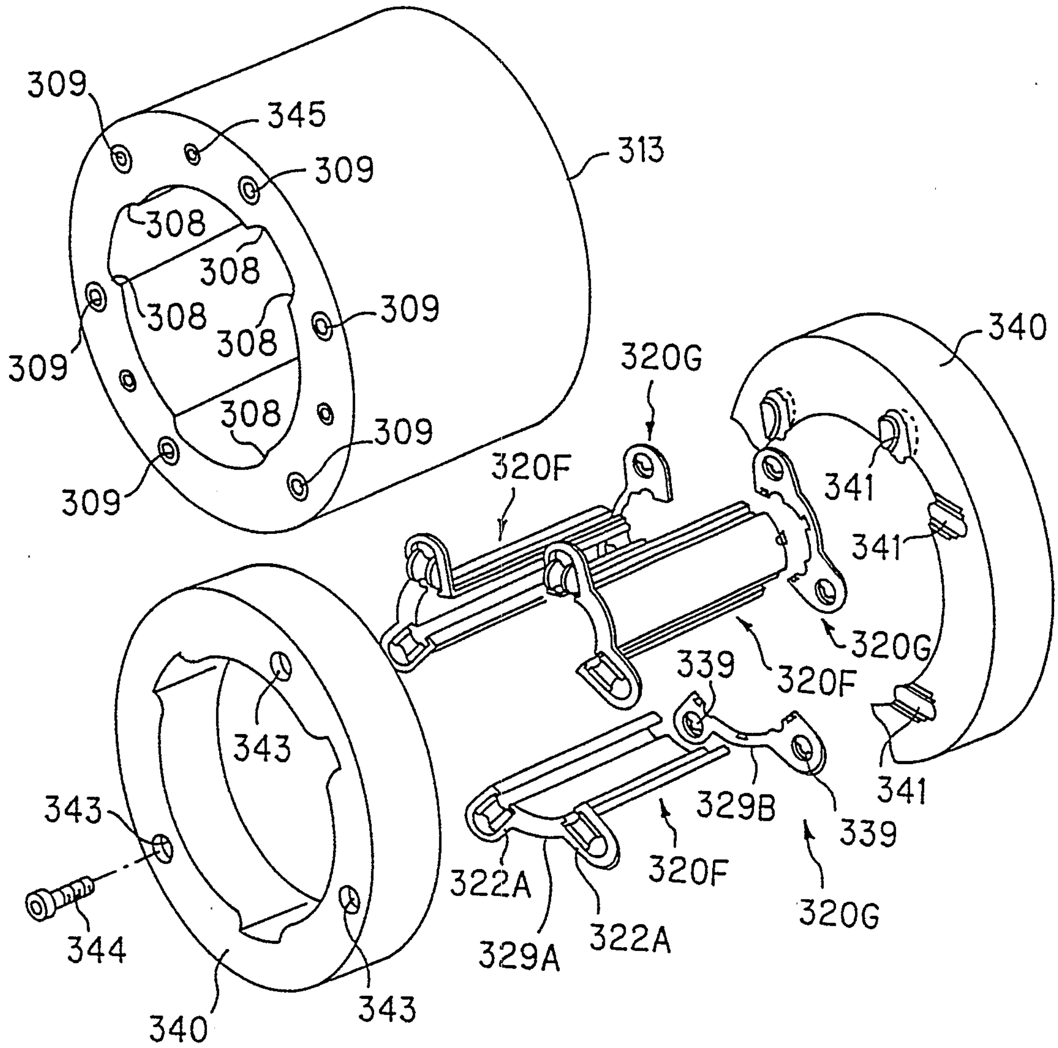


FIG. 37

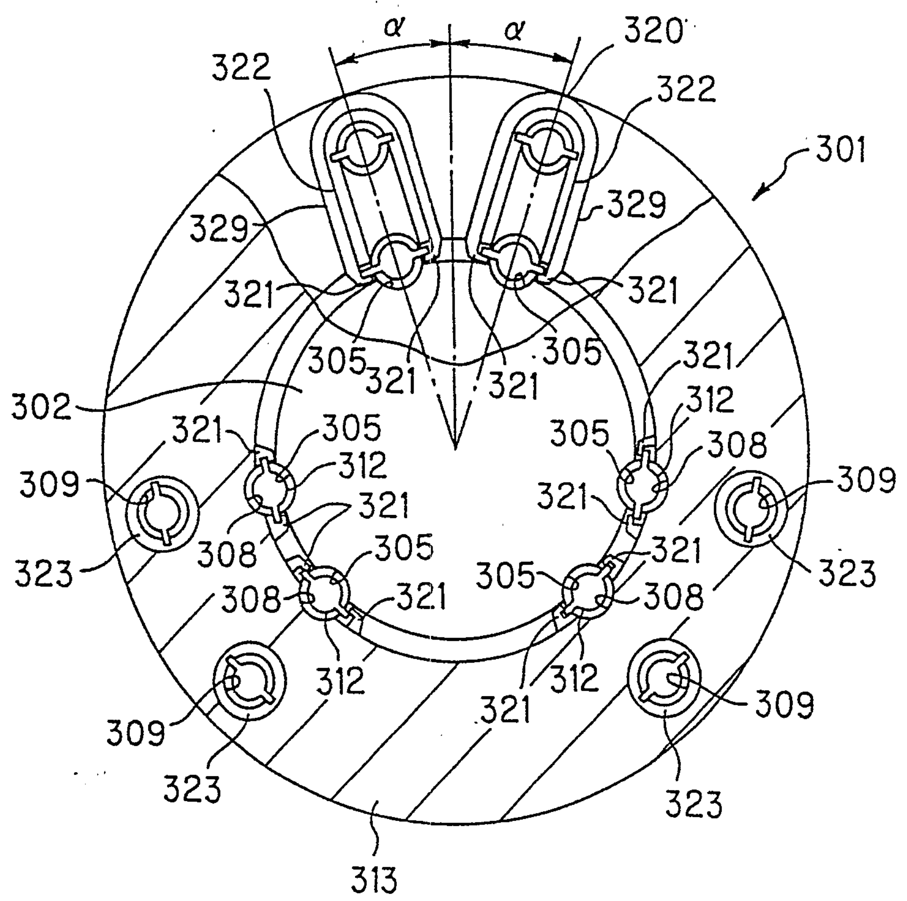

α
α
320
322
322
301
329
329
321
321
321
321
305
305
321
321
302
321
305
312
305
312
308
309
309
321
321
323
323
308
305
305
321
308
308
321
312
312
309
309
321
323
323
313

FIG. 38(a)

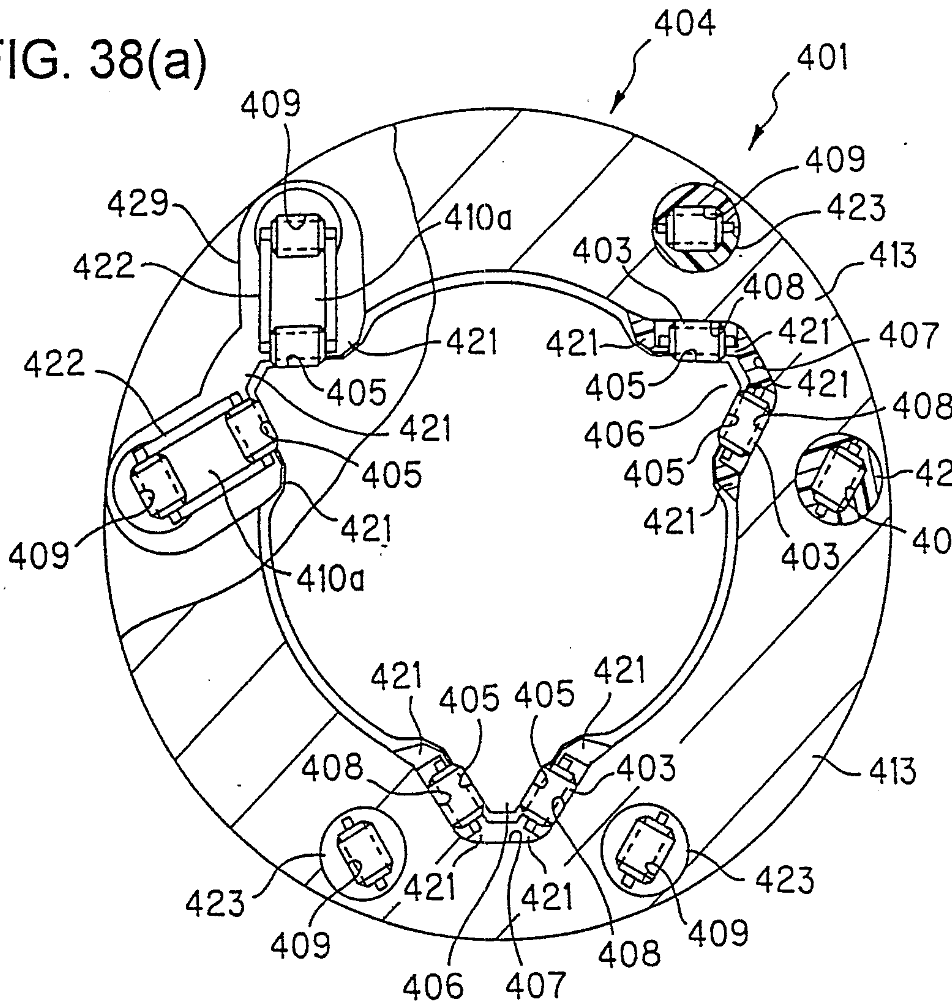


FIG. 38(b)

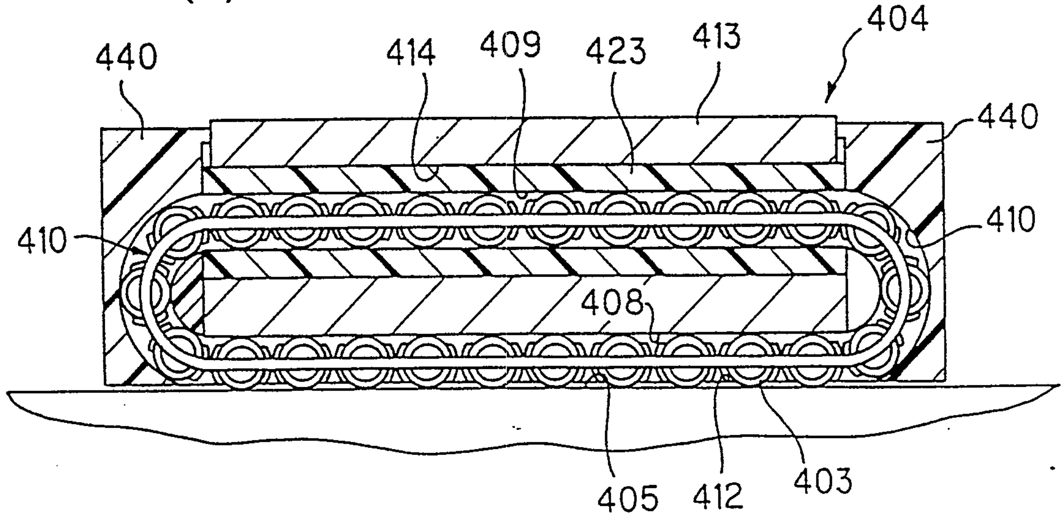


FIG. 39(a)

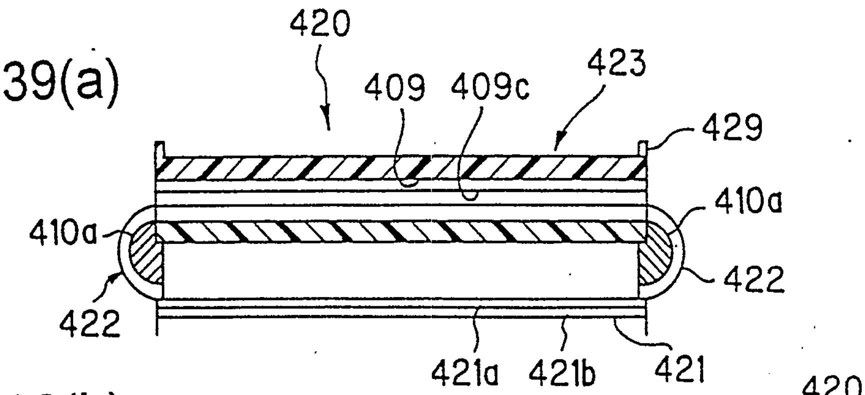


FIG. 39(b)

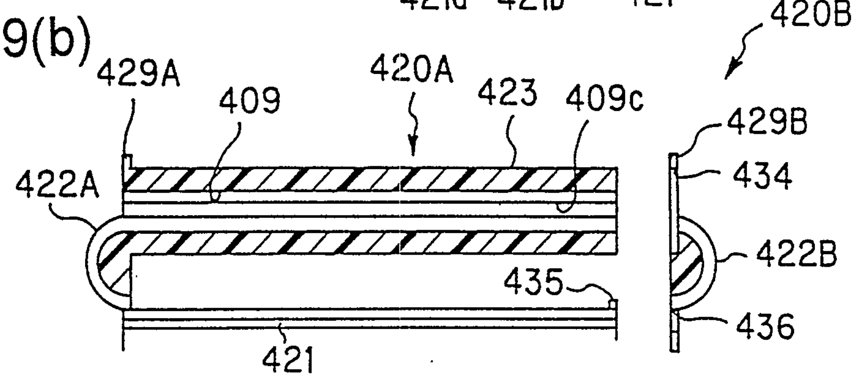


FIG. 39(c)

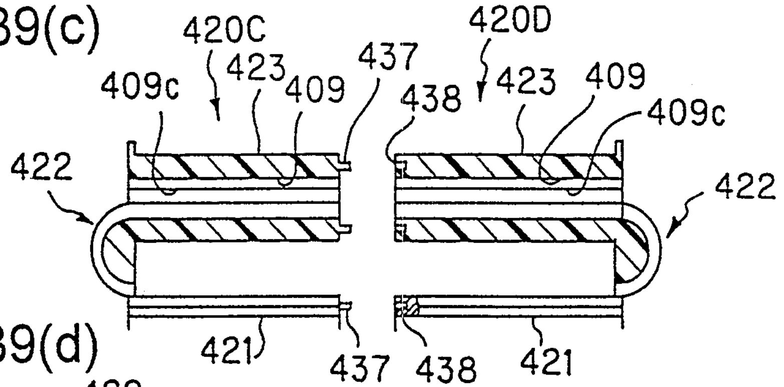


FIG. 39(d)

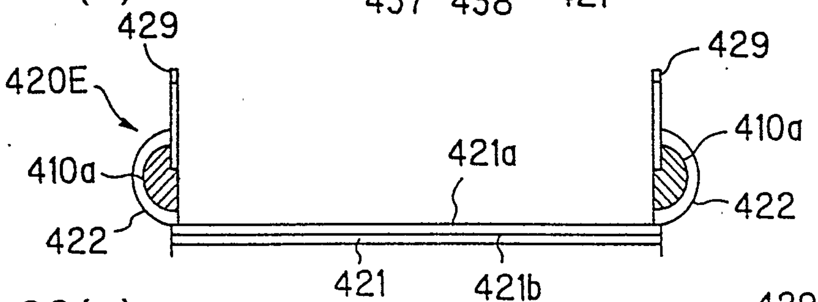


FIG. 39(e)

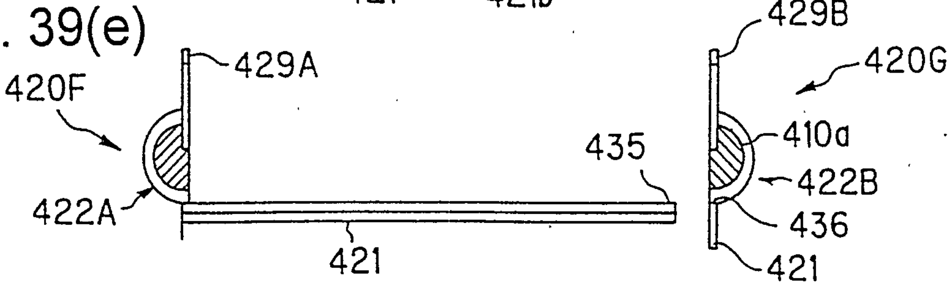


FIG.40(a)

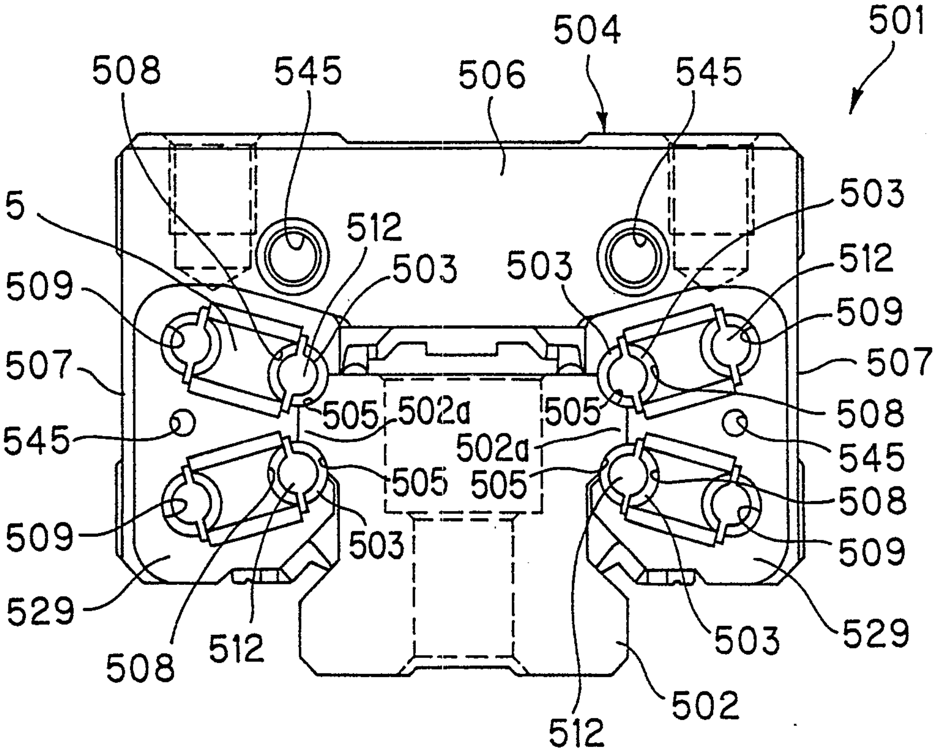
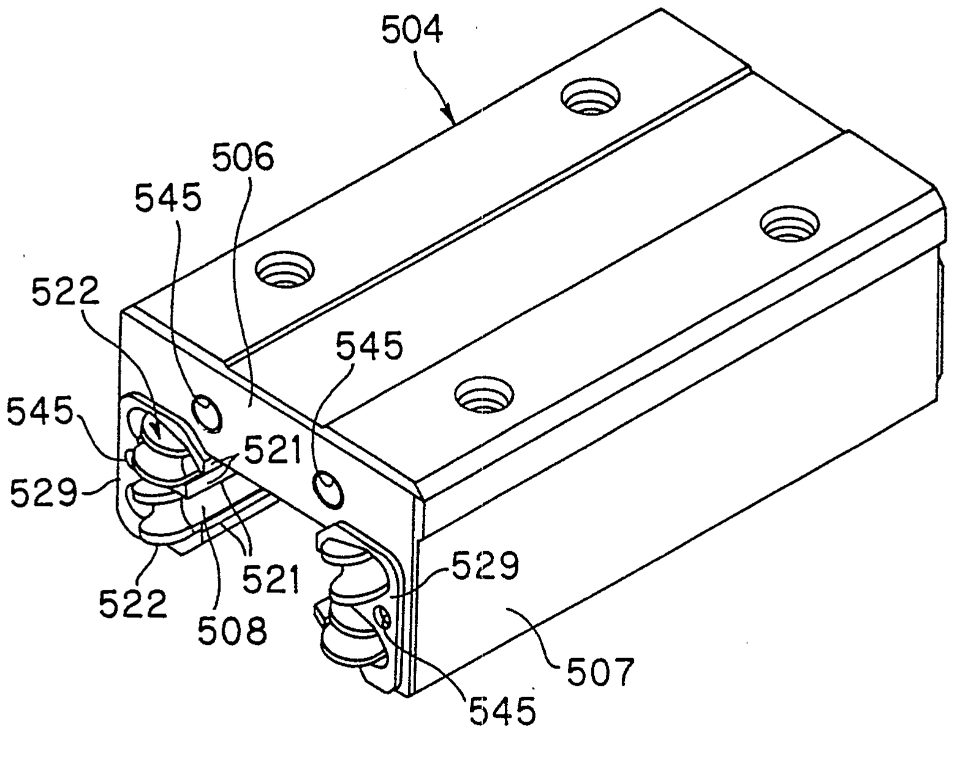
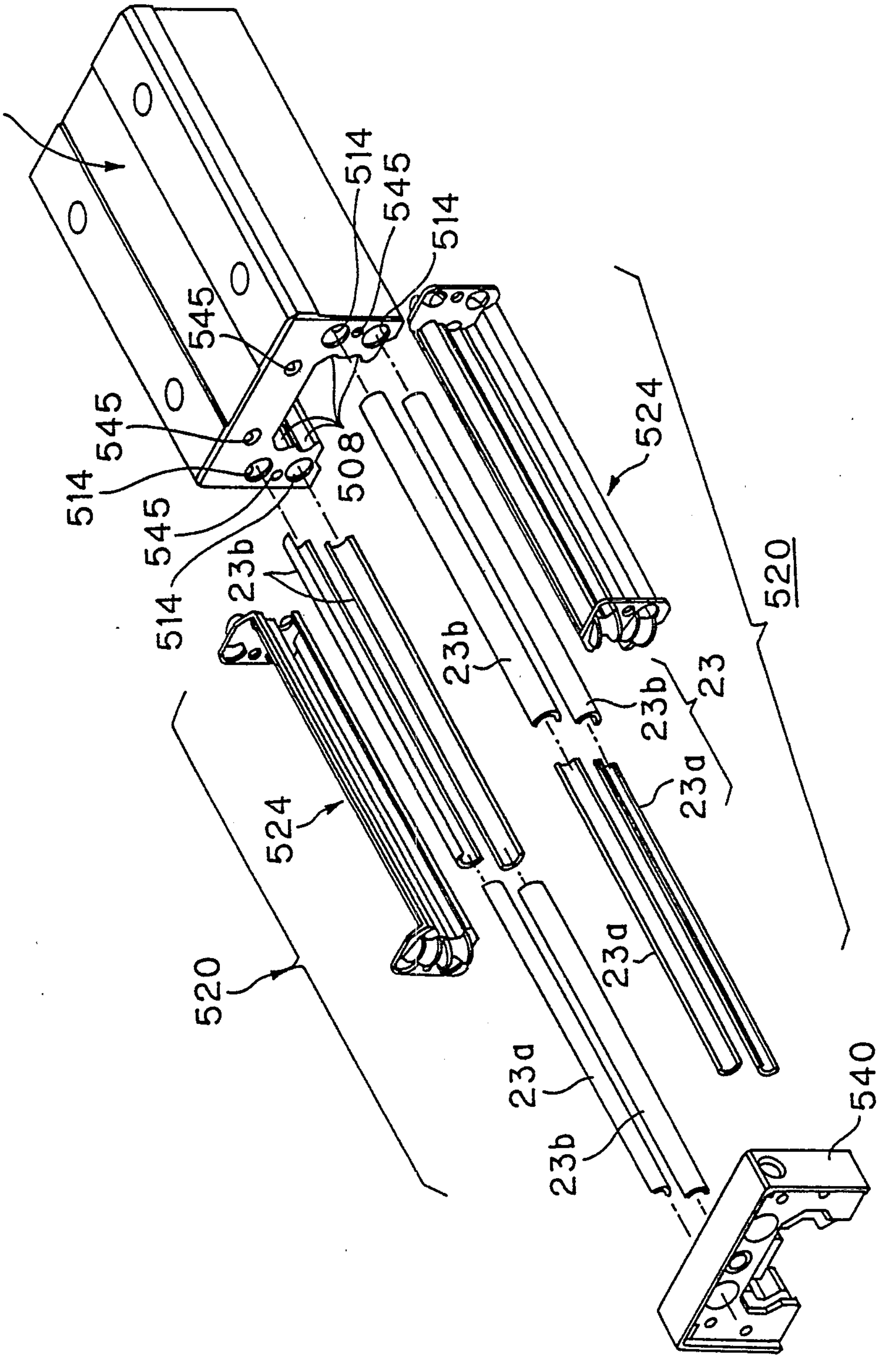


FIG.40(b)



Nummer: DE 198 26 703 A1
Int. Cl.[6]: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

FIG.41



Nummer: DE 198 26 703 A1
Int. Cl.[6]: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

FIG.42(a)

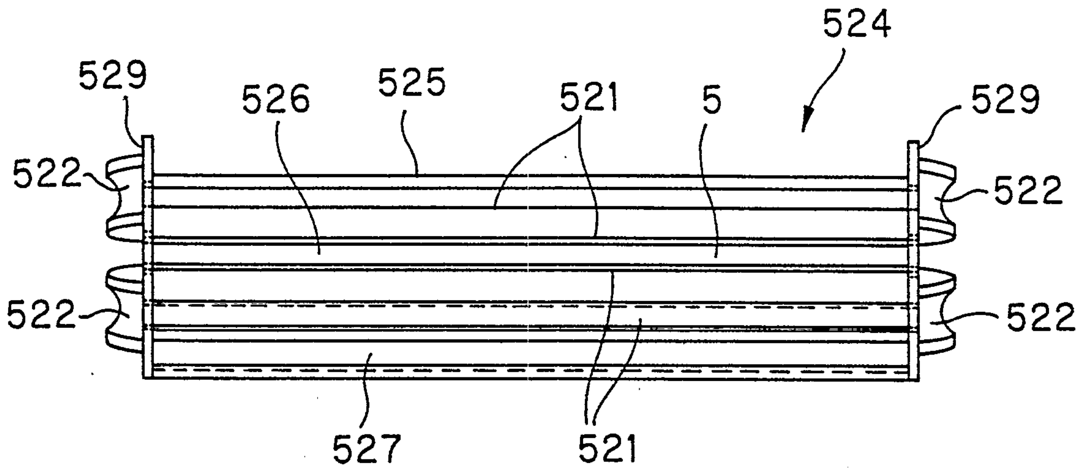


FIG.42(b)

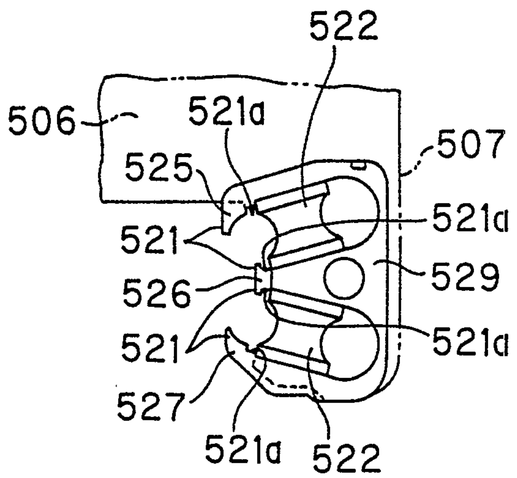
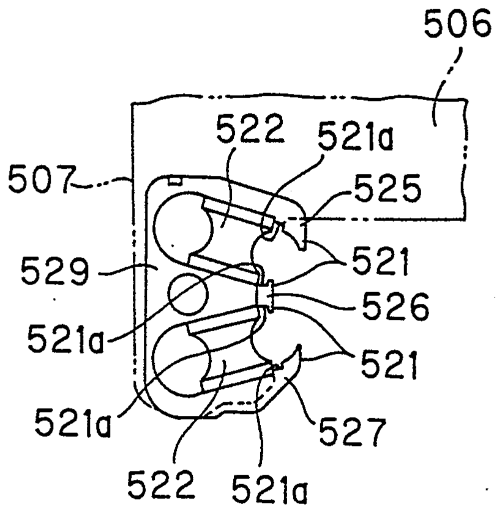


FIG.42(c)



Nummer: **DE 198 26 703 A1**
Int. Cl.[6]: **F 16 C 29/04**
Offenlegungstag: 21. Januar 1999

FIG.43(a)

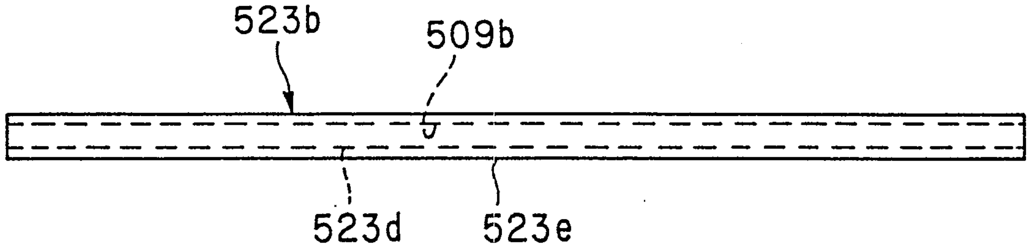


FIG.43(b)

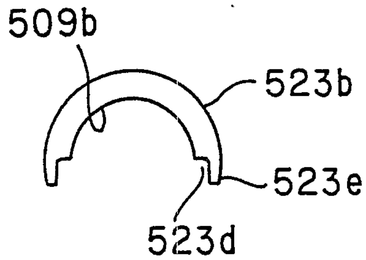


FIG.43(c)

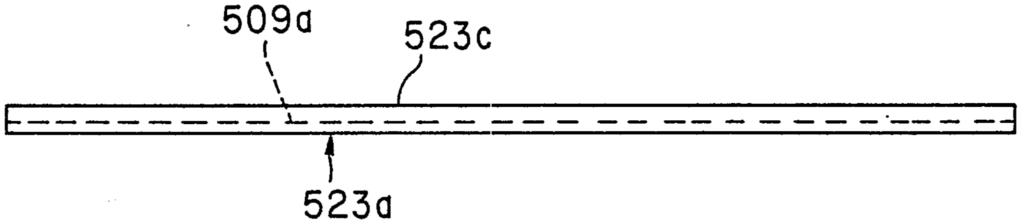
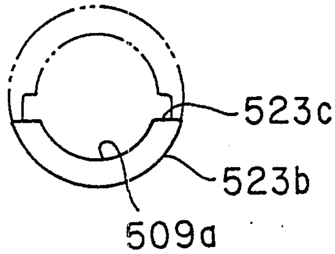


FIG.43(d)



Nummer: DE 198 26 703 A1
Int. Cl.[6]: F 16 C 29/04
Offenlegungstag: 21. Januar 1999

FIG.44(a)

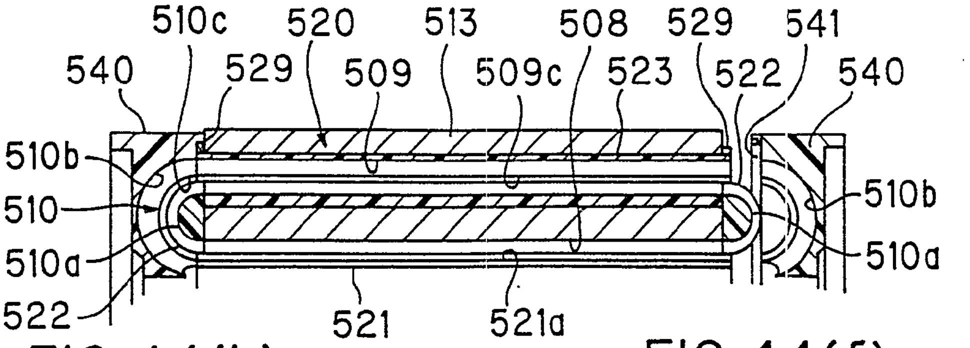


FIG.44(b)

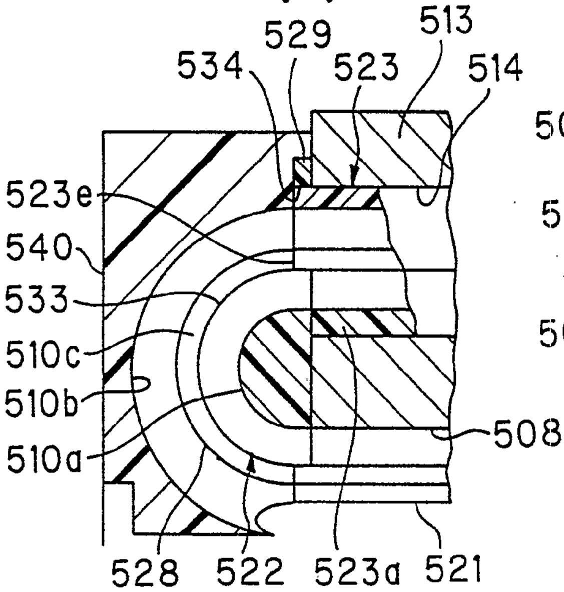


FIG.44(f)

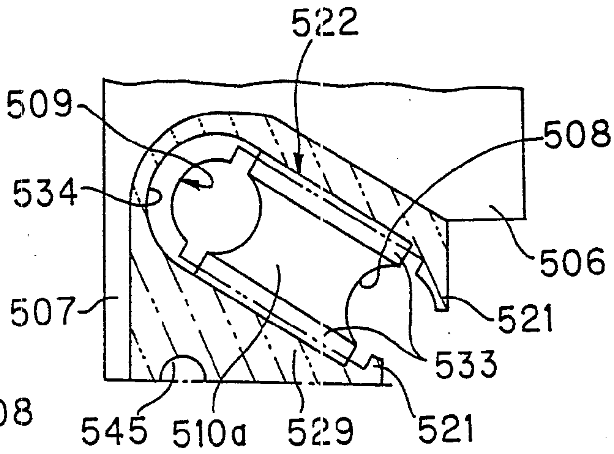


FIG.44(g)

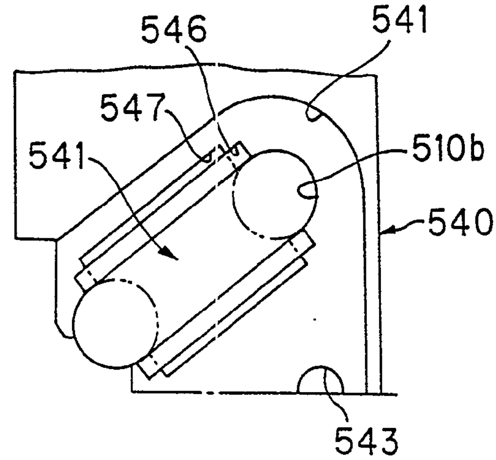


FIG.44(c)

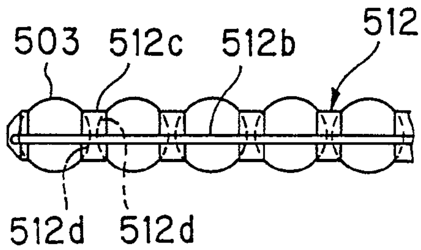


FIG.44(d)

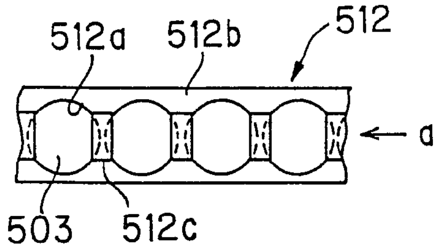
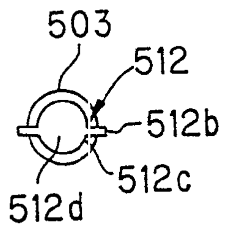


FIG.44(e)



(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENTAMT

(12) **Offenlegungsschrift**

(10) **DE 197 54 454 A 1**

(51) Int. Cl.[6]:
F 16 C 33/66
F 16 C 29/06

(21) Aktenzeichen: 197 54 454.1
(22) Anmeldetag: 8. 12. 97
(43) Offenlegungstag: 10. 6. 98

DE 197 54 454 A 1

(30) Unionspriorität:
328881/96 09. 12. 96 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Vossius & Partner GbR, 81675 München

(72) Erfinder:
Shirai, Takeki, Tokio/Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Schmierölzufuhrsystem für Wälz- oder Rollführungsvorrichtung

(57) Die Erfindung betrifft ein Schmierölzufuhrsystem, das in einer Rollführungsvorrichtung vorgesehen ist, bei der eine Spurspindel bzw. -welle und ein Gleitteil über ein Rollelement, z. B. eine Kugel oder Rolle, im Eingriff stehen, und das eine auf dem Rollelement oder der Spurwelle gebildete Rollfläche des Rollelements schmiert, und insbesondere eine Verbesserung zur sicheren Schmierung der Rollführungsvorrichtung durch einen einfachen und billigen Aufbau. Das Schmierölzufuhrsystem weist auf: ein mit dem Schmieröl getränktes Zufuhrteil, das am Gleitteil befestigt ist und das Schmieröl auf die Rollfläche des Rollelements oder die Spurwelle bei einer Bewegung des Gleitteils aufträgt, einen Speichertank, der das Schmieröl aufnimmt und am beweglichen Element angeordnet ist, und einen Zufuhrschlauch, der ein verfitztes Faserelement im Inneren hat und das Schmieröl im Speichertank in das Zufuhrteil einleitet.

DE 197 54 454 A 1

Beschreibung

Die Erfindung betrifft ein Schmierölzufuhrsystem, das in einer Wälz- oder Rollführungsvorrichtung vorgesehen ist, bei der eine Spurspindel bzw. -welle und ein Gleitteil über ein Rollelement, z. B. eine Kugel oder Rolle, im Eingriff stehen, und das eine auf dem Rollelement oder der Spurwelle gebildete Rollfläche des Rollelements schmiert, und insbesondere eine Verbesserung zur sicheren Schmierung der Rollführungsvorrichtung durch einen einfachen und billigen Aufbau.

Herkömmlich bekannt als Rollführungsvorrichtung dieser Art ist eine Lineargleitvorrichtung, die für einen Linearführungsabschnitt einer Werkzeugmaschine oder einer Übergabevorrichtung verwendet wird und ein bewegliches Element, z. B. einen Tisch, auf einem feststehenden Abschnitt, z. B. einem Bett oder Sattel, führt, sowie eine Kugelgewindevorrichtung, die zusammen mit der Lineargleitvorrichtung verwendet wird und einen Linearbewegungshub in Übereinstimmung mit einem Drehbetrag eines Motors auf das bewegliche Element ausübt.

Die zuerst genannte Lineargleitvorrichtung weist auf: eine Spurschiene, die auf dem feststehenden Abschnitt angeordnet ist und eine in Längsrichtung gebildete Kugelrollnut hat, eine Lastrollnut, die der Rollnut der Spurschiene über mehrere Kugeln gegenüberliegt, und einen Gleittisch mit einem Endloskugelumlaufweg, der in der gebildeten Lastrollnut rollt, wobei der das bewegliche Element stützende Gleittisch kontinuierlich eine Linearbewegung auf der Spurschiene vollführt.

Andererseits weist die zuletzt genannte Kugelgewindevorrichtung auf: eine Gewindespindel bzw. -welle mit einer in vorbestimmter Steigung gebildeten spiralförmigen Kugelrollnut, eine Lastrollnut, die der Kugelrollnut über mehrere Kugeln gegenüberliegt, und ein Mutternteil mit einem Endloskugelumlaufweg, der in der Lastrollnut rollt, wobei die Kugeln im Endlosumlaufweg bei einer Relativdrehung zwischen der Gewindewelle und dem Mutternteil umlaufen und sich das Mutternteil kontinuierlich in Axialrichtung der Gewindewelle bewegt.

Bei Einsatz der vorgenannten Rollführungsvorrichtung ist es notwendig, Abrieb der Kugeln selbst oder Abrieb der Spurschiene oder Rollnut der Gewindewelle (im folgenden Spurwelle genannt), in der die Kugeln rollen, oder Abrieb der Lastrollnut des Mutternteils oder Gleittischs (im folgenden Gleitteil genannt) zu verhindern sowie die Kugel- und Lastrollnut zweckmäßig zu schmieren.

Herkömmlich bekannt als solches Schmierverfahren im Stand der Technik ist ein manuelles Ölzufuhrverfahren zur Ölzufuhr zum Gleitteil mit einer Fettpresse sowie ein Zwangs- bzw. Druckölzufuhrverfahren, bei dem vorab eine Ölzufuhrleitung mit dem Gleitteil verbunden und eine konstante Schmierölmenge in konstantem Abstand mit einer automatischen Pumpe unter Druck zugeführt wird. Ferner ist seit einigen Jahren ein Nebelschmierverfahren zum Durchpressen und Zuführen von zerstäubtem Schmieröl zusammen mit starker Druckluft durch eine mit dem Gleitteil verbundene Ölzufuhrleitung bekannt.

Indes muß beim manuellen Ölzufuhrverfahren Öl entsprechend dem Bewegungsweg des Gleitteils periodisch zugeführt werden, so daß bei langem Bewegungsweg des Gleitteils je Zeiteinheit häufig Öl zugeführt werden muß. Als problematisch erweist sich somit, daß dies beschwerlich ist.

Da hingegen beim vorgenannten Druckölzufuhrverfahren und Nebelschmierverfahren die Ölzufuhrleitung fest mit dem Gleitteil verbunden ist, so daß die Schmierölzufuhr automatisch erfolgt, gibt es keine Schwierigkeiten wie beim vorgenannten manuellen Ölzufuhrverfahren; allerdings sind die automatische Pumpe zur periodischen Schmierölzufuhr und die Pumpe zur starken Drucklufterzeugung notwendig. Somit ist problematisch, daß der Aufbau der Vorrichtung kompliziert wird und ihre Kosten steigen.

Zudem kann beim manuellen Ölzufuhrverfahren der Zeitpunkt der Ölzufuhr anhand des Schmierzustands der Rollnut der Spurwelle abgeschätzt werden, so daß Schmiermittelvergeudung kaum zu befürchten ist. Da aber beim Druck- oder Nebelschmierverfahren die vorbestimmte Menge ohne Rücksicht auf die tatsächlich verbrauchte Schmierölmenge quantitativ zum Gleitteil geführt wird, kommt es zu Schmierölvergeudung, was problematisch ist, da die Wartungskosten der Rollführungsvorrichtung steigen.

Die Erfindung berücksichtigt diese Probleme, und eine Aufgabe der Erfindung besteht darin, ein Schmierölzufuhrsystem bereitzustellen, das eine Rollführungsvorrichtung mit einem einfachen und billigen Aufbau schmieren und die Betriebskosten der Rollführungsvorrichtung bei Einschränkung der Schmierölverbrauchsmenge senken kann. Diese Aufgabe wird mit den Merkmalen der Ansprüche gelöst.

Wird gemäß der technischen Einrichtung der Erfindung das Schmieröl, mit dem das Zufuhrteil getränkt ist, zur Spurwelle bei Bewegung des Gleitteils geführt, erfolgt eine Schmierölzufuhr entsprechend der Schmierölverbrauchsmenge zum Zufuhrteil aus dem am beweglichen Element angeordneten Speichertank durch den Zufuhrschlauch.

Da hierbei der Zufuhrschlauch im Inneren mit dem verfitzten Faserelement gefüllt ist, wird auch bei Anordnung des Speichertanks über dem am Gleitteil befestigten Zufuhrelement das Schmieröl im Speichertank allmählich und langsam zum Zufuhrteil geführt, so daß die Schmierölmenge, mit der das Zufuhrteil getränkt ist, stets auf einem geeigneten Wert gehalten werden kann.

Da ferner auch bei Anordnung des Speichertanks auf gleicher oder etwas tieferer Höhe als das Zufuhrteil das Schmieröl im Speichertank allmählich in das Zufuhrteil durch Kapillarwirkung des verfitzten Faserelements im Zufuhrschlauch in Relation zur geringen durch den Auftrag verbrauchten Schmierölmenge gesaugt wird, kann das Schmieröl ohne Verwendung einer Preß- und Aufgabeeinrichtung, z. B. einer Pumpe, zum Zufuhrteil geführt werden.

Auch wenn gemäß dem Schmierölzufuhrsystem der Erfindung das Schmieröl im Speichertank aufgenommen ist, kann somit die Rollfläche des Rollelements oder der Spurwelle der Rollführungsvorrichtung ohne Einsatz eines speziellen maschinellen Werkzeugs, z. B. einer Pumpe, sicher geschmiert werden, wodurch die Schmierung einfach und billig erfolgt.

Bei Realisierung des erfindungsgemäßen Schmierölzufuhrsystems ist bevorzugt, daß der Zufuhrschlauch so aufgebaut ist, daß er frei am Speichertank zu befestigen und von ihm abzunehmen ist, und daß der Speichertank so aufgebaut ist, daß er frei am beweglichen Element zu befestigen und von ihm abzunehmen ist. Sind Speichertank und Zufuhrschlauch so aufgebaut, kann bei leerem Speichertank infolge von Schmierölverbrauch der gesamte Speichertank zur Schmierölzufuhr ausgetauscht werden, so daß keine Probleme infolge von Schmierölzufuhr in den leeren Speichertank entstehen.

Da erfindungsgemaß der Speichertank am beweglichen Element angeordnet ist, das sich auf der Spurwelle der Rollführungsvorrichtung bewegt, würde im Betrieb des beweglichen Elements das Schmieröl im Speichertank im Tank stark durchgeschüttelt und Blasen bilden, weshalb die Gefahr bestünde, daß das Schmieröl im Zufuhrschlauch nicht gleichmäßig fließt. Um solches Durchschütteln zu verhindern, ist daher bevorzugt, ein schmieröleinschließendes Element aus

Filz oder Polyurethan im Speichertank unterzubringen und das einschließende Element mit dem Schmieröl zu tränken.

Die aus dem Speichertank zum Zufuhrteil je Zeiteinheit geführte Schmierölmenge ist durch die Differenz der Anordnungshöhe zwischen beiden Teilen, die Dicke des Zufuhrschlauchs und die Schmierölviskosität beeinflußt; und ist die zur Schmierung der Spurwelle notwendige Schmierölmenge kleiner als die Schmierölzufuhrmenge zum Zufuhrteil, würde mehr Schmieröl als nötig auf die Spurwelle aufgetragen, so daß die Gefahr von Schmierölvergeudung bestünde. Deshalb ist bevorzugt, ein Durchflußmengen-Steuerventil zum Steuern der aus dem Speichertank zum Zufuhrteil geführten Schmierölmenge vorzusehen und nur das zur Schmierung der Rollfläche der Spurwelle notwendige Schmieröl zum Zufuhrteil zu führen, indem die Durchflußmenge des Schmieröls im Zufuhrschlauch mit dem Durchflußmengen-Steuerventil gesteuert wird.

Wie erwähnt wurde, kann gemäß dem Schmierölzufuhrsystem für die Rollführungsvorrichtung der Erfindung Schmieröl in einer Menge, die im wesentlichen gleich der Verbrauchsmenge im Zufuhrteil ist, aus dem Speichertank zum Zufuhrteil geführt werden, ohne eine Preß- und Aufgabeeinrichtung, z. B. Pumpe, zu verwenden, so daß die Rollführungsvorrichtung durch einen einfachen und billigen Aufbau geschmiert werden kann.

Da zudem das Zufuhrteil das Schmieröl auf das Rollelement oder die Spurwelle aufträgt, wird keine über das notwendige Maß hinausgehende große Schmierölmenge verbraucht, so daß sich die Schmierölverbrauchsmenge senken läßt.

Im folgenden wird ein erfindungsgemäßes Schmierölzufuhrsystem für eine Rollführungsvorrichtung anhand der beigefügten Zeichnungen beschrieben. Es zeigen:

Fig. 1 eine Perspektivansicht einer ersten Ausführungsform eines erfindungsgemäßen Schmierölzufuhrsystems;

Fig. 2 eine Querschnittansicht eines Verbindungszustands zwischen einem Zufuhrteil und einem Speichertank gemäß der ersten Ausführungsform;

Fig. 3 eine Explosionsansicht eines Anordnungszustands des Speichertanks an einem beweglichen Element gemäß der ersten Ausführungsform;

Fig. 4 eine Querschnittansicht einer zweiten Ausführungsform eines erfindungsgemäßen Schmierölzufuhrsystems;

Fig. 5 eine Querschnittansicht eines Durchflußsteuerventils gemäß der zweiten Ausführungsform;

Fig. 6 eine Perspektivansicht einer dritten Ausführungsform eines erfindungsgemäßen Schmierölzufuhrsystems; und

Fig. 7 eine Querschnittansicht eines Verbindungszustands zwischen einem Zufuhrteil und einem Speichertank gemäß der dritten Ausführungsform.

Fig. 1 zeigt eine erste Ausführungsform, in der ein Schmierölzufuhrsystem der Erfindung auf eine Lineargleitvorrichtung angewendet ist. In der Zeichnung bezeichnet die Bezugszahl **1** eine Lineargleitvorrichtung (Rollführungsvorrichtung), die aufgebaut ist aus einer Spurschiene (Spurwelle) **2**, die an einer (nicht gezeigten) feststehenden Position, z. B. einem Bett oder Sattel, befestigt ist, und einem Gleittisch (Gleitteil) **3**, der einen Eingriff mit der Spurschiene **2** über mehrere Kugeln herstellt und sich auf der Spurschiene **2** bewegt. Ferner bezeichnet die Bezugszahl **4** ein bewegliches Element, z. B. einen am Gleittisch **3** befestigten Tisch. In dieser Ausführungsform wird die Bewegung des beweglichen Elements **4** auf dem feststehenden Abschnitt durch zwei Spurschienen **2** und vier Gleittische **3** gestützt, von denen jeweils zwei einen Eingriff mit jeder der Spurschienen **2** herstellen.

Außerdem bezeichnet die Bezugszahl **5** ein Zufuhrteil, das an einem Endabschnitt des Gleittischs **3** in Bewegungsrichtung befestigt ist und das Schmieröl zur Spurschiene **2** bei der Bewegung des Gleittischs **3** führt, die Bezugszahl **6** bezeichnet einen Speichertank, der das zur Lineargleitvorrichtung **1** zu führende Schmieröl aufnimmt und am beweglichen Element **4** angeordnet ist, und die Bezugszahl **7** bezeichnet einen Zufuhrschlauch zum Zuführen des Schmieröls aus dem Speichertank **6** zum Zufuhrteil **5**.

Gemäß **Fig.** 2 ist eine Rollnut **9**, in der Kugeln **8** rollen, in der Spurschiene **2** gebildet, wogegen eine Lastrollnut **10** gegenüber der Kugelrollnut **9** der Spurschiene **2** im Gleittisch **3** gebildet ist, so daß die Kugeln **8** bei Lastausübung zwischen der Rollnut **9** und der Lastrollnut **10** rollen. Ferner ist ein Endlosumlaufweg **11** zum schließlichen Zurückführen der zu einem Ende der Lastrollnut **10** rollenden Kugeln **8** zu einem Anfang der Lastrollnut **10** im Gleittisch **3** gebildet, so daß sich der Gleittisch **3** kontinuierlich auf der Spurschiene **2** durch den Umlauf der Kugeln **8** im Endlosumlaufweg **11** bewegen kann.

Das Zufuhrteil **5** hat eine Kastenform mit einem Innenraum, wobei der Raum durch ein Gehäuse **12** mit einer zur Spurschiene **2** weisenden Öffnung und einem im Gehäuse **12** aufgenommenen schmierölhaltigen Element **13** gebildet ist, das mit der Spurschiene **2** in Berührung zu bringen und mit dem Schmieröl getränkt ist, und das Zufuhrteil **5** ist an der Endfläche des Gleittischs **3** in Bewegungsrichtung mit einem durch das Gehäuse **12** verlaufenden Befestigungsbolzen **14** befestigt. Das schmierölhaltige Element **13** reicht aus, solange es eine bestimmte Schmierölmenge absorbieren und halten kann, wobei ein Polyurethan- oder Filzmaterial zum Einsatz kommen können.

Bewegt sich der Gleittisch **3** auf der Spurschiene **2**, wischt das in Berührung mit der Spurschiene **2** gebrachte schmierölhaltige Element **13** über die Spurschiene **2**, wodurch das Schmieröl, mit dem das schmierölhaltige Element **13** getränkt ist, auf die Kugelrollnut **9** der Spurschiene **2** so aufgetragen wird, daß die in der Kugelrollnut **9** rollenden Kugeln **8** geschmiert werden.

Zudem ist das Zufuhrteil **5** mit dem am beweglichen Element **4** angeordneten Speichertank **6** über den Zufuhrschlauch **7** verbunden, so daß das im Speichertank **6** gespeicherte Schmieröl über den Zufuhrschlauch **7** vom schmierölhaltigen Element **13** im Zufuhrteil **5** absorbiert wird. In den Zufuhrschlauch **7** ist ein verfitztes Faserelement, z. B. aus Filz, so eingefügt, daß das Schmieröl im Speichertank **6** nicht auf einmal in das Zufuhrteil **5** fließt, sondern zum Zufuhrteil **5** unter Absorption durch das verfitzte Faserelement abgegeben wird.

Außerdem kann der Zufuhrschlauch **7** frei am Zufuhrteil **5** und Speichertank **6** angeordnet und davon abgenommen, wenn das schmierölhaltige Element **13** mit Schmieröl getränkt ist, und auch bei Entfernung des Zufuhrschlauchs **7** kann das Zufuhrteil **5** die Kugelrollnut **9** der Spurschiene **2** schmieren.

Dazu kommt, daß ein aus einem Filzmaterial hergestelltes schmierölgetränktes Element **15** in den Speichertank **6** eingefügt und das Schmieröl im Speichertank **6** in einem Zustand gespeichert ist, in dem es im schmierölgetränkten Element **15** gehalten wird. Da der Speichertank **6** am beweglichen Element **4** angeordnet ist, würde bei direkter Schmierölspeicherung im Tank **6** das Schmieröl im Speichertank **6** bei schnellem Hin- und Hergehen des beweglichen Elements **4** durchgeschüttelt, so daß die Gefahr von Blasenbildung im Schmieröl entstünde. Allerdings lassen sich diese Probleme vermeiden, wenn das im getränkten Element **15** absorbierte Schmieröl im Speichertank **6** gespeichert ist.

Gemäß **Fig.** 3 ragt ein hakenartiger Anordnungsabschnitt

16 von der Rückseite des Speichertanks **6** so vor, daß der Speichertank **6** am beweglichen Element **4** durch Einhängen des Anordnungsabschnitts **16** in eine am beweglichen Element **4** befestigte Halterung befestigt werden kann. Folglich läßt sich der Speichertank **6** frei am beweglichen Element **4** anordnen und von ihm abnehmen; ist das Schmieröl im Speichertank **6** verbraucht, wird ein neuer schmierölspeichernder Speichertank **6** wieder an der Halterung **17** angeordnet und der Zufuhrschlauch **7** vom alten Tank wieder am neuen Tank angeschlossen, so daß Schmieröl problemlos zugeführt werden kann. In dieser Ausführungsform ist der Speichertank **6** an der Seitenfläche des beweglichen Elements **4** angeordnet; sofern er nicht die in der Umgebung des beweglichen Elements **4** vorhandenen Ausrüstungen stört, kann der Speichertank **6** aber auch an der Ober- oder Unterseite des beweglichen Elements **4** angeordnet sein.

Bewegt sich gemäß dem so aufgebauten Schmierölzufuhrsystem der Erfindung ferner der Gleittisch **3** der Lineargleitvorrichtung **1** zusammen mit dem beweglichen Element, wischt das Zufuhrteil **5** durch das schmierölhaltige Element **13** bei der Bewegung über die Spurschiene **4**, so daß die Kugelrollnut **9** und die in ihr rollenden Kugeln **8** durch das Schmieröl geschmiert werden, mit dem das schmierölhaltige Element **13** getränkt ist. Die Schmierölmenge, mit der das schmierölhaltige Element **13** getränkt ist, verringert sich allmählich durch Wiederholen dieser Bewegung; da aber der Speichertank **6** mit dem Zufuhrteil **5** über den Zufuhrschlauch **7** verbunden ist, wird Schmieröl entsprechend der durch Auftragen auf die Spurschiene **2** verbrauchten Menge sukzessiv aus dem Speichertank **6** zugeführt.

Da hierbei das verfitzte Faserelement in den Zufuhrschlauch eingefügt ist, wird das Schmieröl im Speichertank **6** zum Zufuhrteil **5** unter Absorption durch das verfitzte Faserelement geführt, und andererseits wird im Zufuhrteil **5** das Schmieröl entsprechend der Verbrauchsmenge aus dem verfitzten Faserelement des Zufuhrschlauchs **7** durch das schmierölhaltige Element **13** absorbiert. Da hierbei der Speichertank **6** am durch den Gleittisch **3** gestützten beweglichen Element **4** angeordnet ist, besteht nahezu kein Höhenunterschied zwischen dem Gleittisch **3**, an dem das Zufuhrteil **5** befestigt ist, und dem Speichertank **6**, und selbst wenn der Speichertank **6** etwas tiefer als das Zufuhrteil **5** liegt, wird das Schmieröl im Speichertank **6** durch Kapillarwirkung des verfitzten Faserelements im Zufuhrschlauch **7** allmählich aufgesaugt.

Um festzustellen, wie weit das Schmieröl durch Kapillarwirkung im Zufuhrschlauch **7** aufsteigen kann, wurde im Rahmen der Erfindung ein Experiment durchgeführt. Der für das Experiment verwendete Zufuhrschlauch **7** wurde durch Einfügen eines Jutebands in einen transparenten Schlauch aus Vinylmaterial mit einem Innendurchmesser von etwa 3 mm hergestellt, und im Experiment wurde das untere Ende des Zufuhrschlauchs senkrecht abhängend in das Schmieröl eingetaucht. Es wurde als Ergebnis festgestellt, daß das Juteband im transparenten Schlauch mit Schmieröl getränkt wurde, das über einen Weg von etwa 50 bis 60 cm im Zufuhrschlauch **7** aufstieg. Auch wenn gemäß dem Ergebnis dieses Experiments das Zufuhrteil **5** etwa 50 bis 60 cm über dem Speichertank **6** positioniert ist, wurde somit festgestellt, daß das Schmieröl zum Zufuhrteil **5** geführt werden kann und nicht im Speichertank **6** verbleibt.

Ist dagegen der Speichertank **6** höher als das Zufuhrteil **5** angeordnet, dient das in den Zufuhrschlauch **7** eingefügte verfitzte Faserelement als Widerstand gegenüber dem Schmierölfluß auf dem Fließweg, so daß das Schmieröl im Speichertank **6** nicht auf einmal unter Schwerkrafteinfluß in das Zufuhrteil **5** fließt, sondern das schmierölhaltige Element **13** im Zufuhrteil **5** das Schmieröl aus dem Zufuhrschlauch **7** nur entsprechend dem Verbrauchsgrad aufnimmt.

Gemäß dieser Ausführungsform kann somit ohne Verwendung eines speziellen Mechanismus, z. B. einer Pumpe, das Schmieröl im Speichertank **6** zum Zufuhrteil **5** in einem der Verbrauchsmenge entsprechenden Grad abgegeben werden, so daß das Zufuhrteil **5** das Schmieröl kontinuierlich auf die Spurschiene **2** auftragen kann, bis das im Speichertank **6** gespeicherte Schmieröl verbraucht ist.

In **Fig.** 4 ist eine zweite Ausführungsform gezeigt, in der das erfindungsgemäße Schmierölzufuhrsystem auf eine Lineargleitvorrichtung angewendet ist.

Um gemäß dem Schmierölzufuhrsystem der zweiten Ausführungsform die Durchflußmenge des zum Zufuhrteil **5** aus dem Speichertank **6** geführten Schmieröls zu steuern, ist ein Durchflußmengen-Steuerventil **18** im Weg des den Speichertank **6** und das Zufuhrteil **5** verbindenden Zufuhrschlauchs **7** vorgesehen, wobei eine Betätigung des Durchflußmengen-Steuerventils **18** verhindert, daß Schmieröl in größerer Menge als notwendig zum Zufuhrteil **5** geführt wird.

Gebildet ist das Durchflußmengen-Steuerventil **18** gemäß **Fig.** 5 durch ein Gehäuse mit einem Durchflußkanal **19** für das Schmieröl und ein Handrad **22**, das in das Gehäuse **20** eingreift und einen an seinem vorderen Ende gebildeten nadelartigen Ventilkörper **21** hat, so daß der Ventilkörper **21** in einen im Weg des Durchflußkanals **19** gebildeten Ventilsitz **23** durch Betätigung des Handrads eingebracht und daraus entfernt wird, um so die Durchflußmenge des im Durchflußkanal **19** fließenden Schmieröls zu steuern. Hierbei bezeichnet die Bezugszahl **24** in der Zeichnung einen Verbindungsanschluß für den Zufuhrschlauch **7**.

Da gemäß dem so aufgebauten Schmierölzufuhrsystem der Erfindung die Durchflußmenge des aus dem Speichertank **6** zum Zufuhrteil **5** geführten Schmieröls wahlweise durch Betätigen des Durchflußmengen-Steuerventils **18** eingestellt werden kann, läßt sich eine optimale Schmierölmenge entsprechend der Nutzung der Lineargleitvorrichtung aus dem Zufuhrteil auf die Kugelrollnut **9** der Spurwelle **2** auftragen.

In der zweiten Ausführungsform ist der Aufbau so, daß das verfitzte Faserelement, z. B. Filz, nicht in den Innenabschnitt des Durchflußkanals **19** des Durchflußmengen-Steuerventils **18** eingefügt und der Durchflußkanal **19** nur mit dem Schmieröl gefüllt ist, wobei jedoch der Aufbau auch so sein kann, daß das verfitzte Faserelement sowohl in den Durchflußkanal **19** als auch den Zufuhrschlauch **7** eingefügt ist. In diesem Fall wird die Durchlaßmenge des Schmieröls, d. h. die Zufuhrmenge, durch Zusammendrücken des verfitzten Faserelements im Durchflußkanal **19** in Richtung auf den Ventilsitz **23** durch den Ventilkörper **21** sowie durch Ändern des Betrags, in dem es zusammengedrückt wird, eingestellt.

Fig. 6 und 7 zeigen eine dritte Ausführungsform, in der die Erfindung auf eine Kugelgewindevorrichtung angewendet ist.

In der Zeichnung bezeichnet die Bezugszahl **30** eine Gewindewelle (Spurwelle) mit einer in vorbestimmter Steigung gebildeten spiralförmigen Kugelrollnut **31**, die Bezugszahl **32** bezeichnet ein Mutternteil (Gleitteil), das eine Endlosspur, in der Kugeln **33** umlaufen, hat und einen Eingriff mit der Gewindewelle **30** über die Kugeln **33** herstellt, und die Bezugszahl **39** bezeichnet ein Zufuhrteil, das an beiden Endflächen des Mutternteils **32** in Längsrichtung angeordnet ist.

Gebildet ist das Mutternteil **32** hier durch einen Stahlmutternkörper **36**, der mit einem Flanschabschnitt **35** zum Befestigen des Mutternteils **32** auf vorstehende Weise versehen ist, mehrere Ablenkelemente bzw. Deflektoren **37**, die an einer Innenumfangsfläche des Mutternkörpers **36** befestigt sind, und ein Paar Abdichtungsteilen **38** zum Abdichten eines Spalts zwischen dem Mutternkörper und der Gewindewelle. Der Deflektor **37** ist am Mutternteil **32** so befestigt, daß er die Kugelrollnut **31** der Gewindewelle **30** nur in einem solchen Windungsgrad überspannt, daß die in der Kugelrollnut **31** der Gewindewelle **30** rollenden Kugeln **33** eine Richtungsänderung durch den Deflektor **37** erfahren und über den Außendurchmesser der Gewindewelle **30** laufen, um zur Kugelrollnut **31** eines vorherigen Windungszustands zurückgeführt zu werden. Folglich ist der Deflektor **37** so aufgebaut, daß die Kugeln **33** im Innenabschnitt des Mutternteils **32** im Endlosumlauf geführt werden. Ferner sind in dieser Ausführungsform vier Deflektoren **37** so am Mutternteil **32** befestigt, daß sie den Kreisumfang des Mutternteils **32** in vier gleiche Teile aufteilen, so daß die Endlosspur der Kugeln **33** alle vier Teile aufweist.

Andererseits ist der Aufbau so, daß ein Zufuhrteil **39** ein mit dem Schmieröl getränktes schmierölhaltiges Element **41** in einem Gehäuse **40** aufnimmt, und das schmierölhaltige Element **41** mit der Kugelrollnut **31** der Gewindewelle **30** auf die gleiche Weise wie in der ersten Ausführungsform in Berührung gebracht ist. Zudem ist das Zufuhrteil **39** am Mutternteil **32** durch einen (nicht gezeigten) Befestigungsbolzen befestigt.

Außerdem ist wie in der ersten und zweiten Ausführungsform das Zufuhrteil **39** mit dem Speichertank **6** durch den Zufuhrschlauch **7** verbunden, und der Aufbau ist so, daß das Schmieröl im Speichertank **6** zum Zufuhrteil **39** bei Abnahme des Schmieröls geführt wird, mit dem das schmierölhaltige Element **41** getränkt ist. Da der Aufbau des Speichertanks **6**, Zufuhrschlauchs **7** und Durchflußmengen-Steuerventils **18** dem der ersten und zweiten Ausführungsform gleicht, sind in der Zeichnung die gleichen Bezugszahlen für die gleichen Elemente vergeben, und auf ihre nähere Beschreibung wird verzichtet.

Werden im so aufgebauten Schmierölzufuhrsystem gemäß dieser Ausführungsform die Gewindewelle **30** und das Mutternteil **32** der Kugelgewindevorrichtung in Relativdrehung versetzt, trägt das Zufuhrteil **39** während der Drehung kontinuierlich das Schmieröl auf die Kugelrollnut **31** der Gewindeweile **20** auf, so daß die Schmierölmenge, mit der das schmierölhaltige Element **41** im Zufuhrteil **39** getränkt ist, allmählich abnimmt. Da aber der Speichertank **6** über den Zufuhrschlauch **7** mit dem Zufuhrteil **39** verbunden und das verfitzte Faserelement in den Zufuhrschlauch **7** eingefügt ist, wird das Schmieröl aus dem Speichertank **6** allmählich durch Kapillarwirkung zum Zufuhrteil **39** geführt, so daß ohne Einsatz eines speziellen Mechanismus, z. B. einer Pumpe, das Schmieröl entsprechend der Verbrauchsmenge nacheinander aus dem Speichertank **6** zum Zufuhrteil **39** geführt werden kann.

Patentansprüche

1. Schmierölzufuhrsystem mit einer Spurwelle und einem mit ihr über ein Wälz- oder Rollelement im Eingriff stehendes Führungsteil, die in einer Rollführungsvorrichtung zum Führen eines an dem Führungsteil befestigten beweglichen Elements auf der Spurwelle vorgesehen sind, und das eine Rollfläche des Rollelements oder ein auf der Spurwelle gebildetes Rollelement schmiert, mit:
einem mit Schmieröl getränktem Zufuhrteil, das an dem Führungsteil befestigt ist und das Schmieröl auf die Rollfläche des Rollelements oder die Spurwelle bei einer Bewegung des Führungsteils aufträgt, einem Speichertank, der das Schmieröl aufnimmt und an dem beweglichen Element angeordnet ist, und einem Zufuhrschlauch, der ein verfitztes Faserelement im Inneren hat und das Schmieröl aus dem Speichertank in das Zufuhrteil einleitet.

2. System nach Anspruch 1, wobei der Zufuhrschlauch an dem Speichertank frei anzuordnen und von ihm abzunehmen ist und der Speichertank an dem beweglichen Element frei anzuordnen und von ihm abzunehmen ist.

3. System nach Anspruch 1 oder 2, wobei ein das Schmieröl einschließendes Element in dem Speichertank aufgenommen und das einschließende Element mit dem Schmieröl getränkt ist.

4. System nach Anspruch 1, 2 oder 3, wobei ein Durchflußmengen-Steuerventil zum Steuern einer aus dem Speichertank zu dem Zufuhrteil geführten Schmierölmenge vorgesehen ist.

Hierzu 7 Seite(n) Zeichnungen

Nummer: DE 197 54 454 A1
Int. Cl.6: F 16 C 33/66
Offenlegungstag: 10. Juni 1998

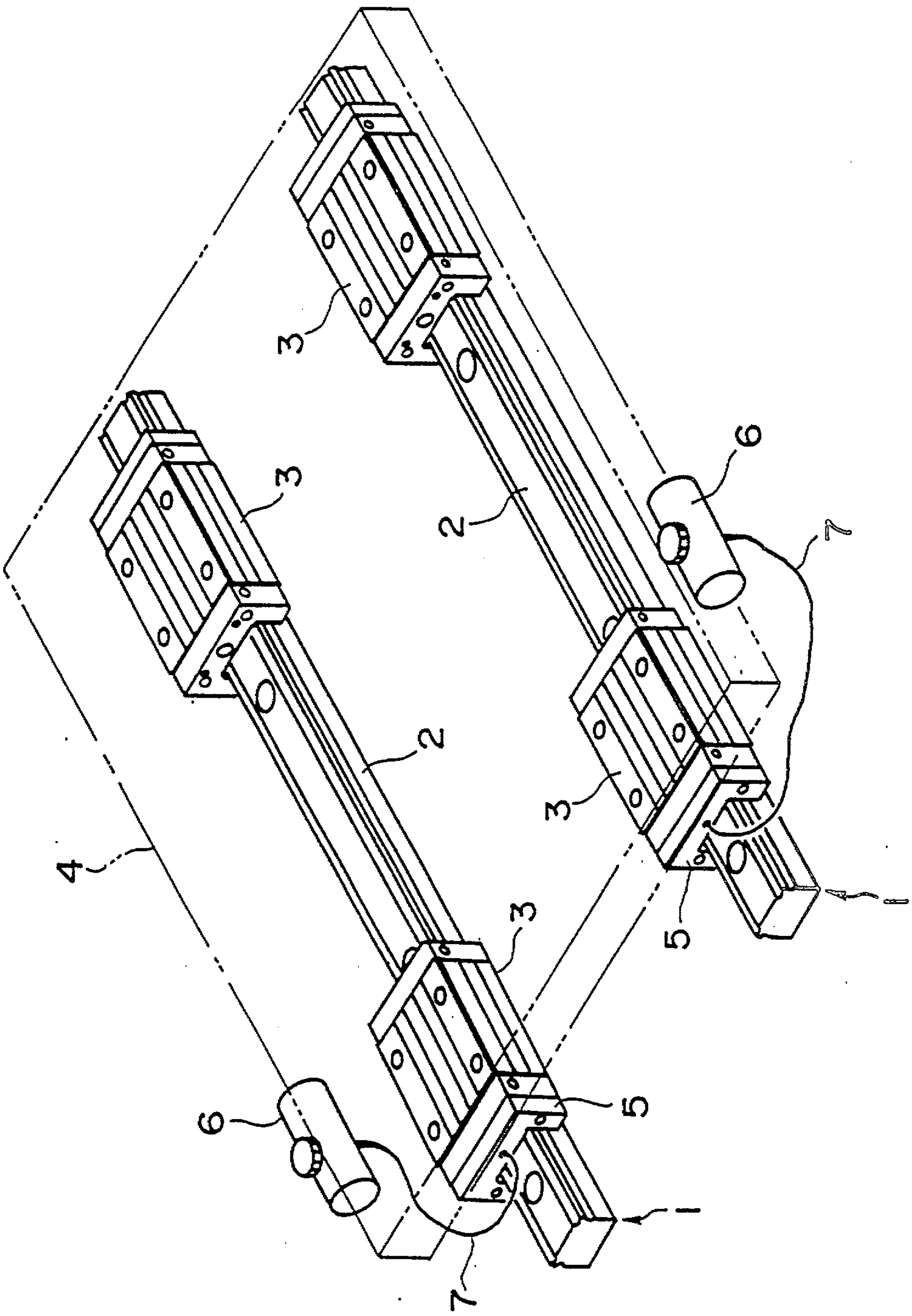
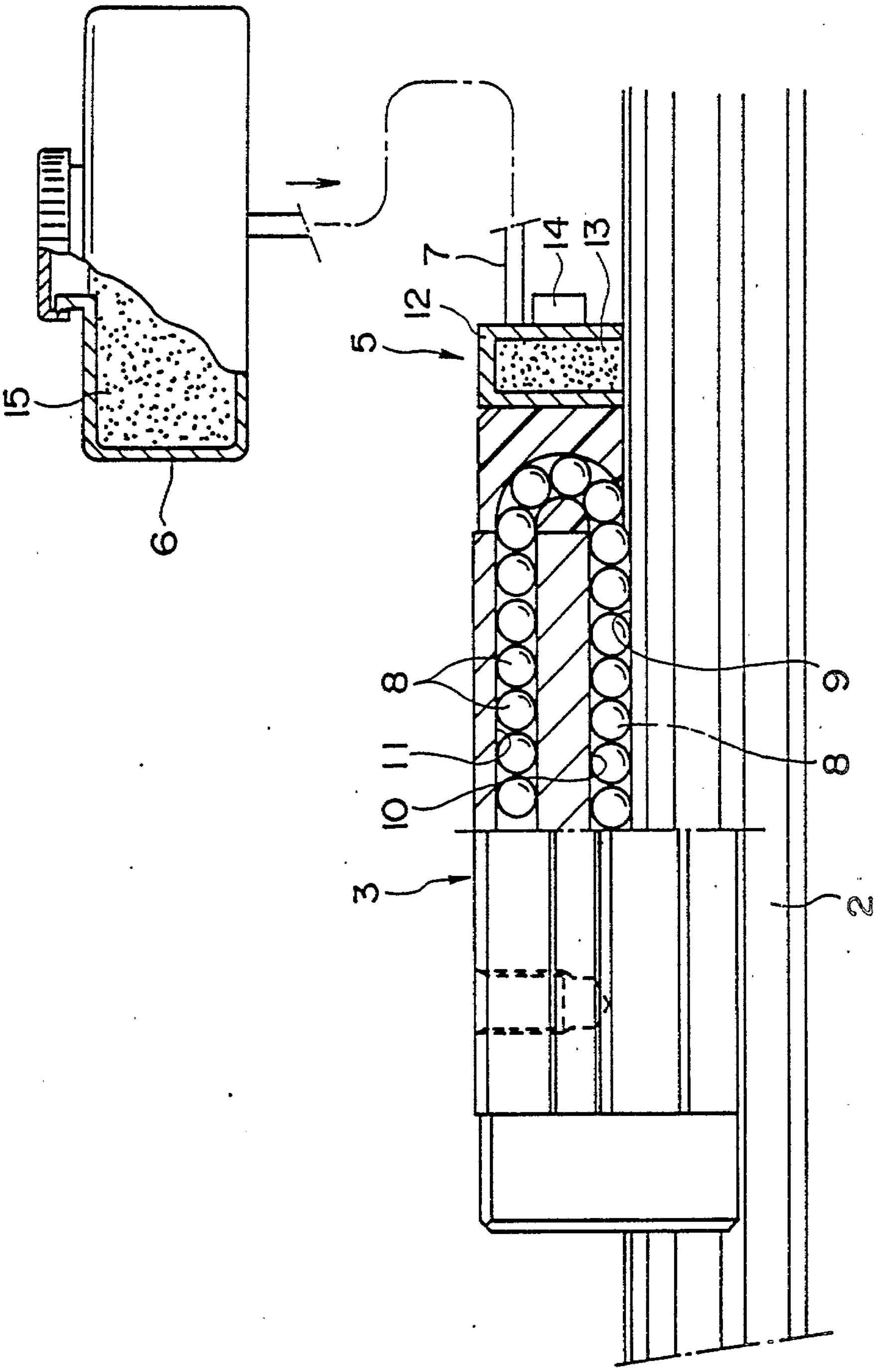


FIG. 1

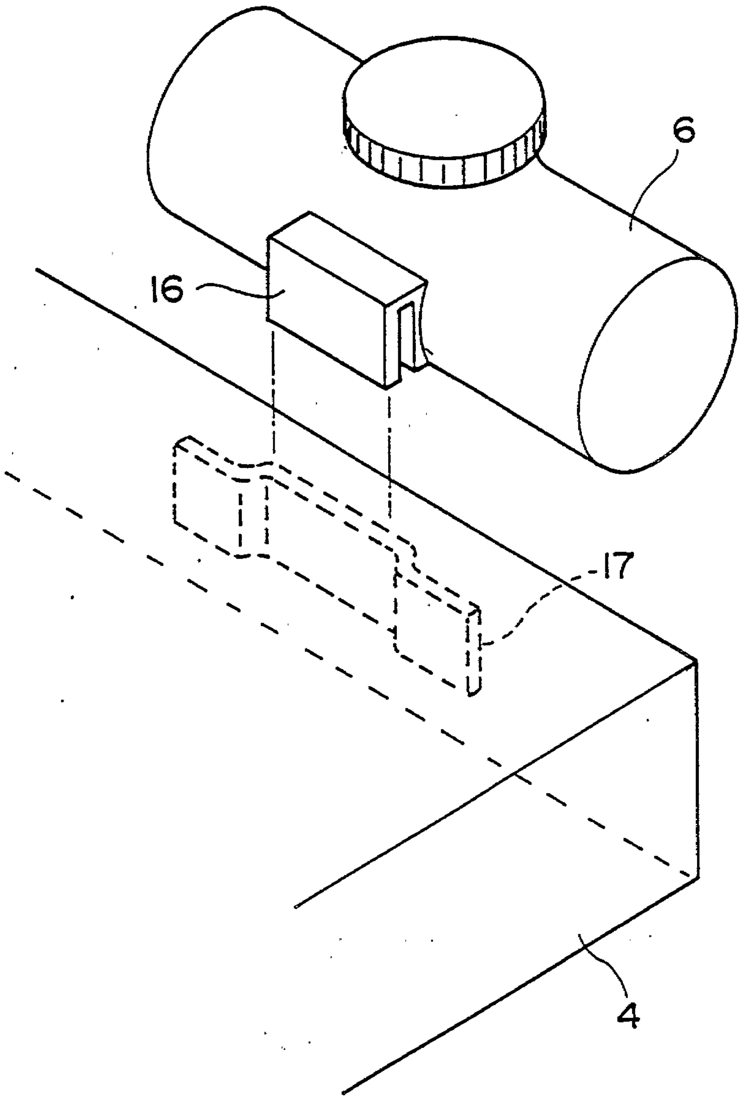
Nummer: **DE 197 54 454 A1**
Int. Cl.[6]: **F 16 C 33/66**
Offenlegungstag: 10. Juni 1998

F I G. 2

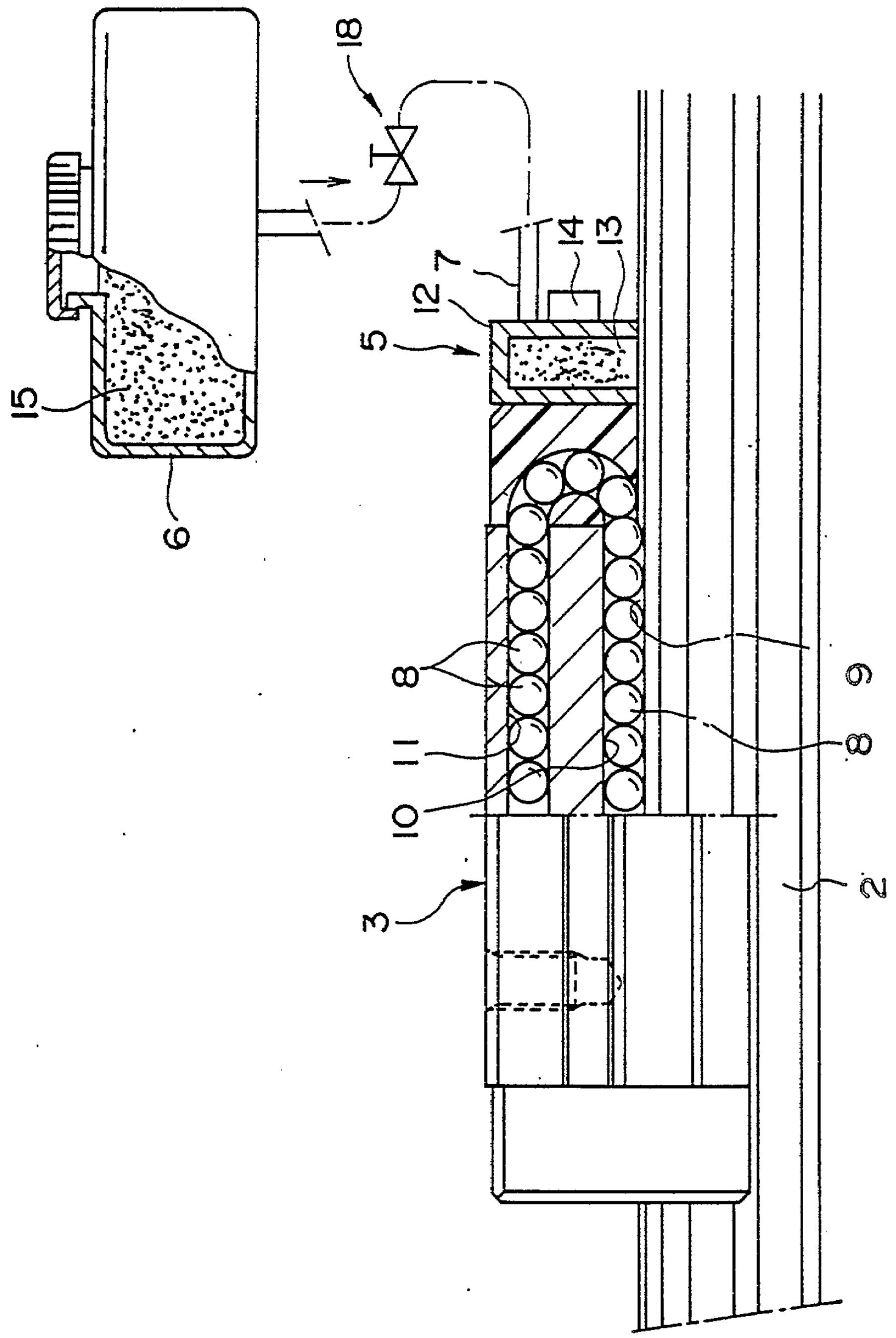


Nummer: **DE 197 54 454 A1**
Int. Cl.[6]: **F 16 C 33/66**
Offenlegungstag: 10. Juni 1998

F I G. 3

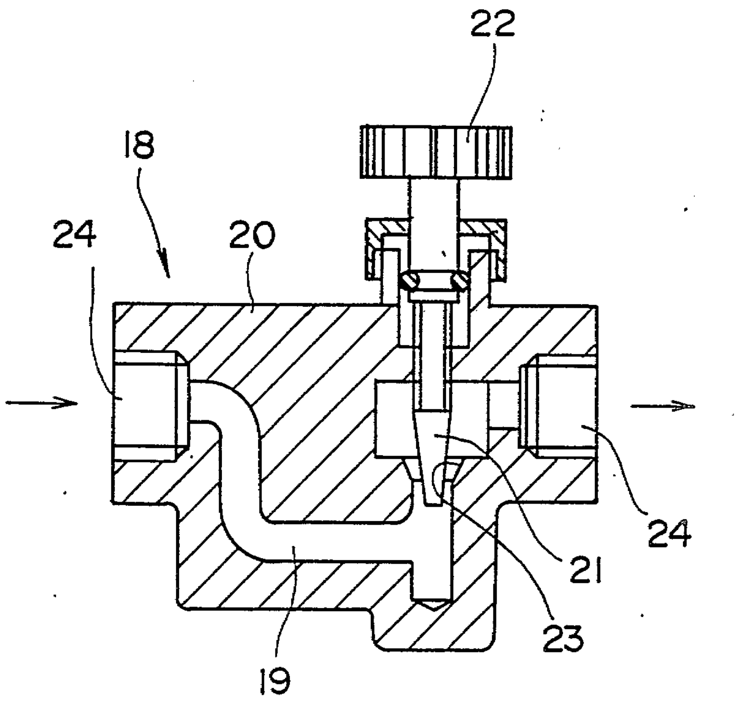


Nummer: DE 197 54 454 A1
Int. Cl.[6]: F 16 C 33/66
Offenlegungstag: 10. Juni 1998



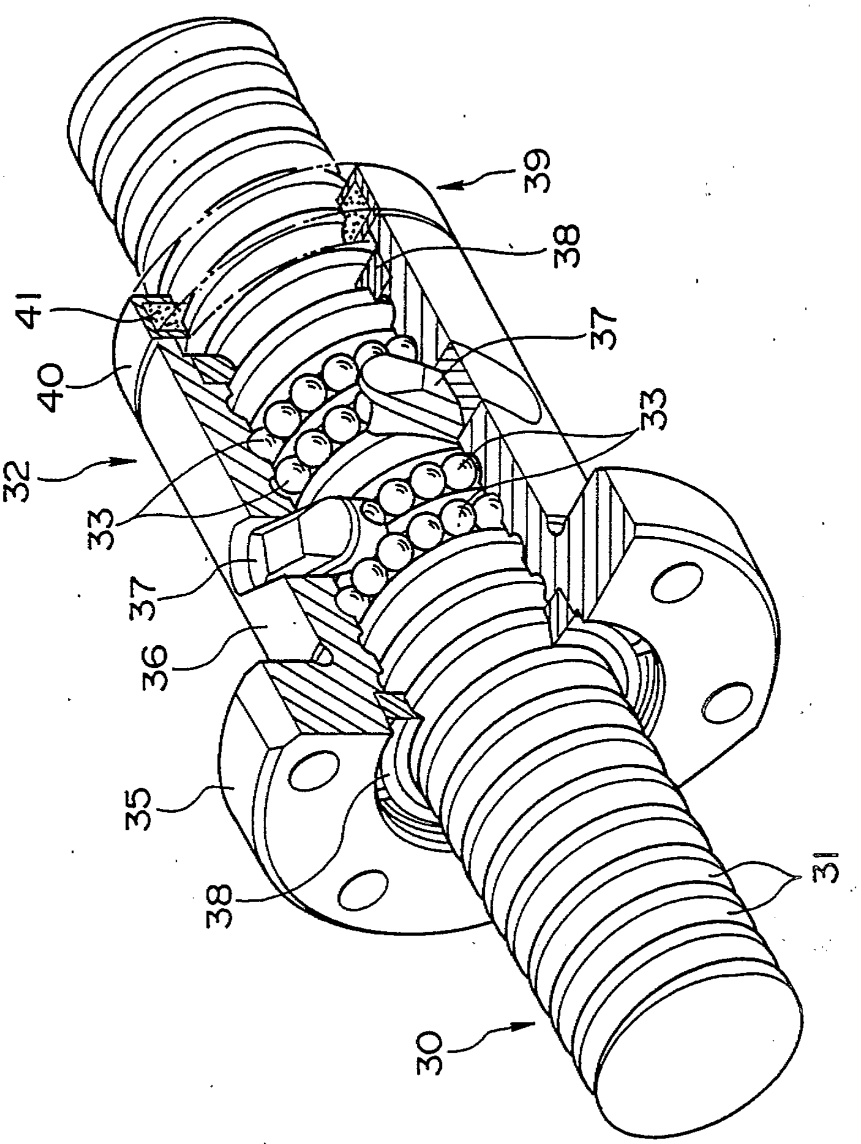
F I G. 4

F I G. 5

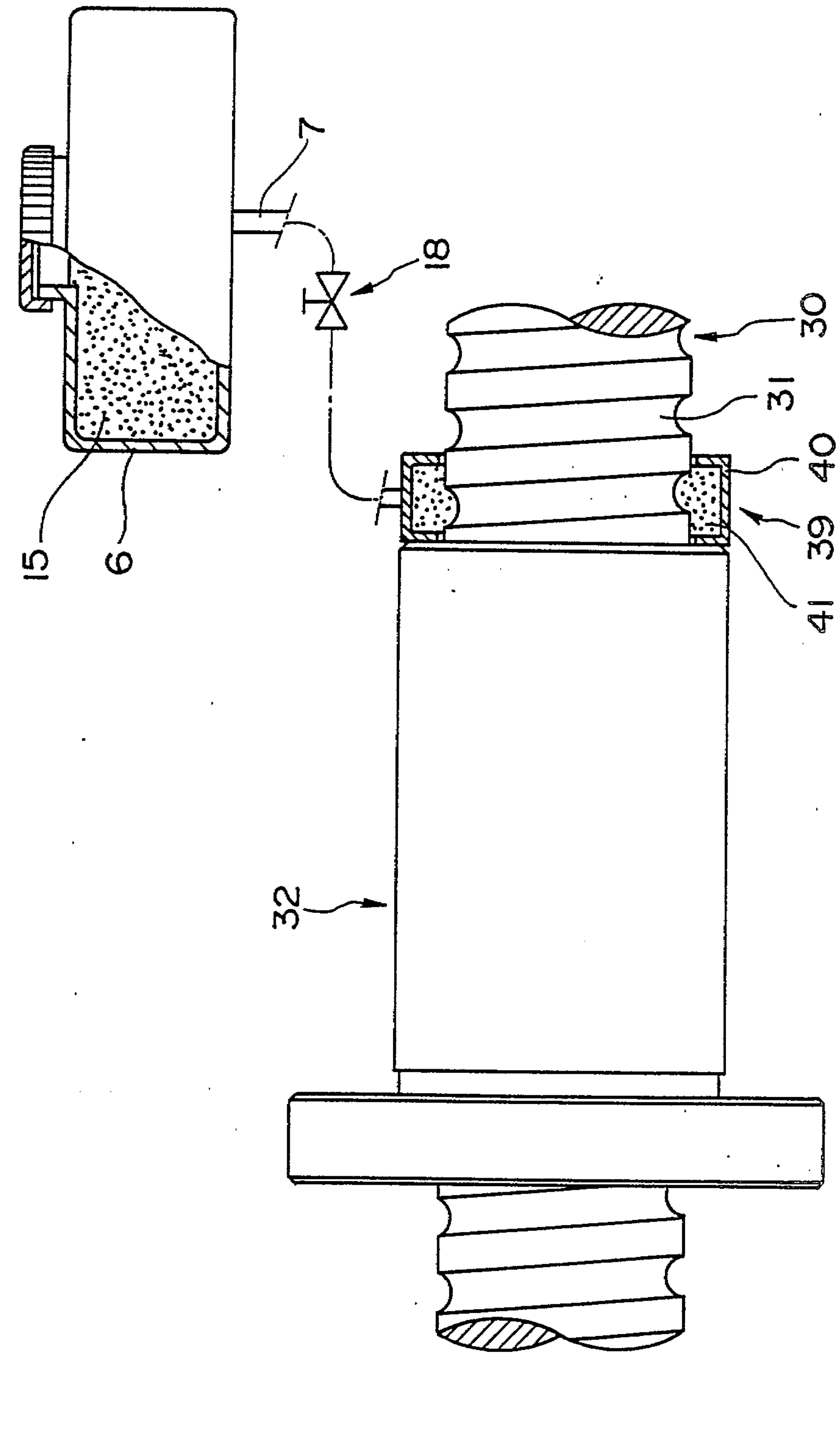


Nummer: **DE 197 54 454 A1**
Int. Cl.[6]: **F 16 C 33/66**
Offenlegungstag: 10. Juni 1998

F I G. 6



Nummer: **DE 197 54 454 A1**
Int. Cl.[6]: **F 16 C 33/66**
Offenlegungstag: 10. Juni 1998



F I G. 7

(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENTAMT

(12) **Offenlegungsschrift**

(10) **DE 197 47 146 A 1**

(51) Int. Cl.[6]:
F 16 H 25/20

(21) Aktenzeichen: 197 47 146.3
(22) Anmeldetag: 24. 10. 97
(43) Offenlegungstag: 28. 5. 98

DE 197 47 146 A 1

(30) Unionspriorität:
8-299268 24. 10. 96 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Grünecker, Kinkeldey, Stockmair & Schwanhäusser, Anwaltssozietät, 80538 München

(72) Erfinder:
Ishikawa, Hirokazu, Tokio/Tokyo, JP; Shirai, Takeki, Tokio/Tokyo, JP; Hirokawa, Tadashi, Tokio/Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Linearbewegungsvorrichtung

(57) Eine Linearbewegungsvorrichtung umfaßt eine geradlinige Führungsschiene mit einer Rollenlaufrille; eine Vorschubgewindestange, die drehbar parallel zur Führungsschiene angeordnet ist; und einen bewegbaren Block, der auf der Führungsschiene über Rollenkörper angeordnet und mit einem Mutternabschnitt, der eine Gewindebohrung aufweist, in die die Vorschubgewindestange einschraubbar ist, versehen ist. Der bewegbare Block umfaßt (i) einen Blockkörper mit einer Gegenrollenlaufrille, die der Rollenlaufrille der Führungsschiene zugekehrt ist und einen Rollenkörperrückführdurchlaß sowie (ii) Richtungswechseldurchlässe formende Teile, die jeweils auf beiden Seiten des Blockkörpers vorgesehen sind, wobei jedes der Teile einen U-förmigen Richtungswechseldurchlaß bildet, der die Gegenrollenlaufrille und den Rollenkörperrückführdurchlaß miteinander verbindet. Der bewegbare Block ist geradlinig auf der Führungsschiene durch Drehung der Vorschubgewindestange über die Rollenkörper geradlinig bewegbar. Der Mutternabschnitt ist einteilig auf dem den Richtungswechseldurchlaß bildenden Teil ausgebildet und eine Lage einer Mittelachse der Gewindebohrung des Mutternabschnittes wird durch das den Richtungswechseldurchlaß bildenden Teil aufgrund einer Lage der Gegenrollenlaufrille bestimmt.

DE 197 47 146 A 1

Beschreibung

HINTERGRUND DER ERFINDUNG

Gebiet der Erfindung

Die vorliegende Erfindung bezieht sich auf eine Linearbewegungsvorrichtung, bei der ein bewegbarer Block mit einem Mutternabschnitt, mit dem eine Vorschubgewindestange verschraubt ist, linear auf einer Führungsschiene durch Rotation der Vorschubgewindestange linear bewegt wird.

Beschreibung der verwandten Technik

Bei einer solchermaßen bekannten Linearbewegungsvorrichtung sind eine geradlinige Führungsschiene und eine drehbare Vorschubgewindestange parallel zueinander angeordnet und ein bewegbarer Block ist über eine große Anzahl von Rollkörpern bewegbar auf der Schiene angeordnet.

Der bewegbare Block ist mit einem Mutternabschnitt versehen, der eine Gewindebohrung aufweist, in die die Vorschubgewindestange geschraubt wird. Dementsprechend kann der bewegbare Block auf der Führungsschiene durch die Drehbewegung der Vorschubgewindestange bewegt werden.

Bei der oben beschriebenen, bekannten Linearbewegungsvorrichtung ist eine genaue Maschinenarbeit bezüglich des Parallelverlaufs einer Mittelachse der Gewindebohrung des Mutternabschnittes, der auf dem bewegbaren Block vorgesehen ist, zu einer Gegenrollenlaufrille des bewegbaren Blocks erforderlich, um einen leichten Lauf des bewegbaren Blocks zu erzielen. Aufgrund der Tatsache, daß der bewegbare Block und der Mutternabschnitt getrennt gefertigt werden, ist allerdings eine genaue Lage der Mittelachse der Gewindebohrung des Mutternabschnittes bezüglich der Gegenrollenlaufrille des bewegbaren Blocks schwer zu bestimmen. Da es desweiteren einen unvermeidbaren Arbeitsfehler bei der Fertigung des bewegbaren Blocks und des Mutternabschnittes gibt und darüber hinaus zusätzliche Teile zwischen diesen angeordnet sein können, ist auch die genaue Lage der Mittelachse der Gewindebohrung des Mutternabschnittes bezüglich der Gegenrollenlaufrille des bewegbaren Blocks schwer zu bestimmen. Aus diesem Grunde ist es schwierig, eine korrekte Gewindebohrung im Mutternabschnitt in einer genauen Lagebeziehung zur Gegenrollenlaufrille des bewegbaren Blocks maschinell herzustellen.

ZUSAMMENFASSUNG DER ERFINDUNG

Die vorliegende Erfindung hat daher zum Ziel, eine Linearbewegungsvorrichtung bereitzustellen, die einen einfachen Aufbau aufweist, einen korrekten Parallelverlauf der Mittelachse der Gewindebohrung des Mutternabschnittes, der auf dem bewegbaren Block vorgesehen ist, zu der Gegenrollenlaufrille des bewegbaren Blockes wahrt und einen leichten Lauf des bewegbaren Blocks ermöglicht.

Um das obenerwähnte Ziel zu erreichen, umfaßt die erfindungsgemäße Linearbewegungsvorrichtung folgende Merkmale:

Eine geradlinige Führungsschiene mit einer sich geradlinig erstreckenden Rollenlaufrille;

eine Vorschubgewindestange, die drehbar und parallel zu der Führungsschiene angeordnet ist; und

einen bewegbaren Block, der über eine große Anzahl von Rollkörpern bewegbar auf der Führungsschiene angeordnet und mit einem Mutternabschnitt mit einer Gewindebohrung, in die die Vorschubgewindestange einschraubbar ist, versehen ist;

wobei der bewegbare Block (i) einen Blockkörper mit einer Gegenrollenlaufrille, die der Rollenlaufrille der Führungsschiene zugekehrt ist, und mit einem Rollenrückführdurchlaß, der in einem vorbestimmten Abstand von der Gegenrollenlaufrille angebracht ist,

und (ii) ein Paar Richtungswechseldurchlässe bildende Teile aufweist, die jeweils auf beiden Enden des Blockkörpers vorgesehen sind, wobei ein jedes Teil einen U-förmigen Richtungswechseldurchlaß bildet, der die Gegenrollenlaufrille und den Rollenrückführdurchlaß miteinander verbindet;

wobei der bewegbare Block über die Rollenkörper auf der Führungsschiene durch eine Drehbewegung der Vorschubgewindestange linear bewegt wird;

dadurch gekennzeichnet, daß der Mutternabschnitt einteilig an zumindest einem der Richtungswechseldurchlässe bildenden Teile angeformt ist, und eine Lage einer Mittelachse der Gewindebohrung des Mutternabschnittes über zumindest ein die Richtungswechseldurchlässe bildendes Teil aufgrund der Lage der Gegenrollenlaufrille bestimmt wird.

Gemäß dem oben beschriebenen Merkmal der vorliegenden Erfindung ist es möglich, den genauen Parallelverlauf der Mittelachse der Gewindebohrung des Mutternabschnittes, der auf dem bewegbaren Block vorgesehen ist, zu der Gegenrollenlaufrille des bewegbaren Blocks zu erreichen, da die Lage der Mittelachse der Gewindebohrung des Mutternabschnittes direkt über das den Richtungswechseldurchlaß bildende Teil aufgrund der Lage der Gegenrollenlaufrille bestimmt wird.

Das oben erwähnte, den Richtungswechseldurchlaß bildende Teil kann ein Innenteil, das eine innere Führungsfläche für den Richtungswechseldurchlaß bildet, und ein Außenteil, das eine äußere Führungsfläche für den Richtungswechseldurchlaß bildet, aufweisen und der Mutternabschnitt kann einteilig am inneren Bauteil ausgebildet sein. Gemäß diesem Merkmal kann die Lage der Mittelachse der Gewindebohrung des Mutternabschnittes relativ zur Gegenrollenlaufrille noch genauer bestimmt werden, da das oben erwähnte, innere Bauteil mit dem Ende des Blockkörpers des bewegbaren Blocks, der die Rollenlaufrille aufweist, durchgängig verbunden ist.

Das oben erwähnte Innenteil des den Richtungswechseldurchlaß bildenden Bauteils und der Mutternabschnitt können am Blockkörper einteilig durch ein Verfahren zum Einsatzformen, bei dem die Lage des Blockkörpers aufgrund der Lage der Gegenrollenlaufrille in einer Gußform festgestellt und die Gußform mit einem Formmaterial gefüllt wird, ausgebildet sein. Die einteilige Ausbildung des Innenteils und des Mutternabschnittes mit dem Blockkörper ermöglicht es, eine genaue Lagebeziehung zwischen der Gegenrollenlaufrille des Blockkörpers und dem Mutternabschnitt festzustellen. Insbesondere wird das Innenteil fest am steifen Blockkörper befestigt und die Lage des Innenteils fest gesichert. Dadurch kann das Innenteil am Blockkörper wie geplant an Hand der Lage der Gegenlaufrille ausgestaltet werden und der Mutternabschnitt, der einteilig mit dem Innenteil ausgebildet ist, kann ebenfalls genau parallel zu der Gegenlaufrille ausgestaltet werden.

Das obenerwähnte, den Richtungswechseldurchlaß bildende Teil kann ein Innenteil, das eine innere Führungsfläche für den Richtungswechseldurchlaß bildet, und ein Außenteil, das eine äußere Führungsfläche des Richtungswechseldurchlasses bildet, aufweisen und der Mutternabschnitt kann einteilig am Außenteil ausgebildet sein. Gemäß diesem Merkmal kann die Lage der Mittelachse der Gewindebohrung des Mutternabschnittes relativ zu der Gegenrollenlaufrille genauer bestimmt werden, da die Lage des obenerwähnten Außenteils relativ zu der Gegenrollenlaufrille des Blockkörpers festgestellt wird.

Der obenerwähnte Mutternabschnitt weist vorzugsweise einen Schlitz auf, der am Mutternabschnitt ausgebildet ist und ihn in zwei Teile teilt. Die Phasengänge der Mutterngewindeabschnitte der getrennten Teile des Mutternabschnittes weichen voneinander ab. Gemäß diesem Merkmal ist es möglich, den toten Gang zwischen der Vorschubgewindestange und dem Mutternabschnitt zu verringern, wodurch ein genauer und präziser Lauf des bewegbaren Blocks ermöglicht wird.

Ein Mechanismus zur Abstandseinstellung kann zwischen den getrennten Teilen des Mutternabschnittes vorgesehen sein, um die Gewindegänge des Mutterngewindeabschnittes der obenerwähnten getrennten Teile des Mutternabschnittes voneinander abweichen zu lassen. Gemäß diesem Merkmal ist es möglich, zwischen der Vorschubgewindestange und dem Mutternabschnitt eine größere Vorspannung aufzubringen.

KURZE BESCHREIBUNG DER ZEICHNUNGEN

Fig. 1 zeigt eine Draufsicht, die eine Linearbewegungsvorrichtung gemäß der ersten Ausführungsform der vorliegenden Erfindung erläutert;

Fig. 2 zeigt eine Vorderansicht der Linearbewegungsvorrichtung nach **Fig.** 1;

Fig. 3 zeigt eine Schnittansicht entlang einer Linie A-A in **Fig.** 1;

Fig. 4 zeigt eine Schnittansicht entlang einer Linie B-B in **Fig.** 2;

Fig. 5 zeigt eine Schnittansicht, die eine Linearbewegungsvorrichtung gemäß der zweiten Ausführungsform der vorliegenden Erfindung erläutert.

GENAUE BESCHREIBUNG DER BEVORZUGTEN AUSFÜHRUNGSFORMEN

Im folgenden werden die erfindungsgemäßen Ausführungsformen, wie in den Zeichnungen gezeigt, genauer beschrieben.

Fig. 1 bis 4 erläutern die Linearbewegungsvorrichtung der ersten Ausführungsform der vorliegenden Erfindung.

Eine geradlinige Führungsschiene **2** und eine Vorschubgewindestange **3** sind parallel zueinander zwischen einem Paar Lagerkörper angeordnet. Die Vorschubgewindestange kann mittels eines Antriebsmotors **4** gedreht werden. Ein bewegbarer Block **5** ist auf der Führungsschiene **2** linear bewegbar über eine große Anzahl von Rollkörpern **6**, beispielsweise Kugeln, angeordnet.

Der bewegbare Block **5** ist mit einem Mutternabschnitt **8** mit einer Gewindebohrung, in die die obenerwähnte Vorschubgewindestange **3** geschraubt wird, versehen.

Die Führungsschiene **2** ist mit einem Paar Rollenlaufrillen **9** versehen, die sich geradlinig erstrecken.

Der bewegbare Block **5** umfaßt einen Blockkörper **12** und ein Paar den Richtungswechseldurchlaß bildende Teile **14**. Der Blockkörper **12** weist eine Gegenrollenlaufrille **10**, die der Rollenlaufrille der Führungsschiene **2** zugekehrt ist, und einen Rollenrückführdurchlaß **11** auf, der in einem vorbestimmten Abstand von der Gegenrollenlaufrille **10** angeordnet ist. Die den Richtungswechseldurchlaß bildenden Teile **14** sind jeweils auf beiden Enden des Blockkörpers **12** vorgesehen. Jedes der den Richtungswechseldurchlaß bildende Teile **14** bildet einen U-förmigen Richtungswechseldurchlaß **13**, der die Gegenrollenlaufrille **10** und den Rollenrückführdurchlaß **11** miteinander verbindet.

Der obenerwähnte Mutternabschnitt **8** ist einteilig am Richtungswechseldurchlaß bildenden Teil **14** ausgebildet. Die Lage der Mittelachse der Gewindebohrung **7** des Mutternabschnittes **8** wird durch das den Richtungswechseldurchlaß bildende Teil **14** aufgrund der Lage der Gegenrollenlaufrille **10** bestimmt.

Insbesondere weist das den Richtungswechseldurchlaß bildende Teil **14** ein Innenteil **15** aus Kunstharz, das eine innere Führungsfläche **13**a für den U-förmigen Richtungswechseldurchlaß **13** bildet, und eine Seitenplatte **16** aus Kunstharz als ein Außenteil, das eine äußere Führungsfläche **13**b für den Richtungswechseldurchlaß **13** bildet, auf. In der ersten Ausführungsform der vorliegenden Erfindung ist der Mutternabschnitt **8** einteilig am obenerwähnten Innenteil **15** ausgebildet.

Die Lage der Mittelachse der Gewindebohrung **7** des Mutternabschnittes **8** wird direkt durch das Innenteil **15** des den Richtungswechseldurchlaß bildenden Teils **14** aufgrund der Lage der Gegenrollenlaufrille **10** auf diese Weise bestimmt. Das Innenteil **15** ist durchgängig mit dem Ende des Blockkörpers **12** des bewegbaren Blockes **5**, der die Gegenrollenlaufrille **10** aufweist, verbunden. Dadurch ist es möglich, den genauen Parallelverlauf der Mittelachse der Gewindebohrung **7** des Mutternabschnittes **8** zu der Rollenlaufrille **10** des bewegbaren Blocks **5** zu erreichen. Der obenerwähnte Aufbau verbessert den Parallelverlauf der Mittelachse der Gewindebohrung **7** des Mutternabschnittes **8** zu der Gegenrollenlaufrille **10** des bewegbaren Blocks **5**. Selbst wenn ein Verarbeitungsfehler im Parallelverlauf der Mittelachse der Gewindebohrung **7** des Mutternabschnittes **8** zur Gegenrollenlaufrille **10** des bewegbaren Blocks **5** und/oder im Parallelverlauf der Führungsschiene **2** zur Vorschubgewindestange **3** auftritt, können das Innenteil **15** und dem dazu einteilig ausgebildeten Mutternabschnitt **8**, die beide aus Kunstharz bestehen, einen solchen Verarbeitungsfehler ausgleichen.

Zusätzlich sind in der ersten Ausführungsform der vorliegenden Erfindung das Innenteil **15** des den Richtungswechseldurchlaß bildenden Teils **14** und der Mutternabschnitt **8** einteilig durch ein Verfahren zum Einsatzformen, bei dem die Lage des Blockkörpers **12** aufgrund der Lage der Gegenrollenlaufrille **10** in einer Gußform bestimmt und die Gußform mit Kunstharz als Formmaterial gefüllt wird, einteilig am Blockkörper **12** ausgebildet. In dieser Ausführungsform ist der Mutternabschnitt **8** auf einer Seite des Blockkörpers **12**, d. h. der Vorschubgewindestangenseite des Blockkörpers **12**, angeordnet und jede der beiden Endflächen des Blockkörpers **12** wird durch das Innenteil **15** und einem aus Kunstharz gebildeten, einteilig daran angeformten Abschnitt bedeckt, die beide auch einteilig mit dem Mutternabschnitt **8** gestaltet sind. Des weiteren wird die Innenfläche des Rollenrückführdurchlasses **11** des Blockkörpers **12** durch einen aus Kunstharz geformten Abschnitt **20** bedeckt, der einteilig mit dem Innenteil **15** und dem aus Kunstharz geformten Abschnitt **19** ausgebildet ist.

Wenn das Innenteil **15** und der Mutternabschnitt **8** in dieser Art einteilig mit dem Blockkörper **12** gebildet sind, ist es möglich, die genaue Lagebeziehung zwischen der Gegenrollenlaufrille **10** des Blockkörpers und dem Mutternabschnitt **8** zu bestimmen. Insbesondere ist das Innenteil fest an dem Blockkörper **12**, der eine hohe Steifigkeit aufweist, befestigt und die Lage des Innenteils ist fest gesichert. Daher kann das Innenteil **15** am Blockkörper **12** genau geformt werden, wie aufgrund der Lage der Gegenrollenlaufrille **10** vorgesehen. Der Mutternabschnitt **8**, der einteilig mit dem Innenteil **15** ausgebildet ist, kann ebenfalls genau parallel zu der Gegenrollenlaufrille **10** ausgebildet werden.

Zusätzlich weist der Mutternabschnitt **8** einen Schlitz **17** auf, der auf dem Mutternabschnitt **8** ausgebildet ist und ihn in zwei Teile teilt, wobei die Phasengänge der Mutterngewindeabschnitte der beiden Teile **81, 81** voneinander abweichen.

Bei diesem Aufbau wird eine niedrige Vorspannung auf die Vorschubgewindestange **3** durch die Rückstellkraft, die von der Elastizität der getrennten Teile **81, 81** des Mutternabschnittes **8** erzeugt wird, aufgebracht. Daher ist es möglich, den toten Gang zwischen der Vorschubgewindestange **3** und dem Mutternabschnitt **8** zu verringern und so den genauen und präzisen Lauf des bewegbaren Blockes **5** zu ermöglichen.

Wenn ein Mechanismus **18** zum Einstellen eines Abstandes, wie beispielsweise einer Einstellschraube, die die Phasengänge der Mutterngewindeabschnitte der getrennten Teile **81, 81** des Mutternabschnittes **8** zueinander verstellt, zwischen den getrennten Teilen **81, 81** wie in einer doppelt strichpunktierten Linie in **Fig.** 1 gezeigt, vorgesehen ist, so ist es möglich, eine größere Vorspannung zwischen der Vorschubgewindestange **3** und dem Mutternabschnitt **8** aufzubringen.

Im folgenden wird die Linearbewegungsvorrichtung gemäß der zweiten Ausführungsform der vorliegenden Erfindung unter Bezugnahme auf **Fig.** 5 beschrieben.

In der zweiten Ausführungsform der vorliegenden Erfindung ist der Mutternabschnitt **8** einteilig mit der Seitenplatte **16** als ein Außenteil gestaltet, obwohl der Mutternabschnitt **8** einteilig mit dem Innenteil **15** des den Richtungswechseldurchlaß bildenden Teils **14** in der ersten Ausführungsform der vorliegenden Erfindung einteilig ausgestaltet ist.

Die Lage der Seitenplatte **16** als Außenteil wird relativ zur Gegenrollenlaufrille **10** des Blockkörpers **12** bestimmt. Dadurch kann die Lage der Mittelachse der Gewindebohrung **7** des Mutternabschnittes **8** bezüglich der Gegenrollenrücklaufrille **10** genauer bestimmt werden.

Dieser Gesichtspunkt wird im folgenden genau erläutert. Das Innenteil **15**, das einen Teil des den Richtungswechseldurchlaß bildenden Teils **14** darstellt, wird einteilig mit dem Blockkörper **12** an Hand der Lage der Gegenrollenrücklaufrille **10** des Blockkörpers **12** ausgestaltet. Der Blockkörper **12** weist eine so hohe Steifigkeit auf, daß er sich im wesentlichen nicht verformt, und folglich wird die Lage des Innenteils **15**, das fest am Blockkörper **12** befestigt ist, fixiert. Wenn die Innenteile **15**, die jeweils auf beiden Enden des Blockkörpers **12** angeordnet sind, einteilig miteinander entlang der axialen Richtung des Blockkörpers **12** durch Abschnitte aus Kunstharz (nicht gezeigt) verbunden sind, mit denen die Ober- oder Seitenflächen des Blockkörpers **12** und die inneren Umflächen des Rollkörperrückführdurchlasses **11** bedeckt sind, dann werden die Innenteile **15** durch die obenerwähnten, aus Kunstharz geformten Abschnitten begrenzt, eine feste Befestigung der Innenteile **15** am Blockkörper **12** möglich ist.

Die Seitenplatte **16** wird andererseits als ein äußerer Führungsabschnitt für den Richtungswechseldurchlaß **13** zur selben Zeit geformt, zu der ein Muttergewinde zur Bildung des Gewindeloches **7** im Mutternabschnitt **8** geformt wird. Aus diesem Grund kann im Mutternabschnitt **8** die Gewindebohrung **7** mit ihrer axialen Flucht wie geplant ausgestaltet werden und die äußere Führungsfläche **13**b der Seitenplatte **16** kann ebenfalls wie geplant gebildet werden.

Der Richtungswechseldurchlaß **13** wird dadurch gebildet, daß die innere Führungsfläche **13**a des Innenteils **15**, das auf der Endfläche des Blockkörpers **12** ausgebildet ist, der äußeren Führungsfläche **13**b der Seitenplatte **16** zugekehrt wird. Die beiden Enden des solchermaßen gebildeten Richtungswechseldurchlasses **13** sind jeweils mit der Gegenrollenrücklaufrille **10** und dem Rollenkörperrücklaufdurchlaß **11** verbunden, um eine korrekte Ausrichtung dieser Teile zu erhalten. Die glatte Durchgängigkeit des Richtungswechseldurchlasses **13**, der Gegenrollenrücklaufrille **10** und des Rollenkörperrücklaufdurchlasses **11** ist sichergestellt, womit ein glatter Umlauf der Rollenkörper **6** ermöglicht wird.

Das Innenteil **15** und die Seitenplatte **16** als ein Außenteil sind derart ausgebildet, daß die innere Führungsfläche **13**a des Innenteils **15** der äußeren Führungsfläche **13**b der Seitenplatte **16** gegenüber zu liegen kommt und den Richtungswechseldurchlaß **13** bildet. Dabei ist die Seitenplatte **16** fest bezüglich der Seitenfläche des Blockkörpers **12** befestigt und der Mutternabschnitt **8** ist einteilig mit der Seitenplatte **16** ausgebildet. Dadurch ist eine genaue Bestimmung der Lage der Mittelachse der Gewindebohrung **7** des Mutternabschnittes **8** bezüglich der Gegenrollenlaufrille **10** des Blockkörpers **12** genau zu bestimmen und die Beibehaltung des korrekten Parallelverlaufs der Mittelachse der Gewindebohrung **7** des Mutternabschnittes **8** zu der Gegenrollenlaufrille **10** des Blockkörpers **12** möglich.

In der oben beschriebenen zweiten Ausführungsform der vorliegenden Erfindung ist der Mutternabschnitt **8** einteilig mit einem der Paare von Seitenplatten **16,16** ausgebildet. Zwei Mutternabschnitte **8, 8** können jedoch auch einteilig mit jeweils den beiden Seitenplatten **16, 16** ausgebildet sein. In solch einem Fall ist es im Gegensatz zu der ersten und zweiten Ausführungsform der vorliegenden Erfindung nicht notwendig, einen Schlitz auf dem Mutternabschnitt zu fertigen, um eine Vorspannung auf die Vorschubgewindestange **3** aufzubringen.

Gemäß der vorliegenden, im Detail beschriebenen Erfindung ist es möglich, einen genauen Parallelverlauf der Mittelachse der Gewindebohrung des Mutternabschnittes, die auf dem bewegbaren Block vorgesehen ist, zu der Gegenrollenlaufrille des bewegbaren Blocks zu erhalten, da die Lage der Mittelachse der Gewindebohrung des Mutternabschnittes direkt durch das den Richtungswechseldurchlaß bildende Teil aufgrund der Lage der Gegenrollenlaufrille bestimmt ist.

Wenn der Mutternabschnitt einteilig am Innenteil des den Richtungswechseldurchlasses bildenden Teils ausgebildet ist, so kann die Lage der Mittelachse der Gewindebohrung des Mutternabschnittes genauer zu der Gegenrollenlaufrille bestimmt werden, da das oben angeführte Innenteil durchgängig mit dem Ende des Blockkörpers des bewegbaren Blockes, der die Gegenrollenlaufrille aufweist, verbunden ist.

Wenn das oben erwähnte Innenteil des den Richtungswechseldurchlaß bildenden Teils und der Mutternabschnitt einteilig am Blockkörper mittels eines Verfahrens mit einer Einsatzform ausgebildet werden, bei der die Lage des Blockkörpers aufgrund der Lage der Gegenrollenlaufrille in einer Gußform bestimmt und die Gußform mit einem Formmaterial gefüllt wird, ist die Bestimmung der genauen Lagebeziehung zwischen der Gegenrollenlaufrille des Blockkörpers und des Mutternabschnittes möglich.

Wenn der Mutternabschnitt einteilig am Außenteil des den Richtungswechseldurchlaß bildenden Teils ausgebildet ist, kann die Lage der Mittelachse der Gewindebohrung des Mutternabschnittes bezüglich der Gegenrollenlaufrille genauer bestimmt werden, da die Lage des obenerwähnten Außenteils relativ zu der Gegenrollenlaufrille des Blockkörpers bestimmt ist.

Wenn der obenerwähnte Mutternabschnitt einen Schlitz aufweist, der den Mutternabschnitt in zwei Teile teilt und wenn die Phasengänge der Mutterngewindeabschnitte der getrennten Teile des Mutternabschnittes voneinander abweichen, ist es möglich, den toten Gang zwischen der Vorschubgewindestange und dem Mutternabschnitt zu reduzieren und so die genaue und präzise Bewegung des bewegbaren Blockes zu ermöglichen.

Wenn ein Mechanismus zur Abstandseinstellung zwischen den getrennten Teilen des Mutternabschnittes vorgesehen ist, um die Phasengänge der Mutterngewindeabschnitte der obenerwähnten getrennten Teile des Mutternabschnittes voneinander abweichen zu lassen, dann ist es möglich, eine höhere Vorspannung zwischen der Vorschubgewindestange und dem Mutternabschnitt aufzubringen.

Patentansprüche

1. Linearbewegungsvorrichtung, die folgende Merkmale umfaßt:
Eine geradlinige Führungsschiene (**2**) mit einer sich geradlinig erstreckenden Rollenlaufrille (**9**);
eine Vorschubgewindestange (**3**), die drehbar und parallel zu der Führungsschiene (**2**) angeordnet ist; und
einen bewegbaren Block (**5**), der auf der Führungsschiene (**2**) über eine große Anzahl von Rollenkörpern (**6**) bewegbar angeordnet ist und bei dem ein Mutternabschnitt (**8**), der eine Gewindebohrung (**7**) aufweist, in die die Vorschubgewindestange (**3**) einschraubbar ist, vorgesehen ist;
wobei der bewegbare Block (**5**) (i) einen Blockkörper (**12**) mit einer Gegenrollenlaufrille (**10**), die der Rollenlaufrille (**9**) der Führungsschiene (**2**) zugekehrt ist, und
mit einem Rollenrückführdurchlaß (**11**), der in einem vorbestimmten Abstand von der Gegenrollenlaufrille (**10**) angeordnet ist und (ii) ein Paar von Richtungswechseldurchlässen bildenden Teilen (**14**), die jeweils an beiden Enden des Blockkörpers (**12**) vorgesehen sind, wobei jedes der Teile einen U-förmigen Richtungswechseldurchlaß (**13**) bildet, der die Gegenrollenlaufrille (**10**) und den Rollenrückführdurchlaß (**11**) miteinander verbindet, aufweist;
der bewegbare Block (**5**) ist durch Drehung der Vorschubgewindestange (**3**) geradlinig auf der Führungsschiene (**2**) über die Rollenkörper (**6**) bewegbar;
dadurch gekennzeichnet, daß der Mutternabschnitt (**8**) einteilig an zumindest einem der den Richtungswechseldurchlaß bildenden Teile (**14**) ausgebildet ist und daß eine Lage einer Mittelachse der Gewindebohrung (**7**) des Mutternabschnittes (**8**) durch zumindest einem der den Richtungswechseldurchlaß bildenden Teile (**14**) an Hand einer Lage der Gegenrollenlaufrille (**10**) bestimmt wird.

2. Linearbewegungsvorrichtung nach Anspruch 1, wobei das den Richtungswechseldurchlaß bildende Teil (**14**) ein Innenteil (**15**), das eine innere Führungsfläche (**13**a) für den Richtungswechseldurchlaß (**13**) bildet, und ein Außenteil (**16**), das eine äußere Führungsfläche (**13**b) für den Richtungswechseldurchlaß (**13**) bildet, aufweist, und wobei der Mutternabschnitt (**8**) einteilig an dem Innenteil (**15**) ausgestaltet ist.

3. Linearbewegungsvorrichtung nach Anspruch 2, wobei das Innenteil (**15**) des den Richtungswechseldurchlaß bildenden Teils (**14**) und der Mutternabschnitt (**8**) einteilig an dem Blockkörper (**12**) mittels eines Einsatzformverfahrens, in der eine Lage des Blockkörpers (**12**) aufgrund einer Lage der Gegenrollenlaufrille (**10**) in einer Gußform festgestellt und die Gußform mit einem Formmaterial gefüllt wird, ausgebildet sind.

4. Linearbewegungsvorrichtung nach Anspruch 1, wobei das den Richtungswechseldurchlaß bildende Teil (**14**) ein Innenteil (**15**), das eine innere Führungsfläche (**13**a) für den Richtungswechseldurchlaß (**13**) bildet, und ein Außenteil (**16**), das eine äußere Führungsfläche (**13**b) für den Richtungswechseldurchlaß (**13**) bildet, aufweist, und wobei der Mutternabschnitt (**8**) einteilig an dem Außenteil (**16**) ausgebildet ist.

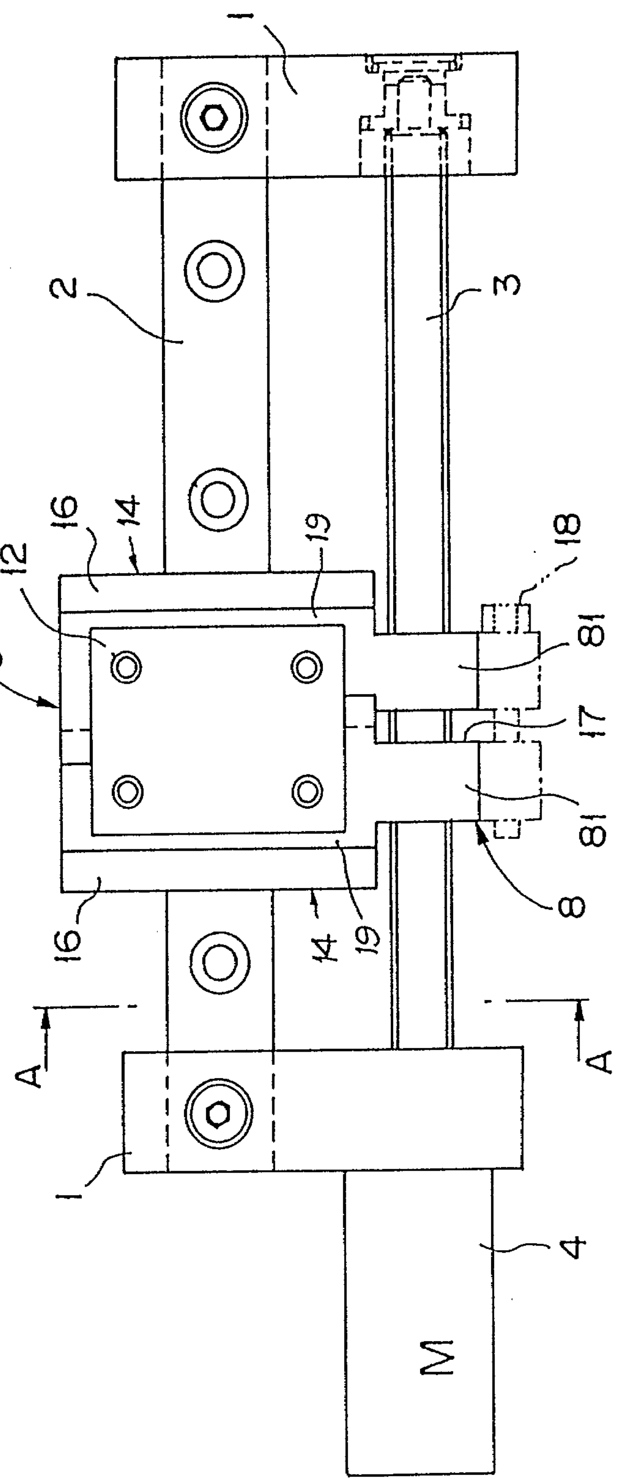
5. Linearbewegungsvorrichtung nach einem der Ansprüche 1 bis 3, wobei der Mutternabschnitt (**8**) einen Schlitz (**17**) aufweist, der auf dem Mutternabschnitt (**8**) ausgebildet ist und den Mutternabschnitt (**8**) in zwei Teile teilt, wobei Phasengänge der Mutterngewindeabschnitte der getrennten Teile des Mutternabschnittes (**8**) voneinander abweichen.

6. Linearbewegungsvorrichtung nach Anspruch 5, wobei ein Mechanismus zur Abstandseinstellung zwischen den getrennten Teilen des Mutternabschnittes (**8**) vorgesehen ist, um die Phasengänge der Mutterngewindeabschnitte der getrennten Teile des Mutternabschnittes (**8**) voneinander abweichen zu lassen.

Hierzu 4 Seite(n) Zeichnungen

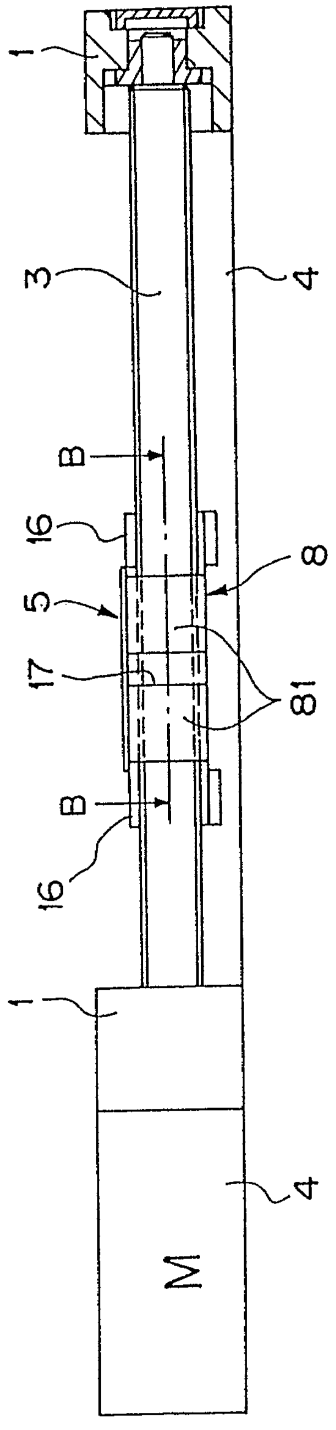
- Leerseite -

Nummer: **DE 197 47 146 A1**
Int. Cl.[6]: **F 16 H 25/20**
Offenlegungstag: 28. Mai 1998



F I G. 1

F I G. 2



Nummer: DE 197 47 146 A1
Int. Cl.⁶: F 16 H 25/20
Offenlegungstag: 28. Mai 1998

FIG. 3

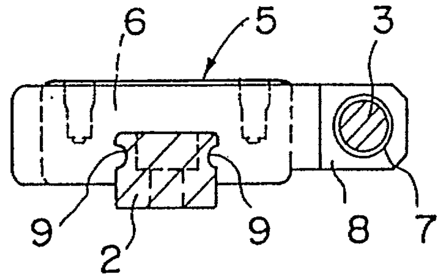
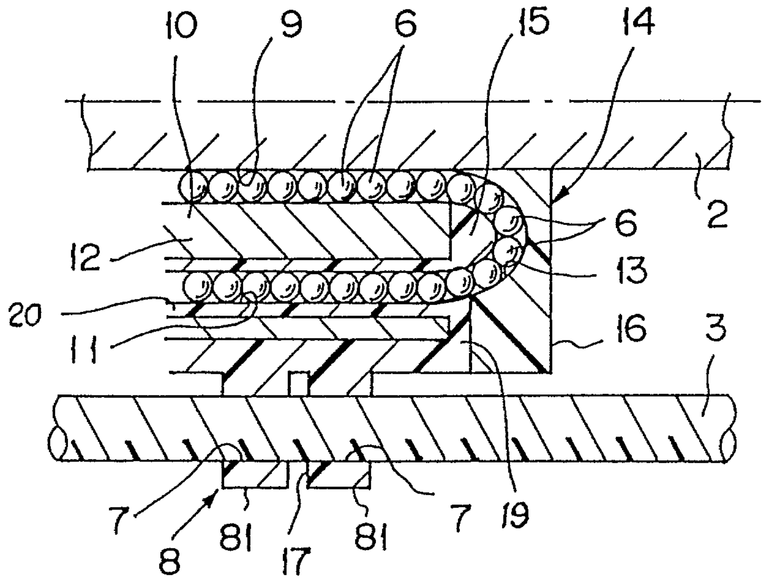
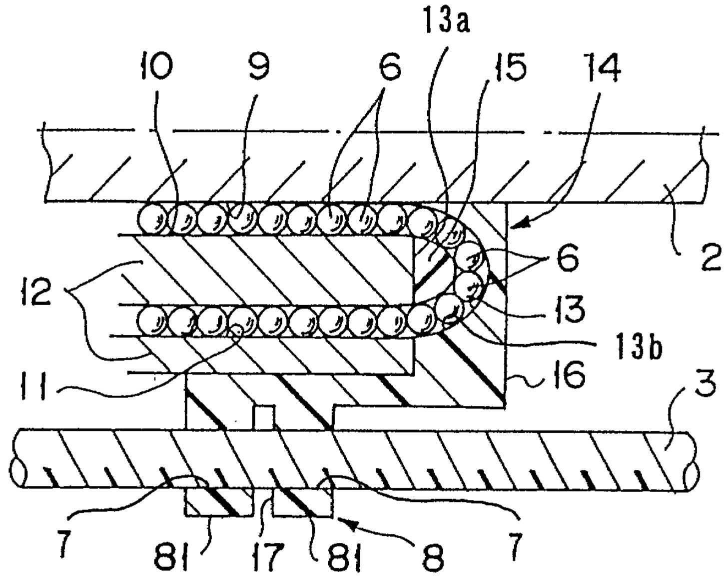


FIG. 4



F I G. 5



(19) Bundesrepublik Deutschland
Deutsches Patent- und Markenamt

(10) **DE 103 93 641 T5** 2005.10.06

(12) **Veröffentlichung**

der internationalen Anmeldung mit der
(87) Veröffentlichungs-Nr.: **WO 2004/044444**
in deutscher Übersetzung (Art. III § 8 Abs. 2 IntPatÜG)
(21) Deutsches Aktenzeichen: **103 93 641.6**
(86) PCT-Aktenzeichen: **PCT/JP2003/014253**
(86) PCT-Anmeldetag: **10.11.2003**
(87) PCT-Veröffentlichungstag: **27.05.2004**
(43) Veröffentlichungstag der PCT Anmeldung
in deutscher Übersetzung: **06.10.2005**

(51) Int Cl.[7]: **F16C 33/58**
F16C 33/64, F16C 29/06, F16H 25/22, B24B 5/04

(30) Unionspriorität:
2002-326800 11.11.2002 JP

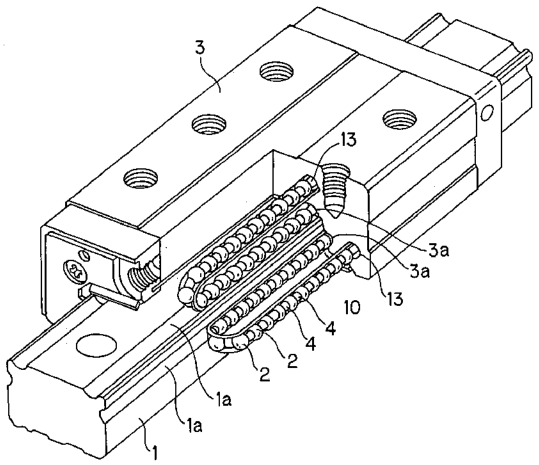
(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Viering, Jentschura & Partner, 80538 München

(72) Erfinder:
Shirai, Takeki, Tokio/Tokyo, JP; Tachikake, Yuuji, Tokio/Tokyo, JP

(54) Bezeichnung: **Bewegungsführungsvorrichtung, Kugelumlaufspindel und Verfahren zum Formen einer Kugellaufrille**

(57) Hauptanspruch: Bewegungsführungsvorrichtung, aufweisend ein Führungsteil und ein bewegbares Teil, bei welcher wenigstens eines des Führungsteils und des bewegbaren Teils mit einer Kugellaufrille versehen ist, die als eine Führungsbahn zu einer Zeit wirkt, wenn eine zwischen dem Führungsteil und dem bewegbaren Teil angeordnete Kugel wälzt,
wobei eine Mehrzahl von elastisch verformbaren, vorstehenden Streifen an der Kugellaufrille derart ausgebildet sind, dass sie sich in einer Richtung erstrecken, in welcher sich die Kugellaufrille erstreckt, und wobei die Kugel, die der Belastung zwischen dem Führungsteil und dem bewegbaren Teil ausgesetzt ist, die mehreren vorstehenden Streifen vor dem Kontaktieren ausgesparter Abschnitte zwischen den mehreren vorstehenden Streifen kontaktiert.



Beschreibung

Technisches Gebiet

[0001] Die vorliegende Erfindung betrifft eine Bewegungsführungsvorrichtung zum Führen einer Linearbewegung oder Drehbewegung eines zu führenden Gegenstandes, bei welcher eine Anzahl von Kugeln, die eine Wälzbewegung durchführen, zwischen einem Spurteil und einem bewegbaren Teil angeordnet sind, oder betrifft eine Kugelumlaufspindel, bei welcher eine Anzahl von Kugeln, die eine Wälzbewegung durchführen, zwischen einer Spindelwelle und einer Mutter angeordnet sind.

Stand der Technik

[0002] Eine Kugellaufrille ist an einem Führungsteil und einem bewegbaren Teil einer Bewegungsführungsvorrichtung als eine Führungsbahn ausgebildet, entlang welcher die Kugeln wälzen. Verschiedene Formen können von der Kugellaufrille entsprechend einer Weise, wie die Last als ein Gegenstand zu tragen ist, angenommen werden.

[0003] Fig. 12 zeigt eine Schnittansicht einer Kugellaufrille. Die Kugellaufrillen umfassen zwei typische Arten von Kreisbogenrille und Spitzbogenrille. Wie in Fig. 12A gezeigt ist, hat die Kreisbogenrille eine Querschnittsform eines Kreisbogens, und wenn die Kugel zwischen dem Führungsteil und dem bewegbaren Teil geklemmt ist, die beide die Kreisbogenrillen aufweisen, kontaktiert die Kugel diese an zwei Punkten, daher „Zweipunktkontakt" genannt. Andererseits hat, wie in Fig. 12B gezeigt ist, die Spitzbogenrille eine Querschnittsform von zwei Kreisbögen, so dass die Kugel üblicherweise an vier Punkten kontaktiert, daher „Vierpunktkontakt" genannt. (Zum Beispiel mit Bezug auf die folgende Nichtpatentliteratur 1).

[0004] Bei der Zweipunktkontaktform sind zwei Kontaktpunkte einander gegenüberliegend, wobei die Kugel dazwischen angeordnet ist, und bei der Vierpunktkontaktform sind vier Kontaktpunkte in einem Winkelabstand von etwa 90 Grad in Bezug auf die Mitte der Kugel ausgebildet. Ferner kann, wenn auch in einem seltenen Fall, eine Dreipunktkontaktform angenommen werden, bei welcher drei Kontaktpunkte in einem gleichen Winkelabstand in Bezug auf die Mitte der Kugel ausgebildet sind. Bei jeder dieser Formen bildet jeder Kontaktpunkt einen Punktkontakt zwischen der Kugel und einer glatten gekrümmten Fläche.

[Nichtpatentliteratur 1]

„Ursprung des Linearsystems", herausgegeben von Linear System Edditing Commissioner, am 15. Juni 2000, Seite 40, von Shimizu und anderen (neun).

[0005] Bei einer herkömmlichen Bewegungsführungsvorrichtung mit einer glatten Kugellaufrille wird die Tragfähigkeit jeder Kugel durch geometrische Formen und Werkstoffe der Kugel und der Kugellaufrille eindeutig bestimmt. Aus diesem Grunde wurde, um die Tragfähigkeit unter Verwendung der Kugeln mit demselben Werkstoff und derselben Abmessung zu erhöhen, ein Verfahren zur Anpassung des Krümmungsradius der Kugellaufrille an den Radius der Kugel angewendet. Jedoch erfordert die Technologie der Anpassung des Krümmungsradius der Kugellaufrille an den Radius der Kugel eine hohe Arbeitsleistung, wodurch die Herstellungskosten steigen, was daher industriell nachteilig ist.

Offenbarung der Erfindung

[0006] Dementsprechend ist es ein Ziel der vorliegenden Erfindung, eine Bewegungsführungsvorrichtung, eine Kugelumlaufspindel und ein Verfahren zu deren Herstellung zu schaffen, ohne den Krümmungsradius der Kugellaufrille an den Radius der Kugel anzupassen.

[0007] Die vorliegende Erfindung wird nachfolgend beschrieben. Um das obige Ziel zu erreichen, konzipierten die Erfinder eine Struktur, bei welcher eine Mehrzahl von elastisch verformbaren, vorstehenden Streifen (Rippen), die sich in einer Richtung erstrecken, entlang welcher sich die Kugellaufrille erstreckt, in der Nähe des Kontaktpunktes der Kugellaufrille in einer Weise ausgebildet sind, dass eine die Last tragende Kugel die mehreren vorstehenden Streifen kontaktiert.

[0008] Das heißt, die Erfindung nach Anspruch 1 stellt eine Bewegungsführungsvorrichtung bereit, bei welcher wenigstens eines des Führungsteils und des bewegbaren Teils mit einer Kugellaufrille als eine Führungsbahn zu einer Zeit, wenn eine zwischen dem Führungsteil und dem bewegbaren Teil angeordnete Kugel wälzt, versehen ist, wobei eine Mehrzahl von elastisch verformbaren, vorstehenden Streifen in der Kugellaufrille derart ausgebildet sind, dass sie sich in einer Richtung erstrecken, in welcher sich die Kugellaufrille erstreckt, und wobei die Kugel, die der Belastung zwischen dem Führungsteil und dem bewegbaren Teil ausgesetzt ist, die mehreren vorstehenden Streifen vor dem Kontaktieren ausgesparter Abschnitte zwischen den mehreren vorstehenden Streifen kontaktiert.

[0009] Gemäß dieser Erfindung werden die Kugel und die Kugellaufrille in einer Mehrzahl von Kontaktpunkten, und nicht einem, miteinander kontaktiert, so dass die auf die Kugel ausgeübte Belastung auf die mehreren Punkte verteilt wird und daher das Auftreten einer hohen Spannungskonzentration in einem bestimmten Punkt verhindert werden kann. Darüber hinaus wirkt, da sich die Mehrzahl von vorstehenden

Streifen gleichmäßig in einer Richtung erstrecken, in welcher sich die Kugellaufrille erstreckt, keinerlei Kraft zur Änderung der Drehachse der Kugel und folglich zur Änderung der Drehung der Kugel während des Wälzens der Kugel. Daher wird selbst bei dem Vorhandensein eines Kontaktpunktes oder mehrerer Kontaktpunkte keinerlei Einfluss auf den Widerstand während des Wälzens der Kugel ausgeübt.

[0010] Es ist erwünscht, dass die vorstehenden Streifen derart elastisch verformt werden, dass die Kugel den ausgesparten Abschnitt kontaktiert.

[0011] Gemäß dieser Erfindung kann, da der vorstehende Abschnitt elastisch verformt wird und eine breite Kontaktfläche zwischen der Kugel und der Kugellaufrille sichergestellt werden kann, eine breite Lastfläche an der Kugellaufrille sichergestellt werden.

[0012] Die Bewegungsführungsvorrichtung der vorliegenden Erfindung kann vorzugsweise für eine lineare oder gekrümmte Bewegungsführungsvorrichtung oder ein Wälzlager verwendet werden, bei welchem ein ringförmiges bewegbares Teil an einem ringförmigen Führungsteil drehbar montiert ist.

[0013] Ferner stellt die vorliegende Erfindung eine Kugelumlaufspindel bereit, die eine Spindelwelle und eine Mutter aufweist, bei welcher spiralförmige Kugellaufrillen als ein Führungsteil, das zu einer Zeit wirkt, wenn eine zwischen der Spindelwelle und der Mutter angeordnete Kugel wälzt, in der Spindelwelle und der Mutter ausgebildet sind, wobei eine Mehrzahl von elastisch verformbaren, vorstehenden Streifen in den Kugellaufrillen derart ausgebildet sind, dass sie sich in einer Richtung erstrecken, in welcher sich die Kugellaufrillen erstrecken, und wobei die Kugel, die der Belastung zwischen dem Führungsteil und dem bewegbaren Teil ausgesetzt ist, die mehreren vorstehenden Streifen vor dem Kontaktieren ausgesparter Abschnitte zwischen den mehreren vorstehenden Streifen kontaktiert.

[0014] Noch darüber hinaus kann das obige Ziel durch die vorliegende Erfindung erreicht werden, indem ein Verfahren zum Formen einer Kugellaufrille bereitgestellt wird, bei welchem wenigstens eines des Führungsteils und des bewegbaren Teils mit einer Kugellaufrille als eine Führungsbahn versehen ist, die zu einer Zeit wirkt, wenn eine zwischen dem Führungsteil und dem bewegbaren Teil angeordnete Kugel wälzt, wobei das Verfahren die Schritte aufweist: Bewegen eines scheibenförmigen Fräsers oder Schleifsteins mit einem Radius, der kleiner als jener der Kugel ist, in einer Richtung, in welcher sich die Kugellaufrille erstreckt, und Übertragen einer Außenumfangsform des scheibenförmigen Fräsers oder Schleifsteins auf die Kugellaufrille; Bewegen des Fräsers oder Schleifsteins in einer Ebene senkrecht zu einer Richtung, in welcher sich die Kugellaufrille erstreckt; und Bewegen des Fräsers oder Schleifsteins in der Richtung, in welcher sich die Kugellaufrille erstreckt, und Übertragen der Außenumfangsform des scheibenförmigen Fräsers oder Schleifsteins auf die Kugellaufrille, wobei eine Mehrzahl von elastisch verformbaren, vorstehenden Streifen derart geformt werden, dass sie sich in der Richtung erstrecken, in welcher sich die Kugellaufrille erstreckt.

[0015] Gemäß dieser Erfindung können die mehreren ausgesparten Abschnitte einen Krümmungsradius bereitstellen, der kleiner als der Radius der Kugel ist, so dass die Kugel und die Kugellaufrille in einer Mehrzahl von Kontaktpunkten, und nicht einem kontaktieren.

KURZBESCHREIBUNG DER ZEICHNUNGEN

[0016] Fig. 1 ist eine perspektivische Ansicht (mit einem teilweisen Schnitt) einer Bewegungsführungsvorrichtung (Linearführung) gemäß einer ersten Ausführungsform der vorliegenden Erfindung.

[0017] Fig. 2 ist eine Schnittansicht einer endlosen Umlaufbahn entlang einer Erstreckungsrichtung einer endlosen Umlaufbahn der Bewegungsführungsvorrichtung der obigen Ausführungsform.

[0018] Fig. 3 ist eine Schnittansicht der Kugellaufrille in einer Ebene senkrecht zu der Erstreckungsrichtung der Kugellaufrille.

[0019] Fig. 4 ist eine Ansicht, die eine Verteilung einer erzeugten Spannung (Von Mses Spannung) darstellt (in dem Fall, dass die Kugel und die glatte Fläche in einem Punkt kontaktieren).

[0020] Fig. 5 ist eine Ansicht, die eine Verteilung einer erzeugten Spannung (Von Mses Spannung) darstellt (in dem Fall, dass die Kugel und die glatte Fläche in zwei Punkten kontaktieren.

[0021] Fig. 6 ist eine Ansicht, die eine Verteilung einer erzeugten Scherkraft (XY Scher) darstellt (in dem Fall, dass die Kugel und die glatte Fläche in einem Punkt kontaktieren.

[0022] Fig. 7 ist eine Ansicht, die eine Verteilung einer erzeugten Scherkraft (XY Scher) darstellt (in dem Fall, dass die Kugel und die glatte Fläche in zwei Punkten kontaktieren).

[0023] Fig. 8 ist eine Ansicht, die ein Verfahren zum Formen einer Kugellaufrille zeigt (Schnittansicht in einer Richtung senkrecht zu der Kugellaufrille).

[0024] Fig. 9 ist eine perspektivische Ansicht einer Bewegungsführungsvorrichtung (Kugelrille) gemäß einer zweiten Ausführungsform der vorliegenden Erfindung.

[0025] Fig. 10 ist eine perspektivische Ansicht einer Kugelumlaufspindel gemäß einer dritten Ausführungsform der vorliegenden Erfindung.

[0026] Fig. 11 ist eine Schnittansicht eines Radialwälzlagers gemäß einer vierten Ausführungsform der vorliegenden Erfindung.

[0027] Fig. 12 ist eine Schnittansicht einer herkömmlichen üblichen Kugellaufrille (in welcher Fig. 12A eine Kreisbogenrille und Fig. 12B eine Spitzbogenrolle zeigt).

BEVORZUGTE AUSFÜHRUNGSFORM DER ERFINDUNG

[0028] Fig. 1 zeigt eine perspektivische Ansicht einer Bewegungsführungsvorrichtung gemäß der ersten Ausführungsform der vorliegenden Erfindung, welche eine Linearführung als eine lineare Bewegungsführungsvorrichtung zeigt. Die Linearführung ist mit einer Führungsschiene **1** als ein Führungsteil und einem bewegbaren Block **3** als bewegbares Teil versehen, der an der Führungsschiene **1** mittels einer Anzahl von Kugeln **2** verschiebbar montiert ist. Die Führungsschiene **1** ist ein sich längs erstreckendes Teil, das derart ausgebildet ist, dass es eine etwa rechteckige Querschnittsform senkrecht zu der Längsrichtung der Führungsschiene **1** bildet, und Kugellaufrillen **1a**, **1a**, die Führungsbahnen während des Wälzens der Kugel bilden, sind in deren oberen Fläche und beiden Seitenflächen entlang einer gesamten Länge der Führungsschiene **1** ausgebildet.

[0029] Ferner kann die Führungsschiene **1** eine lineare Struktur oder eine gekrümmte Struktur aufweisen, und in der dargestellten Ausführungsform kann, obwohl zwei Reihen von Kugellaufrillen **1a**, **1a** an jeder der seitlichen Seiten ausgebildet sind, d.h. insgesamt vier an beiden Seiten, die Anzahl solcher Reihen von Rillen entsprechend dem Gebrauch, der Gegenstände oder ähnlich der Linearführung verändert werden.

[0030] Der bewegbare Block **3** ist auch mit Kugellaufrillen **3a**, **3a** versehen, die den Kugellaufrillen **1a**, **1a** entsprechen, die in der Führungsschiene **1** ausgebildet sind. Eine Lastlaufbahn **12** ist zwischen der entsprechenden Kugellaufrille **1a** der Führungsschiene **1** und der Kugellaufrille **3a** des bewegbaren Blockes **3** ausgebildet, zwischen welchen eine Anzahl von Kugeln **2**, **2** in einem Klemmzustand angeordnet sind. Der bewegbare Block **3** ist ferner mit vier Reihen von Rücklaufbahnen **13**, **13**, die sich jeweils parallel zu den Kugellaufrillen **1a**, **1a** erstrecken, und Umlenkbahnen **5** versehen, die jeweils die entsprechende Lastlaufbahn **12** und Rücklaufbahn **13** verbinden. Dementsprechend wird durch die Kombination von einer Lastlaufbahn **12**, einer Rücklaufbahn **13** und einem Paar Umlenkbahnen **5**, die diese Lastlaufbahn **12** und die Rücklaufbahn **13** an deren beiden Enden verbinden, eine endlose Umlaufbahn gebildet, wie in Fig. 2 gezeigt ist.

[0031] Fig. 2 ist eine Schnittansicht der endlosen Umlaufbahn in deren Erstreckungsrichtung. In jeder der endlosen Umlaufbahnen sind eine Anzahl von Kugeln **2**, **2** in einem Kettenverbindungszustand mittels Kupplungsteilen **8** untergebracht. Das Kupplungsteil **8** ist mit einer Anzahl von Abstandsstücken **4**, **4** versehen, die in einem vorbestimmten Abstand benachbart zueinander angeordnet sind, und einem Paar Riemen **10**, **10** versehen, die diese Abstandsstücke **4**, **4** an ihren Seitenabschnitten verbinden. Die Kugel **2** ist zwischen den benachbarten Abstandsstücken **4**, **4** angeordnet und gehalten. Flächen der Abstandsstücke **4**, die den Kugelflächen zugewandt sind, sind als sphärisch ausgesparte Flächen derart ausgebildet, dass sie mit der Außenfläche der Kugel übereinstimmen, wodurch der direkte Kontakt der Kugeln **2**, **2** verhindert werden kann und ein sanfter Kugelumlauf in der endlosen Umlaufbahn sichergestellt werden kann.

[0032] Entsprechend der Bewegung des bewegbaren Blocks **3** entlang der Führungsschiene **1** führen die Kugeln **2**, **2** die Wälzbewegung in der Lastlaufbahn **12** von deren einem Ende zu deren anderem Ende unter Belastung durch, werden dann in die eine Umlenkbahn **5** geschoben, und werden danach zu der Rücklaufbahn **13** geführt. Die Kugeln **2**, **2** werden danach weiter in die andere Umlenkbahn **5** geschoben und dann zu dem ersten Ende der Lastlaufbahn **12** zurückgeführt.

[0033] Fig. 3 zeigt eine Schnittansicht der Kugellaufrille **1a** in einer Ebene senkrecht zu der Richtung, entlang welcher sich die Kugellaufrille **1a** erstreckt. Allgemein bildet die Kugellaufrille **1a**, die eine Führungsbahn während des Wälzens der Kugel bildet, eine glatte Fläche und hat eine Form, die uneingeschränkt einer geometrischen Kreisbogenform entspricht. Andererseits sind in der vorliegenden Ausführungsform eine Mehrzahl von vorstehenden Streifen (Rippen) **7** in der Nähe der Kontaktpunkte zwischen der Kugel **2** und der Kugellaufrille **1a** derart ausgebildet, dass sie sich entlang der Kugellaufrille **1a** erstrecken. Dieser vorstehende Streifen **7** bildet keine rauhe Fläche mit beliebigen Aussparungen und Vorsprüngen, sondern hat eine gleichmäßige Form in der Kugelvorlaufrichtung (in einer Richtung senkrecht zu dem Zeichnungsblatt) und kontaktiert die Kugel **2** in einer Mehrzahl von Punkten in einer Ebene senkrecht zu der Kugelvorlaufrichtung. Das Profil der Kugellaufrille **1a**, an welcher die vorstehenden Streifen **7**, **7** ausgebildet sind, kann derart geformt sein, dass es eine Kreisbogenrillenform, Spitzbogenrillenform oder glatte, flache ebene Form bildet.

[0034] Auf die Kugel **2**, die zwischen der Führungsschiene **1** und dem bewegbaren Block **3** angeordnet ist, wird eine Belastung ausgeübt. Die Kugel, auf welche die Belastung einwirkt, kontaktiert, wie in Fig. 3(A) gezeigt ist, die mehreren vorstehenden Streifen **7**, bevor sie die ausgesparten Abschnitte **39**, **39** zwischen den vorstehenden Streifen **7**, **7** kontaktiert. Das heißt, in einem Zustand, in dem die Kugel in der Kugellaufrille platziert ist (d.h. in einem unbelasteten Zustand), kontaktiert die Kugel **2** nur die paarweise vorstehenden Streifen **7**, **7** und kontaktiert nicht die ausgesparten Abschnitte **39**, **39**. wenn die Belastung auf die Kugel **2** ausgeübt wird, wie in Fig. 3(B) gezeigt ist, werden die vorstehenden Streifen **7**, **7** elastisch verformt, und die Kugel **2** kontaktiert auch die ausgesparten Abschnitte **39**, **39**. Zu der Zeit, wenn die Kugel **2** die ausgesparten Abschnitte **39**, **39** zwischen den vorstehenden Streifen **7**, **7** kontaktiert, werden die vorstehenden Streifen **7**, **7** elastisch verformt, jedoch nicht plastisch verformt. Aus diesem Grunde kehren, wenn die Kugel **2** von der Belastung freigegeben wird, die vorstehenden Streifen **7**, **7** in den unbelasteten Zustand zurück, wie in Fig. 3(A) gezeigt ist.

[0035] Die Teilung der vorstehenden Streifen **7**, **7** wird zum Beispiel in der folgenden Weise bestimmt. Es gibt eine vorausberechnete Kontaktfläche zwischen der Kugel **2** und der Kugellaufrille **1a** bei einer angenommenen Belastung, zum Beispiel einer statischen Tragzahl. Bei einer solchen Kontaktfläche wird die Teilung der vorstehenden Streifen **7**, **7** derart festgelegt, dass drei bis vier Streifen der Vorsprünge **7**, **7** die Kugel **2** kontaktieren. Der Begriff „statische Tragzahl" bedeutet hierbei eine statische Last mit konstanter Richtung und Größe derart, dass an dem Kontaktabschnitt, auf den die maximale Spannung ausgeübt wird, die Summe der permanenten Verformung der Kugel **2** und der permanenten Verformung der Kugellaufrille **1a** das 1/10000-fache des Durchmessers der Kugel **2** ist.

[0036] Die mehreren vorstehenden Streifen **7**, **7** wirken als Schienen, auf welchen die Kugeln wälzen. Wenn die Kugel **2** entlang der Kugellaufrille **1a** wälzt, hat die Kugel **2** eine Drehachse **14**. In einer Situation, in der eine Kraft zur Begrenzung der Drehachse **14** ausgeübt wird, wird eine Reibung an dem Kontaktpunkt zwischen der Kugel **2** und der Kugellaufrille **1a** verursacht. In dem Fall, dass die Kugel **2** in nur einem Punkt die Kugellaufrille **1a** mit der vollständigen Kreisbogenform kontaktiert, und in dem Fall, dass die Kugel **2** in zwei Punkten die paarweise vorstehenden Streifen **7**, **7** kontaktiert, wird keine Kraft verursacht, welche die Kugel **2** begrenzt. Dementsprechend wird sogar bei Vorhandensein der vorstehenden Streifen **7**, **7** weniger Einfluss auf den Widerstand in der Kugellaufrichtung ausgeübt.

[0037] Außerdem wird die auf die Kugel **2** ausgeübte Belastung in einer Mehrzahl von Punkten, und nicht in einem Punkt gehalten, die Kontaktfläche wird im Vergleich zu der Belastung frühzeitig erweitert, und die Tragfähigkeit kann in Übereinstimmung mit der erweiterten Größe der Kontaktfläche groß gestaltet werden.

[0038] Fig. 4 bis Fig. 7 zeigen Ergebnisse des Analysierens von Spannungen und Scherkräften mit FEM (Finite Elemente Verfahren), die in dem Fall, dass die Kugel und die glatte Fläche in einem Punkt kontaktieren, und in dem Fall, dass die Kugel und die glatte Fläche in zwei Punkten kontaktieren, erzeugt werden. Hierbei wird eine Belastung von bestimmter Größe auf die Kugel mit einem Durchmesser von 12,7 mm derart ausgeübt, dass sie heftig gegen die glatte Fläche von 5 µm oder gegen den vorstehenden Abschnitt mit einer Höhe von 3 bis 5 µm gedrückt wird. Fig. 4 bis Fig. 7 zeigen den Kontaktabschnitt zwischen der Kugel und der glatten Fläche in vergrößerten Maßstäben.

[0039] Fig. 4 und Fig. 5 zeigen die Verteilung der erzeugten Spannung (Von Mses Spannung), in welchen Fig. 4 den Fall zeigt, dass die Kugel und die glatte Fläche in einem Punkt wie üblich kontaktieren, und Fig. 5 den Fall zeigt, dass die Kugel und die glatte Fläche in zwei Punkten kontaktieren, und in welchen dieselben Schraffurlinien für Abschnitte mit äquivalenter oder derselben Spannung beschrieben sind.

[0040] Wie in Fig. 5 gezeigt ist, beginnen in dem Fall von zwei Kontaktpunkten die Kugel und die glatte Fläche in zwei Punkten zu kontaktieren, die mit einem Freiraum zwischen ihnen leicht voneinander getrennt sind. Es wird beobachtet, dass, wenn die Belastung auf die Kugel **2** ausgeübt wird, die Belastung auch auf die beiden getrennten Punkte ausgeübt wird und sich dann die Kontaktfläche zwischen der Kugel und der glatten Fläche innerhalb und außerhalb der vorstehenden Abschnitte ausbreitet. Somit wird die Spannung dementsprechend vollständig verteilt, und eine große Spannung wird kaum verursacht.

[0041] Fig. 6 und Fig. 7 zeigen Verteilungen der erzeugten Scherkräfte (XY Scher), in welchen Fig. 6 den Fall zeigt, das die Kugel und die glatte Fläche in einem Punkt wie üblich kontaktieren, und Fig. 7 den Fall zeigt, dass die Kugel und die glatte Fläche in zwei Punkten kontaktieren, und in welchen dieselben Schraffurlinien für Abschnitte mit äquivalenter oder derselben Scherkraft beschrieben sind.

[0042] Der bedeutendste Aspekt bei der Betrachtung der Zerstörung der Kugel ist die maximale Scherkraft. Wenn auf die Kugel die Belastung ausgeübt wird, ist ein Abschnitt, an welchem die maximale Scherkraft ausgeübt wird, etwas innerhalb des Kontaktpunktes der Kugel positioniert, und wenn eine Kraft eine Gleitbewegung an dem Abschnitt verursacht, an welchem die maximale Scherkraft wirkt, wird das Material zerstört.

[0043] Wie in Fig. 7 gezeigt ist, wird festgestellt, dass in dem Fall von zwei Kontaktpunkten ein Bereich, in welchem die Scherkraft erhöht ist, reduziert wird, und die Scherkraft wird vollständig verteilt.

[0044] Fig. 8 zeigt ein Verfahren zum Formen (Herstellen) der Kugellaufrille **1a**. Ein scheibenförmiger Schleifstein **15** mit einem Durchmesser, der kleiner als der Radius der Kugel **2** ist, wird zuerst bereitgestellt. Als nächstes wird der Schleifstein **15** in einer Richtung (Richtung senkrecht zu diesem Zeichnungsblatt), in welcher sich die Kugellaufrille **1a** erstreckt, unter Drehung bewegt, und die Kugellaufrille **1a** wird durch die Außenumfangsfläche des Schleifsteins **15** von einer unbearbeiteten Arbeitsfläche zu einer glatten Lauffläche geschliffen, so dass die Kugellaufrille **1a** die Lauffläche übereinstimmend mit der Außenumfangsfläche des Schleifsteins **15** bereitstellt. Als nächstes wird der Schleifstein **15** zum Beispiel aus der Schleifsteinposition Nr. 9 in die Schleifsteinposition Nr. 10 in Fig. 8 in der Ebene senkrecht zu der Richtung, in welcher sich die Kugellaufrille erstreckt, in einem vorbestimmten Abstand bewegt. Der Schleifstein **15** wird wieder in der Richtung bewegt, in welcher sich die Kugellaufrille **1a** erstreckt, so dass die Außenumfangsfläche des Schleifsteins **15** auf die Kugellaufrille **1a** übertragen wird. Gemäß einer solchen Bewegung wird ein vorstehender Abschnitt **7** zwischen der Schleifsteinposition Nr. 9 und der Schleifsteinposition Nr. 10 geformt. In dieser Fig. 8 stellt der vorstehende Abschnitt **7** eine Abmessung bereit, die größer als dessen tatsächliche Abmessung ist.

[0045] Ferner kann durch eine Linearbewegung des Schleifsteins in der Richtung, in welcher sich die Kugellaufrille **1a** erstreckt, eine Kugellaufrille für eine lineare Bewegungsführungsvorrichtung geformt werden, durch dessen Kreisbewegung eine Kugellaufrille für ein Wälzlager geformt werden, und durch dessen Spiralbewegung eine Kugellaufrille für eine Kugelumlaufspindel geformt werden.

[0046] Darüber hinaus können bei einem anderen Verfahren als dem oben erwähnten Verfahren zum Formen einer Kugellaufrille eine Mehrzahl von vorstehenden Streifen an der Kugellaufrille geformt werden, indem eine Fläche mit Vorsprüngen und Aussparungen an einer Außenumfangsfläche eines Schleifsteins unter Verwendung einer NC (Numerische Steuerung) Technologie geformt wird und dieser Schleifstein in der Erstreckungsrichtung der Kugellaufrille derart bewegt wird, dass die Außenumfangsfläche des Schleifsteins auf die Kugellaufrille übertragen wird. Ein Fräserblatt kann ersatzweise für den Schleifstein verwendet werden.

[0047] Fig. 9 zeigt eine perspektivische Ansicht einer Bewegungsführungsvorrichtung gemäß der zweiten Ausführungsform der vorliegenden Erfindung. Diese Figur zeigt eine Kugelnutung als lineare Bewegungsführungsvorrichtung. Die Kugelnutung weist eine Keilwelle **21** als ein Führungsteil und eine Außenhülse **23** als ein bewegbares Teil auf, die an der Keilwelle **21** mit einer Anzahl von dazwischen angeordneten Kugeln **22**, **22** bewegbar montiert ist.

[0048] Die Keilwelle **21** hat eine Außenfläche, in welcher Kugellaufrillen **21a**, **21a**, die als Führungsbahnen der Kugeln **22**, **22** dienen, derart ausgebildet sind, dass sie sich in der Axialrichtung der Keilwelle **21** erstrecken. Die Außenhülse **23**, die an der Keilwelle **21** montiert ist, ist an ihrer Innenumfangsfläche mit Kugellaufrillen versehen, die den Kugellaufrillen **21a**, **21a** entsprechen, die in der Keilwelle **21** ausgebildet sind, und eine Mehrzahl von vorstehenden Streifen sind in einer Richtung ausgebildet, in welcher sich die Kugellaufrillen **21a**, **21a** erstrecken.

[0049] Eine Kugellaufbahn wird zwischen den entsprechenden Kugellaufrillen gebildet, die in der Außenhülse **23** und der Keilwelle **21** ausgebildet sind. Eine unbelastete Rücklaufbahn, in welcher sich die von der Last befreiten Kugeln **22**, **22** entlang dieser Bahn bewegen, ist benachbart zu der Kugellaufbahn ausgebildet. Ein Halter **24** zum Anbringen und Halten der Kugeln **22**, **22** in Form eines Kreises ist an der Außenhülse **23** montiert.

[0050] Fig. 10 zeigt eine perspektivische Ansicht einer Kugelumlaufspindel gemäß einer dritten Ausführungsform der vorliegenden Erfindung. Die Kugelumlaufspindel weist eine Spindelwelle **31** auf, und eine Kugellaufrille **31a**, welche eine Spiralform mit einer konstanten Steigung hat und eine halbkreisförmige Querschnittsform hat, ist in einer Außenumfangsfläche der Spindelwelle **31** ausgebildet. Die Kugelumlaufspindel weist auch eine Mutter **32** auf, und eine Kugellaufrille **32a**, welche einen halbkreisförmigen Querschnitt hat, ist in einer Innenumfangsfläche der Mutter **32** derart ausgebildet, dass sie der Kugellaufrille **31a** der Spindelwelle **31** zugewandt ist. Eine Mehrzahl von vorstehenden Streifen sind an diesen Kugellaufrillen **31a** und **32a** derart ausgebildet, dass sie sich spiralförmig in der Richtung erstrecken, in welcher sich die Kugellaufrillen **31a** und **32a** erstrecken.

[0051] Eine Anzahl von Kugeln **34**, **34** sind in der Kugellaufbahn untergebracht, die von den Kugellaufrillen **31a** und **32a** der Spindelwelle **31** und der Mutter **32** gebildet wird. An der Mutter **32** sind Teile **33**, **33** für den Umlauf der Kugeln angebracht. Die Umlaufteile **33**, **33** bilden eine unbelastete Rücklaufbahn, die das eine und das andere Ende der Kugellaufrille verbindet, in welcher die Kugeln **34**, **34** in Verbindung mit der Relativbewegung der Mutter **32** in Bezug auf die Spindelwelle **31** umlaufen.

[0052] Fig. 11 zeigt eine Schnittansicht eines Radialwälzlagers gemäß der vierten Ausführungsform der vorliegenden Erfindung. Dieses Wälzlager ist mit einem Außenring **41** als ein ringförmiges Führungsteil und einem an dem Außenring **41** montierten Innenring **42** als ein ringförmiges bewegbares Teil versehen. Der Außen- und der Innenring **41** und **42** sind mit Kugellaufrillen **41a** bzw. **42a** versehen, zwischen welchen die Kugeln **43** angeordnet sind. Eine Mehrzahl von ringförmigen vorstehenden Streifen sind an Abschnitten zwischen diesen Kugellaufrillen **41a** und **42a** derart ausgebildet, dass sie sich in einer Richtung erstrecken, in welcher sich die Kugellaufrillen erstrecken. In dieser Ausführungsform können, obwohl das Radialwälzlager erwähnt ist, die Kugellaufrillen mit einer Mehrzahl von vorstehenden Streifen für ein Axialwälzlager vorgesehen sein.

[0053] Ferner ist die vorliegende Erfindung nicht auf die beschriebenen Ausführungsformen beschränkt, und viele andere Modifikationen können vorgenommen werden, ohne den Gegenstand der vorliegenden Erfindung zu verändern. Zum Beispiel ist es nicht notwendig, dass die Kugellaufrille, die mit einer Mehrzahl von vorstehenden Streifen versehen ist, sowohl an dem Führungsteil als auch an dem bewegbaren Teil ausgebildet ist, und die Kugellaufrille kann an einem dieser Teile ausgebildet sein.

[0054] Wie oben erwähnt, sind gemäß der vorliegenden Erfindung eine Mehrzahl von vorstehenden Streifen derart ausgebildet, dass sie sich in einer Richtung, in welcher sich die Kugellaufrillen erstrecken, in Abschnitten nahe der Kontaktpunkte der Kugel in den Kugellaufrillen erstrecken, um dadurch die Kugel durch die auf die Kugeln ausgeübte Belastung mit den vorstehenden Streifen in Kontakt zu bringen. Dementsprechend wird die auf die Kugel ausgeübte Belastung auf die jeweiligen Kontaktpunkte verteilt, wodurch verhindert wird, dass die Spannung auf den bestimmten einen Punkt gerichtet ist. Daher kann die Tragfähigkeit erhöht werden, ohne den Krümmungsradius der Kugellaufrille an den Radius der Kugel anzupassen.

Zusammenfassung

[0055] Bewegungsführungsvorrichtung, die geeignet ist, eine Tragfähigkeit zu erhöhen, ohne einen Krümmungsradius einer Kugellaufrille an einen Radius einer Kugel anzupassen. Die Kugellaufrillen sind in einer Führungsschiene und einem bewegbaren Block einer Linearführung als eine Führungsbahn ausgebildet, entlang welcher die zwischen der Führungsschiene und dem bewegbaren Block angeordneten Kugeln wälzen. Eine Mehrzahl von elastisch verformbaren, vorstehenden Streifen (Rillen) sind derart ausgebildet, dass sie sich in einer Richtung, in welcher sich die Kugellaufrille erstreckt, in der Nähe von Kontaktpunkten der Kugellaufrille, in welchen die Kugel kontaktiert wird, derart erstrecken, dass die Kugel und die mehreren vorstehenden Streifen durch die auf die Kugel wirkende Belastung einander kontaktieren. Die auf die Kugel ausgeübte Belastung wird auf jeden Punkt der vorstehenden Streifen verteilt, um dadurch zu verhindern, dass eine hohe Spannung auf einen bestimmten Punkt gerichtet ist. Dementsprechend kann die Tragfähigkeit der Bewegungsführungsvorrichtung erhöht werden, ohne den Krümmungsradius der Kugellaufrille an den Radius der Kugel anzupassen.

Patentansprüche

1. Bewegungsführungsvorrichtung, aufweisend ein Führungsteil und ein bewegbares Teil, bei welcher wenigstens eines des Führungsteils und des bewegbaren Teils mit einer Kugellaufrille versehen ist, die als eine Führungsbahn zu einer Zeit wirkt, wenn eine zwischen dem Führungsteil und dem bewegbaren Teil angeordnete Kugel wälzt,
wobei eine Mehrzahl von elastisch verformbaren, vorstehenden Streifen an der Kugellaufrille derart ausgebildet sind, dass sie sich in einer Richtung erstrecken, in welcher sich die Kugellaufrille erstreckt, und wobei die Kugel, die der Belastung zwischen dem Führungsteil und dem bewegbaren Teil ausgesetzt ist, die mehreren vorstehenden Streifen vor dem Kontaktieren ausgesparter Abschnitte zwischen den mehreren vorstehenden Streifen kontaktiert.

2. Bewegungsführungsvorrichtung gemäß Anspruch 1, wobei die vorstehenden Streifen durch die Belastung derart elastisch verformt werden, dass die Kugel die ausgesparten Abschnitte dazwischen kontaktiert.

3. Bewegungsführungsvorrichtung nach Anspruch 1 oder 2, wobei die Bewegungsführungsvorrichtung eine lineare oder gekrümmte Bewegungsführungsvorrichtung oder ein Wälzlager ist, bei welchem ein ringförmiges bewegbares Teil an einem ringförmigen Führungsteil drehbar montiert ist.

4. Kugelumlaufspindel, aufweisend eine Spindelwelle und eine Mutter, bei welcher spiralförmige Kugellaufrillen als ein Führungsteil, das zu einer Zeit wirkt, wenn eine zwischen der Spindelwelle und der Mutter angeordnete Kugel wälzt, in der Spindelwelle und der Mutter ausgebildet sind, wobei eine Mehrzahl von elastisch verformbaren, vorstehenden Streifen in den Kugellaufrillen derart ausgebildet sind, dass sie sich in einer Richtung erstrecken, in welcher sich die Kugellaufrillen erstrecken, und wobei die Kugel, die der Belastung zwischen dem Führungsteil und dem bewegbaren Teil ausgesetzt ist, die mehreren vorste-

henden Streifen vor dem Kontaktieren ausgesparter Abschnitte zwischen den mehreren vorstehenden Streifen kontaktiert.

5. Verfahren zum Formen einer Kugellaufrille, bei welchem wenigstens eines des Führungsteils und des bewegbaren Teils mit einer Kugellaufrille als eine Führungsbahn versehen ist, die zu einer Zeit wirkt, wenn eine zwischen dem Führungsteil und dem bewegbaren Teil angeordnete Kugel wälzt, wobei das Verfahren die Schritte aufweist:
Bewegen eines scheibenförmigen Fräsers oder Schleifsteins mit einem Radius, der kleiner als jener der Kugel ist, in einer Richtung, in welcher sich die Kugellaufrille erstreckt, und Übertragen einer Außenumfangsform des scheibenförmigen Fräsers oder Schleifsteins auf die Kugellaufrille;
Bewegen des Fräsers oder Schleifsteins in einer Ebene senkrecht zu einer Richtung, in welcher sich die Kugellaufrille erstreckt; und
Bewegen des Fräsers oder Schleifsteins in der Richtung, in welcher sich die Kugellaufrille erstreckt, und Übertragen der Außenumfangsform des scheibenförmigen Fräsers oder Schleifsteins auf die Kugellaufrille,
wobei eine Mehrzahl von elastisch verformbaren, vorstehenden Streifen derart geformt werden, dass sie sich in der Richtung erstrecken, in welcher sich die Kugellaufrille erstreckt.

Es folgen 10 Blatt Zeichnungen

Anhängende Zeichnungen

FIG. 1

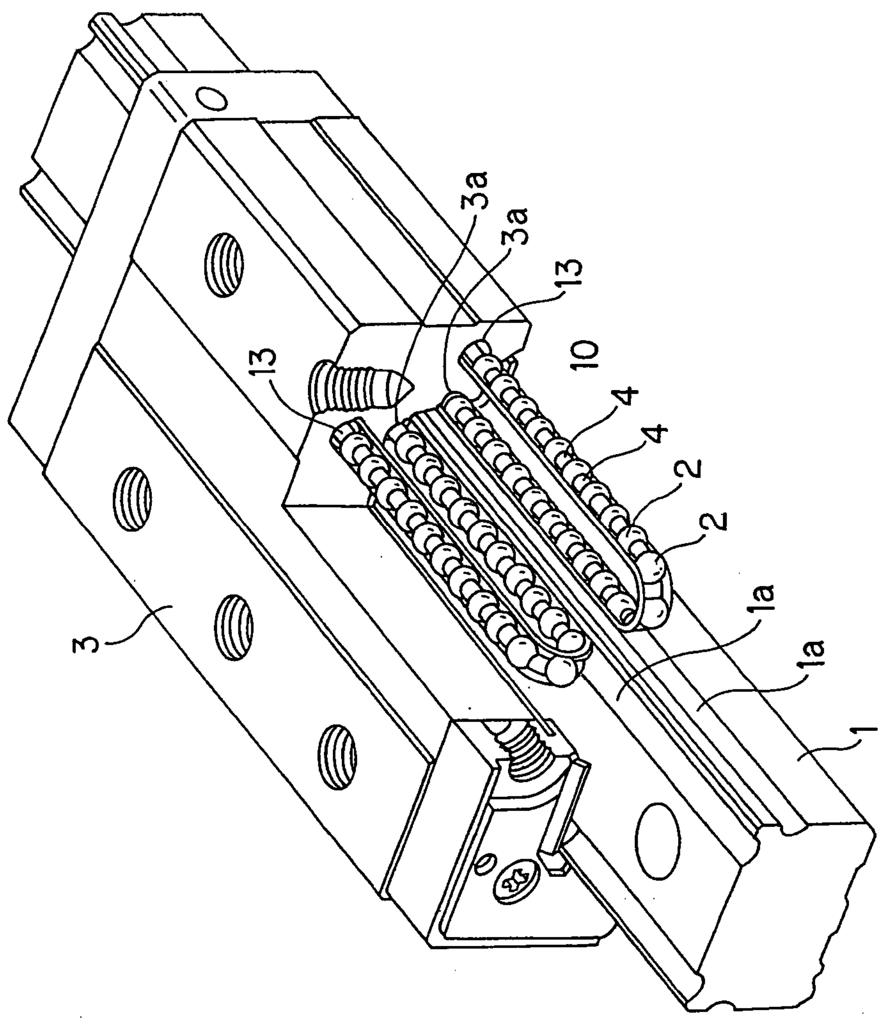


FIG. 2

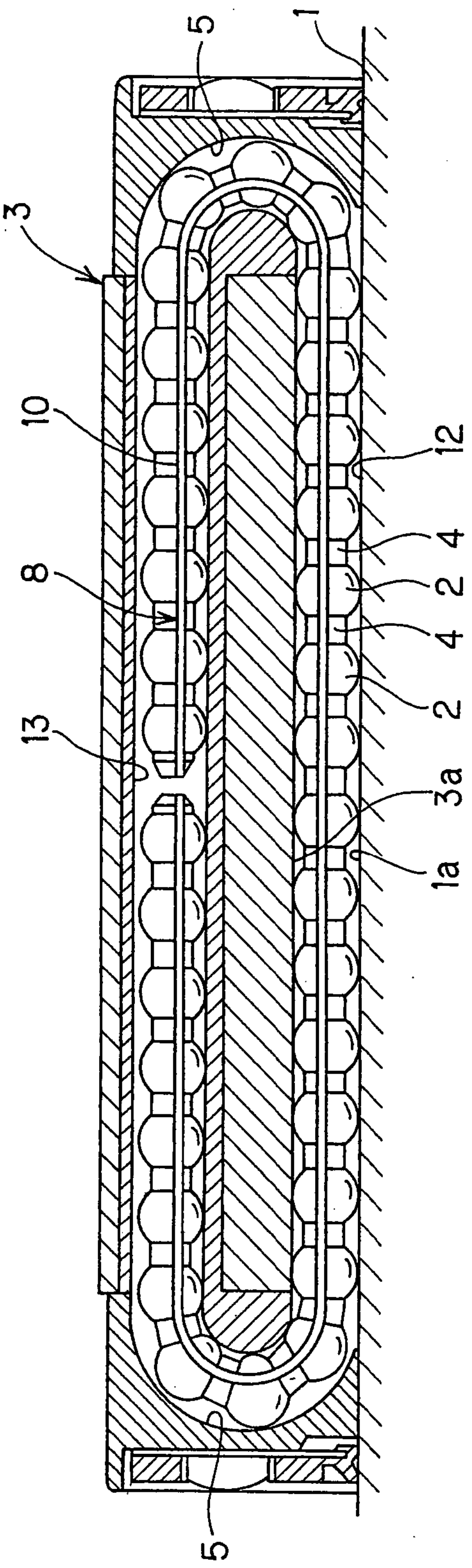


FIG. 3

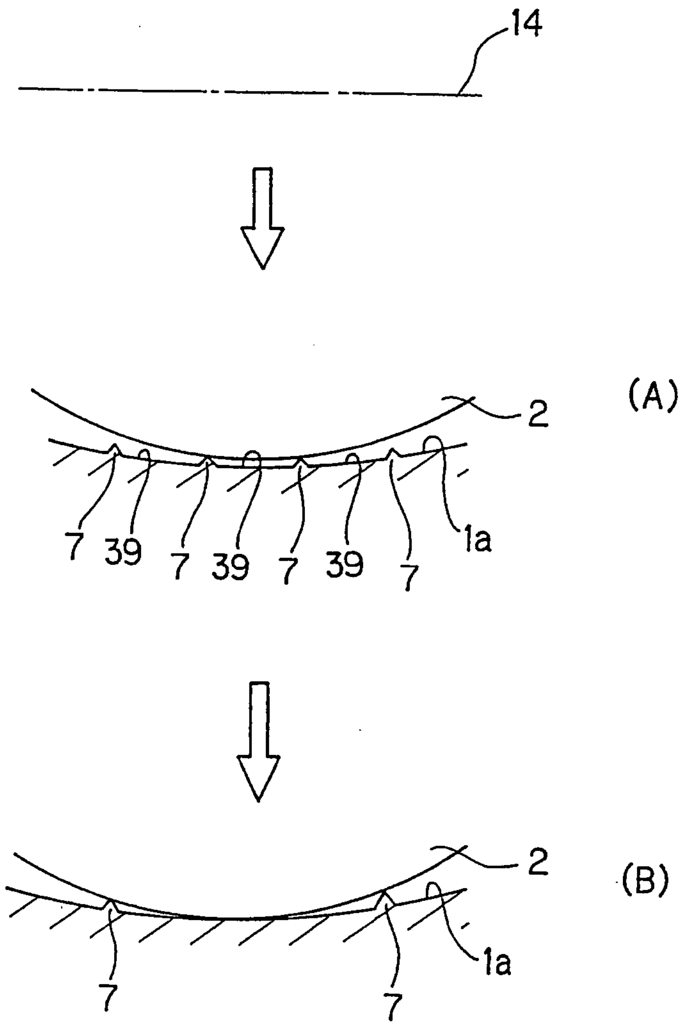


FIG. 4

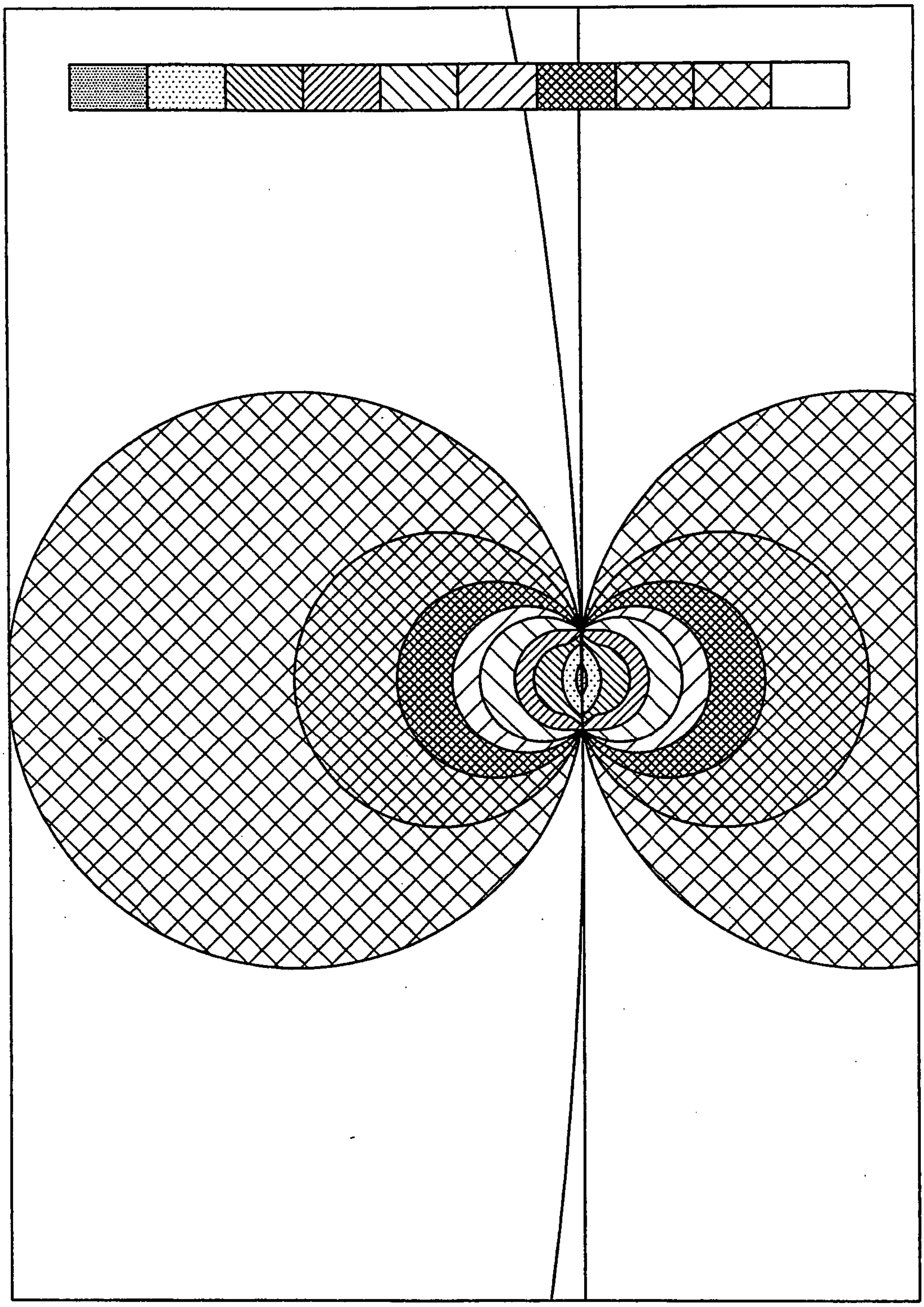


FIG. 5

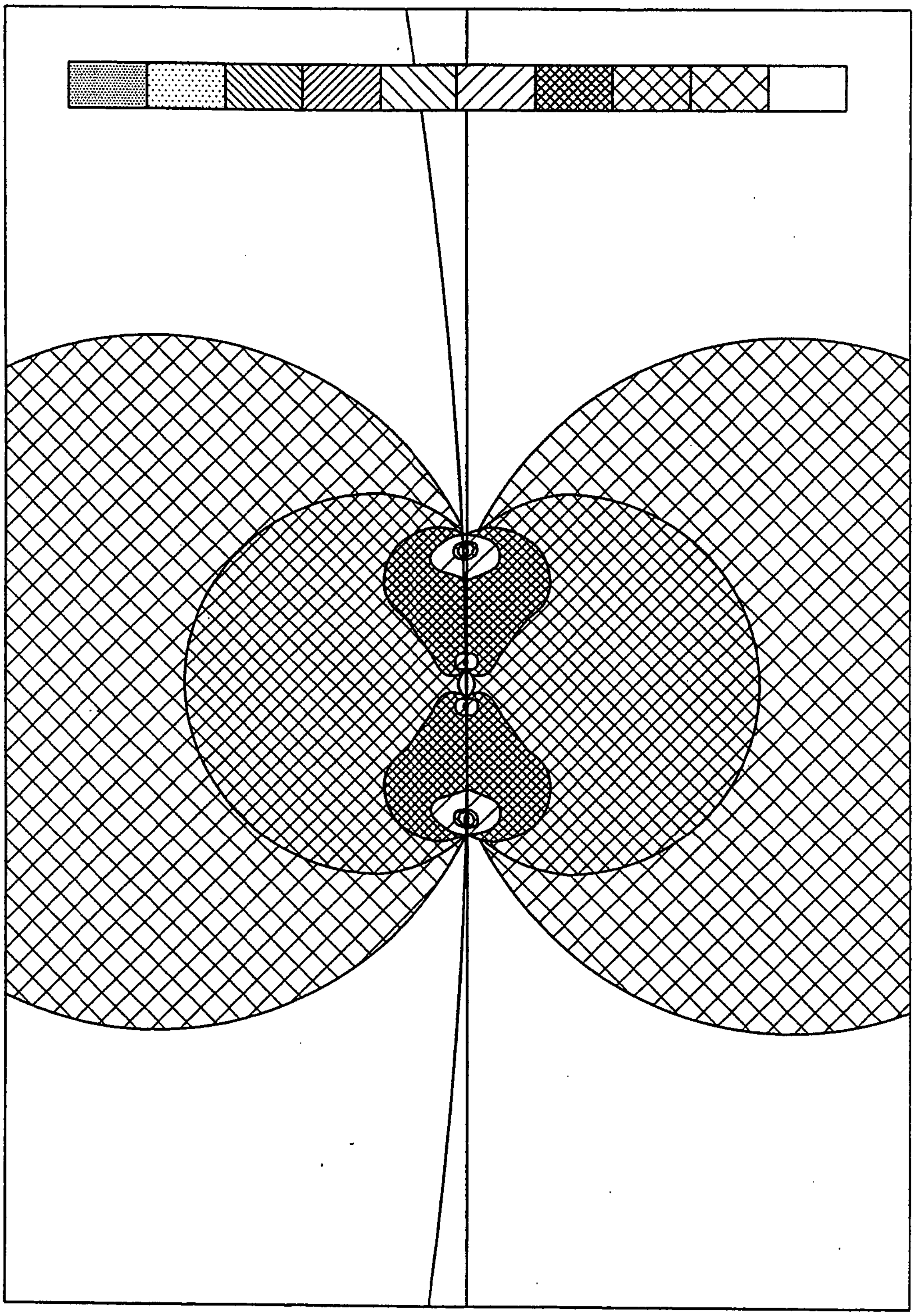


FIG. 6

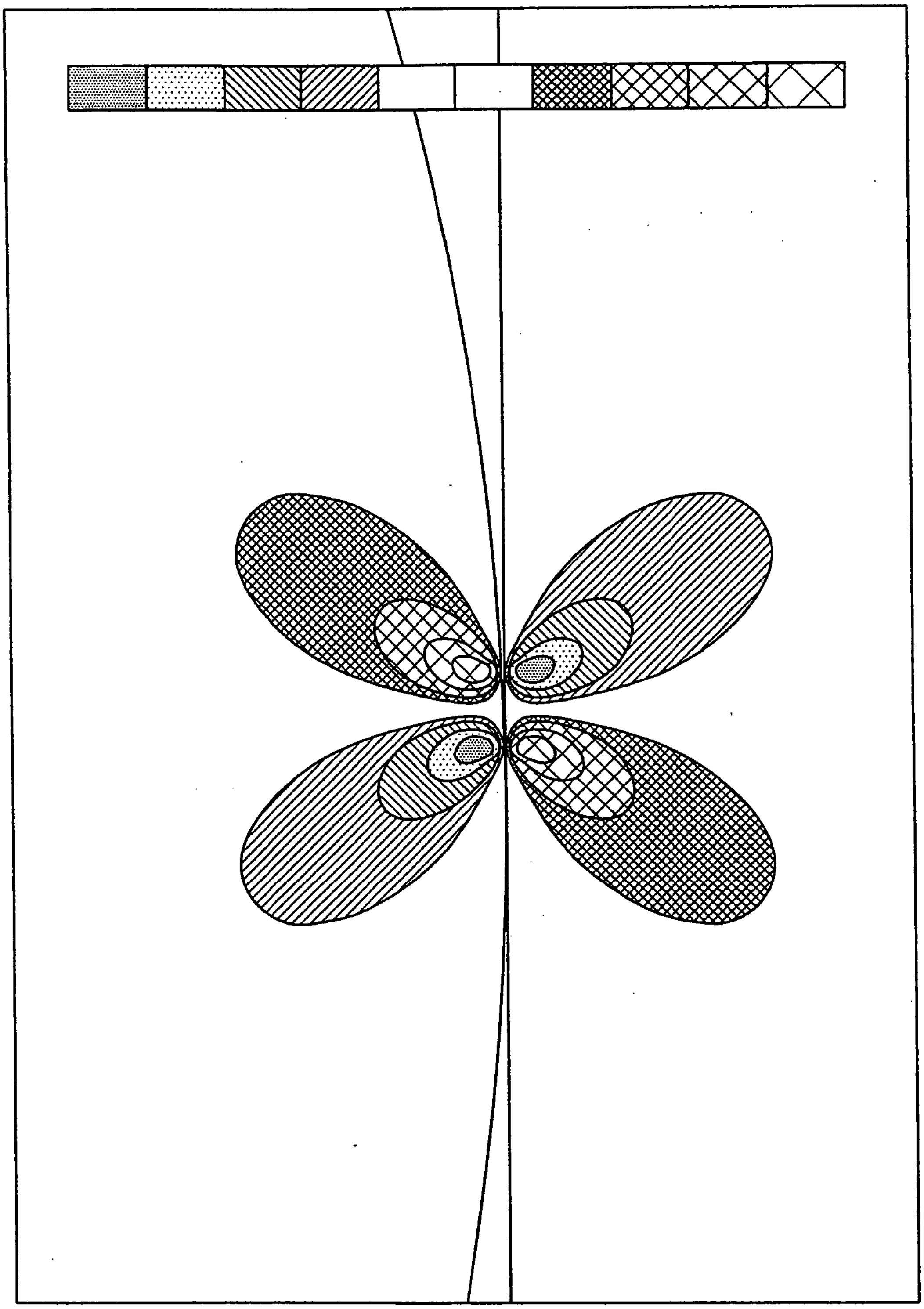


FIG. 7

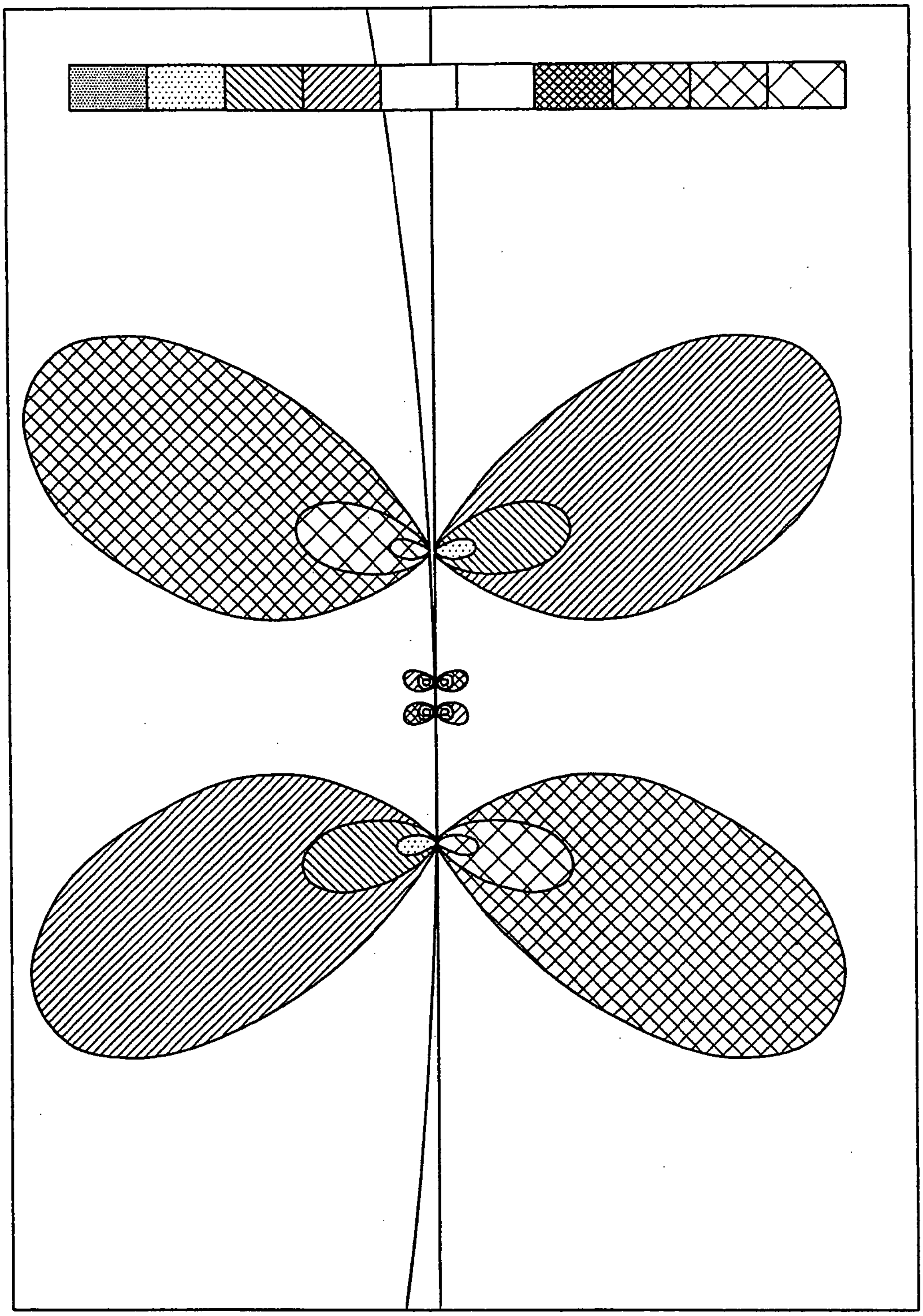


FIG. 8

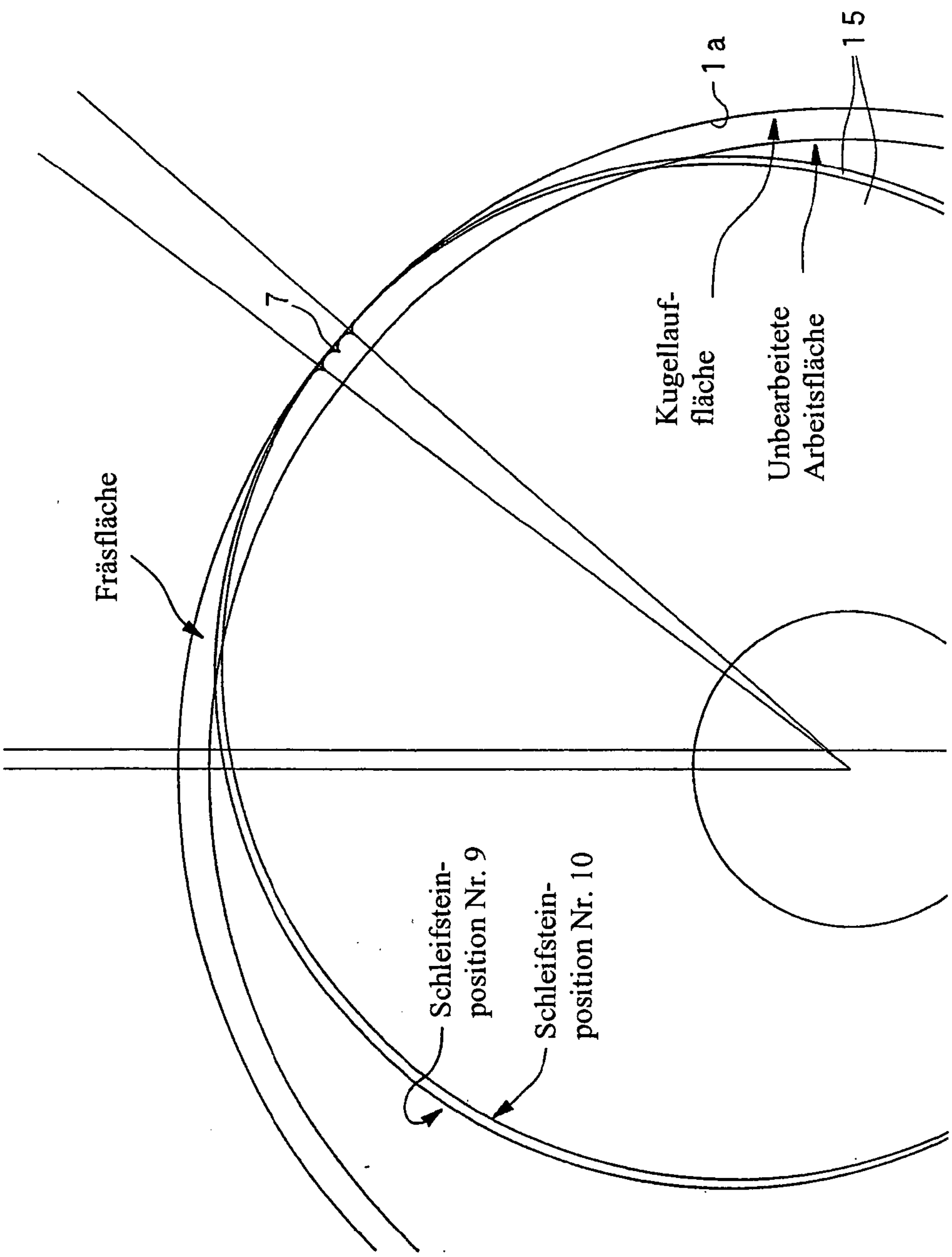

Fräsfläche
7
1 a
1 5
Kugellauf-
fläche
Unbearbeitete
Arbeitsfläche
Schleifstein-
position Nr. 9
Schleifstein-
position Nr. 10

FIG. 9

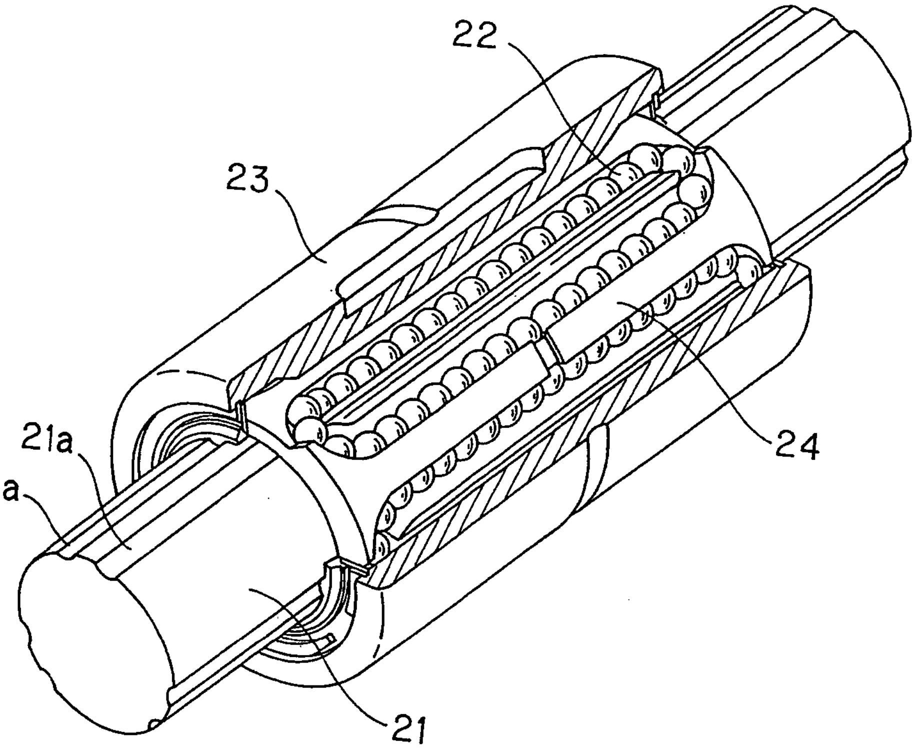


FIG. 10

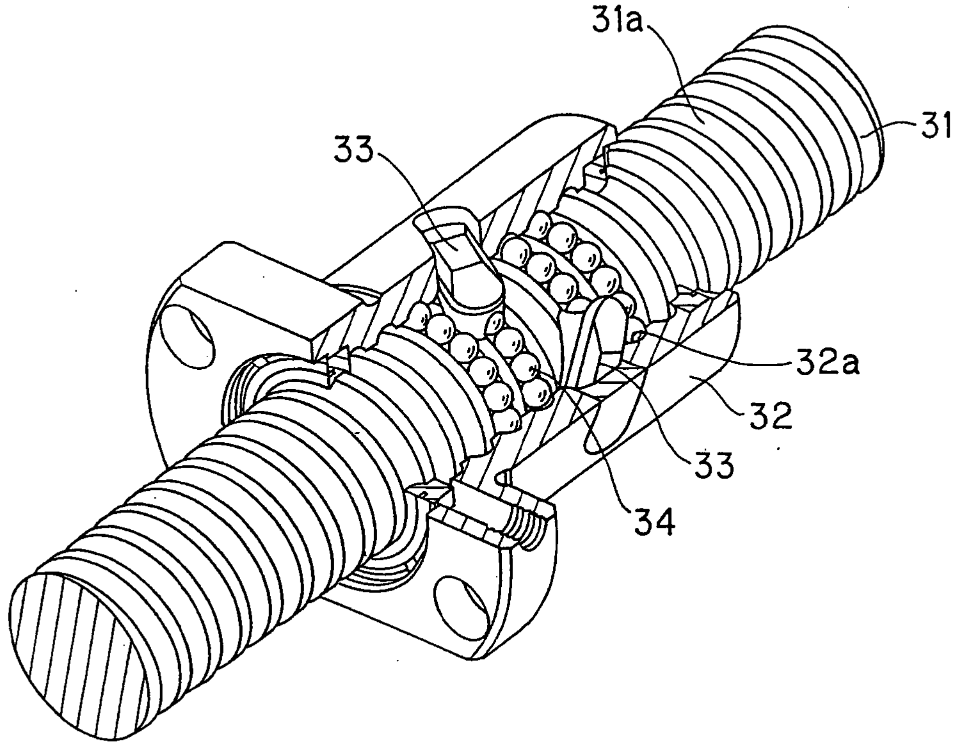


FIG. 11

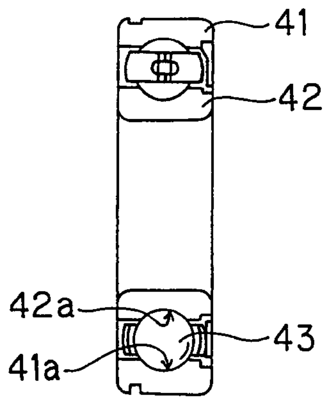
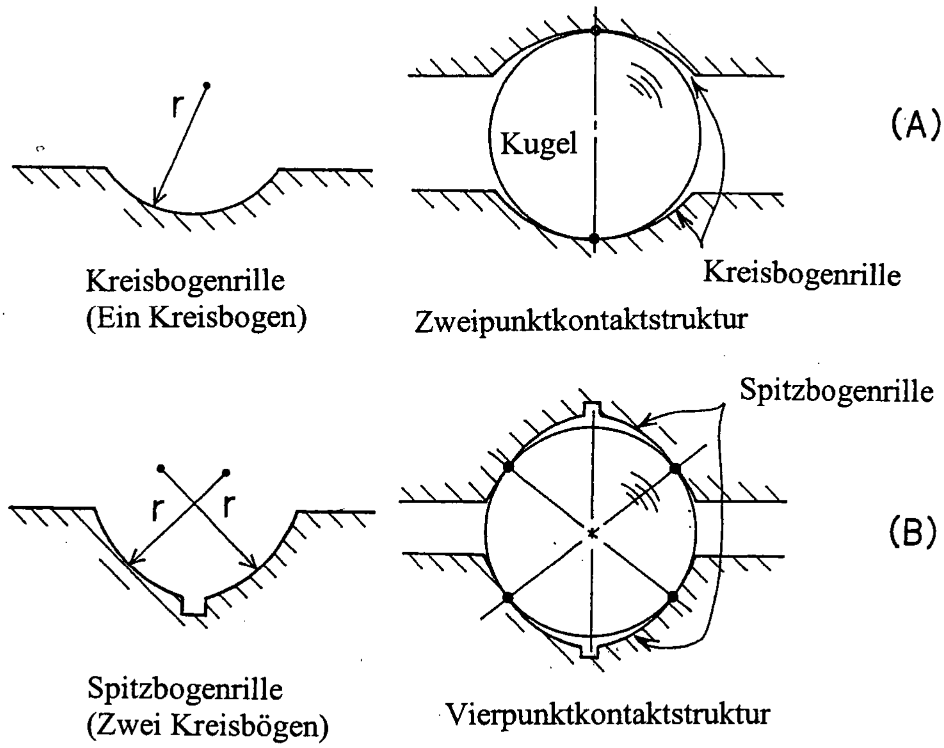

41
42
42a
43
41a

FIG. 12


r
Kreisbogenrille
(Ein Kreisbogen)
Kugel
Kreisbogenrille
Zweipunktkontaktstruktur
(A)
Spitzbogenrille
r
r
Spitzbogenrille
(Zwei Kreisbögen)
Vierpunktkontaktstruktur
(B)

(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 103 09 859 A 1**

(51) Int. Cl.^{7}: **G 05 G 5/00**

(21) Aktenzeichen: 103 09 859.3
(22) Anmeldetag: 6. 3. 2003
(43) Offenlegungstag: 18. 9. 2003

(30) Unionspriorität:
2002/060192 06. 03. 2002 JP
2002/300036 15. 10. 2002 JP

(71) Anmelder:
Beldex Corp., Tokio/Tokyo, JP; THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Viering, Jentschura & Partner, 80538 München

(72) Erfinder:
Ishikawa, Hirokazu, Tokio/Tokyo, JP; Nakazato, Yoichi, Tokio/Tokyo, JP

DE 103 09 859 A 1

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Winkeleinstellvorrichtung

(57) Winkeleinstellvorrichtung mit einem Sockel, einem Paar Führungsteile mit einer bogenförmigen Spur, einem Schwenkkörper, der entlang der Spur der Führungsteile bewegbar ist, und einem Bewegungskörper zum Bewegen des Schwenkkörpers, um die Winkelposition des Schwenkkörpers um die Schwenkachse einzustellen. Das Bewegungsteil hat einen Motor, der im Sockel vorgesehen ist, ein Kupplungszapfen, der im Schwenkkörper vorgesehen ist, und einen Kupplungsmechanismus, der zwischen Motor und Kupplungszapfen angeordnet ist. Ein Hauptkupplungsteil des Kupplungsmechanismus ist mit einem vorderen Endabschnitt der Abtriebswelle drehbar um die Achse parallel zur Schwenkachse gekuppelt und mit dem Kupplungszapfen gekuppelt, um linear bewegbar in dessen Axialrichtung zu sein. Die Führungsteile haben zwei flache Referenzebenen und sind in einem Zustand befestigt, in dem die Referenzebenen mit zwei flachen Stellebenen des Sockels in Kontakt stehen.

DE 103 09 859 A 1

Beschreibung

[0001] Die Erfindung betrifft eine Winkeleinstellvorrichtung, eine so genannte Drehschwenkbühne (engl.: "goniostage" oder "swivel-stage").

[0002] Ein das den Stand der Technik repräsentierende Dokument über die erfindungsgemäße Winkeleinstellvorrichtung ist JP-A-2000-230548 (**Fig.** 1, **Fig.** 10). Diese Veröffentlichung offenbart eine zweiachsige Winkeleinstellvorrichtung. In einer ersten Ausführungsform dieser Vorrichtung sind eine untere Bühnenstruktur und eine obere Bühnenstruktur im wesentlichen gleich. In jeder Bühne hat die Vorrichtung einen Sockel, der einen U-förmigen Querschnitt hat, mit einer Bodenwand und zwei Seitenwänden. Der obere Rand der beiden Seitenwände des Sockels ist wie ein Kreisbogen ausgebildet und ein Führungsteil, das eine bogenförmige Form hat, ist an einer vertikalen, flachen Außenfläche (Stellebene) entlang dem oberen Rand befestigt. Das Führungsteil ist mittels einer Schraube von außen an die Seitenwand befestigt. Eine bogenförmige Nut (Spur) ist an der oberen und an der unteren Fläche des Führungsteils ausgebildet.

[0003] Außerdem weist die Vorrichtung einen Schwenkkörper in jeder Bühne auf. Der Schwenkkörper weist einen Schwenktisch, der einen U-förmigen Querschnitt hat, mit einer oberen Wand und zwei Seitenwänden und einen Durchgangsblock, der an der Innenfläche der beiden Seitenwände des Schwenktischs befestigt ist. Jeder Durchgangsblock hat eine Endlosumlaufpassage und Kugeln sind in der Endlosumlaufpassage angeordnet. Ein Teil der Endlosumlaufpassage ist einer Spur des Führungsteils zugewandt und die dazwischen angeordneten Kugeln rollen, während sie entlang der Spur des Durchgangslochs sich bewegen.

[0004] Ferner hat die Vorrichtung ein Bewegungsmittel. Dieses Bewegungsmittel bewegt den Schwenkkörper entlang der bogenförmigen Spur, um die Winkelposition des Schwenkkörpers um eine Schwenkachse (Achse verläuft durch den Krümmungsmittelpunkt der Spur) einzustellen. Das Bewegungsmittel weist einen Motor auf, der im Schwenktisch vorgesehen ist, und eine bogenförmige Zahnstange, die gemäß der ersten Ausführungsform der vorhergehenden Veröffentlichung mit einem Ritzel in Eingriff steht, wie in **Fig.** 1 gezeigt. Die Zahnstange ist nahe dem oberen Rand der Innenfläche der beiden Seitenwände des Sockels fixiert. Zusammen mit der Motordrehung wird der Schwenkkörper via den Eingriff des Ritzels und der Zahnstange entlang der Spur bewegt.

[0005] In einer vierten Ausführungsform der Veröffentlichung, wie in **Fig.** 10 gezeigt, ist das Bewegungsmittel der unteren Bühne unterschiedlich von dem der ersten Ausführungsform. Das Bewegungsmittel in der untern Bühne weist einen Motor, der im Sockel vorgesehen ist, einen Kugelgewindespindelmechanismus, der mit dem Motor gekuppelt ist, einen ersten Bewegungskörper, der linear durch den Kugelgewindespindelmechanismus horizontal bewegbar ist, und einen zweiten Bewegungskörper auf, der verschiebbar vertikal auf dem ersten Bewegungskörper vorgesehen ist. Der Schwenktisch ist drehbar mit dem zweiten Bewegungskörper gekuppelt. In dieser Ausführungsform ist der erste Bewegungskörper via den Kugelgewindespindelmechanismus zusammen mit der Motordrehung horizontal bewegbar, wobei die Horizontalbewegung via den zweiten Bewegungskörper in die Bewegung des Schwenktisch entlang der Spur umgewandelt wird.

[0006] Eine Vorrichtung gemäß JP-A-2001-99150 (**Fig.** 2, **Fig.** 4) weist wie die vorhergehende Veröffentlichung einen Sockel, ein Paar bogenförmiger Führungsteile, die am Sockel befestigt sind, einen Schwenkkörper, der entlang der Spur der Führungsteile bewegbar ist, und ein Bewegungsmittel zum Bewegen des Schwenkkörpers auf, um die Winkelposition des Schwenkkörpers um eine Schwenkachse (Achse verläuft durch den Krümmungsmittelpunkt der bogenförmigen Spur) einzustellen. Ein konvexer Abschnitt ist im Zentrum des Sockels ausgebildet und dient als eine erste Stellebene, wo beide Seitenflächen des konvexen Abschnitts vertikal sind. Eine obere Fläche, die an den konvexen Abschnitt angrenzt, ist ebenfalls eine bogenförmige Fläche, die als eine zweite Stellebene dient. Übrigens ist eine Seitenfläche des Führungsteils eine erste Referenzebene, flach, und eine bogenförmige Nut, die als Spur dient, auf der anderen Seite der Fläche ausgebildet. Außerdem ist eine untere Fläche des Führungsteils eine zweite Referenzebene, die als eine bogenförmige Fläche dient. Das Führungsteil ist am Sockel mittels einer Schraube gegen die zweite Stellebene in einem Zustand befestigt, in dem die flache erste Referenzebene des Führungsteils mit der ersten Stellebene des Sockels in Kontakt steht und die zweite Referenzebene der bogenförmigen Fläche mit der zweiten Stellebene in Kontakt steht.

[0007] Das Bewegungsmittel der Vorrichtung gemäß JP-A-2001-99150 weist einen Motor, der im Sockel vorgesehen ist, eine Schnecke, die durch den Motor gedreht wird, und einen Verzahnungsabschnitt auf, der auf dem Schwenkkörper ausgebildet ist und mit der Schnecke in Eingriff steht. Zusammen mit der Motordrehung wird der Schwenkkörper via den Eingriff der Schnecke und des Verzahnungsabschnitts gedreht.

[0008] In den letzten Jahren gibt es das Erfordernis die Feinwinkeleinstellung mit hoher Präzision auszuführen. Jedoch kann mit der herkömmlichen Winkeleinstellvorrichtung mit der Vorrichtung der vorhergehenden Veröffentlichungen dieses Erfordernis nicht erfüllt werden. Der Grund wird im folgenden erläutert.

[0009] Bei der Vorrichtung gemäß JP-A-2000-230548 wird das bogenförmige Führungsteil dann deformiert, wenn die Schraube angezogen wird, so dass sich die Rundheit der Spur verschlechtert, da das Führungsteil mittels der Schrauben in einem Zustand befestigt wird, in dem die bogenförmige, flache Referenzfläche mit der flachen Stellebene des Sockels in Kontakt ist. Bei der Vorrichtung gemäß JP-A-2001-99150 wird ebenfalls das Führungsteil deformiert und die Rundheit der Spur des Führungsteils verschlechtert, so dass die Genauigkeit der Winkelpositioneinstellung verschlechtert wird, da die zweite Referenzebene des Führungsteils mit der kreisförmigen Fläche der zweiten Stellebene des Sockels ausgerichtet ist, wenn die Rundheit des Kreisbogens der zweiten Stellebene gering ist oder die zweite Stellebene und die zweite Referenzebene einen geringfügig unterschiedlichen Krümmungsradius des Kreisbogens haben.

[0010] In der Ausführungsform gemäß JP-A-2000-230548 sind die Zahnstange und das Ritzel in jedem Schwenkkörper und im Sockel vorgesehen. In der vierten Ausführungsform ist der maßgefertigte Kugelgewindespindelmechanismus im Sockel eingebaut. In der Vorrichtung gemäß JP-A-2001-99150 sind die Schnecke und der Verzahnungsabschnitt im Sockel und im Schwenkkörper vorgesehen. Bei diesen Strukturen hat die Winkelpositioneinstellung keine hohe Genauigkeit wegen des Spiels eines nach außen freiliegenden Eingriffsabschnitts.

[0011] Durch die Erfindung wird die Aufgabe gelöst eine Winkeleinstellvorrichtung zu schaffen, mit der die Mikrowinkeleinstellungen mit hoher Genauigkeit durchgeführt werden können.

[0012] Die erfindungsgemäße Winkeleinstellvorrichtung weist auf: einen Sockel mit einer ersten und einer zweiten

Stellebene, die einander schneiden, einen Führungsteil, das am Sockel befestigt ist und einen spurausbildenden Abschnitt, eine bogenförmige Spur, die auf dem spurausbildenden Abschnitt ausgebildet ist, und einen Basisabschnitt hat, der eine erste und eine zweite Referenzebene hat, einen Schwenkkörper, der entlang der Spur des Führungsteils bewegbar ist, und ein Bewegungsteil zum Bewegen des Schwenkkörpers, um die Winkelposition des Schwenkkörpers um eine Schwenkachse einzustellen, die durch den Krümmungsmittelpunkt der Spur verläuft, wobei der spurausbildende Abschnitt und der Basisabschnitt einstückig ausgebildet sind, und das Führungsteil in einem Zustand, in dem die erste und die zweite Referenzebene mit der ersten und der zweiten Stellebene des Sockels in Kontakt sind, am Sockel befestigt ist.

[0013] Mit der vorhergehenden Konstruktion ist das Führungsteil am Sockel derart befestigt, dass die erste und die zweite flache Referenzebene des Basisabschnitts des Führungsteils mit der ersten und der zweiten flachen Stellebene des Sockels ausgerichtet sind, wobei die bogenförmige Spur nicht deformiert ist und die schlechte Rundheit der Spur vermeidbar ist. Deshalb ist die Winkeleinstellung des Schwenkkörpers bei hoher Genauigkeit durchführbar.

[0014] Bevorzugt ist das Führungsteil am Sockel befestigt, so dass die erste Referenzebene gegen die erste Stellebene durch eine erste Schraube gedrückt ist, die die erste Stellebene und die erste Referenzebene durchdringt, und am Sockel befestigt ist, so dass die zweite Referenzebene gegen die zweite Stellebene durch eine zweite Schraube gedrückt ist, die die zweite Stellebene und die zweite Referenzebene durchdringt. Dadurch ist das Positionieren des Führungsteils zuverlässiger durchführbar.

[0015] Bevorzugt hat der Sockel ein Paar Stellabschnitte, die im Abstand voneinander in Richtung parallel zur Schwenkachse angeordnet sind, wobei jeder Stellabschnitt jeweils mit der ersten und der zweiten Stellebene ausgebildet ist, wobei das Führungsteil ein Paar Führungsteile aufweist, die jeweils an einem Stellabschnitt befestigt sind, um sich einander zugewandt zu sein, wobei der spurausbildende Abschnitt jedes Führungsteils vom Basisabschnitt vorsteht, wobei der Schwenkkörper angeordnet ist, um das Paar Führungsteile quer zu überragen, wobei jeder spurausbildende Abschnitt mit einem Paar Spuren ausgebildet ist, die jeweils eine unterschiedliche Krümmung haben, wobei die Spuren im Abstand voneinander in Richtung senkrecht zur Normale der Ebene angeordnet sind, entlang der die Führungsteile einander zugeordnet sind, und wobei mindestens ein Teil des Bewegungsteils in einem Raum aufgenommen ist, der durch den Sockel, den Schwenkkörper und dem Paar Führungsteile gebildet ist.

[0016] Dadurch nimmt das Bewegungsteil keinen großen Raum in Anspruch und die Größe der Vorrichtung ist reduziert. Und der Schwenkkörper ist in Summe mittels vier Spuren stabil geführt.

[0017] Bevorzugt hat die Spur eine Rollkontaktfläche für Rollelemente, wobei der Schwenkkörper mit einer Endlosumlaufpassage ausgebildet ist, die eine Rollkontaktfläche für Rollelemente aufweist, die der Rollkontaktfläche der Spur zugewandt ist, wobei eine Mehrzahl von Rollelementen, die mit der Bewegung des Schwenkkörpers umlaufen, in der Endlosumlaufpassage angeordnet sind, und wobei die Rollelemente in einem vorgespannten Zustand zwischen der Rollelement-Rollkontaktfläche der Spur und der Rollkontaktflächen angeordnet sind. Dadurch hat der Schwenkkörper eine erhöhte Steifheit gegen das Führungsteil. Die Steifheit ist eine Größe, die die Elastizität des Versatzes oder der Deformation anzeigt, wenn eine Kraft oder ein Moment auf eine Komponente oder zwischen Komponenten wirkt, und als eine statische Steifheit und als eine dynamische Steifheit gegeben ist.

[0018] Um das vorhergehende Problem zu lösen, schaffte gemäß einem anderen Aspekt der Erfindung die Erfindung eine Winkeleinstellvorrichtung mit: einem Sockel, einem Führungsteil, das am Sockel befestigt ist und eine bogenförmige Spur aufweist, einem Schwenkkörper, der entlang der Spur des Führungsteils bewegbar ist, und einem Bewegungsteil zum Bewegen eine Schwenkkörpers, um die Winkelposition des Schwenkkörpers um die Schwenkachse einzustellen, die durch den Krümmungsmittelpunkt der Spur verläuft, wobei das Bewegungsteil aufweist: einen Antriebsabschnitt mit einer Abtriebswelle, die in Richtung senkrecht zur Schwenkachse sich erstreckt und einen einstellbaren Vorsprungsbetrag hat und im Sockel bzw. im Schwenkkörper vorgesehen ist, eine Kupplungszapfen, der im Schwenkkörper bzw. im Sockel vorgesehen ist, und einen Kupplungsmechanismus, der zwischen einem vorderen Endabschnitt der Abtriebswelle und des Kupplungszapfens angeordnet ist, um die Axialbewegung der Abtriebswelle in eine Bewegung des Schwenkkörpers entlang der Spur umzuwandeln, wobei der Kupplungsmechanismus ein Hauptkupplungsteil aufweist, das mit dem vorderen Endabschnitt der Abtriebswelle drehbar um eine Drehachse parallel zur Schwenkachse gekuppelt ist und das mit dem Kupplungszapfen gekuppelt ist, um linear bewegbar in Axialrichtung des Kupplungszapfens zu sein.

[0019] Mit der vorhergehenden Konstruktion hat der Kupplungsmechanismus keinen Eingriffsabschnitt, wie zum Beispiel eine Schraube, wodurch es ermöglicht ist eine Verschlechterung der Winkeleinstellgenauigkeit wegen Spiel zu verhindern. Eine Spannungsfeder ist ebenfalls nicht notwendig, um das Spiel abzubauen und eine hohe Lebensdauer zu erreichen.

[0020] Bevorzugt ist das Hauptkupplungsteil via einer Kugelkeilwelle mit dem Kupplungszapfen in der Art und Weise gekuppelt, dass das Hauptkupplungsteil linear bewegbar ist. Dadurch ist das Hauptkupplungsteil entlang des Kupplungszapfens stabil bewegbar.

[0021] Wenn die Abtriebswelle vorrückbar oder zurückziehbar unter Drehung ist, wobei der Kupplungsmechanismus ein Hilfskupplungsteil aufweist, das zwischen dem vorderen Endabschnitt der Abtriebswelle und dem Hauptkupplungsteil angeordnet ist, wobei das Hilfskupplungsteil mit dem vorderen Endabschnitt der Abtriebswelle gekuppelt ist, um relativ drehbar um die Längsachse der Abtriebswelle zu sein, und wobei das Hauptkupplungsteil und das Hilfskupplungsteil drehbar um die Drehachse parallel zur Schwenkachse gekuppelt sind.

[0022] Bevorzugt weist das Führungsteil ein Paar Führungsteile auf, die im Abstand voneinander angeordnet in Richtung parallel zur Schwenkachse auf dem Sockel vorgesehen sind, wobei der Schwenkkörper angeordnet ist, um das Paar Führungsteile quer zu überragen, und wobei der vordere Endabschnitt der Abtriebswelle, der Kupplungszapfen und der Kupplungsmechanismus in einem Raum angeordnet sind, der durch den Sockel, den Schwenkkörper und dem Paar Führungsteile gebildet ist. Dadurch, wenn die Abtriebswelle vorgerückt oder zurückgezogen wird, werden der linke und der rechte Abschnitt des Schwenkkörpers synchron bewegt, wobei das Auftreten von Verklemmen der linken und der rechten Spur verhindert wird.

[0023] Bevorzugt weist die Winkeleinstellvorrichtung ferner einen Winkelpositiondetektor, wobei der Winkelpositiondetektor ein Skalenaufzeichnungsteil, das im Sockel bzw. im Schwenkkörper vorgesehen ist, und einen Detektor zum Detektieren der Skala des Skalenaufzeichnungsteils auf, wobei der Detektor im Schwenkkörper bzw. im Sockel. Dadurch ist die Beziehung zwischen der abgetasteten Ausgabegröße und der Winkelposition des Schwenkkörpers linear und die Winkelposition wird direkt detektiert, woraus die Winkelpositiondetektion bei hoher Genauigkeit folgt.

[0024] Um das vorhergehende Problem zu lösen, schafft gemäß einer weiteren erfindungsgemäßen Ausführungsform die Erfindung eine Winkeleinstellvorrichtung mit: einem Sockel, einem Führungsteil, das am Sockel befestigt ist und eine bogenförmige Spur aufweist, einem Schwenkkörper, der entlang der Spur des Führungsteils bewegbar ist, und einem Bewegungsteil zum Bewegen des Schwenkkörpers, um die Winkelposition des Schwenkkörpers um eine Schwenkachse einzustellen, die durch den Krümmungsmittelpunkt der Spur verläuft, wobei das Bewegungsteil aufweist: einen Antriebsabschnitt mit einer Abtriebswelle, die in Richtung senkrecht zur Schwenkachse sich erstreckt und einen einstellbaren Vorsprungsbetrag hat und im Sockel vorgesehen ist, und ein Kupplungsmechanismus, der zwischen einem vorderen Endabschnitt der Abtriebswelle und dem Antriebsabschnitt des Schwenkkörpers angeordnet ist, um die Axialbewegung der Abtriebswelle in eine Bewegung des Schwenkkörpers entlang der Spur umzuwandeln, und wobei der Kupplungsmechanismus eine Blattfeder aufweist, wobei der Krümmungsgrad der Blattfeder verändert wird, wenn der Schwenkkörper entlang der Spur sich bewegt, um den Abstand zwischen einer Fixierposition der Blattfeder zum Schwenkkörper und der Abtriebswelle zu variieren.

[0025] Mit der vorhergehenden Konstruktion weist der Kupplungsmechanismus die Blattfeder auf und die Axialbewegung der Abtriebswelle wird via der Blattfeder in die Bewegung des Schwenkkörpers entlang der Spur umgewandelt. Deshalb hat der Kupplungsmechanismus keinen Eingriffsabschnitt, wie z. B. eine Schraube, wodurch es ermöglich ist, eine Verschlechterung der Winkeleinstellgenauigkeit wegen Spiel zu verhindern. Durch den Gebrauch der Blattfeder ist die Struktur ebenfalls vereinfacht bei niedrigen Kosten.

[0026] Wenn die Abtriebswelle vorrückbar oder zurückziehbar unter Drehung ist, wobei der Kupplungsmechanismus ein Kupplungsteil aufweist, wobei das Kupplungsteil mit dem vorderen Endabschnitt der Abtriebswelle gekuppelt ist, um relativ drehbar um die Antriebswelle zu sein, wobei ein Endabschnitt der Blattfeder am Kupplungsteil befestigt ist.

[0027] Bevorzugt weist das Führungsteil ein Paar Führungsteile auf, die auf dem Sockel im Abstand voneinander in Richtung parallel zur Schwenkachse vorgesehen sind, wobei der Schwenkkörper angeordnet ist, um das Paar Führungsteile quer zu überragen, und wobei der vordere Endabschnitt der Abtriebswelle und der Kupplungsmechanismus in einem Raum angeordnet sind, der durch den Sockel, den Schwenkkörper und dem Paar Führungsteile gebildet ist. Dadurch, wenn die Abtriebswelle vorgerückt oder zurückgezogen wird, werden der linke und der rechte Abschnitt des Schwenkkörpers synchron bewegt, wobei das Auftreten von Verklemmen der linken und der rechten Spur verhindert wird.

[0028] Im Folgenden wird die Erfindung anhand bevorzugter Ausführungsformen mit Bezugnahme auf die Zeichnungen erläutert. In der Zeichnung zeigen:

[0029] **Fig.** 1 eine Längsquerschnittsdarstellung einer Winkeleinstellvorrichtung gemäß einer erfindungsgemäßen ersten Ausführungsform,

[0030] **Fig.** 2 eine Draufsicht der Winkeleinstellvorrichtung,

[0031] **Fig.** 3 eine Draufsicht der Winkeleinstellvorrichtung, wobei ein Sockel und ein Bewegungsteil teilweise geschnitten dargestellt sind,

[0032] **Fig.** 4 eine Ansicht der Winkeleinstellvorrichtung von rechts,

[0033] **Fig.** 5 eine Ansicht der Winkeleinstellvorrichtung von rechts, wobei der Sockel, ein Bewegungsteil, ein Durchgangsblock und ein Schwenktisch der Vorrichtung in einer Explosionsdarstellung dargestellt sind,

[0034] **Fig.** 6 eine Seitenansicht der Winkeleinstellvorrichtung, wobei der Sockel, das Führungsteil und der Durchgangsblock zusammengebaut sind,

[0035] **Fig.** 7 eine Seitenansicht des Sockels und des Führungsteils, die in einer Explosionsdarstellung dargestellt ist,

[0036] **Fig.** 8 eine Seitenansicht, die teilweise ein Winkelpositiondetektiermittel der Winkeleinstellvorrichtung zeigt,

[0037] **Fig.** 9 eine Seitenansicht, die eine Glasplatte des Winkelpositiondetektiermittels zeigt,

[0038] **Fig.** 10A bis 10C Längsquerschnittsdarstellungen, die teilweise eine Winkeleinstellvorrichtung gemäß einer zweiten erfindungsgemäßen Ausführungsform zeigen, wobei in **Fig.** 10A bis 100 unterschiedliche Stellungen gezeigt sind,

[0039] **Fig.** 11 eine Längsquerschnittsdarstellung, die teilweise eine Winkeleinstellvorrichtung gemäß einer erfindungsgemäßen dritten Ausführungsform zeigt, und

[0040] **Fig.** 12 eine Längsquerschnittsdarstellung, die teilweise eine Winkeleinstellvorrichtung gemäß einer erfindungsgemäßen vierten Ausführungsform zeigt.

[0041] Unter Bezugnahme auf **Fig.** 1 bis 9 wird eine Winkeleinstellvorrichtung gemäß einer erfindungsgemäßen ersten Ausführungsform nachfolgend beschrieben. Die Winkeleinstellvorrichtung weist einen Sockel **10**, ein Paar Führungsteile **20**, die am Sockel **10** befestigt sind, einen Schwenkkörper **30**, der entlang der Führungsteile **20** geführt ist, ein Bewegungsteil **40** zum Bewegen des Schwenkkörpers **30**, und einen Detektor **50** zum Detektieren der Winkelposition des Schwenkkörpers **30** auf, wie in **Fig.** 1 bis 4 gezeigt.

[0042] Der Schwenkkörper **30** ist entlang einer kreisbogenförmigen Kurve bewegbar, was nachfolgend beschrieben wird, wobei eine Schwenkachse Ox als die Achse im Mittelpunkt der Kreisbogenkurve in **Fig.** 1 bis 4 gezeigt ist. Die Schwenkachse Ox ist senkrecht zur Zeichenfläche in **Fig.** 1, erstreckt sich jedoch von links nach rechts in **Fig.** 4. Komponenten werden nachfolgend im Detail beschrieben. Die Anordnung der Komponenten werden unter Bezugnahme auf die Schwenkachse Ox beschrieben.

[0043] Der Sockel **10** hat einen Basisabschnitt **11** mit in Form einer horizontalen Platte und einen Vorsprung **12**, der von der oberen Fläche des Basisabschnitts **10** vorsteht. Der Vorsprung **12** erstreckt sich horizontal in Richtung senkrecht zur Schwenkachse Ox, und ein konkaver Abschnitt **13**, der sich in Längsrichtung des Vorsprungs **12** erstreckt, ist an dessen oberen Fläche ausgebildet. Durchgangslöcher **14** sind an den vier Ecken des Basisabschnitts **11** ausgebildet, um die Vorrichtung an einem Fundamenttisch (nicht gezeigt) mittels Schrauben (nicht gezeigt) zu befestigen, die durch die Durchgangslöcher **14** gesteckt sind. Die Bezeichnung "Sockel" weist den Fundamenttisch auf.

[0044] Wie aus **Fig.** 3 bis 7 ersichtlich sind zwei Seiten des Vorsprungs **12** des Sockels **10** als ein Paar Stellebenen **15** vorgesehen, die flach und vertikal sind und deren Funktion nachfolgend beschrieben wird. Die oberen Flächen nahe des Vorsprungs **12** im Basisabschnitt **11** des Sockels **10** sind ebenfalls als ein Paar zweite Stellebenen **16** vorgesehen, die flach und horizontal sind. Die erste Stellebene **15** und die zweite Stellebene **16** schneiden einander senkrecht. Eine Normale der ersten Stellebene **15** ist parallel zur Schwenkachse Ox und erstreckt sich horizontal und eine Normale der zweiten Stellebene **16** ist senkrecht zur

Schwenkachse Ox und erstreckt sich vertikal. Das Paar Stellabschnitte (nahe den beiden Seiten des Vorsprungs **12**), die die Stellebenen **15** und **16** aufweisen, sind im Abstand voneinander in Richtung parallel zur Schwenkachse Ox angeordnet.

[0045] Wie aus **Fig.** 4 bis 7 ersichtlich ist das Paar Führungsteile **20** am Paar Stellabschnitte befestigt, wobei die Führungsteile **20** im Abstand voneinander in Richtung parallel zur Schwenkachse Ox und einander gegenüberliegend angeordnet sind. Jedes Führungsteil **20** hat einen Basisabschnitt **21** und einen spurausbildenden Abschnitt **22**. Der Basisabschnitt **21** hat eine Seitenfläche, die als eine erste Referenzebene **25** vorgesehen ist, die flach und vertikal ist, und eine untere Fläche, die als eine zweite Referenzebene **26** vorgesehen ist, die flach und horizontal ist. Die erste Referenzebene **25** steht in Kontakt mit der ersten Stellebene **15** des Sockels **10** und die zweite Referenzebene **26** steht in Kontakt mit der zweiten Stellebene **16** des Sockels **10**, so dass die Führungsteile **20** positioniert sind. In diesem Zustand sind die Führungsteile **20** am Sockel **10** befestigt.

[0046] Ausführlich gesehen heißt das, dass das Führungsteil **20** ein horizontales Durchgangsloch **25**a mit einem Ende hat, das offen zur ersten Referenzebene **25** ist. Der Sockel **10** hat ein Gewindeloch **15**a mit einem Ende, das offen zur Stellebene **15** ist. Durch Einsetzen einer Schraube **61** (erste Schraube) durch das Durchgangsloch **25**a von außen und Einschrauben derselben in das Gewindeloch **15**a wird das Führungsteil **20** derart befestigt, dass die erste Referenzebene **25** gegen die erste Stellebene **15** gedrückt wird. Der Sockel **10** hat ebenfalls ein vertikales Durchgangsloch **16**a mit einem Ende, das offen zur zweiten Stellebene **16** ist, und das Führungsteil **20** hat ein Gewindeloch **26**a mit einem Ende, das offen zur zweiten Referenzebene **26** ist. Durch Einsetzen einer Schraube **62** (zweite Schraube) durch das Durchgangsloch **16**a von der Unterseite und Einschrauben derselben in das Gewindeloch **26**a wird das Führungsteil **20** derart befestigt, dass die zweite Referenzebene **26** gegen die zweite Stellebene **16** gedrückt wird. Jedes Führungsteil **20** ist durch zwei (mehrere) Schrauben **61** und zwei Schrauben **62** befestigt.

[0047] Der spurausbildende Abschnitt **22** des Führungsteils **20** hat eine Kreisbogenform, steht vom vorderen Endabschnitt des Basisabschnitts **21** nach Außen vor (in Richtung weg vom Vorsprung **12** des Sockels **10** und in Richtung weg von der Seite der direkt angrenzenden Seite des Führungsteils **20**). Die Spuren **23**a und **23**b, die aus einer kreisbogenförmigen Nut bestehen, sind auf der oberen und der unteren Fläche des spurausbildenden Abschnitts **22** ausgebildet. Die Nut der Spuren **23**a und **23**b bildet eine Rollkontaktfläche von Rollelementen. Die beiden Spuren **23**a und **23**b des Spurenpaars haben unterschiedliche Krümmungsradien, jedoch haben sie den gleichen Krümmungsradiusmittelpunkt. Die Spuren **23**a und **23**b des Spurenpaars sind im Abstand voneinander in Richtung senkrecht zur Normale der Ebene angeordnet, entlang der die beiden Führungsteile **20** einander zugewandt sind.

[0048] Wie aus **Fig.** 1, 2 und 4 bis 6 ersichtlich hat der Schwenkkörper **30** einen Schwenktisch **31** und einen Durchgangsblock (Durchgangskörper) **35**. Der Schwenktisch **31** hat eine obere Wand **32**, die eben und quadratisch ist, und ein Paar Seitenwände **33**, die sich vertikal von beiden Seitenrändern der oberen Wand **32** nach unten erstrecken. Eine Normale im Mittelpunkt der oberen Fläche der oberen Wand **32** ist in **Fig.** 1 mit Lx bezeichnet. Die Normale Lx schneidet die Schwenkachse Ox. Zwei Durchgangsblöcke **35** sind durch Bolzen an die Innenseitenfläche jeder Seitenwand **33** jeweils befestigt. Jeder Durchgangsblock **35** weist eine obere und eine untere Endlosumlaufpassage **36** auf (mit einer Rollkontaktfläche für Rollelemente, die den Spuren **23**a und **23**b des Führungsteils **20** zugewandt sind).

[0049] Eine Mehrzahl von Kugeln **37** (Rollelemente) sind in der Endlosumlaufpassage **36** angeordnet, die durch die Endlosumlaufpassage **36** zusammen mit der Bewegung des Durchlaufblocks **35** umlaufen und die auf den Rollkontaktflächen zwischen dem Führungsteil **20** und dem Transitblock **35** rollen. Der Durchmesser der Kugel **37** ist geringfügig größer als das Spiel zwischen den Rollkontaktflächen. Die Rollkontaktflächen und die Kugeln **37** sind durch Einsetzen der Kugeln in die Rollkontaktflächen elastisch deformiert, wodurch die Kugeln **37** vorgespannt sind.

[0050] Das Bewegungsteil **40** wird im Folgenden beschrieben. Das Bewegungsteil **40** weist eine Antriebseinheit **42** (Antriebsabschnitt) auf, die via einer Halterung **41** am Sockel **10** befestigt ist, wie in **Fig.** 1 und 3 gezeigt. Eine Abtriebswelle **42**a der Antriebseinheit **42** erstreckt sich horizontal in Richtung senkrecht zur Schwenkachse Ox, ihr vorderer Endabschnitt tritt in einen Raum ein, der durch den Sockel **10**, den Schwenktisch **31** und dem Paar Führungsteile **20** gebildet ist. In dieser Ausführungsform ist ein Basisendabschnitt der Abtriebswelle **42**a eine Kugelgewindespindel, die mit einer Mutter (nicht gezeigt) innerhalb eines Gehäuses **42**x der Antriebseinheit **42** gepaart ist. Ein Schrittmotor (nicht gezeigt), der innerhalb des Gehäuses **42**x der Antriebseinheit **42** untergebracht ist, wird angetrieben, um die Mutter zu drehen, so dass die Abtriebswelle **42**a vorgerückt oder zurückgezogen wird, wodurch deren Vorsprungsbetrag eingestellt wird.

[0051] Ferner weist das Bewegungsteil **40** einen Kupplungszapfen **43** auf, der im Schwenkkörper **30** vorgesehen ist. Der Kupplungszapfen **43** ist im Zentrum des Schwenktischs **31** befestigt, senkrecht zur oberen Wand **32** des Schwenktischs **31** und erstreckt sich nach unten. Der Kupplungszapfen **43** ist innerhalb des Raums aufgenommen, der durch den Sockel **10**, den Schwenktisch **31** und dem Paar Führungsteile **20** gebildet ist, wobei sein vorderer Endabschnitt in den konkaven Abschnitt **13** des Sockels **10** eintritt.

[0052] Wie aus **Fig.** 1 und 3 ersichtlich ist ein Kupplungsmechanismus **45** zwischen der Abtriebswelle **42**a bzw. der Antriebseinheit **42** und dem Kupplungszapfen **43** angeordnet. Der Kupplungsmechanismus **45** hat zwei Kupplungsteile **45** und **46**. Der Basisendabschnitt des Kupplungsteils **45** ist am vorderen Endabschnitt der Abtriebswelle **42**a befestigt.

[0053] Das Kupplungsteil **45** weist ein Paar plattenähnliche Stücke an seinem vorderen Endabschnitt auf, in dem eine Welle **48** via einem Lager **47** drehbar abgestützt ist. Das Kupplungsteil (Hauptkupplungsteil) **46** hat ein Durchgangsloch **45**x, in das die Welle **48** eingesetzt und befestigt ist. Folglich ist das Kupplungsteil **46** mit dem vorderen Endabschnitt der Abtriebswelle **42** drehbar um die Welle **48** (Drehachse parallel zur Schwenkachse Ox) gekuppelt. Außerdem ist das Kupplungsteil **46** via einer zylindrischen Kugelkeilwelle **49** mit dem Kupplungszapfen **43** in Axialrichtung des Kupplungszapfens bewegbar gekuppelt, die den Kupplungszapfen **43** umschließt.

[0054] Wenn der Schrittmotor der Antriebseinheit **42** angetrieben wird, wird die Abtriebswelle **42**a axial bewegt, um dessen Vorsprungsbetrag zu ändern. Da das Kupplungsteil **46** via dem Kupplungsteil **45** mit der Abtriebswelle **42**a gekuppelt ist, um relativ drehbar aber nicht relativ axial bewegbar zu sein, wird es in die gleiche Richtung bewegt, um den Kupplungszapfen **43** zusammen mit der Axialbewegung der Abtriebswelle **42**a zu drücken. Folglich neigt sich der Kupplungszapfen **43**. Der Durchgangsblock **35** bewegt sich entlang der Spuren **23**a und **23**b der Führungsteile **20** gemäß der Neigung der Kupplungszapfen **43**, so dass der Schwenktisch **31** geneigt wird, um die Winkelposition um die Schwenkachse Ox zu ändern. Das Kupplungsteil **46** ist drehbar bezüglich der Abtriebswelle **42**a und axial bewegbar bezüglich des Kupplungszapfen **43**, wodurch die Neigung des Kupplungszapfens **43** zusammen mit der Axialbewegung der Abtriebswelle **42**a ermöglicht ist.

[0055] Der Durchgangsblock **35** wird in der Spur **23** mit den rollenden und umlaufenden Kugeln **37** geführt und unter Beschreiben eines Kreisbogens bewegt, und der Schwenktisch **31** wird unter Beschreiben des Kreisbogens geneigt. Der Mittelpunkt des Kreisbogens liegt auf der Schwenkachse Ox.

[0056] Wie aus **Fig.** 2 und 4 ersichtlich hat ein Winkelpositiondetektor **50** zum detektieren der Winkelposition des Schwenktisch **31** eine Lichtemittiereinheit **52** und eine Lichtempfangseinheit **53** (Skalendetektierteil), das via einer Halterung **51** auf dem Sockel vorgesehen ist, und eine Glasplatte **56** (Skalenaufzeichnungsteil), das via einer Halterung **55** an der Seitenwand **33** des Schwenktisch **31** vorgesehen ist. Die Lichtemittiereinheit **52** und die Lichtempfangseinheit **53** sind im Abstand voneinander in Richtung parallel zur Schwenkachse Ox angeordnet. Wie aus **Fig.** 8 ersichtlich ist die Lichtemittiereinheit **52** in vier Lichtemittieranteile **52**a aufgeteilt, nämlich obere, untere, linke und rechte Anteile, und entsprechend ist die Lichtempfangseinheit **53** ebenfalls in vier Lichtempfanganteile (nicht gezeigt) aufgeteilt, nämlich obere, unter, linke und rechte Anteile.

[0057] Die Glasplatte **56** hat einen Skalenabschnitt **56**a kreisbogenförmiger Form, der zwischen der Lichtemittiereinheit **52** und der Lichtempfangseinheit **53** angeordnet ist. Der Skalenabschnitt **56**a hat ein Skalenraster.

[0058] Ein Detektiersignal wird von der Lichtempfangseinheit **53** für jede Mikrowinkeleinheit (Skala) mit dem Wechsel der Winkelposition des Schwenktischs **31** ausgegeben. Dieses Prinzip ist bekannt und es wird auf eine detaillierte Beschreibung verzichtet. Das Winkelpositiondetektiersignal ist mit einem Mikrocomputer (nicht gezeigt) rückgekoppelt, der den Schrittmotor der Antriebseinheit **42** steuert, um die Winkeleinstellung des Schwenktischs **31** auf Basis des Detektiersignals durchzuführen.

[0059] In der Vorrichtung gemäß der vorhergehenden Konstruktion ist die erste flache Referenzebene **25** im Basisabschnitt **21** des Führungsteils **20** mit der flachen ersten Stellebene **15** des Sockels **10** ausgerichtet, und das Führungsteil **20** ist mittels den ersten Schrauben **61** an die erste Stellebene **15** unter Druck befestigt, und die zweite flache Referenzebene **26** ist mit der zweiten Stellebene **16** ausgerichtet, und das Führungsteil **20** ist mittels der Schrauben **62** an die zweite Stellebene **16** unter Druck befestigt. Deshalb werden die Spuren **23**a und **23**b kreisbogenförmiger Form nicht deformiert, wodurch es ermöglicht ist eine Verschlechterung der Rundheit der Spur **23** zu verhindern und die Winkeleinstellung des Schwenkkörpers **30** mit hoher Genauigkeit durchzuführen.

[0060] Für das Bewegungsteil **40** kann die Antriebseinheit **42** verwendet werden, die kommerziell erhältlich ist, in der der Motor und der Kugelgewindespindelmechanismus in das Gehäuse **42**x eingebaut sind. Deshalb ist es nicht notwendig den Gewindeabschnitt im Sockel **10** und im Schwenkkörper auszubilden, wodurch es ermöglicht ist eine Verschlechterung der Winkeleinstellgenauigkeit wegen Spiel zu verhindern.

[0061] Da der vordere Endabschnitt der Abtriebswelle **42**a des Bewegungsteils **40**, die Kupplungszapfen **43** und der Kupplungsmechanismus **45** im Raum aufgenommen sind, der durch den Sockel **10**, dem Paar Führungsteile **20** und dem Schwenkkörper **30** gebildet wird, ist es nicht notwendig einen großen Unterbringungsraum für das Bewegungsteil **40** vorzusehen, wodurch die Größe der Vorrichtung reduziert ist.

[0062] Wenn die Abtriebswelle **42**a, die in der Mitte angeordnet ist, vorgeschoben oder zurückgezogen wird, werden der linke und der rechte Abschnitt des Schwenkkörpers **30** synchron bewegt, wobei der linke und der rechte Abschnitt in der linken und der rechten Spur **23**a und **23**b geführt werden, wodurch ein Verklemmen der linken und der rechten Spur **23**a und **23**b verhindert wird. Außerdem wird der Schwenkkörper **30** in Summe mittels vier Spuren stabil geführt. Da die Kugeln **37** vorgespannt sind, ist die Steifheit des Schwenkkörpers **30** zum Führungsteil **20** erhöht.

[0063] Zur Winkelpositiondetektion des Schwenkkörpers **30** wird die Lichtempfangseinheit **53**, die auf dem Sockel **10** vorgesehen ist, mit einer Skala der Glasplatte **56**, die auf dem Schwenkkörper **30** vorgesehen ist, verwendet, wodurch die Beziehung zwischen der detektierten Ausgabegröße und der Winkelposition des Schwenkkörpers **30** linear sein kann und die Winkelposition direkt detektiert werden kann (d. h. die Winkelposition wird nicht indirekt aus der Anzahl von Ausgabeschritten des Schrittmotors der Antriebseinheit **42** berechnet), so dass die Winkelposition mit hoher Genauigkeit detektiert wird. Und die Nullpunkteinstellung ist möglich.

[0064] Unter Bezugnahme auf **Fig.** 10 bis 12 werden andere Ausführungsformen im Folgenden beschrieben. Diese Ausführungsformen haben die gleiche Grundkonstruktion wie die erste Ausführungsform, es werden im Folgenden nur unterschiedliche Teile beschrieben. Die vergleichbaren Teile sind mit denselben Bezugszeichen bezeichnet und werden nicht beschrieben.

[0065] **Fig.** 10 zeigt eine erfindungsgemäße zweite Ausführungsform. In dieser Ausführungsform führt der konkave Abschnitt **13** zur Seite der Antriebseinheit **42**, der im Vorsprung **12** des Sockels **10** ausgebildet ist. Ein Kupplungsmechanismus **80**, der unterschiedlich von dem der ersten Ausführungsform ist, ist zwischen dem vorderen Endabschnitt der Abtriebswelle **42**a der Antriebseinheit **42** und dem Schwenktisch **31** angeordnet.

[0066] Der Kupplungsmechanismus **80** wird im Folgenden beschrieben. Ein Kupplungsteil **81** ist am vorderen Endabschnitt der Abtriebswelle **42**a befestigt und eine Halterung **82** ist am Kupplungsteil **81** befestigt. Die obere Fläche der Halterung **82** ist eine Anbringfläche **82**a, die horizontal und parallel zur Längsachse der Abtriebswelle **42**a ist. Auf der Anbringfläche **82**a ist das eine Ende einer breiten Blattfeder **83** befestigt, die sich in Längsrichtung der Abtriebswelle **42**a erstreckt. Andererseits ist ein konvexer Abschnitt **84** auf der unteren Fläche der oberen Wand **42** des Schwenktischs **31** ausgebildet. Die untere Fläche des konvexen Abschnitts **84** ist eine geneigte Anbringfläche **84**a, an der das andere Ende der Blattfeder **83** befestigt ist. Eine Plattenfläche der Blattfeder **83** ist dem Schwenktisch **31** zugewandt, und die andere Plattenfläche der Blattfeder **83** ist dem Sockel **10** zugewandt.

[0067] Die Blattfeder **83** hat eine gekrümmte Form in einem Zustand (Horizontalzustand), in dem der Schwenktisch **31** parallel zum Sockel **10** ist, wie in **Fig.** 10A gezeigt. Wenn die Abtriebswelle **42**a mittels des Schrittmotors der Antriebseinheit **42** axial bewegt wird, wird die Schwenkeinheit via der Blattfeder **83** entlang der kreisbogenförmigen Spur **30** bewegt. Da die Blattfeder **83** aus einer SUS-Stahlplatte hergestellt und breit ist, hat die Blattfeder **83** eine genügend hohe Steifheit, wodurch die Umwandlung der Bewegung ermöglicht ist.

[0068] Wenn die Abtriebswelle **42**a vorgerückt wird, um den Vorsprungsbetrag zu erhöhen, wie in **Fig.** 10B gezeigt, wird der Schwenktisch **31** bewegt, um nach rechts geneigt zu werden, so dass ein Fixierabschnitt der Blattfeder **83** auf dem Schwenktisch **31** nach oben verlagert wird, wodurch der Abstand vom Vorsprung der Abtriebswelle **42**a vergrößert wird. Die Verlagerung des Fixierabschnitts der Blattfeder **83** nach oben ist wegen einer Erhöhung des Krümmungsgrads der Blattfeder **83** ermöglicht.

[0069] Wenn die Abtriebswelle **42**a zurückgezogen wird, um den Vorsprungsbetrag zu verkleinern, wie in **Fig.** 10C gezeigt, wird der Schwenktisch **31** bewegt, um nach links geneigt zu werden, so dass ein Fixierabschnitt der Blattfeder **83** auf dem Schwenktisch **31** nach unten verlagert wird, wodurch der Abstand vom Vorsprung der Abtriebswelle **42**a verkleinert wird. Die Verlagerung des Fixierabschnitts der Blattfeder **83** nach unten ist wegen einer Erhöhung des Krümmungsgrads der Blattfeder **83** ermöglicht. In der zweiten Ausführungsform ist die Blattfeder **83** innerhalb des Winkeleinstellbereichs des Schwenktischs **31** stets gekrümmt. D. h., die Blattfeder **83** ist leicht gekrümmt, sogar wenn der Vorsprungsbetrag der Abtriebswelle **42**a am kleinsten ist.

[0070] In der zweiten Ausführungsform ist eine Ausbildung des Gewindeabschnitts im Sockel **10** und im Schwenkkörper **30** nicht notwendig, wodurch es ermöglicht ist, eine Verschlechterung der Winkeleinstellgenauigkeit wegen Spiel zu vermeiden. Die Verwendung der Blattfeder **83**, des Lagers **47** und der Kugelkeilwelle **49** in der ersten Ausführungsform ist vermeidbar, um eine einfache und kostengünstige Struktur zu erhalten.

[0071] Gemäß einer erfindungsgemäßen dritten Ausführungsform, wie in **Fig.** 11 gezeigt, wird eine Mikroschraube **70**, die manuell betätigbar ist, als der Antriebsabschnitt verwendet. Eine Abtriebswelle **70**a der Mikroschraube **70** hat ein Kupplungsteil **45**a, das koaxial an der Abtriebswelle **70**a befestigt ist. Am vorderen Endabschnitt mit kleinerem Durchmesser des Kupplungsteils **45**a ist ein Kupplungsteil **45**b (Hilfskupplungsteil), das einen zylindrischen Basisendabschnitt hat, via einem Lager **90** drehbar gekuppelt. Der Drehmittelpunkt des Kupplungsteils **45**b fällt mit der Längsachse der Abtriebswelle **70**a zusammen. Die Kupplungsteile **45**a und **45**b sind relativ in Axialrichtung der Abtriebswelle **70**a unbeweglich. Am vorderen Endabschnitt des Kupplungsteils **45**b ist das Kupplungsteil **46** via dem Lager **47** und der Welle **48** wie gemäß der ersten Ausführungsform gekuppelt.

[0072] Da das Kupplungsteil **45**b via dem Kupplungsteil **45**a mit der Abtriebswelle **70**a gekuppelt ist, um relativ drehbar zu sein, jedoch um relativ axial unbeweglich zu sein, wird es axial bewegt, indem es der Axialbewegung der Abtriebswelle **70**a unter Drehung folgt, um den Schwenktisch **31** via dem Kupplungsteil **46** und dem Kupplungszapfen **43** zu neigen.

[0073] Gemäß einer vierten Ausführungsform, wie in **Fig.** 12 gezeigt, ist eine Blattfeder **83** gemäß der zweiten Ausführungsform und die Mikroschraube **70**, die manuell betätigbar ist, verwendet. Der vordere Endabschnitt der Abtriebswelle **70**a der Mikroschraube **70** ist via den Kupplungsteilen **45**a und **45**b und den Lager **70** mit der Halterung **82** gekuppelt. Der restliche Aufbau und die Funktion sind gleich wie gemäß der dritten Ausführungsform.

[0074] Es ist bevorzugt, dass der Befestigungsabschnitt der Blattfeder **83** zur Welle **70**a fast auf dem Vorsprung der Welle **70**a angeordnet ist, oder darüber (mehr am Schwenktisch **31**) wie gemäß der zweiten Ausführungsform. Gemäß dieser Art und Weise ist es ausreichend, dass die Blattfeder **83** eine geringere elastische Deformierbarkeit und eine kleinere elastische Rückstellkraft hat, die vom Antriebsabschnitt aufgenommen wird.

[0075] Gemäß einer weiteren erfindungsgemäßen Ausführungsform kann die Abtriebswelle ein Antriebsabschnitt eines Motors sein, die vorrückbar oder zurückziehbar unter Drehung ist, oder kann eine Mikroschraube sein, die manuell betätigbar und vorrückbar oder zurückziehbar ohne Drehung ist. Im Gegensatz zu den vorhergehenden Ausführungsformen kann der Antriebsabschnitt auf dem Schwenktisch vorgesehen sein und die Kupplungszapfen könnte auf dem Sockel vorgesehen sein. Der Winkelpositiondetektor ist nicht auf den optischen Detektor beschränkt, er kann ein magnetischer Detektor sein.

[0076] Die Erfindung könnte bei einer zweiachsen Winkeleinstellvorrichtung angewendet werden. In diesem Fall sind die obere und die untere Bühne gemäß den vorhergehenden Ausführungsformen konstituiert, wobei der Sockel **10** in der oberen Bühne am Schwenktisch **31** in der unteren Bühne befestigt ist. Der Schwenktisch in der oberen Bühne und der Sockel in der unteren Bühne können einstückig ausgebildet sein.

[0077] Wie vorgehend beschrieben, kann erfindungsgemäß die Mikrowinkelpositioneinstellung bei hoher Genauigkeit durchgeführt werden.

Patentansprüche

1. Winkeleinstellvorrichtung mit:
einem Sockel (**10**) mit einer ersten und einer zweiten Stellebene (**15**, **16**), die einander schneiden,
einem Führungsteil (**20**), das am Sockel (**10**) befestigt ist und einen spurausbildenden Abschnitt (**22**), eine bogenförmige Spur (**23**a, **23**b), die auf dem spurausbildenden Abschnitt (**22**) ausgebildet ist, und einen Basisabschnitt (**21**) hat, der eine erste und eine zweite Referenzebene hat (**25**, **26**)
einem Schwenkkörper (**30**), der entlang der Spur (**23**a, **23**b) des Führungsteils (**20**) bewegbar ist, und
einem Bewegungsteil (**40**) zum Bewegen des Schwenkkörpers (**30**), um die Winkelposition des Schwenkkörpers (**30**) um eine Schwenkachse (Ox) einzustellen, die durch den Krümmungsmittelpunkt der Spur (**23**a, **23**b) verläuft, wobei der spurausbildende Abschnitt (**22**) und der Basisabschnitt (**21**) einstückig ausgebildet sind, und das Führungsteil (**20**) in einem Zustand, in dem die erste und die zweite Referenzebene (**25**, **26**) mit der ersten und der zweiten Stellebene (**15**, **16**) des Sockels (**10**) in Kontakt sind, am Sockel (**10**) befestigt ist.

2. Winkeleinstellvorrichtung gemäß Anspruch 1, wobei das Führungsteil (**20**) am Sockel (**10**) befestigt ist, so dass die erste Referenzebene (**25**) gegen die erste Stellebene (**15**) durch eine erste Schraube (**61**) gedrückt ist, die die erste Stellebene (**15**) und die erste Referenzebene (**25**) durchdringt, und am Sockel (**10**) befestigt ist, so dass die zweite Referenzebene (**26**) gegen die zweite Stellebene (**16**) durch eine zweite Schraube (**62**) gedrückt ist, die die zweite Stellebene (**16**) und die zweite Referenzebene (**26**) durchdringt.

3. Winkeleinstellvorrichtung gemäß Anspruch 1, wobei der Sockel (**10**) ein Paar Stellabschnitte hat, die im Abstand voneinander in Richtung parallel zur Schwenkachse (Ox) angeordnet sind, wobei jeder Stellabschnitt jeweils mit der ersten und der zweiten Stellebene (**15**, **16**) ausgebildet ist, wobei
das Führungsteil (**20**) ein Paar Führungsteile (**20**) aufweist, die jeweils an einem Stellabschnitt befestigt sind, um einander zugewandt zu sein, wobei
der spurausbildende Abschnitt (**22**) jedes Führungsteils (**20**) vom Basisabschnitt (**21**) vorsteht, wobei
der Schwenkkörper (**30**) angeordnet ist, um das Paar

Führungsteile (**20**) quer zu überragen, wobei
jeder spurausbildende Abschnitt (**22**) mit einem Paar Spuren (**23**a, **23**b) ausgebildet ist, die jeweils eine unterschiedliche Krümmung haben, wobei die Spuren (**23**a, **23**b) im Abstand voneinander in Richtung senkrecht zur Normale der Ebene angeordnet sind, entlang der die Führungsteile (**20**) einander zugeordnet sind, und wobei
mindestens ein Teil des Bewegungsteils in einem Raum aufgenommen ist, der durch den Sockel (**10**), den Schwenkkörper (**30**) und dem Paar Führungsteile (**20**) gebildet ist.
4. Winkeleinstellvorrichtung gemäß Anspruch 1, wobei die Spur (**23**a, **23**b) eine Rollkontaktfläche für Rollelemente (**37**) hat, wobei
der Schwenkkörper (**30**) mit einer Endlosumlaufpassage (**36**) ausgebildet ist, die eine Rollkontaktfläche für Rollelemente (**37**) aufweist, die der Rollkontaktfläche der Spur (**23**a, **23**b) zugewandt ist, wobei
eine Mehrzahl von Rollelementen (**37**), die mit der Bewegung des Schwenkkörpers (**30**) umlaufen, in der Endlosumlaufpassage (**36**) angeordnet sind, und wobei die Rollelemente (**37**) in einem vorgespannten Zustand zwischen der Rollelement-Rollkontaktfläche der Spur (**23**a, **23**b) und der Rollkontaktflächen angeordnet sind.
5. Winkeleinstellvorrichtung mit:
einem Sockel (**10**),
einem Führungsteil (**20**), das am Sockel (**10**) befestigt ist und eine bogenförmige Spur (**23**a, **23**b) aufweist,
einem Schwenkkörper (**30**), der entlang der Spur (**23**a, **23**b) des Führungsteils (**20**) bewegbar ist, und
einem Bewegungsteil (**40**) zum Bewegen eines Schwenkkörpers (**30**), um die Winkelposition des Schwenkkörpers (**30**) um die Schwenkachse (Ox) einzustellen, die durch den Krümmungsmittelpunkt der Spur (**23**a, **23**b) verläuft, wobei das Bewegungsteil (**40**) aufweist:
einen Antriebsabschnitt (**42**) mit einer Abtriebswelle (**42**a), die in Richtung senkrecht zur Schwenkachse (Ox) sich erstreckt und einen einstellbaren Vorsprungsbetrag hat und im Sockel (**10**) bzw. im Schwenkkörper (**30**) vorgesehen ist,
einen Kupplungszapfen (**43**), der im Schwenkkörper (**30**) bzw. im Sockel (**10**) vorgesehen ist, und
einen Kupplungsmechanismus (**45**), der zwischen einem vorderen Endabschnitt der Abtriebswelle und des Kupplungszapfens angeordnet ist, um die Axialbewegung der Abtriebswelle in eine Bewegung des Schwenkkörpers entlang der Spur umzuwandeln, wobei
der Kupplungsmechanismus ein Hauptkupplungsteil aufweist, das mit dem vorderen Endabschnitt der Abtriebswelle (**42**a) drehbar um eine Drehachse parallel zur Schwenkachse (Ox) gekuppelt ist und das mit dem Kupplungszapfen (**43**) gekuppelt ist, um linear bewegbar in Axialrichtung des Kupplungszapfens (**43**) zu sein.
6. Winkeleinstellvorrichtung gemäß Anspruch 5, wobei das Hauptkupplungsteil (**46**) via einer Kugelkeilwelle mit dem Kupplungszapfen (**43**) in der Art und Weise gekuppelt ist, dass das Hauptkupplungsteil (**46**) linear bewegbar ist.
7. Winkeleinstellvorrichtung gemäß Anspruch 5, wobei die Abtriebswelle (**42**a) vorrückbar oder zurückziehbar unter Drehung ist,
wobei der Kupplungsmechanismus (**45**) ein Hilfskupplungsteil (**45**b) aufweist, das zwischen dem vorderen Endabschnitt der Abtriebswelle (**42**a) und dem Hauptkupplungsteil (**46**) angeordnet ist, wobei das Hilfskupplungsteil (**45**a) mit dem vorderen Endabschnitt der Abtriebswelle (**42**a) gekuppelt ist, um relativ drehbar um die Längsachse der Abtriebswelle (**42**a) zu sein, und wobei
das Hauptkupplungsteil (**46**) und das Hilfskupplungsteil (**45**b) drehbar um die Drehachse parallel zur Schwenkachse (Ox) gekuppelt sind.
8. Winkeleinstellvorrichtung gemäß Anspruch 5, wobei das Führungsteil (**20**) ein Paar Führungsteile (**20**) aufweist, die im Abstand voneinander angeordnet in Richtung parallel zur Schwenkachse (Ox) auf dem Sockel (**10**) vorgesehen sind, wobei der Schwenkkörper (**30**) angeordnet ist, um das Paar Führungsteile (**20**) quer zu überragen, und wobei der vordere Endabschnitt der Abtriebswelle (**42**a), der Kupplungszapfen (**43**) und der Kupplungsmechanismus (**45**) in einem Raum angeordnet sind, der durch den Sockel (**10**), den Schwenkkörper (**30**) und dem Paar Führungsteile (**20**) gebildet ist.
9. Winkeleinstellvorrichtung gemäß Anspruch 5, mit einem Winkelpositiondetektor (**50**), wobei der Winkelpositiondetektor (**50**) ein Skalenaufzeichnungsteil (**56**), das im Sockel (**10**) bzw. im Schwenkkörper (**30**) vorgesehen ist, und einem Detektor (**50**) zum Detektieren der Skala des Skalenaufzeichnungsteils (**56**) aufweist, wobei der Detektor (**50**) im Schwenkkörper (**30**) bzw. im Sockel (**10**) vorgesehen ist.
10. Winkeleinstellvorrichtung mit:
einem Sockel (**10**),
einem Führungsteil (**20**), das am Sockel (**10**) befestigt ist und eine bogenförmige Spur (**23**a, **23**b) aufweist,
einem Schwenkkörper (**30**), der entlang der Spur (**23**a, **23**b) des Führungsteils (**20**) bewegbar ist, und
einem Bewegungsteil (**40**) zum Bewegen des Schwenkkörpers (**30**), um die Winkelposition des Schwenkkörpers (**30**) um eine Schwenkachse (Ox) einzustellen, die durch den Krümmungsmittelpunkt der Spur (**23**a, **23**b) verläuft, wobei das Bewegungsteil (**40**) aufweist:
einen Antriebsabschnitt (**42**) mit einer Abtriebswelle (**42**a), die in Richtung senkrecht zur Schwenkachse (Ox) sich erstreckt und einen einstellbaren Vorsprungsbetrag hat und im Sockel (**10**) vorgesehen ist, und
ein Kupplungsmechanismus (**80**), der zwischen einem vorderen Endabschnitt der Abtriebswelle (**42**a) und dem Antriebsabschnitt (**42**) des Schwenkkörpers (**30**) angeordnet ist, um die Axialbewegung der Abtriebswelle (**42**a) in eine Bewegung des Schwenkkörpers (**30**) entlang der Spur (**23**a, **23**b) umzuwandeln, und wobei der Kupplungsmechanismus (**80**) eine Blattfeder (**83**) aufweist, wobei der Krümmungsgrad der Blattfeder (**83**) verändert wird, wenn der Schwenkkörper (**30**) entlang der Spur (**23**a, **23**b) sich bewegt, um den Abstand zwischen einer Fixierposition der Blattfeder (**83**) zum Schwenkkörper (**30**) und der Abtriebswelle (**42**a) zu variieren.
11. Winkeleinstellvorrichtung gemäß Anspruch 10, wobei die Abtriebswelle vorrückbar oder zurückziehbar unter Drehung ist, wobei der Kupplungsmechanismus (**80**) ein Kupplungsteil (**45**a) aufweist, wobei das Kupplungsteil (**45**a) mit dem vorderen Endabschnitt der Abtriebswelle (**42**a) gekuppelt ist, um relativ drehbar um die Antriebswelle (**42**a) zu sein, wobei ein Endabschnitt der Blattfeder (**83**) am Kupplungsteil (**45**a) befestigt ist.
12. Winkeleinstellvorrichtung gemäß Anspruch 10, wobei das Führungsteil (**20**) ein Paar Führungsteile

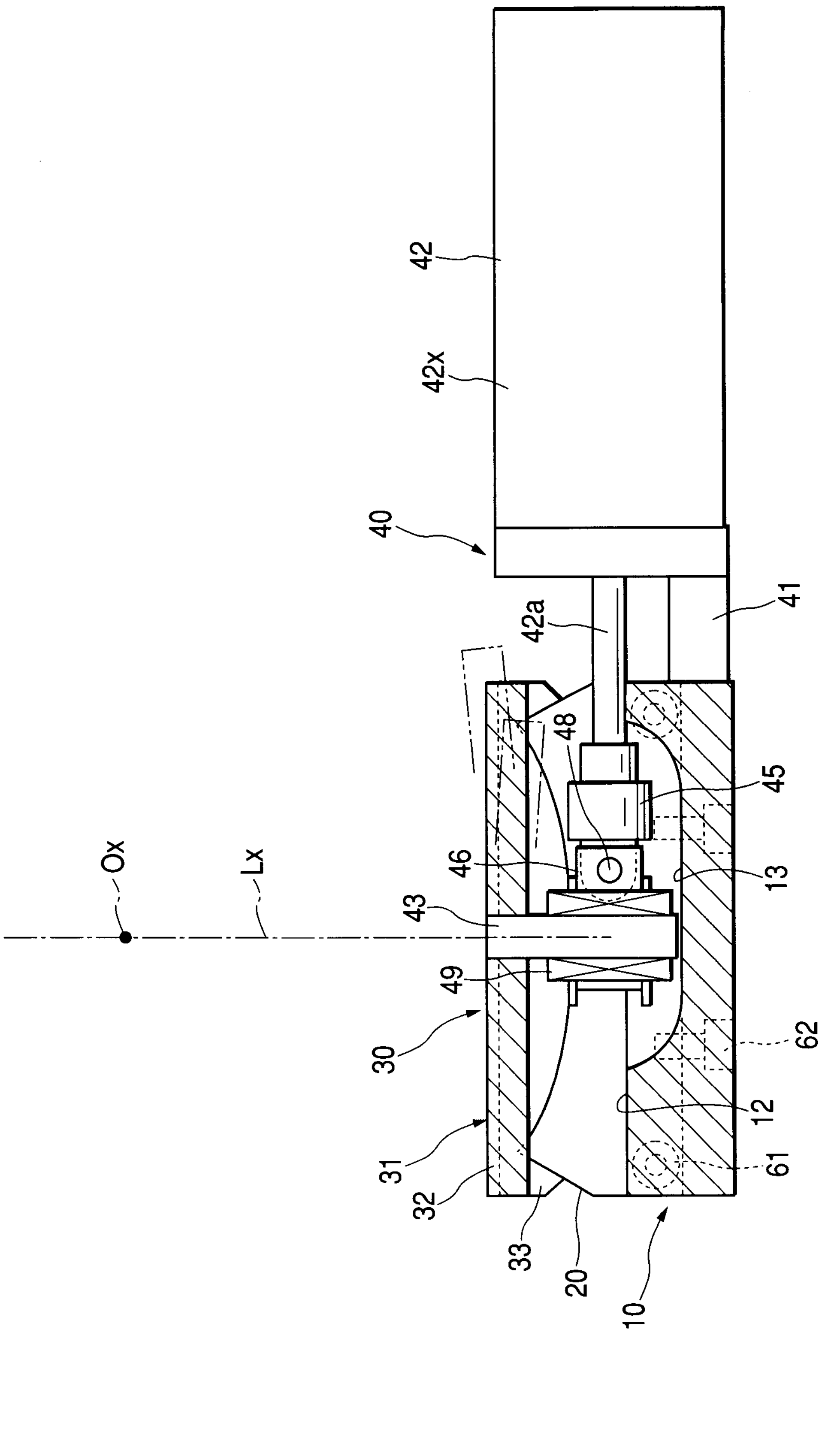
(**20**) aufweist, die auf dem Sockel (**10**) im Abstand voneinander in Richtung parallel zur Schwenkachse (Ox) vorgesehen sind, wobei der Schwenkkörper (**30**) angeordnet ist, um das Paar Führungsteile (**20**) quer zu überragen, und wobei der vordere Endabschnitt der Abtriebswelle (**42**a) und der Kupplungsmechanismus (**80**) in einem Raum angeordnet sind, der durch den Sockel (**10**), den Schwenkkörper (**30**) und dem Paar Führungsteile (**20**) gebildet ist.

Hierzu 8 Seite(n) Zeichnungen

- Leerseite -

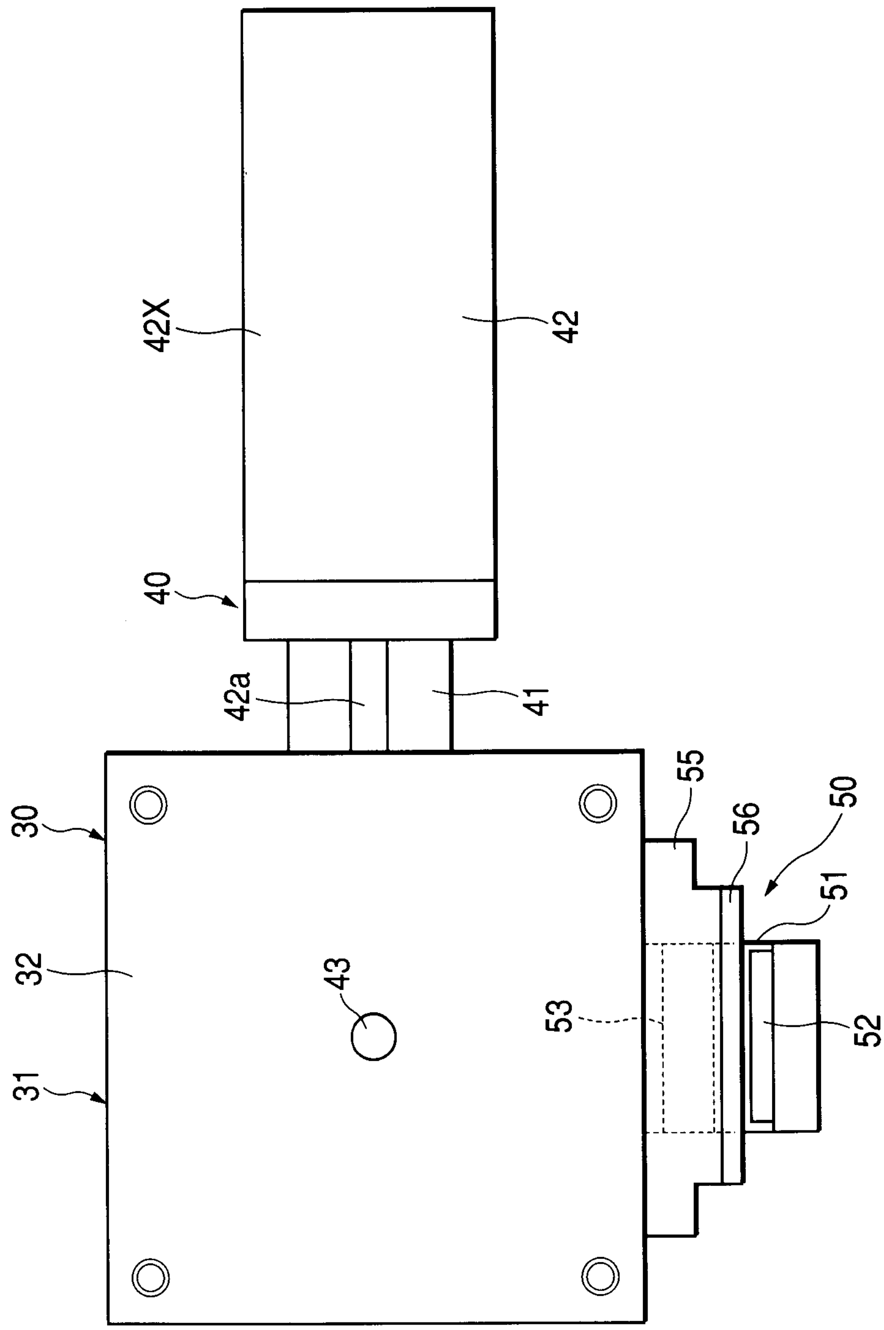
Nummer: **DE 103 09 859 A1**
Int. Cl.[7]: **G 05 G 5/00**
Offenlegungstag: 18. September 2003

FIG. 1



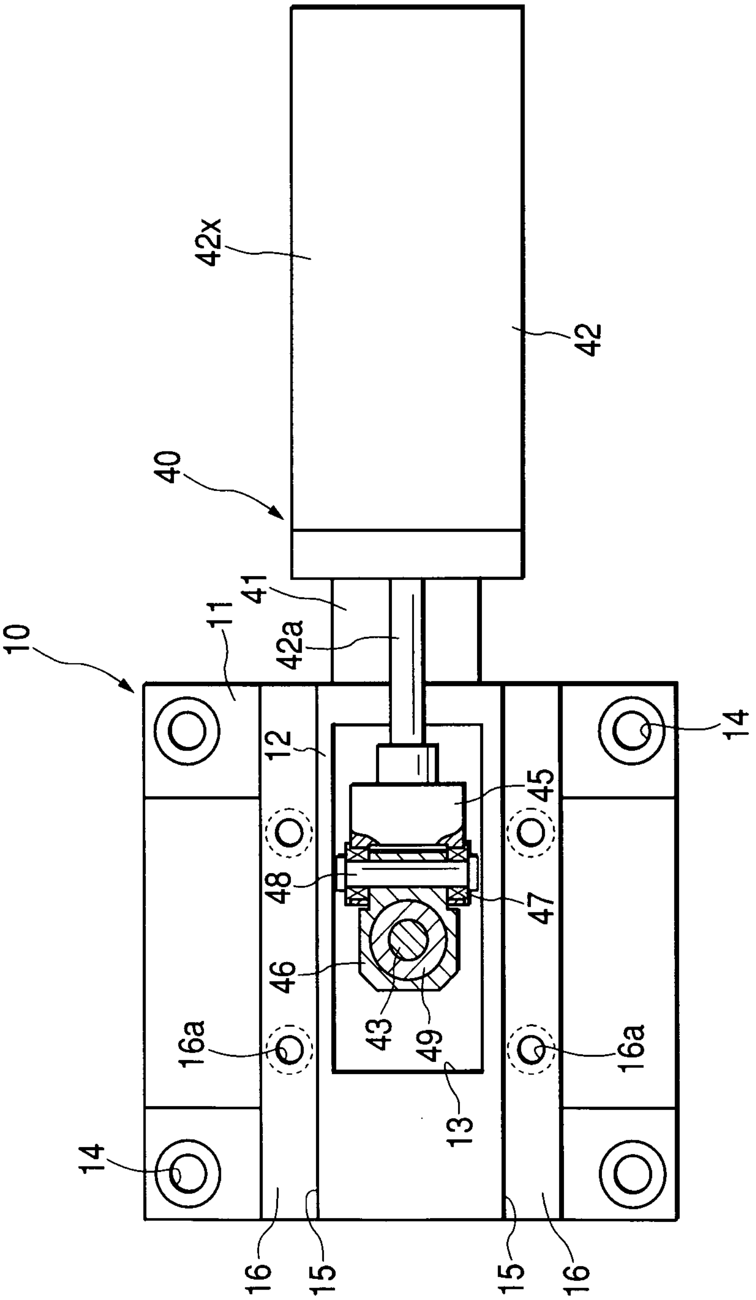
Nummer: **DE 103 09 859 A1**
Int. Cl.[7]: **G 05 G 5/00**
Offenlegungstag: 18. September 2003

FIG. 2



Nummer: **DE 103 09 859 A1**
Int. Cl.[7]: **G 05 G 5/00**
Offenlegungstag: 18. September 2003

FIG. 3



Nummer: DE 103 09 859 A1
Int. Cl.[7]: G 05 G 5/00
Offenlegungstag: 18. September 2003

FIG. 4

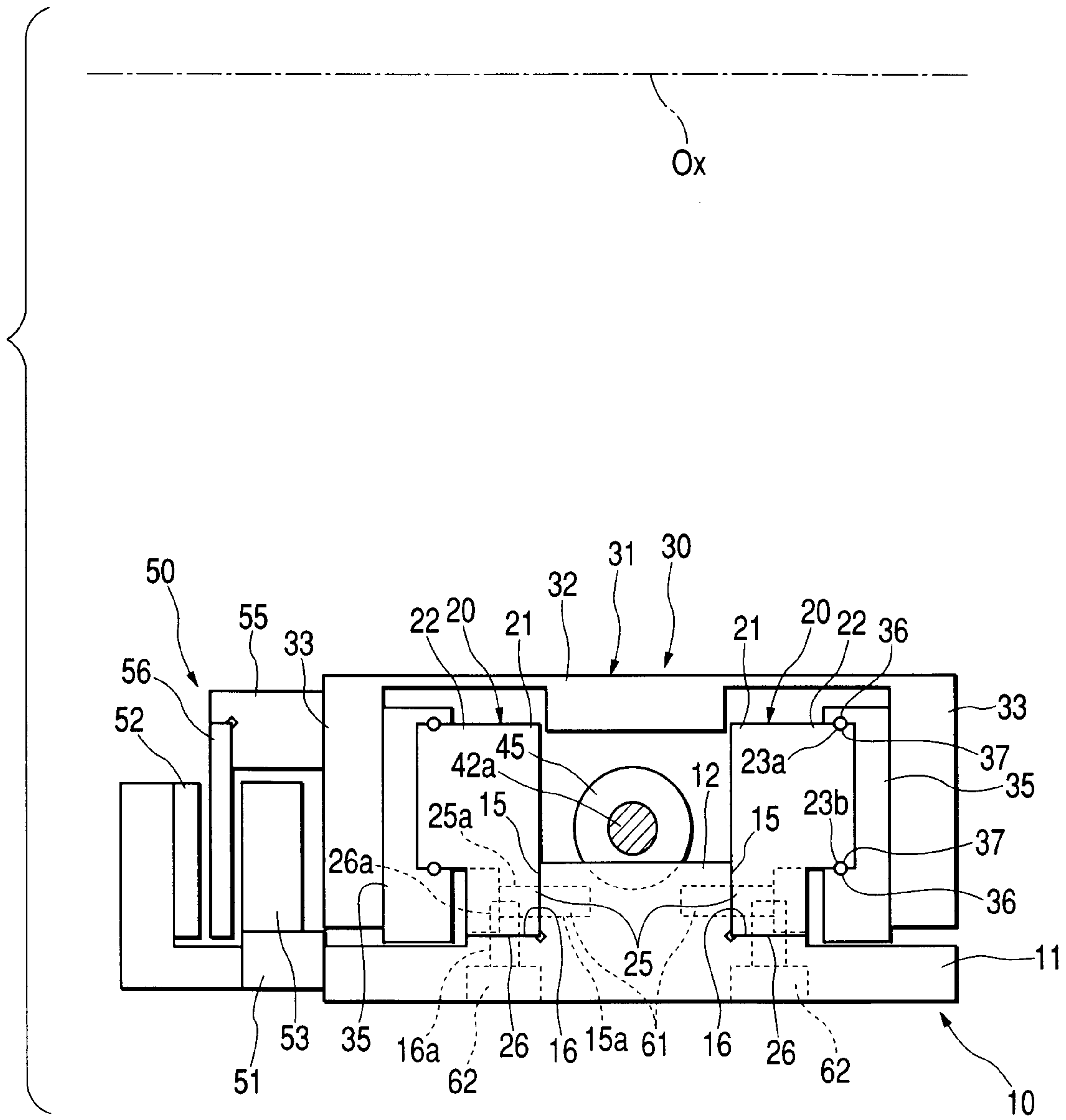


FIG. 5

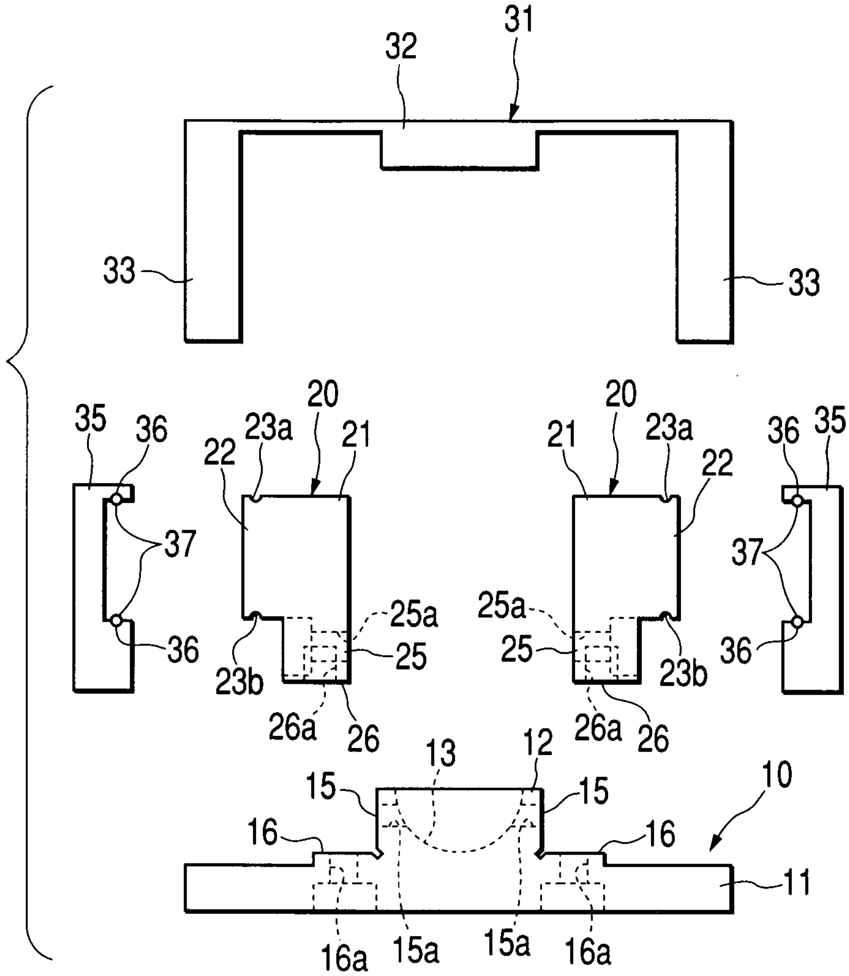
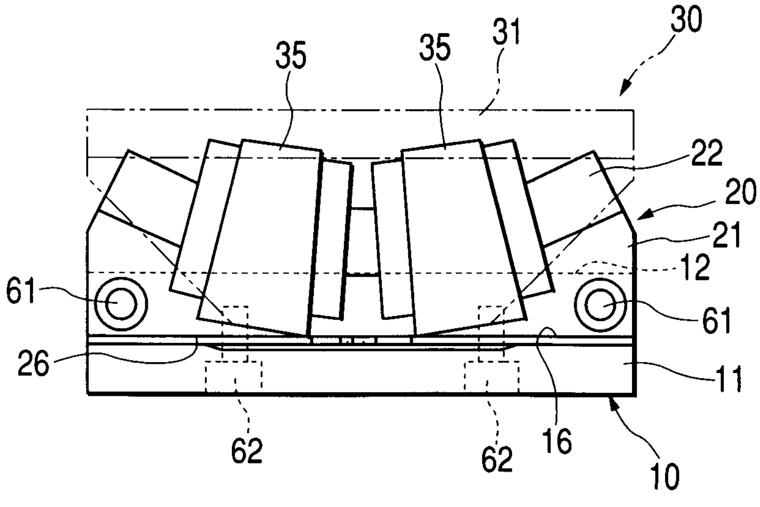

31
32
33
33
20
20
35
36
22
23a
21
21
23a
22
36
35
37
37
25a
25a
36
25
25
36
23b
23b
26a
26
26a
26
13
12
10
15
15
16
16
11
16a
15a
15a
16a

FIG. 6


30
35
35
31
22
20
21
12
61
61
26
11
62
62
16
10

Nummer: DE 103 09 859 A1
Int. Cl.^{7}: G 05 G 5/00
Offenlegungstag: 18. September 2003

FIG. 7

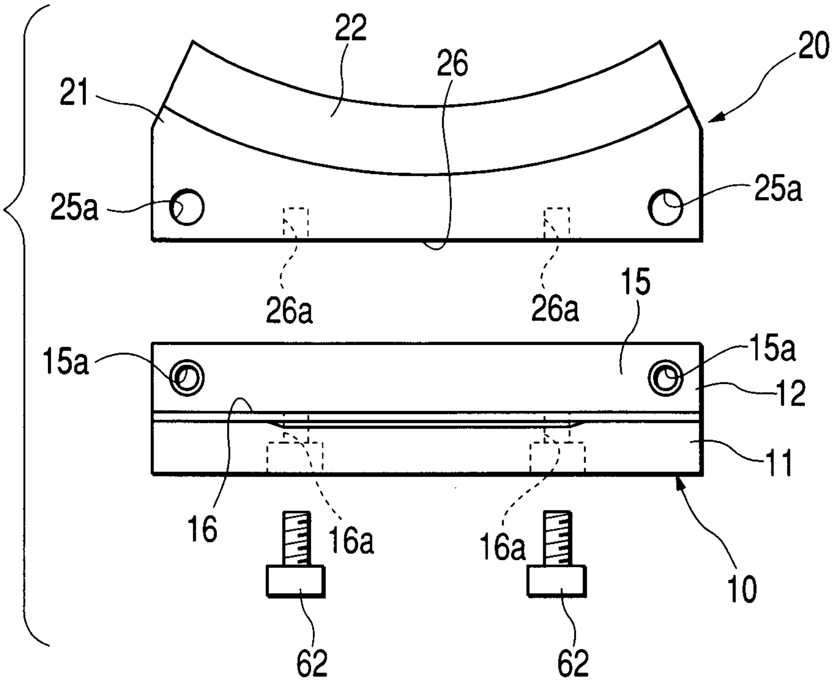


FIG. 8

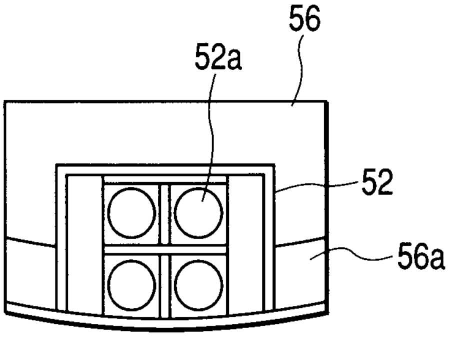
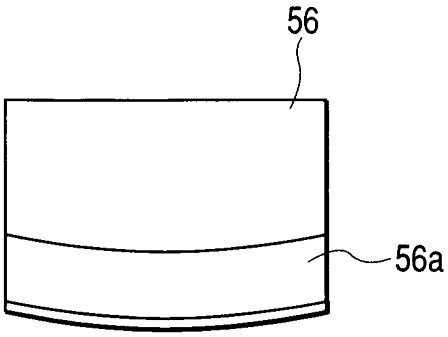


FIG. 9



Nummer: **DE 103 09 859 A1**
Int. Cl.[7]: **G 05 G 5/00**
Offenlegungstag: 18. September 2003

FIG. 10A

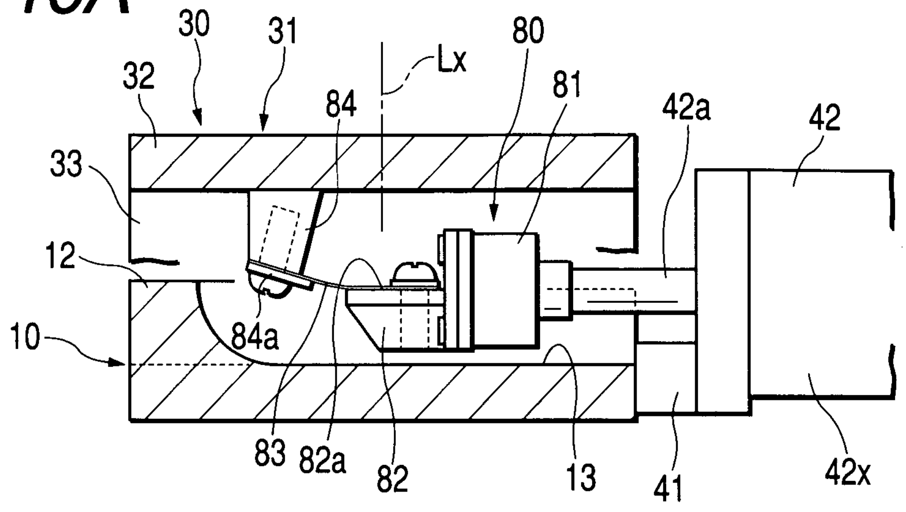


FIG. 10B

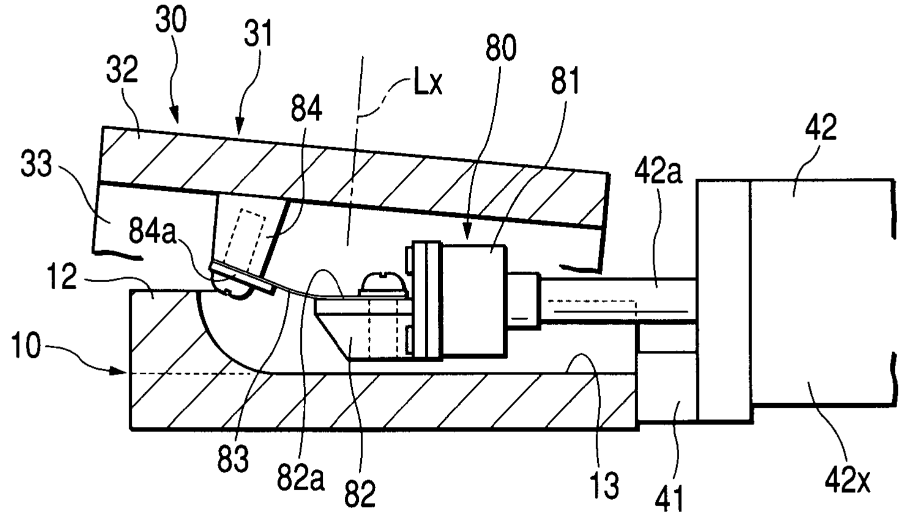


FIG. 10C

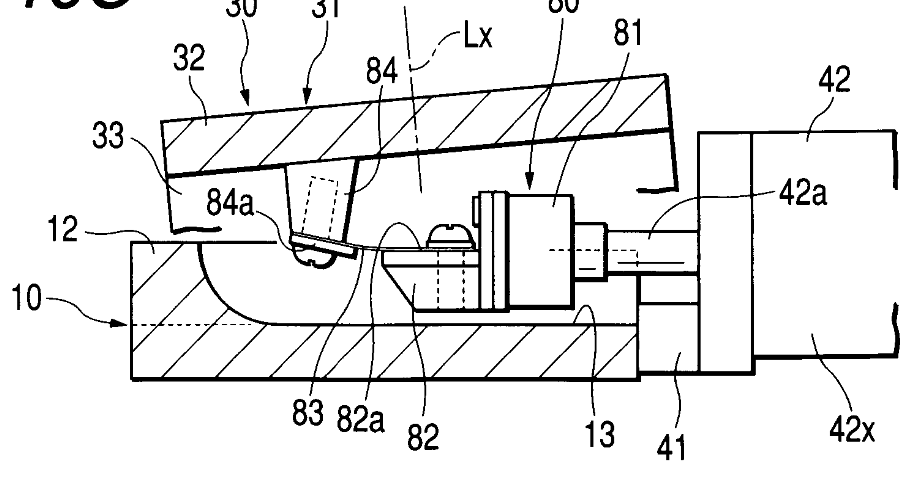


FIG. 11

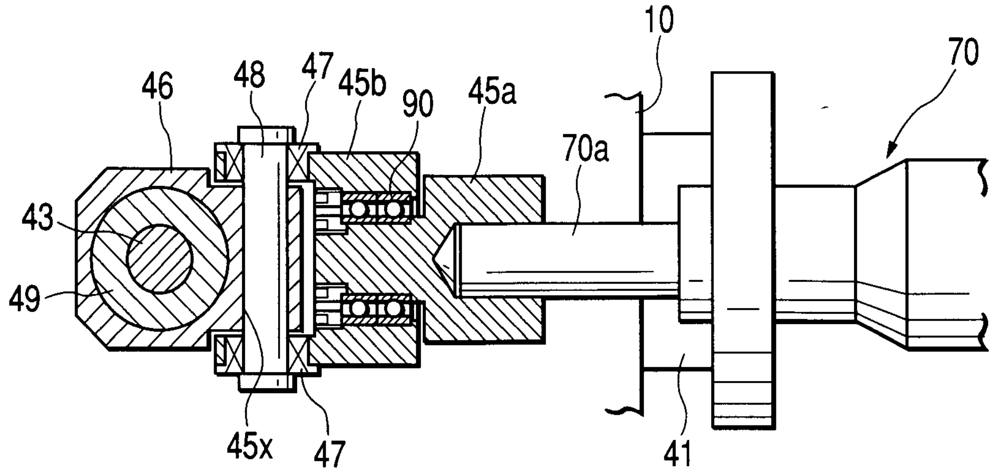
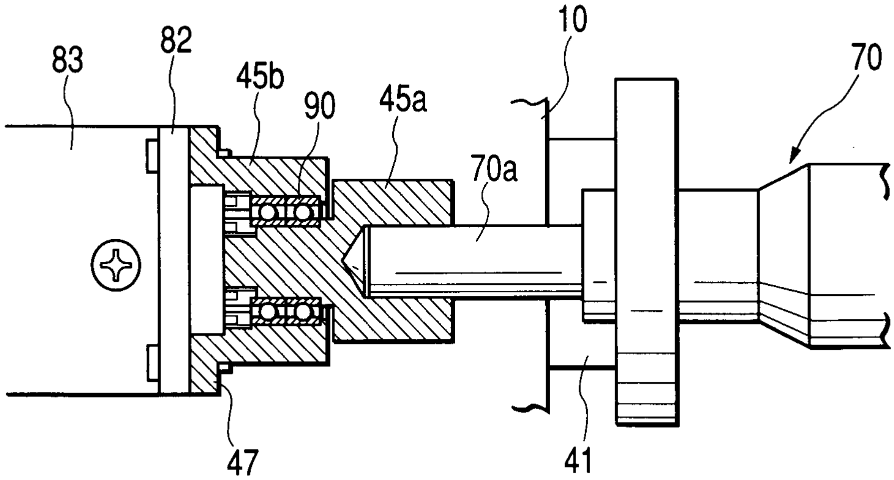

10
70
46
48
47
45b
90
45a
70a
43
49
45x
47
41

FIG. 12


10
83
82
45b
90
45a
70
70a
47
41

(19) Bundesrepublik Deutschland
Deutsches Patent- und Markenamt

(10) **DE 102 55 588 A1** 2004.06.24

(12) **Offenlegungsschrift**

(21) Aktenzeichen: **102 55 588.5**
(22) Anmeldetag: **28.11.2002**
(43) Offenlegungstag: **24.06.2004**

(51) Int Cl.[7]: **F16C 29/04**
B23Q 1/40

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

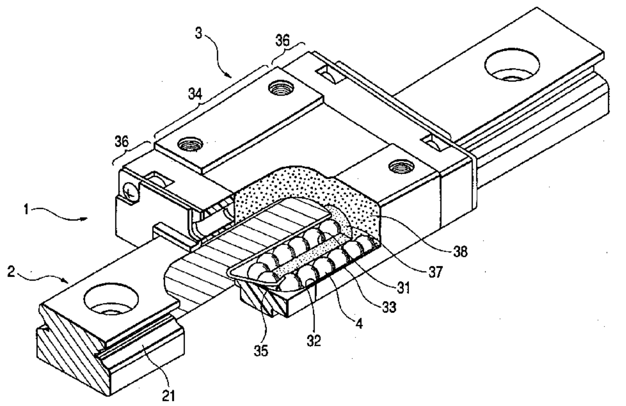
(74) Vertreter:
HOFFMANN · EITLE, 81925 München

(72) Erfinder:
Ueno, Yoshihiko, Tokio/Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Bezeichnung: **Wälzführungsvorrichtung**

(57) Zusammenfassung: Eine Wälzführungsvorrichtung umfasst einen Laufschaft, auf dem eine Wälzelementabwälzoberfläche in einer Längsrichtung davon ausgebildet ist, und ein Gleittisch mit einem endlosen Zirkulationskanal. Der endlose Zirkulationskanal umfasst eine Lastabwälzooberfläche entsprechend der Wälzelementabwälzoberfläche. Mehrere Wälzelemente sind in dem endlosen Zirkulationskanal aufgenommen. Der Gleittisch hat eine Gleittischhaupteinheit und Seitenabdeckungen, die an den entsprechenden Enden der Gleittischhaupteinheit angebracht sind. Die Gleittischhaupteinheit weist einen Lastabwälzooberflächenabschnitt, der die Lastabwälzoberfläche aufweist, und einen Hauptkörperabschnitt auf. Der Lastabwälzoberflächenabschnitt ist aus technischer Keramik hergestellt. Der Hauptkörperabschnitt ist aus bearbeitbarer Keramik hergestellt.



Beschreibung

HINTERGRUND DER ERFINDUNG 1. Gebiet der Erfindung

[0001] Die vorliegende Erfindung bezieht sich auf eine Wälzführungsvorrichtung mit leichtem Gewicht und hoher Festigkeit, welcher für lineare Führungsvorrichtungen, wie zum Beispiel eine Werkzeugmaschine oder einen X-Y-Tisch verwendbar sind.

Stand der Technik

2. Beschreibung des Stand der Technik

[0002] Eine Wälzführungsvorrichtung, die in einer Werkzeugmaschine oder ähnlichem eingebaut ist und einen Tisch zum Aufnehmen eines Werkstücks führt, umfasst einen Laufschaft, in dem eine Wälzelementabwälzoberfläche in einer Längsrichtung davon ausgebildet ist; und einen Gleittisch, der einen endlosen Zirkulationskanal umfassend einer Lastabwälzoberfläche entsprechend der Wälzelementabwälzoberfläche aufweist, und der an dem Laufschaft über mehrere Wälzelemente angebracht ist, die in dem endlosen Zirkulationskanal aufgenommen sind. Der Laufschaft und der Gleittisch sind relativ zueinander mittels der Wälzelemente beweglich.

[0003] Der Gleittisch umfasst einen Gleittischhauptkörper, in dem die Lastabwälzoberfläche und ein Wälzelementrückführkanal im wesentlichen parallel zu der Lastabwälzoberfläche ausgebildet sind; und Seitenabdeckungen, in denen Richtungsumkehrkanäle zum Verbinden beider Enden des Lastabwälzkanals und der Wälzelementrückführkanäle vorgesehen sind, und welche an den entsprechenden Enden des Gleittischhauptkörpers angebracht sind.

[0004] Nachforschungen auf dem Gebiet derartiger Wälzführungsvorrichtungen wurden durchgeführt mit der Absicht den Gleittisch leichter zu gestalten, die Massenkraft zu reduzieren und Hochgeschwindigkeits-Start- und Stoppvorgänge zu ermöglichen. Wälzführungsvorrichtungen, wie sie in den japanischen Patentanmeldungen mit den Veröffentlichungsnummern 219520/1984 und 219153/1996 beschrieben sind, haben eine Gleittischhaupteinheit, wobei die Gleittischhaupteinheit mit Ausnahme einer Lastabwälzoberfläche aus Kunstharz hergestellt ist.

[0005] Nachforschungen auf dem Gebiet der Lastabwälzoberflächen von Gleittischhauptkörpern wurden durchgeführt, um die Abwälzzeitfestigkeit und um die Abriebfestigkeit der Wälzelemente zu verbessern. Die japanische Patentanmeldung mit der Veröffentlichungsnummer 325414/1998 offenbart ein Formen der Führungsoberflächen eines Gleittisches oder des gesamten Gleittisches aus einer Keramik, um die Erzeugung von Abnutzungen zu verhindern, welche andererseits verursacht würde, wenn die Wälzelemente mit der Wälzelementabwälzoberfläche in Verbindung kommen.

[0006] Nachfrage besteht für eine Gleittischhaupteinheit mit herausragenden mechanischen Eigenschaften, wie z.B. Biegesteifigkeit, und welche leicht maschinell herstellbar ist. Eine Gleittischhaupteinheit, die bis auf die Lastabwälzoberfläche aus Kunstharz hergestellt ist, ist leicht maschinell herstellbar, weist aber nicht unbedingt herausragenden mechanische Eigenschaften auf.

[0007] Auch in dem Fall, in dem die Lastabwälzoberfläche aus Keramik hergestellt ist, um die Erzeugung von Abnutzungen zu verhindern, ist die Abwälzzeitfestigkeit und die Abriebfestigkeit der Wälzelemente nicht ausreichend.

Aufgabenstellung

ZUSAMMENFASSUNG DER ERFINDUNG

[0008] Die vorliegende Erfindung schlägt eine Wälzführungsvorrichtung vor, die für eine lineare Führungsvorrichtung wie z.B. eine Werkzeugmaschine oder einen X-Y-Tisch verwendbar ist, und insbesondere eine Wälzführungsvorrichtung, die ein leichtes Gewicht und eine hohe Festigkeit aufweist, was durch einen Verbund aus Keramikausgangsmaterial erreicht wird.

[0009] Gemäß einem ersten Aspekt der vorliegenden Erfindung ist eine Wälzführungsvorrichtung vorgeschlagen, umfassend ein Laufschaft mit einer Wälzelementabwälzoberfläche, die in einer Längsrichtung davon ausgebildet ist; ein Gleittisch mit einem endlosen Zirkulationskanal umfassend einer Lastabwälzoberfläche entsprechend der Wälzelementabwälzoberfläche, wobei der Gleittisch relativ zu dem Laufschaft bewegbar ist; und mehrere Wälzelemente, die in dem endlosen Zirkulationskanal untergebracht sind, um entsprechend der Relativbewegung des Laufschafts und des Gleittisches zu zirkulieren, wobei der Gleittisch umfasst: eine Gleittischhaupteinheit mit der Lastabwälzoberfläche und einem im wesentlichen parallel zu der Lastabwälzoberfläche vorgesehenen Wälzelementrückführkanal; und Seitenabdeckungen, die jeweils einen Richtungsumkehrkanal zum Verbinden der Enden der Lastabwälzoberfläche und des Abwälzelementrückführkanals aufweisen, wobei die Seitenabdeckungen an den entsprechenden Enden der Gleittischhaupteinheit angebracht sind, und wobei die Gleittischhaupteinheit umfasst: einen Lastabwälzoberflächenabschnitt hergestellt aus technischer Keramik, und umfassend der Lastabwälzoberfläche; und ein Hauptkörperabschnitt hergestellt aus bearbeitbarer Keramik.

[0010] Gemäß dem ersten Aspekt ist der Lastabwälzoberflächenabschnitt mit der Lastabwälzoberfläche aus technischer Keramik hergestellt, die eine herausragende Abwälzzeitfestigkeit und eine herausragende Abriebsbeständigkeit aufweist. Der Hauptkörperabschnitt, welcher der restliche Abschnitt der Gleittischhaupteinheit ist, ist aus bearbeitbarer Keramik hergestellt, die herausragenden mechanische Eigenschaften aufweist und leicht zu bearbeiten ist. Folglich erfüllt die Gleittischhaupteinheit die Eigenschaften, die bisher erforderlich waren und erfüllt die Anforderungen an die Gewichtsreduzierung und hohe Festigkeit. Folglich sind Hochgeschwindigkeits-Start- und Stoppvorgänge mit kleiner Massenkraft realisierbar.

[0011] Gemäß einem zweiten Aspekt der Erfindung umfasst die Wälzführungsvorrichtung ferner eine Laufgehäusenut, die in dem Hauptkörperabschnitt ausgebildet ist; und einen Laufring, der als Lastabwälzoberflächenabschnitt dient, welcher Laufring in die Laufgehäusenut eingepasst ist.

[0012] Gemäß dem zweiten Aspekt kann die Laufgehäusenut leicht in dem Hauptkörperabschnitt, der aus bearbeitbarer Keramik mit einer leichten Bearbeitbarkeit hergestellt ist, gebildet werden. Folglich kann ein Laufring, der eine herausragende Abwälzzeitfestigkeit aufweist und als ein Lastabwälzoberflächenabschnitt wirkt, leicht in die Laufgehäusenut eingepasst werden. Der Laufring ist aus technischer Keramik hergestellt und weist eine herausragende Abwälzzeitfestigkeit auf. Folglich kann eine langlebige Wälzführungsvorrichtung realisiert werden.

[0013] Gemäß einem dritten Aspekt der vorliegenden Erfindung haben die Laufgehäusenut und der Laufring halbkreisförmige Querschnittsprofile, die komplement zueinander sind, welcher Laufring in Bezug auf die Laufgehäusenut drehbar ist.

[0014] Gemäß dem dritten Aspekt haben die Laufgehäusenut und der Laufring halbkreisförmige Querschnittsprofile, die komplement zueinander sind und die Laufgehäusenut und der Laufring sind derart ausgebildet, dass sie drehbar sind. Folglich kann ein Selbstausrichtungsvorgang realisiert werden.

Ausführungsbeispiel

[0015] **Fig.** 1 ist eine teilweise aufgebrochene perspektivische Ansicht, die ein Beispiel einer Wälzführungsvorrichtung der Erfindung zeigt;

[0016] **Fig.** 2 ist eine Seitenansicht, die die Wälzführungsvorrichtung zeigt;

[0017] **Fig.** 3 ist eine Vorderansicht der Wälzführungsvorrichtung, die einen Querschnitt entlang der in **Fig.** 2 dargestellten Linie A-A teilweise darstellt;

[0018] **Fig.** 4 ist eine Vorderansicht der Wälzführungsvorrichtung, die einen Querschnitt entlang der in **Fig.** 3 dargestellten Linie B-B teilweise darstellt;

[0019] **Fig.** 5 ist eine perspektivische Explosionsansicht, die einen Modus zeigt, in dem ein Laufring in eine Laufgehäusenut eingepasst ist; und

[0020] **Fig.** 6A und 6B sind beschreibende Ansichten, wobei **Fig.** 6A einen Reziprok-Schub-Abwälzlebensdauerprüfer und **Fig.** 6B ein Prüfstück darstellt.

GENAUE BESCHREIBUNG DER BEVORZUGTEN AUSFÜHRUNGSFORMEN

[0021] Eine Wälzführungsvorrichtung der Erfindung wird unter Bezugnahme auf die begleitenden Zeichnungen im folgenden beschrieben.

[0022] Eine Wälzführungsvorrichtung **1**, wie in **Fig.** 1 dargestellt, umfasst eine Schiene **2**, auf der eine Wälzelementabwälzoberfläche **21** in einer Längsrichtung ausgebildet ist, und die als Laufschaft dient; einen Block **3**, der einen endlosen Zirkulationskanal **32** umfassend einer Lastabwälzoberfläche **31** entsprechend der Wälzelementabwälzoberfläche **21** aufweist und der als relativ zu der Schiene **2** beweglicher Gleittisch dient; und mehreren Wälzelementen **4**, die in dem endlosen Zirkulationskanal **32** aufgenommen sind und entsprechend der Relativbewegung, die zwischen der Schiene **2** und dem Block auftritt, zirkulieren.

[0023] Der Block **3** umfasst einen Gleittischhauptkörper (im folgenden als "Blockhaupteinheit **34**" bezeichnet) in dem die Lastabwälzoberfläche **31** und ein im wesentlichen parallel zu der Lastabwälzoberfläche **32** vorgesehener Wälzelementrückführkanal **33** ausgebildet sind; und Seitenabdeckungen **36**, die an den entsprechenden Enden der Blockhaupteinheit **34** angebracht sind. In jeder der Seitenabdeckungen ist ein Richtungsumkehrkanal **35** ausgebildet zum Verbinden der Enden der Lastabwälzoberflächen **31** und der Wälzelementrückführkanäle **33**.

[0024] Die Blockhaupteinheit **34** weist einen Lastabwälzoberflächenabschnitt **37**, der die Lastabwälzoberfläche **31** aufweist und aus technischer Keramik hergestellt ist; und ein Hauptkörperabschnitt **38** hergestellt aus bearbeitbarer Keramik auf.

[0025] Die Wälzführungsvorrichtung **1** ist nicht auf einen speziellen Typ begrenzt und kann eine Schiene **2** der linearen Art, wie in **Fig.** 1 dargestellt oder eine Schiene der gekrümmten Art aufweisen. Die Wälzelemente sind nicht auf Wälzelemente einer bestimmten Art begrenzt und können kugelförmige Wälzelemente **4**, wie in **Fig.** 1 dargestellt oder walzenförmige Wälzelemente sein. Die Wälzführungsvorrichtung der Erfindung ist verwendbar in Wälzführungsvorrichtungen mit verschiedensten Arten von Schienen **2** oder verschiedensten Arten von Wälzelementen **4**.

[0026] Der Lastabwälzoberflächenabschnitt **37** der Blockeinheit **34** weist mindestens die Lastabwälzoberfläche **32** auf. Die Lastabwälzoberfläche ist nicht auf eine spezifische Form begrenzt und kann eine Vielzahl von Formen annehmen. Der Lastabwälzoberflächenabschnitt **37** ist aus technischer Keramik hergestellt. Folglich wird ein Lastabwälzoberflächenabschnitt **37** umfassend der Lastabwälzoberfläche **31** mit einer herausragenden Abwälzzeitfestigkeit und Abriebsbeständigkeit bereitgestellt.

[0027] Bei der technischen Keramik, die den Lastabwälzoberflächenabschnitt **37** bildet, handelt es sich um eine technische Keramik mit einer volumenspezifischen Gewichtskraft von 2,5 bis 6,5 g/cm^3, einer Vierpunkt-Zeitfestigkeit von 300 bis 1500 MPa bei Raumtemperatur vorgeschrieben durch JIS-R-1601; einer Vickers Härte von 1000 bis 3000 Hv; und einem thermischen Ausdehnungskoeffizienten von 3,0 bis 11,0 × 10^{-6} / °C bei einer Temperatur von 40 bis 800°C. Hierbei versteht man unter "11,0 × 10^{-6}" entsprechend "11,0 mal 10^{-6}". Die technische Keramik mit derartigen Eigenschaften weist ein niedriges Gewicht auf und ist im Sinne der Festigkeit, Abriebsbeständigkeit und der Dimensionsstabilität hochwertig. Folglich wird eine derartige technische Keramik vorzugsweise für den Lastabwälzoberflächenabschnitt **37** der Blockhaupteinheit **34** verwendet.

[0028] In dem Fall, in dem die technische Keramik eine volumenspezifische Gewichtskraft von weniger als 2,5 g/cm^3 aufweist, kann der Wert für die Zeitfestigkeit des Lastabwälzoberflächenabschnitts aus dem vorstehenden Bereich herausfallen. In dem Fall, in dem die technische Keramik eine volumenspezifische Gewichtskraft von mehr als 6,5 g/cm^3 aufweist, wird der Lastabwälzoberflächenabschnitt **37** schwer. Ein bevorzugter volumenspezifischer Gewichtskraftbereich liegt zwischen 3,0 und 6,0 g/cm^3. Si_3N_4, welches später näher beschrieben werden wird, weist einen mehr bevorzugten volumenspezifischen Gewichtskraftbereich von 3,0 bis 3,4 g/cm^3 auf. Da eine derartige technische Keramik im Gewicht leichter als Metall ist, welches bisher für die Blockhaupteinheit verwendet wurde, ist der Lastabwälzoberflächenabschnitt **37** leichter. Insbesondere weist Keramiknitrit eine volumenspezifische Gewichtskraft von ungefähr 3,2 g/cm^3 auf und trägt daher zu einer Reduzierung des Gewichts des gesamten Blocks bei. Folglich wird die Massenkraft des Blocks verringert und dadurch Hochgeschwindigkeitsstart- und Stoppvorgänge des Blocks ermöglicht.

[0029] In dem Fall, in dem die technische Keramik eine Biegefestigkeit von weniger als 300 MPa aufweist, kann die erforderliche Festigkeit für den Lastabwälzoberflächenabschnitt **37** nicht erreicht werden. Der Grund, warum die Biegefestigkeit der technischen Keramik auf einen Wert von 1500 MPa oder weniger festgelegt ist, ist der, dass unter den momentanen Umständen Schwierigkeiten in der Herstellung einer technischen Keramik mit einer Biegesteifigkeit von mehr als 1500 MPa und den vorstehenden Eigenschaften auftreten. Eine bevorzugte Biegefestigkeit liegt zwischen 700 bis 1200 MPa bei Raumtemperatur, festgestellt durch eine Vierpunkt-Biegetest vorgeschrieben in JIS-R-1601. Si_3N_4, welches einer isostatischen Hochtemperaturkompression (HIP) unterzogen wurde, wird insbesondere bevorzugt als technische Keramik verwendet, die in den vorstehenden Bereich fällt.

[0030] In dem Fall, in dem die technische Keramik eine Vickers Härte von weniger als 1000 Hv aufweist, kann eine ausreichende erforderliche Festigkeit für den Lastabwälzoberflächenabschnitt **37** manchmal nicht erreicht werden. Der Grund, warum die Vickers Härte auf einen Wert von 3000 Hv oder weniger festgelegt ist, ist der, dass unter den momentanen Umständen Schwierigkeiten in der Herstellung einer technischen Keramik mit einer Vickers Härte von mehr als 3000 Hv und den vorstehenden Eigenschaften auftreten. Eine bevorzugte Vickers Härte entspricht 1300 bis 2000 Hv, und eine mehr bevorzugte Vickers Härte beträgt 1400 bis 1700 Hv.

[0031] In dem Fall, in dem der thermische Expansionskoeffizient der technischen Keramik bei 40 bis 800° C 11,0 × 10^{-6} /°C überschreitet, kann es scheitern, dass der Lastabwälzoberflächenabschnitt **37** eine ausreichende Dimensionsstabilität erreicht. Der Grund, warum der thermische Expansionskoeffizient auf 3,0 × 10^{-6} /°C oder mehr festgelegt ist, ist der, dass unter den momentanen Umständen Schwierigkeiten in der Herstellung einer technischen Keramik mit einem thermischen Expansionskoeffizienten von weniger als 3,0 × 10^{-6} /°C und den vorstehenden Eigenschaften auftreten. Ein bevorzugter thermischer Expansionskoeffizient ist 3,0 bis 4,0 × 10^{-6} /°C.

[0032] Die technische Keramik ist nicht auf eine spezifische Keramik begrenzt, solange die Keramik innerhalb des bevorzugten Eigenschaftsbereichs liegt. Folglich kann eine Vielfalt von technischen Keramiken verwendet werden. Insbesondere ist eine gesinterter Körper bestehend aus Siliziumnitrit (Si_3N_4) als technische Keramik bevorzugt. Siliziumnitrit (Si_3N_4), welches einer isostatischen Hochtemperaturkompression (HIP) unterzogen wurde, ist insbesondere bevorzugt.

[0033] Ein gesinterter Verbundkörper, welcher aus technischer Keramik wie Siliziumnitrit hergestellt ist, in dem ein anderer Typ keramischer Partikel dispergiert ist, kann ebenfalls verwendet werden. Dispergierte Partikel des gesinterten Verbundkörpers umfassen Keramikmaterialien wie Titannitrid (TiN), Siliziumkarbid (SiC), teilweise stabilisiertes Zirkondioxyd (ZrO_2), Aluminiumzirkondioxyd (Al_2O_3-ZrO_3), Aluminiumoxyd (Al_2O_3), einen SIALON Komplex (SiAlON), oder Mullit ($3Al_3O_3$-SiO_2). Auch in diesem Fall ist ein gesinterter Verbundkörper, der einer isostatischen Hochtemperaturkompression unterzogen wurde, insbesondere bevorzugt.

[0034] Ferner weist die technische Keramik eine herausragende Abwälzzeitfestigkeit, Druckfestigkeit und Gleiteigenschaft auf. Folglich sind die Abwälzzeitfestigkeit, Abriebsbeständigkeit und Gleiteigenschaft der Lastabwälzoberfläche **31** des Lastabwälzoberflächenabschnitts **37** verbessert. Infolgedessen kann der Abrieb und das Festfressen des Blocks **3** unfassend einen solchen Lastabwälzoberflächenabschnitt **37** verhindert werden, was in anderer Weise verursacht würde, wenn der Block **3** startet und stoppt. Ferner kann der Block **3** über einen langen Zeitraum ohne ein Vorkommen von Oberflächenblähung verwendet werden. Eine derartige technische Keramik weist eine niedrigere thermischen Expansion auf, als das Material, aus dem ein gewöhnlicher Block **3** gebildet ist. Folglich kann die Präzision der Lastabwälzoberfläche unabhängig von Änderungen in der Umgebungstemperatur gesichert werden. Infolgedessen kann ein Hochgeschwindigkeits-, Hochpräzisionsbetrieb des Blocks **3** realisiert werden.

[0035] Der Lastabwälzoberflächenabschnitt **37** kann als ein Laufring mit einem halbkreisförmigen Querschnittsprofil, wie z.B. dem in **Fig.** 5 dargestellten, integriert sein. Der Laufring **37'**, der als der vorangehende Lastabwälzoberflächenabschnitt **37** dient, ist in eine Laufgehäusenut **39** eingepasst, die in dem Hauptkörperabschnitt **38** der Blockhaupteinheit **37** ausgebildet und in der Blockhaupteinheit **34** aufgenommen ist. Der Lastabwälzoberflächenabschnitt **37**, der aus technischer Keramik hergestellt ist, ist durch ein gewöhnliches Herstellungsverfahren für ein keramisches Element, wie später beschrieben wird, hergestellt.

[0036] Wie in **Fig.** 5 dargestellt, ist der so gebildete Laufring **37'** in die Laufgehäusenut **39** eingepasst, die in der Blockhaupteinheit **34** ausgebildet ist. In dem Fall, in dem kugelförmige Wälzelemente verwendet werden, sind die Laufgehäusenut **39** und der Laufring **37'** vorzugsweise mit halbkreisförmigen Querschnittsprofilen versehen, die einander entsprechen. Auch in dem Fall, in dem walzenförmige Wälzelemente verwendet werden, sind die Laufgehäusenut **39** und der Laufring **37'** vorzugsweise mit Querschnittsprofilen versehen, die einander entsprechen. Mittels eines derartigen Profils kann der Laufring **37'** leicht in die Laufgehäusenut **39** eingepasst und eingearbeitet werden. Da der Laufring **37'** aus technischer Keramik hergestellt ist, die eine herausragenden Abwälzzeitfestigkeit aufweist, wird eine langlebige Wälzführungsvorrichtung realisiert.

[0037] Der Laufring **37'** und die Laufgehäusenut **39** sind vorzugsweise mit Querschnittsprofilen versehen, die einander entsprechen und derart ausgebildet, das sie zueinander drehbar sind. Als ein Ergebnis ist ein Selbstausrichtungsvorgang realisiert. Ein Rotationsmittelpunkt P1 des Laufrings **37'** ist mit Bezug auf die Breitenrichtung des Blocks **3** gegenüber einer inneren Position relativ zu einem Mittelpunkt P2 des Wälzkörpers (Kugel) **4**, wie in **Fig.** 3 dargestellt, versetzt.

[0038] Der Hauptkörperabschnitt **38** bildet den gesamten Aufbau der Blockhaupteinheit **34**. Der Hauptkörperabschnitt **38** ist nicht auf eine spezifische Form begrenzt, sondern kann eine Vielfalt von Formen annehmen. Der Hauptkörperabschnitt **38** ist aus bearbeitbarer Keramik hergestellt. Folglich kann ein Hauptkörperabschnitt **38** realisiert sein, der herausragenden mechanische Eigenschaften und eine leichte Bearbeitbarkeit aufweist. In diesem Zusammenhang ist der Ausdruck "bearbeitbare Keramik" eine allgemeine Bezeichnung von Keramik, die im Sinne der leichten spanenden Bearbeitung herausragend ist.

[0039] Als bearbeitbare Keramik, die den Hauptkörperabschnitt **38** bildet, kann eine bearbeitbare Keramik mit einer volumenspezifischen Gewichtskraft von 2,5 bis 6,5 g/cm^3, einer Vierpunkt-Biegefestigkeit von 100 bis 700 MPa bei Raumtemperatur vorgeschrieben durch JIS-R-1601; einer Vickers Härte von 300 bis 800 Hv, und einer Druckfestigkeit von 500 bis 1500 MPa verwendet werden. Die bearbeitbare Keramik mit derartigen Eigenschaften weist eine herausragenden Einfachheit der maschinellen Bearbeitung und eine mechanische Eigenschaft von großer Zeitfestigkeit auf und kann bevorzugter Weise für den Hauptkörperabschnitt **38** der Blockhaupteinheit **34** verwendet werden, welcher Gewindeschneiden oder Bearbeiten von Durchgangslöchern unterzogen wird.

[0040] In dem Fall, in dem die bearbeitbare Keramik eine volumenspezifische Gewichtskraft von weniger als 2,5 g/cm^3 aufweist, fällt der Wert der Zeitfestigkeit des Hauptkörperabschnitts aus dem vorstehenden Bereich. In dem Fall, in dem die bearbeitbare Keramik eine volumenspezifische Gewichtskraft von mehr als 6,5 g/cm^3 wird der Hauptkörperabschnitt **38** schwer. Ein bevorzugter spezifischer Gewichtskraftbereich liegt zwischen 2,5 und 3,5 g/cm^3 und ein mehr bevorzugter spezifischer Gewichtskraftbereich liegt zwischen 2,8 und 3,0 g/cm^3, was der spezifischen Gewichtskraft von AlN-BN Verbundkeramik entspricht, die später beschrieben werden wird. Da eine derartige bearbeitbare Keramik in ihrem Gewicht leichter als Metall ist, das bisher für den Hauptkörperabschnitt **38** verwendet wurde, kann der Hauptkörperabschnitt **38** in seinem Gewicht leichter gestaltet werden. Insbesondere weist AlBN Verbundkeramik eine volumenspezifische Gewichtskraft von ungefähr 2,9 g/cm^3 oder so ungefähr auf und kann folglich zu einer Reduzierung des Gewichts des gesamten Blocks beitragen. Folglich kann die Massenkraft des Blocks geringer gehalten werden und ein Hochgeschwindigkeits-Start- und Stoppvorgang des Blocks ist durchführbar.

[0041] In dem Fall, in dem die bearbeitbare Keramik eine Biegefestigkeit von weniger als 100 MPa aufweist, kann eine ausreichende Festigkeit, die für den Hauptkörperabschnitt **38** erforderlich ist, nicht erreicht werden. In dem Fall, in dem die Biegefestigkeit 700 MPa übersteigt, wird die Einfachheit der Bearbeitung der Keramik mangelhaft. Eine bevorzugte Biegefestigkeit liegt zwischen 250 und 350 MPa, die bei Raumtemperatur festgestellt wird, wie in JIS-R-1601 vorgeschrieben (durch einen Vierpunkt-Biegetest). AlN-BN Verbundkeramik wird insbesondere als bearbeitbare Keramik verwendet, die innerhalb des vorangegangenen Bereichs liegt, bevorzugt.

[0042] In dem Fall, in dem die bearbeitbare Keramik eine Vickers Härte von weniger als 300 Hv aufweist, kann es scheitern, dass die Keramik die mechanische Eigenschaft, die für den Hauptkörperabschnitt **38** bevorzugt ist, aufweist. In dem Fall, in dem die Vickers Härte 800 Hv überschreitet, kann die Einfachheit des mechanischen Bearbeitens vermindert sein. AlN-BN Verbundkeramik mit einer Vickers Härte von 350 bis 450 Hv oder in dieser Umgebung wird insbesondere als die bearbeitbare Keramik bevorzugt verwendet, die in den vorstehenden Bereich fällt.

[0043] In dem Fall, in dem die bearbeitbare Keramik eine Druckfestigkeit von weniger als 500 MPa oder mehr als 1500 MPA aufweist, kann die Einfachheit der Bearbeitung der Keramik vermindert sein. Die bevorzugte Druckfestigkeit reicht von 1000 bis 1200 MPa.

[0044] Die bearbeitbare Keramik ist nicht auf eine spezifische Keramik begrenzt, solange die Keramik innerhalb die bevorzugten Eigenschaftsbereiche fällt. Folglich kann eine Vielfalt von Arten von bearbeitbarer Keramik verwendet werden. Insbesondere ist eine AlBN-BN Verbundkeramik bevorzugt.

[0045] Derartige bearbeitbare Keramiken sind in ihrem Gewicht leichter als Metall, das bisher für die Blockhaupteinheit verwendet wurde. Folglich kann eine Reduzierung des Gewichts der Blockhaupteinheit **34** erreicht werden. Insbesondere weist die AlN-BN Verbundkeramik eine volumenspezifische Gewichtskraft von ungefähr 2,9 auf und kann folglich großartig zu einer Reduzierung des Gewichts des gesamten Blocks beitragen. Infolgedessen kann die Massenkraft des Blocks **3** reduziert werden, wodurch Hochgeschwindigkeits-Start- und Stoppvorgänge ermöglicht werden.

[0046] Die bearbeitbare Keramik hat herausragenden mechanische Eigenschaften, so wie Biegesteifigkeit und Druckfestigkeit. Folglich kann die bearbeitbare Keramik bevorzugter Weise als Hauptkörperabschnitt **38** der Blockhaupteinheit **34** in der Wälzführungsvorrichtung **1** verwendet werden. Da eine derartige bearbeitbare Keramik eine geringere thermische Expansion als das Material aufweist, welches einen gewöhnlich Block **3** bildet, kann trotz Änderungen der Umgebungstemperatur, die Präzision der bearbeitbaren Keramik gesichert werden. Folglich kann eine Hochgeschwindigkeits-, Hochpräzisionsbetrieb des Blocks **3** realisiert werden. Die Laufgehäusenut **39** ist in dem Hauptkörperabschnitt **38** ausgebildet. Die Laufgehäusenut **39** kann gebildet werden, wenn der Hauptkörperabschnitt **38** in einer vorbestimmten Form durch Sintern bearbeitbarer Keramik gebildet wird. Die Laufgehäusenut **39** kann auch geformt werden, nachdem der Hauptkörperabschnitt ohne die Laufgehäusenut **39** durch mechanische Bearbeitung geformt wurde. Der Hauptkörperabschnitt **38**, der aus bearbeitbarer Keramik hergestellt ist, wird durch ein gewöhnliches Herstellungsverfahren von keramischen Elementen gebildet, welches später beschrieben werden wird.

[0047] Die Laufgehäusenut **39** wird in einer vorbestimmten Form entsprechend der Form des Laufrings **37'** gebildet. Wie zuvor erwähnt, wird der Laufring **37'** in die Laufgehäusenut **39** eingepasst. Folglich werden die Dimension der Laufgehäusenut **39** und die des Laufrings **37'** unter Berücksichtigung eines Passungsmodus bestimmt.

[0048] Der Lastabwälzoberflächenabschnitt **37** mit der Lastabwälzoberfläche **31** ist aus technischer Keramik hergestellt, die eine herausragenden Abwälzzeitfestigkeit und Abriebswiderstandsfähigkeit aufweist, und der Hauptkörperabschnitt **38** ist aus bearbeitbarer Keramik hergestellt, die eine herausragende mechanische Eigenschaft und eine herausragende Einfachheit der Bearbeitung aufweist. Folglich kann die Blockhaupteinheit **34** eine Gewichtsreduzierung und hohe Festigkeit erreichen, wodurch Hochgeschwindigkeits-Start- und Stoppvorgänge mit geringer Massenkraft realisiert sind.

[0049] Ein Verfahren zur Herstellung der Blockhaupteinheit **34** mit dem Lastabwälzoberflächenabschnitt **37** bestehend aus technischer Keramik und dem Hauptkörperabschnitt **38** bestehend aus bearbeitbarer Keramik wird nun beschrieben. Der Lastabwälzoberflächenabschnitt **37** und der Hauptkörperabschnitt **38** können gemäß einem gewöhnlichen Verfahren geformt werden.

[0050] Keramik zum Zwecke des Formens, die aus entsprechenden Ausgangsmaterialien besteht, wird durch Granulation zuerst vorbereitet. Die Keramik wird durch Metallformgießen, Gummipressen oder Spritzgießen gegossen. Das Gussteil wird mechanischer Bearbeitung unterzogen und das dadurch bearbeitete Gussteil wird mittels Drucksintern, Heißpressen oder isostatischem Heißpressen gesintert. Im Anschluss wird das Gussteil mittels eines spanabhebenden Verfahrens einer Nachbearbeitung unterzogen, wodurch der Lastabwälzoberflächenabschnitt **37** in einer vorbestimmten Form und der Hauptkörperabschnitt **38** in einer vorbestimmten Form hergestellt werden.

[0051] Die Wälzführungsvorrichtung **1** wird durch Verwendung des derart hergestellten Lastabwälzoberflächenabschnitts **37** und des Hauptkörperabschnitts **38** hergestellt. Die Schiene **2** und die Wälzelemente **4**, die

gemäß einem gewöhnlichen Verfahren hergestellt wurden, werden verwendet.
[0052] Die Erfindung wird unter Bezugnahme auf Beispiele genauer beschrieben.

[Beispiel 1]

[0053] Ein Block **3** des Beispiels **1** umfasst eine Blockhaupteinheit **34**, hergestellt aus Keramik und Seitenabdeckungen **36**, hergestellt aus Metal. Der Block **3** hat eine Form der nominellen Modellzahl RSR7W, hergestellt durch THK Co., Ltd..
[0054] Genauer gesagt weist der Block **3** eine äußere Dimension auf, die einer Höhe von 9mm, einer Breite von 25 mm und einer Länge von 31 mm entspricht. Wie zuvor erwähnt, wird der Block **3** durch den Laufring **37'** mit der Lastabwälzoberfläche **31** und dem Hauptkörperabschnitt **38** gebildet.
[0055] Der Laufring **37'** ist aus Siliziumnitrid (Si3N4: hergestellt durch NGK INSULATORS Ltd.) hergestellt, welches technische Keramik ist, welche Keramik einer isostatischen Hochtemperaturkompression unterzogen wurde und eine volumenspezifische Gewichtskraft von 3,2 g/cm^3 eine Biegesteifigkeit von 1200 MPa, welche bei Raumtemperatur durch einen Vierpunkt-Biegetest festgestellt wird, wie es durch JIS-R-1601 vorgeschrieben ist, eine Vickers Härte von 1500 Hv und einen thermischen Expansionskoeffizienten von $3,0 \times 10^{-6}$ /°C bei 40 bis 800° C aufweist.
[0056] Der Hauptkörperabschnitt **38** ist aus AlN-BN Verbundkeramik hergestellt (Keramiktyp H, hergestellt durch ISHIHARA SANGYO Co., Ltd.). Genauer gesagt weist die AlN-BN Verbundkeramik eine volumenspezifische Gewichtskraft von 2,9 g/cm^3; eine Biegesteifigkeit von 300 MPa, die bei Raumtemperatur durch einen Vierpunkt-Biegetest festgestellt wird, wie es durch JIS-R-1601 vorgeschrieben ist, eine Vickers Härte von 390 Hv, und eine Druckfestigkeit von 1200 MPa auf.
[0057] Die Laufgehäusenut **39** ist in dem Hauptkörperabschnitt **38** ausgebildet und der Laufring **37'** wird in die Laufgehäusenut **39** eingepasst und eingebaut. Die Laufgehäusenut **39** des Hauptkörperabschnitts **38** wird mittels Schleifen gebildet, wobei ein drehender Schleifstein verwendet wird, oder durch spanabhebende Bearbeitung unter Verwendung eines Bohrers oder einer Reibahle. Die Laufgehäusenut **39** und der Laufring **37'** sind mit halbkreisförmigen Profilen versehen, die einander entsprechen.
[0058] Die Seitenabdeckungen **36** und Kugeln **4**, hergestellt aus SUS440C weisen eine spezifische Gewichtskraft von 7,8 g/cm^3 auf und sind an der Blockhaupteinheit **34** angebracht.

[Vergleichsbeispiel 1]

[0059] Ein Block **3** des Vergleichsbeispiels **1** umfasst eine Metallblockhaupteinheit **34** und Metallseitenabdeckungen **36**. Wie indem Fall von Beispiel **1** hat der derart hergestellt Block **3** eine Form der nominellen Modellzahl RSR7W, hergestellt durch THK Co., Ltd.. Genauer gesagt, hat der Block **3** äußere Dimensionen, die einer Höhe von 9 mm, einer Breite von 25 mm und einer Länge von 31 mm entsprechen. Die Blockhaupteinheit **34** ist nicht mit einem Laufring oder einer Laufgehäusenut versehen, so wie die in Verbindung mit Beispiel **1** beschriebenen.
[0060] Die Blockhaupteinheit **34**, Seitenabdeckungen **36** und Kugel sind alle aus SUS440C hergestellt, das eine spezifische Gewichtskraft von 7,8 g/cm^3 aufweist.

(Gewichtsbewertung)

[0061] Das Gewicht der Blockhaupteinheit **34** des Beispiels 1 und des Vergleichsbeispiels 1 wurden bewertet. Die Ergebnisse der Bewertung sind in Tabelle 1 dargestellt.

Tabelle 1

	Block			
	Blockhaupteinheit (g)	Seitenabdeckung (g)	Kugel (g)	Gesamtgewicht (g)
Beispiel 1	7,1	3,6	1,0	11,7
Vergleichs-Beispiel 1	17,2	3,6	1,0	21,8

[0062] Der Block **3** des Beispiels 1 weist ungefähr das halbe Gewicht des Blocks des Vergleichsbeispiels 1 auf, so dass eine bemerkbare Gewichtsreduzierung erreicht wurde. Als der Block **3** des Beispiels 1 tatsächlich auf einer Schiene bewegt wurde, konnten Hochgeschwindigkeits-Start- und Stoppvorgänge mit bemerkenswert kleiner Massenkraft erreicht werden.

(Bewertung der Lebensdauer)

[0063] Die technische Keramik, die in Beispiel 1 verwendet wurde und das SUS440C, das in dem Vergleichsbeispiel 1 verwendet wurde, wurden einer Lebensdauerbewertung unterzogen. Die Lebensdauerbewertung wurde auf der Basis von Ergebnissen eines Wälztests durchgeführt, welcher durch einen Reziprokschubwälzlebensdauerprüfer, wie er in **Fig.** 6A dargestellt ist, ausgeführt wurde. Ein Prüfstück, hergestellt in der Form eines Donuts (mit einem äußeren Durchmesser von 60 mm, einem inneren Durchmesser von 25 mm und einer Dicke von 10 mm), wie er in **Fig.** 6B dargestellt ist, wurde an dem Reziprokschubwälzlebensdauerprüfer angebracht und eine Hauptschaft rotiert.
[0064] Die technische Keramik verwendet in Beispiel 1, ist Si3N4 welches einem HIP unterzogen wurde. Das SU5440C, verwendet in dem Vergleichsbeispiel 1 ist ein gesintertes Stahlprodukt, welches gehärtet und angelassen wurde und eine Oberflächenhärte von 750 Hv oder in dieser Umgebung aufweist.
[0065] Tests wurden durchgeführt unter den folgenden Bedingungen: einer Last von 627 N pro Kugel; sechs Kugeln; einer Rotationsgeschwindigkeit von 800 min^{-1} (rpm); Schmieröl entsprechend LM Öl L68, hergestellt durch THK Co., Ltd.; und einer Ölmenge von 80 cm^3/min.
[0066] Der Wert L50 (Lebensdauerumdrehungen bei akkumulierter Fehlerwahrscheinlichkeit von 50%) der technischen Keramik,. die in Beispiel 1 verwendet wurde, betrug ungefähr 0,96 bis 1,59 × 10^7, wohingegen der Wert L50 des gesinterten Stahlprodukts aus SUS440C, welches in dem Vergleichsbeispiel 1 verwendet wurde, ungefähr 2,1 × 16^6 betrug.
[0067] Wie beschreiben wurde, ist gemäß einer Wälzführungsvorrichtung der Erfindung eine Gleitkörperhaupteinheit durch einen Lastabwälzoberflächenabschnitt, der aus technischer Keramik hergestellt ist und einem Hauptkörperabschnitt, der aus bearbeitbarer Keramik hergestellt ist, gebildet. Folglich können die vorstehenden Eigenschaften, die bisher erforderlich waren, erfüllt werden und eine Gewichtsreduzierung und hohe Festigkeit erreicht werden. Folglich sind Hochgeschwindigkeits-Start- und Stoppvorgänge mit geringer Massenkraft durchführbar.
[0068] Gemäß der Wälzführungsvorrichtung der Erfindung kann eine Laufgehäusenut leicht in den Hauptkörperabschnitt geformt werden, der aus bearbeitbarer Keramik mit einer leichten Bearbeitbarkeit hergestellt ist. Folglich kann ein Laufring, der ein Lastabwälzoberflächenbereich mit einer herausragenden Abwälzzeitfestigkeit ist, leicht in die Laufgehäusenut eingepasst werden. Der Laufring ist aus technischer Keramik hergestellt, die eine herausragenden Abwälzzeitfestigkeit aufweist. Infolgedessen kann eine lange Lebensdauer der Wälzführungsvorrichtung realisiert werden.

Patentansprüche

1. Wälzführungsvorrichtung, umfassend:
einen Laufschaft mit einer Wälzelementabwälzoberfläche, die in einer Längsrichtung davon ausgebildet ist;
ein Gleittisch mit einem endlosen Zirkulationskanal umfassend einer Lastabwälzoberfläche entsprechend der Wälzelementabwälzoberfläche, welcher Gleittisch relativ zu dem Laufschaft beweglich ist; und
mehrere Wälzelemente, die in dem endlosen Zirkulationskanal aufgenommen sind, so dass sie entsprechend der Relativbewegung des Laufschafts und des Gleittischs zirkulieren,
wobei der Gleittisch umfasst: eine Gleittischhaupteinheit mit der Lastabwälzoberfläche und einem zu der Lastabwälzoberfläche im wesentlichen parallelen Wälzelementrückführkanal; und Seitenabdeckungen, die jeweils einen Richtungswechselkanal zum Verbinden der Lastabwälzoberfläche und des Wälzelementrückführkanals aufweisen, welche Seitenabdeckungen an den entsprechenden Enden der Gleittischhaupteinheit angebracht sind, und
wobei die Gleittischhaupteinheit, umfasst: einen Lastabwälzoberflächenabschnitt, der aus technischer Keramik hergestellt ist und die Lastabwälzoberfläche aufweist; und einen Hauptkörperabschnitt, der aus bearbeitbarer Keramik hergestellt ist.

2. Wälzführungsvorrichtung nach Anspruch 1, ferner umfassend:
eine Laufgehäusenut, die in dem Hauptkörperabschnitt ausgebildet ist; und
einen Laufring, der als Lastabwälzoberflächenabschnitt dient, welcher Laufring in die Laufgehäusenut eingepasst ist.

3. Wälzführungsvorrichtung nach Anspruch 2, wobei die Laufgehäusenut und der Laufring halbkreisförmige Querschnittsprofile aufweisen, die einander entsprechen, welcher Laufring in Bezug auf die Laufgehäuse-

nut drehbar ist.

Es folgen 6 Blatt Zeichnungen

Anhängende Zeichnungen

FIG. 1

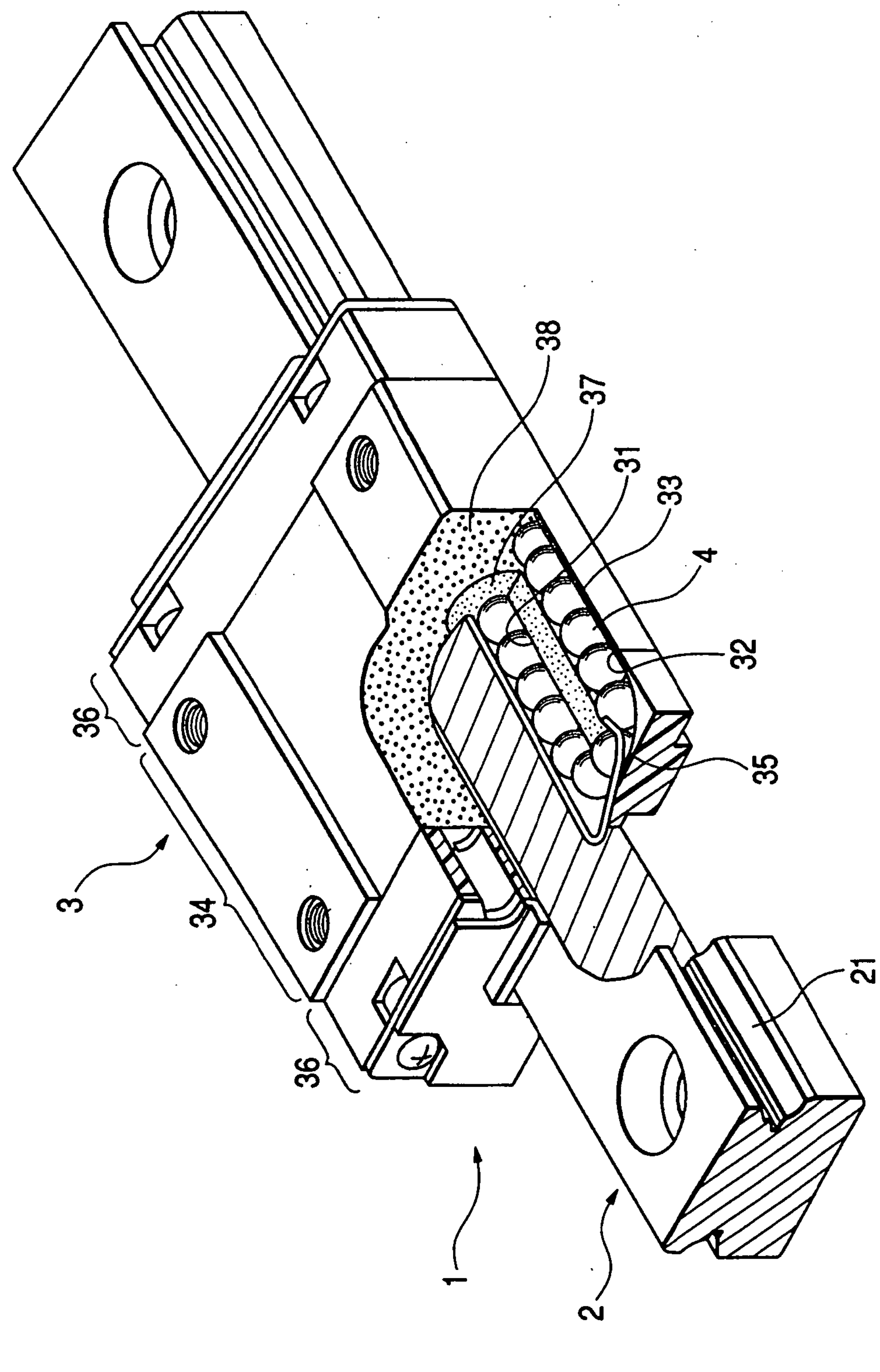


FIG. 2

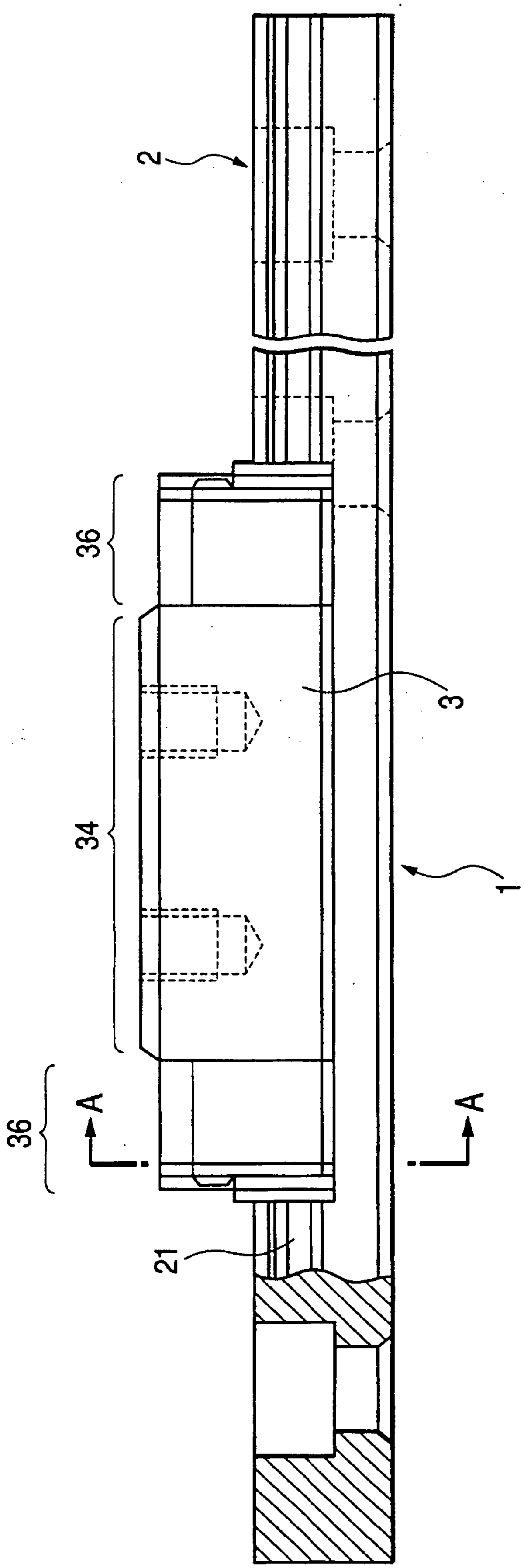


FIG. 3

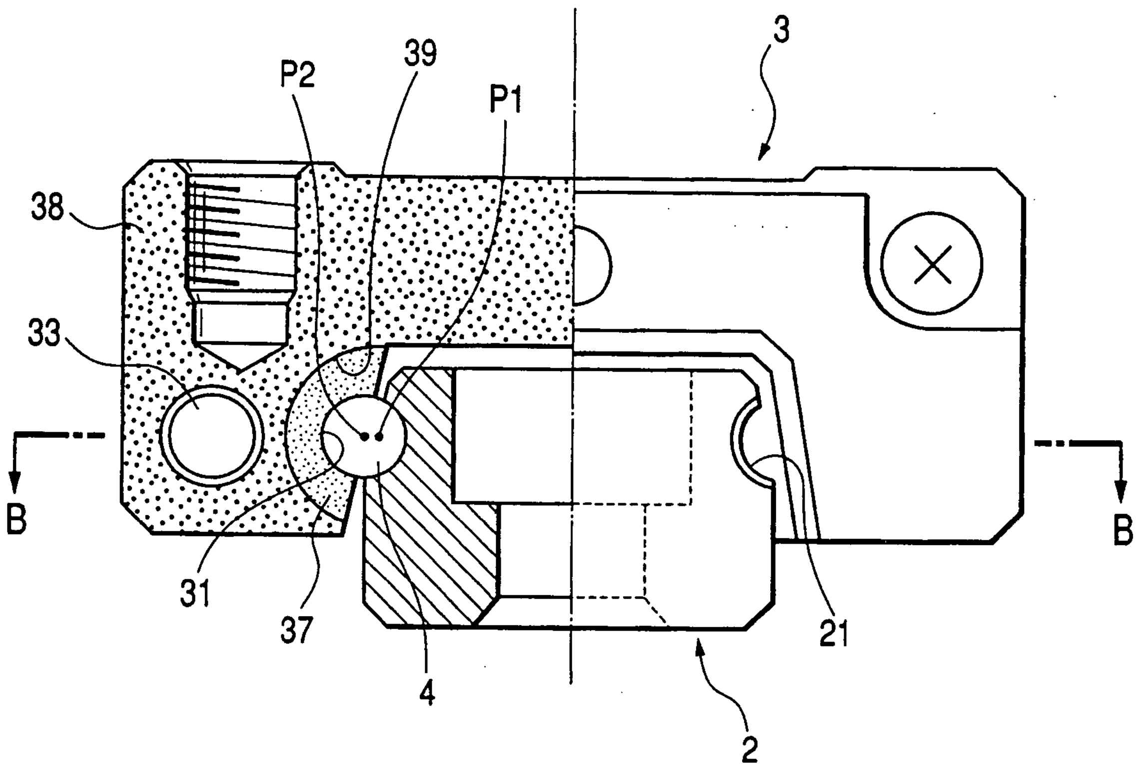
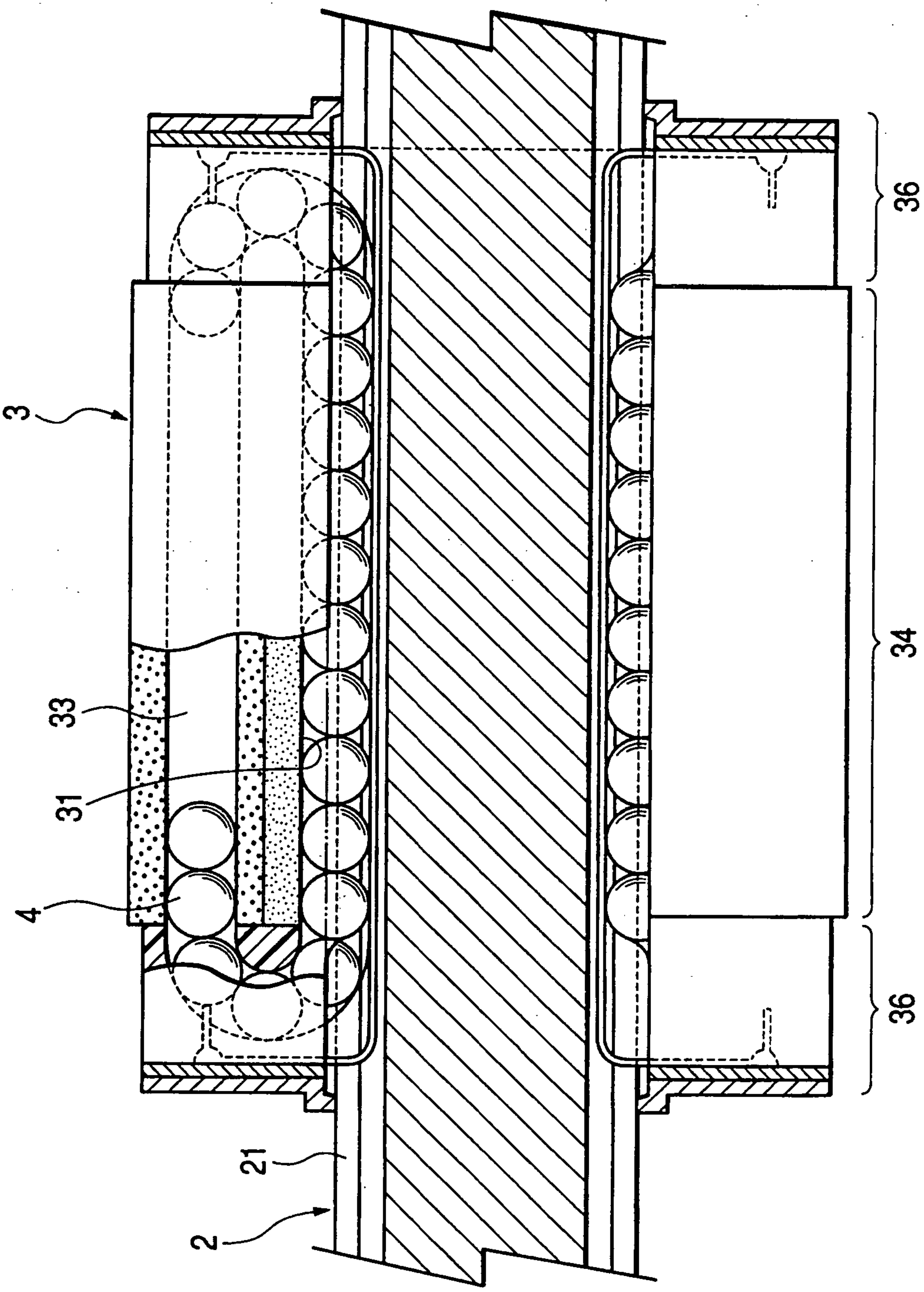


FIG. 4



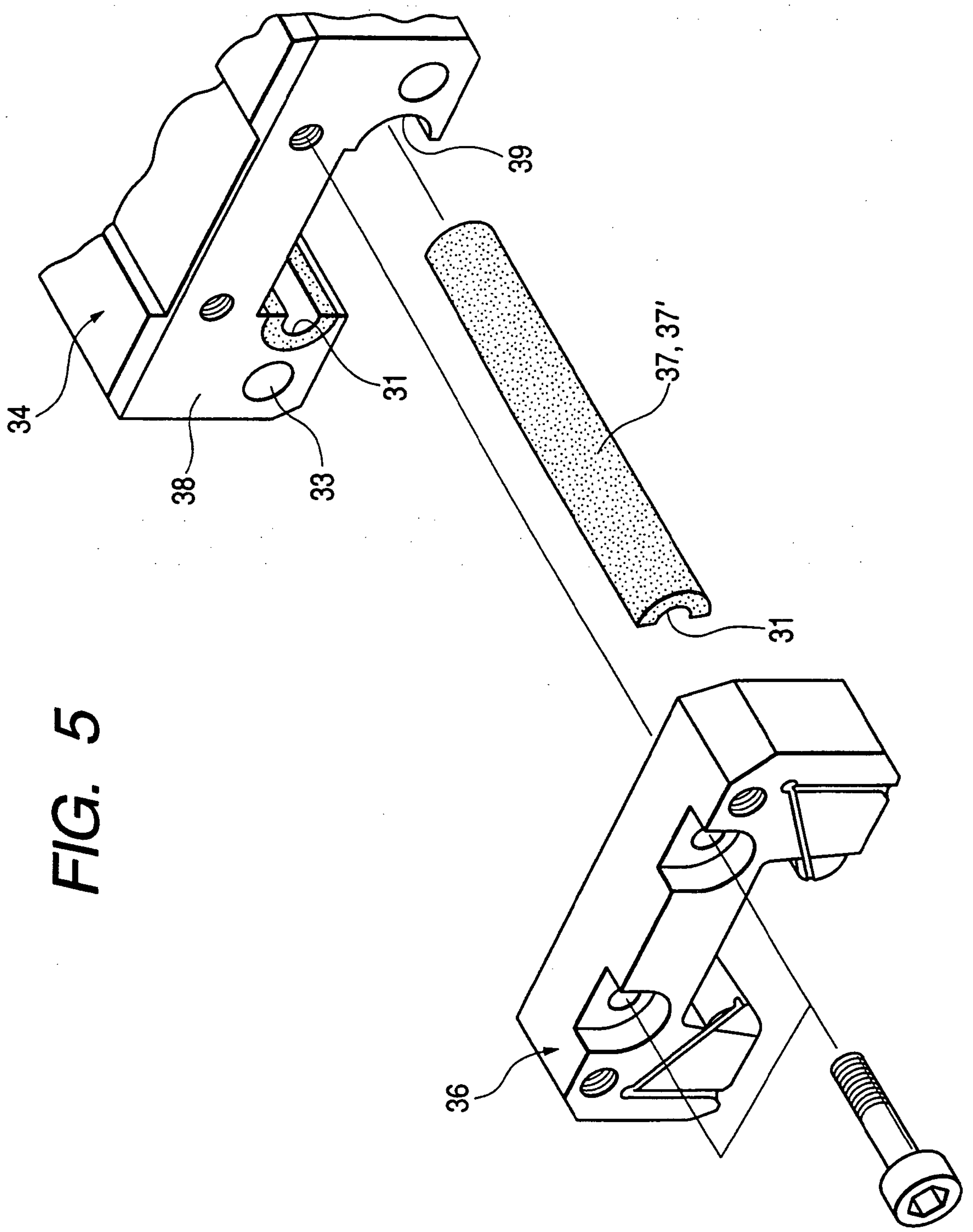


FIG. 5

FIG. 6A

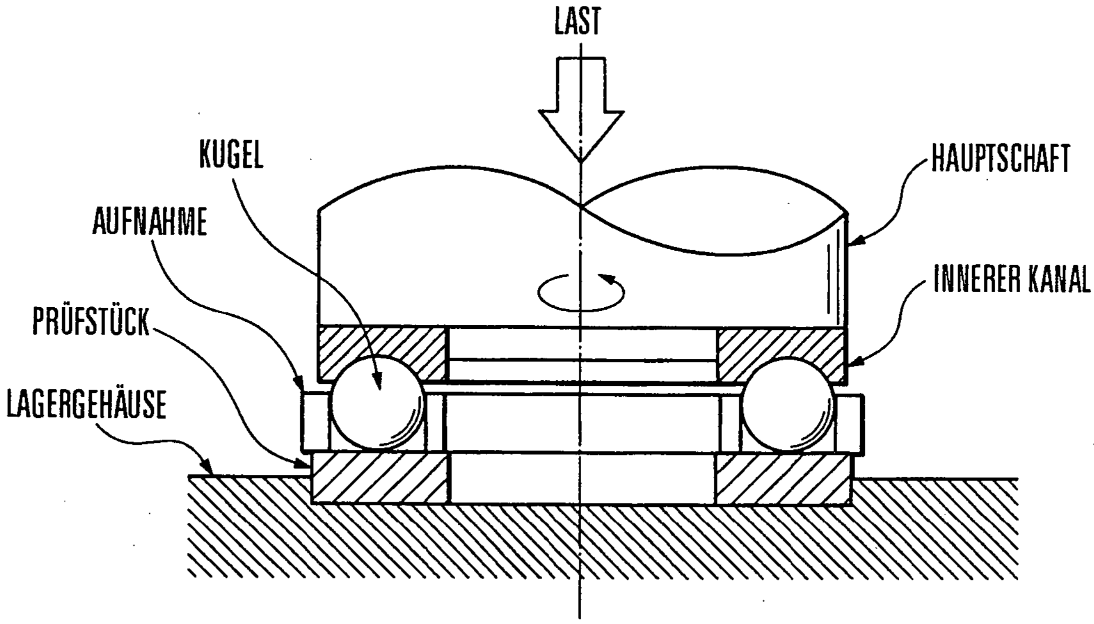
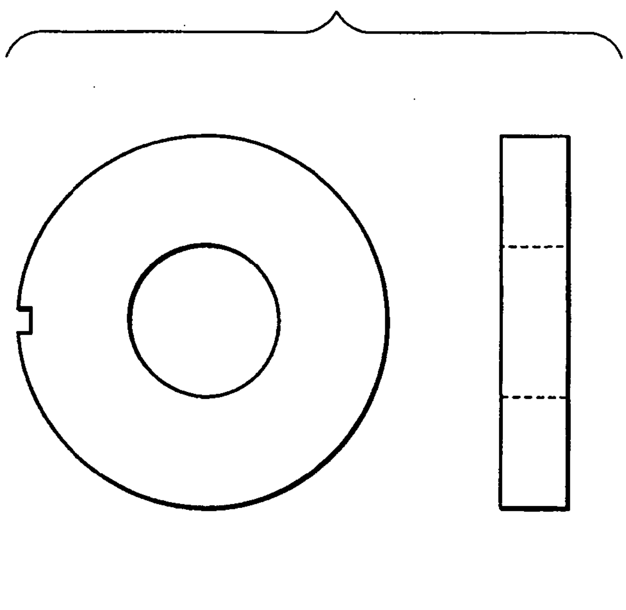

LAST
KUGEL
HAUPTSCHAFT
AUFNAHME
INNERER KANAL
PRÜFSTÜCK
LAGERGEHÄUSE

FIG. 6B



(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 102 36 225 A 1**

(51) Int. Cl.[7]:
F 16 H 29/06
F 16 H 25/04

(21) Aktenzeichen: 102 36 225.4
(22) Anmeldetag: 7. 8. 2002
(43) Offenlegungstag: 13. 3. 2003

(30) Unionspriorität:
01/239592 07. 08. 2001 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
HOFFMANN · EITLE, 81925 München

(72) Erfinder:
Michioka, Hidekazu, Tokyo, JP; Iida, Katsuya, Yamanashi, JP; Murata, Tomozumi, Tokyo, JP; Honjyo, Yoshiyuki, Tokyo, JP

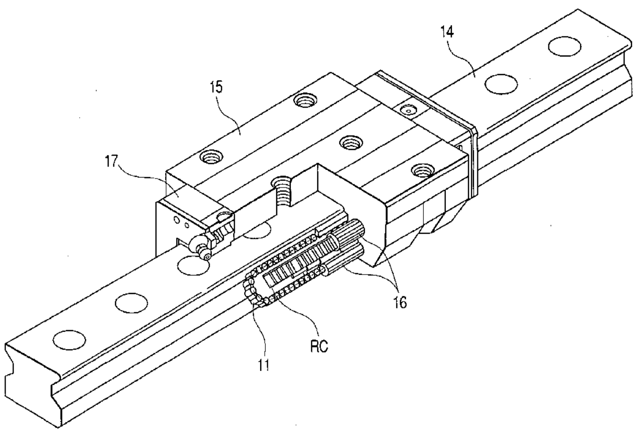
Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Wälzelement-Störungsverhinderer und Führungsvorrichtung

(57) Ein Wälzelement-Störungsverhinderer für eine Führungsvorrichtung verhindert, dass eine Anzahl von Wälzelementen, die unter gleichmäßigen Abständen in einem kontinuierlichen Zirkulationspfad der Führungsvorrichtung zirkulieren, einander stören. Der Wälzelement-Störungsverhinderer ist aus einem Elastomer aus thermoplastischem Harz gebildet, das physikalische Eigenschaften in Übereinstimmung mit einem Ausdruck

$$(A \times B) \div C \geq 18$$

besitzt, wobei A eine Spannung bei 20% Verlängerung darstellt, B eine Zugfestigkeit darstellt und C einen Biege-Elastizitätsmodul darstellt.



DE 102 36 225 A 1

DE 102 36 225 A 1

Beschreibung

1. Technisches Gebiet der Erfindung

[0001] Die vorliegende Erfindung bezieht sich auf einen Wälzelement-Störungsverhinderer für eine Führungsvorrichtung, wie einer Linearführungsvorrichtung, die einen kontinuierlichen Zirkulationspfad für Wälzelemente besitzt, ein Gelenklager, eine Kugelumlaufspindel oder eine Leiste. Der Wälzelement-Störungsverhinderer verhindert, dass Wälzelemente, die in gleichmäßigen Abständen innerhalb des kontinuierlichen Zirkulationspfades, der zwischen einem Paar von Lagerlaufflächen gebildet ist, wälzen, einander stören.

2. Beschreibung des Standes der Technik

[0002] In verschiedenen Wälzführungsvorrichtungen, die ein Lager besitzen, wird eine lineare Bewegung oder Rotation eines Paares von Lagerlaufflächen ermöglicht durch die Verwendung der Wälzbewegung von Wälzelementen, die aus Kugeln oder Walzen bestehen, die zwischen den Lagerlaufflächen getragen sind. Um den Reibwiderstand durch Vermeiden eines Kontakts zwischen den jeweiligen Wälzelementen zu verringern und eine geschmeidige Bewegung durch Anordnen jedes Wälzelementes in einer vorbestimmten Position zu erzeugen, ist es allgemeine Praxis, dass eine Anzahl von Wälzelementen zwischen den Lagerlaufflächen unter Verwendung eines Metallhalters eingebaut wird.

[0003] In der herkömmlichen Führungsvorrichtung, die den Metallhalter verwendet, da ein (Lager-)Käfig eine Anzahl von Taschen besitzt, und Wälzelemente drehbar in diese Taschen eingebaut werden, gibt es einen Vorteil, dass der Vorgang des Einbauens einer Anzahl von Wälzelementen in die Führungsvorrichtung erleichtert wird. Allerdings ist es erforderlich, eine Anzahl von Wälzelementen, die in die Taschen des Käfigs eingebaut sind, zu halten, damit diese nicht herausfallen, was zu einem Problem darin führt, dass es sehr viel Zeit beansprucht, den Käfig selbst herzustellen.

[0004] Um dieses Problem zu lösen, wurde daher ein Kugel-Störungsverhinderer (Wälzelement-Störungsverhinderer) zur Verwendung in einer Führungsvorrichtung vorgeschlagen, um eine gegenseitige Störung zwischen den jeweiligen Kugeln zu verhindern. Die Endlosführungsvorrichtung schließt ein eine Schiene, die einen Wälzpfad besitzt, eine Gleitplatte, die eine dem Wälzpfad gegenüberliegende Wälzrille besitzt und sich entlang der Schiene bewegt, und eine Anzahl von Kugeln (Wälzelementen). Bei einer aufgebrachten Belastung wälzen die Kugeln in einem kontinuierlichen Zirkulationspfad, der zwischen dem Wälzpfad der Schiene und der Wälzrille der Gleitplatte gebildet ist. Der Kugel-Störungsverhinderer ist aus einem flexiblen Harzverbinder zusammengesetzt, der einen eingelegten Abschnitt, der zwischen jeder Kugel eingelegt ist, und einen verbindenden Abschnitt zum Verbinden der eingelegten Abschnitte besitzt und jede Kugel wälzbar in einem angeordneten Zustand hält. Hierdurch wurden zahlreiche vorteilhafte Ergebnisse erzielt, einschließend 1) Erzielen geringen Geräusches und guter Klangqualität durch Beseitigen des metallischen Klangs infolge von Kollisionen zwischen den Kugeln (geringes Geräusch), 2) Vermindern des Verschleißes der Kugeln und Erhöhen des Zurückhaltens von Schmiermittel (Wartungsfreiheit für lange Zeit), 3) Erzielen ausgezeichnet hoher Geschwindigkeit durch Vermindern der relativen Reibungsgeschwindigkeit (hohe Geschwindigkeit), und 4) Glätten der Bewegung durch erhebliches Verringern der Wälzfluktuation (Gleiteigenschaft) (JP-B-6-56181, JP-A-5-52217, JP-A-5-126149, JP-A-5-196036, JP-A-5-196037, und JP-A-9-14264).

[0005] Auf diese Weise wird der derart aufgebaute Kugel-Störungsverhinderer, der aus dem Harzverbinder aufgebaut ist, in Schmierfett, Schmieröl oder Kühlmittel eingetaucht oder diesem unterworfen, in der Umgebung, in welcher der Verhinderer in dem Zirkulationspfad für die Wälzführungsvorrichtung eingeschlossen ist. Ebenso ist der Kugel-Störungsverhinderer Wirkungen unterworfen, wie Biegung, Zug, Druck, Verdrehen oder Kontaktreibung mit der Kugel zu jeglicher Zeit. Wenn er in dem Zirkulationspfad mit hoher Geschwindigkeit hin und her bewegt wird, vollzieht der Störungsverhinderer schwerwiegend und wiederholt einen Vorgang des Biegens, Zuges und Drucks. Darüber hinaus, wenn der Kugel-Störungsverhinderer, der aus dem Harzverbinder aufgebaut ist, in Schmierfett, Schmieröl oder Kühlmittel eingetaucht oder diesem unterworfen ist, absorbiert er Wasser und Öl, um anzuschwellen, was ein Zirkulationsversagen in dem Zirkulationspfad und eine Ablation des Verhinderers verursacht und die Dauerhaftigkeit, Gleiteigenschaften und den Verschleißwiderstand verschlechtert.

[0006] Daher muss der Wälzelement-Störungsverhinderer, der aus dem Harzverbinder aufgebaut ist, einen ausgezeichneten chemischen Ölwiderstand, Wasserwiderstand und chemischen Widerstand gegenüber Schmierfett, Schmieröl und Kühlmittel besitzen, zusätzlich zu der mechanischen Dauerhaftigkeit, den Gleiteigenschaften und den Verschleißwiderstand. Im Hinblick auf die Lebensdauer der Führungsvorrichtung ist es erforderlich, derart Dauerhaftigkeit und Verschleißfest zu sein, um etwas 30 000 km oder mehr zu laufen, bei geringer Variation des Gleitwiderstands, und ebenso gegenüber Öl, Wasser und Chemikalien widerstandsfähig zu sein.

[0007] Darüber hinaus war der Wälzelement-Störungsverhinderer, der aus dem Harzverbinder aufgebaut ist, nicht allzu problematisch darin, dass eine unnatürliche Belastung nur auf einen Teil des Harzverbinders während der Verwendung aufgebracht wurde, da der minimale Krümmungsradius für den kontinuierlichen Zirkulationspfad, der in der Führungsvorrichtung gebildet ist, relativ groß war, die Kugel als Wälzelement eingesetzt wurde, und die Form des Harzverbinders wurde ausgedacht. In den letzten Jahren wurden jedoch geringere Abmessungen und eine höhere Geschwindigkeit für die Führungsvorrichtung gefordert, und Walzen wurden als Wälzelemente eingesetzt, was zu dem Problem führt, dass die Dauerhaftigkeit, der Verschleißwiderstand und die Gleiteigenschaften beeinträchtigt sein können.

ZUSAMMENFASSUNG DER ERFINDUNG

[0008] Die vorliegenden Erfinder führten Forschung durch, um verbesserte Dauerhaftigkeit und Verschleißwiderstand zu erzielen, ohne verschiedene Merkmale (geringes Geräusch, Wartungsfreiheit für lange Zeit, hohe Geschwindigkeit und Gleiteigenschaften) des Wälzelement-Störungsverhinderers zu beeinträchtigen, insbesondere wenn er schwerwiegenden und wiederholten Wirkungen von Biegung, Zug und Druck unterworfen ist, und stellten fest, dass der Wälzelement-Störungsverhinderer unter Verwendung eines Elastomers aus thermoplastischem Harz hergestellt sein sollte, der eine spezifische Balance (Beziehung) für eine Spannung bei 10% Verlängerung, eine Zugfestigkeit und einen Biege-Elastizitätsmodul besitzt, um das Ziel zu erreichen, wodurch die Erfindung vervollständigt wird.

[0009] Dementsprechend ist es eine Aufgabe der Erfindung, einen Wälzelement-Störungsverhinderer für eine Führungsvorrichtung bereitzustellen, der verhindert, dass eine Anzahl von Wälzelementen, die in gleichmäßigen Abständen in einem kontinuierlichen Zirkulationspfad der Führungsvorrichtung zirkulieren, einander stören. Der Wälzelement-Störungsverhinderer besitzt nicht nur ausgezeichnete niedriges Geräusch, Wartungsfreiheit für lange Zeit, hohe Geschwindigkeit und Gleiteigenschaften, sondern auch ausgezeichnete Dauerhaftigkeit und Verschleißwiderstand, und kann stabil über lange Zeit verwendet werden.

[0010] Die vorliegende Erfindung stellt einen Wälzelement-Störungsverhinderer für eine Führungsvorrichtung bereit, um zu verhindern, dass eine Anzahl von Wälzelementen, die in gleichmäßigen Abständen in einem kontinuierlichen Zirkulationspfad der Führungsvorrichtung wälzen, einander stören, worin der Wälzelement-Störungsverhinderer aus einem Elastomer aus thermoplastischen Harz gebildet ist, das physikalische Eigenschaften in Übereinstimmung mit einem Ausdruck $(A \times B) \div C \geq 18$ besitzt, wobei A eine Spannung bei 10% Verlängerung ist, B eine Zugfestigkeit ist und C ein Biege-Elastizitätsmodul ist.

[0011] Als Elastomer aus thermoplastischen Harz können beispielsweise Polyamidharz-Elastomer, Polyesterharz-Elastomer, Polyuretanharz-Elastomer, Styrolharz-Elastomer und Olefinharz-Elastomer verwendet werden. Diese sollten hoch widerstandsfähig gegenüber Öl, Wasser und Chemikalien in der Betriebsumgebung der Wälzführungsvorrichtung sein, insbesondere in der Betriebsumgebung, in welcher die Führungsvorrichtung in Schmierfett, Schmieröl oder Kühlmittel eingetaucht oder diesen unterworfen ist. Der Wasserabsorptionskoeffizient, gemessen in einer Umgebung eines Gleichgewichtsfeuchtigkeitsanteils bei 23°C von 65% RH, beträgt 1,5 Gewichts-% oder weniger, und bevorzugt 0,5 Gewichts-% oder weniger. Der Anschwellfaktor, gemessen in einem Eintauchversuch einer Chemikalie bei einer Temperatur von 85°C für 672 Stunden, beträgt 3% oder weniger. Darüber hinaus beträgt die Zugfestigkeitsaufrechtserhaltung in einem Eintauchversuch in kochendes Wasser bei 100°C 70% oder mehr nach 10 Tagen, und bevorzugt 80% oder mehr.

[0012] In der vorliegenden Erfindung werden Elastomere aus thermoplastischem Harz eingesetzt, die physikalische Eigenschaften besitzen, welche den Ausdruck $(A \times B) \div C \geq 18$ erfüllen (A: Spannung bei 10% Verlängerung, B: Zugfestigkeit, C: Biege-Elastizitätsmodul). Obwohl geringfügig unterschiedlich in Abhängigkeit von der Art der Wälzführungsvorrichtung und davon, ob das Wälzelement eine Kugel oder eine Walze ist, liegt die Spannung bei 10% Verlängerung A im Bereich von 60 bis 200 kgf/cm^2, und bevorzugt von 90 bis 160 kgf/cm^2, die Zugfestigkeit B liegt im Bereich von 340 bis 460 kgf/cm^2, und bevorzugt von 360 bis 430 kgf/cm^2, und der Biege-Elastizitätsmodul C liegt im Bereich von 1000 bis 5000 kgf/cm^2, und bevorzugt von 1200 bis 2700 kgf/cm^2.

[0013] Falls die Spannung bei 10% Verlängerung des Elastomers aus thermoplastischen Harz nicht weniger als 60 kgf/cm^2 ist, wird die Form des Wälzelements-Störungsverhinderers gegenüber einer Zentrifugalkraft, die auf das Wälzelement der Führungsvorrichtung in schnellem Betrieb wirkt, aufrechterhalten, was dazu führt, dass der Gleitwiderstand in dem kontinuierlichen Zirkulationspfad der Führungsvorrichtung abnimmt. Falls im Gegensatz hierzu diese nicht mehr als 200 kgf/cm^2 beträgt, wird ein Problem eines Biegeermüdungsversagens verhindert. Falls die Zugfestigkeit nicht weniger als 340 kgf/cm^2 beträgt, wird die Dauerhaftigkeit erhöht, oder falls sie umgekehrt nicht mehr als 460 kgf/cm^2 beträgt, kann das Problem des Biegeermüdungsversagens verhindert werden. Falls darüber hinaus der Biege-Elastizitätsmodul nicht weniger als 1000 kgf/cm^2 und nicht mehr als 5000 kgf/cm^2 beträgt, werden die Gleiteigenschaften erhöht.

[0014] Hierin ist es erforderlich, dass die Führungsvorrichtung zur Verwendung mit dem Wälzelement-Störungsverhinderer der Erfindung ein Paar von Lagerlaufflächen, und den kontinuierlichen Zirkulationspfad für die Wälzelemente, die mit einer zwischen dem Paar von Lagerlaufflächen aufgebrachten Belastung wälzen, besitzt, und die Führungsvorrichtung kann beispielsweise eine Endlosspur (englisch: endless track), ein Gelenklager, eine Kugelumlaufspindel oder eine Leiste sein.

[0015] Der Wälzelement-Störungsverhinderer der vorliegenden Erfindung kann verschiedene Formen annehmen, in Abhängigkeit von der Art der Führungsvorrichtung, in welcher er angewendet wird. Beispielsweise in einem Fall, in welchem die Führungsvorrichtung eine Linearführungsvorrichtung für eine Endlosspur ist, besitzend eine Spurschiene (eine Lagerlauffläche), die einen Wälzpfad besitzt, eine Gleitplatte (andere Lagerlauffläche), die eine dem Wälzpfad gegenüberliegende Wälzrille besitzt und sich entlang der Spurschiene bewegt, und eine Anzahl von Wälzelementen, die mit einer aufgebrachten Belastung zwischen dem Wälzpfad der Spurschiene und der Wälzrille der Leitplatte wälzen, ist es bevorzugt, dass der Wälzelement-Störungsverhinderer aus einem flexiblen Harzverbinder besteht, der einen eingelegten Abschnitt, der zwischen den jeweiligen Wälzelementen eingelegt ist, und einen verbindenden Abschnitt zum Verbinden jedes eingelegten Abschnitts, und bevorzugt eine Anzahl von Wälzelementen wälzbar durch die eingelegten Abschnitte und den verbindenden Abschnitts halten kann.

[0016] Darüber hinaus, in dem Fall, in welchem der Wälzelement-Störungsverhinderer aus diesem flexiblen Harzverbinder aufgebaut ist, kann der Harzverbinder mit einem abgeschrägten Führungsabschnitt an beiden Enden ausgestattet sein, um den oberen Endabschnitt des Harzverbinders zu führen, wodurch wenn die Führungsvorrichtung in dem kontinuierlichen Zirkulationspfad bewegt wird, insbesondere wenn der obere Abschnitt des Wälzelement-Störungsverhinderers in einen richtungsändernden Pfad des Zirkulationspfades eintritt, oder von dem richtungsändernden Pfad austritt, der obere Endabschnitt geführt wird, um die Führungsvorrichtung sanft zu bewegen. Durch Bilden des abgeschrägten Führungsabschnitts an beiden Enden des Harzverbinders kann der Wälzelement-Störungsverhinderer sanft in jeglicher Vorwärts- und Rückwärtsrichtung in der Hin- und Herbewegung der Führungsvorrichtung geführt werden.

[0017] Die Länge des zu gießenden Wälzelement-Störungsverhinderers wird unter Berücksichtigung der Länge des Zirkulationspfades der Führungsvorrichtung, die diesen verwendet, festgelegt. Falls allerdings die Führungsvorrichtung erhöhte Abmessungen besitzt und die Länge des Zirkulationspfades groß ist, kann der Wälzelement-Störungsverhinderer in zwei oder drei Teile zum Gießen aufgeteilt werden, wodurch die Abmessungen der Form verringert werden können. In diesem Fall ist jeder Harzverbinder, der jeweils aus zwei oder drei Teilen besteht, die aus dem Wälzelement-Störungsverhinderer herausgeteilt sind, mit einem abgeschrägten Führungsabschnitt an beiden Enden gebildet.

[0018] In dem Fall, in welchem der Wälzelement-Störungsverhinderer der Erfindung auf die lineare Führungsvorrichtung für eine Endlosspur angewendet wird, falls die Wälzelemente Kugeln sind, besitzt das Elastomer aus thermoplastischem Harz, das den Harzverbinder bildet, derartige Eigenschaften, dass die Spannung bei 10% Verlängerung A im Bereich von 60 bis 150 kgf/cm^2 liegt, und bevorzugt von 90 bis 130 kgf/cm^2, die Zugfestigkeit B im Bereich von 340 bis 400 kgf/cm^2 liegt, und bevorzugt von 350 bis 380 kgf/cm^2, und der Biege-Elastizitätsmodul C im Bereich von 1000 bis 2000 kgf/cm^2 liegt, und bevorzugt von 1200 bis 1800 kgf/cm^2. Durch Anwenden der Werte in den obigen Bereichen für die Spannung bei 10% Verlängerung A, die Zugfestigkeit B und den Biege-Elastizitätsmodul C kann der Kugel-Störungsverhinderer die ausgezeichneten und ausgeglichenen Leistungsmerkmale (geringes Geräusch, Wartungsfreiheit für lange Zeit, hohe Geschwindigkeit, Gleiteigenschaften, Dauerhaftigkeit und Verschleißwiderstand) aufweisen.

[0019] In dem Fall, in welchem der Wälzelement-Störungsverhinderer der vorliegenden Erfindung auf die lineare Führungsvorrichtung für eine Endlosspur angewendet wird, falls die Wälzelemente Walzen sind, besitzt das Elastomer aus thermoplastischem Harz, das den Harzverbinder bildet, derartige Eigenschaften, dass die Spannung bei 10% Verlängerung A im Bereich von 80 bis 200 kgf/cm^2 liegt, und bevorzugt von 100 bis 160 kgf/cm^2, die Zugfestigkeit B im Bereich von 380 bis 460 kgf/cm^2 liegt, und bevorzugt von 430 bis 460 kgf/cm^2, und der Biege-Elastizitätsmodul C im Bereich von 1500 bis 5000 kgf/cm^2 liegt, und bevorzugt von 2000 bis 4000 kgf/cm^2. Durch Anwenden der Werte in den obigen Bereichen für die Spannung bei 10% Verlängerung A, die Zugfestigkeit B und den Biege-Elastizitätsmodul C kann der Walzen-Störungsverhinderer die ausgezeichneten und ausgeglichenen Leistungsmerkmale (geringes Geräusch, Wartungsfreiheit für lange Zeit, hohe Geschwindigkeit, Gleiteigenschaften, Dauerhaftigkeit und Verschleißwiderstand) aufweisen.

[0020] Darüber hinaus, in dem Fall, in welchem die Führungsvorrichtung eine Kugelumlaufspindel ist, besitzend eine Spindelachse (eine Lagerlauffläche) mit einem spiralförmigen Wälzpfad für eine Kugel, eine Mutter (andere Lagerlauffläche) mit einer spiralförmigen Wälzrille, die dem spiralförmigen Wälzpfad gegenüberliegt, und eine Anzahl von Kugeln, die bei einer aufgebrachten Belastung zwischen dem spiralförmigen Wälzpfad der Spindelachse und der spiralförmigen Wälznut der Mutter wälzen, wobei der Kugel-Störungsverhinderer der Harzverbinder wie derjenige der linearen Führungsvorrichtung für Endlosspur oder ein zwischen den jeweiligen Kugeln eingelegter Abstandhalter sein kann.

[0021] Der Wälzelement-Störungsverhinderer der vorliegenden Erfindung kann durch herkömmliche, bekannte Verfahren hergestellt sein, unter Verwendung des Elastomers aus thermoplastischem Harz wie vorstehend beschrieben.

[0022] Beispielsweise in einem Fall, in welchem der Wälzelement-Störungsverhinderer durch den Harzverbinder gebildet ist kann eine Anzahl von Wälzelementen als ein Kern durch Spritzgießen oder ein sogenanntes Einspritzgießen (englisch: insert molding), (wie in JP-A-6-56181, JP-A-5-52217, JP-A-5-126149, JP-A-5-196036, JP-A-5-196037 und JP-A-9-14264 beschrieben), oder andere Verfahren hergestellt sein.

KURZE BESCHREIBUNG DER ZEICHNUNGEN

[0023] **Fig.** 1 ist eine perspektivische und teilweise geschnittene Ansicht, welche ein linear gleitendes Walzenlager zeigt, in das ein Walzen-Störungsverhinderer gemäß einer ersten Ausführungsform der vorliegenden Erfindung eingebaut ist;

[0024] **Fig.** 2 ist eine teilweise geschnittene Seitenansicht des linear gleitenden Walzenlagers aus **Fig.** 1;

[0025] **Fig.** 3 ist eine Draufsicht, welche den Walzen-Störungsverhinderer aus **Fig.** 1 zeigt;

[0026] **Fig.** 4 ist eine Frontansicht des Walzen-Störungsverhinderers aus **Fig.** 3;

[0027] **Fig.** 5 ist eine Querschnittsansicht des Walzen-Störungsverhinderers, geführt entlang der Linie V-V in **Fig.** 3;

[0028] **Fig.** 6 ist eine vergrößerte Perspektivansicht, welche einen oberen Endabschnitt des in **Fig.** 3 gezeigten Walzen-Störungsverhinderers zeigt;

[0029] **Fig.** 7 ist eine Perspektivansicht, welche einen Walzen-Störungsverhinderer gemäß einer zweiten Ausführungsform der Erfindung zeigt;

[0030] **Fig.** 8 ist eine Draufsicht, welche einen Kugel-Störungsverhinderer gemäß einer dritten Ausführungsform der Erfindung zeigt;

[0031] **Fig.** 9 ist eine Frontansicht des Kugel-Störungsverhinderers aus **Fig.** 8;

[0032] **Fig.** 10 ist eine Querschnittsansicht des Kugel-Störungsverhinderers, geführt in einer Linie X-X in **Fig.** 8;

[0033] **Fig.** 11 ist eine vergrößerte Perspektivansicht, welche einen oberen Endabschnitt des in **Fig.** 8 gezeigten Kugel-Störungsverhinderers zeigt;

[0034] **Fig.** 12 ist eine Querschnittsansicht einer Kugelumlaufspindel, in der ein Kugel-Störungsverhinderer gemäß einer vierten Ausführungsform der Erfindung aufgenommen ist;

[0035] **Fig.** 13 ist eine Perspektivansicht, die zeigt, wie die Kugeln aus **Fig.** 12 zirkulieren;

[0036] **Fig.** 14 ist eine Perspektivansicht, welche den Kugel-Störungsverhinderer (Abstandshalter) aus **Fig.** 12 zeigt;

[0037] **Fig.** 15 ist eine Querschnittsansicht des Kugel-Störungsverhinderers aus **Fig.** 14;

[0038] **Fig.** 16 ist eine perspektivische und teilweise geschnittene Ansicht, die eine Kugelumlaufspindel zeigt, in welche eine Kugel-Störungsverhinderer gemäß einer fünften Ausführungsform der Erfindung aufgenommen ist;

[0039] **Fig.** 17 ist eine Draufsicht, die einen Zustand zeigt, in welchem der Kugel-Störungsverhinderer, der in die Kugelumlaufspindel aus **Fig.** 16 aufgenommen ist, in den Kugelzirkulationspfad zirkuliert; und

[0040] **Fig.** 18 ist eine Perspektivansicht, die einen Zustand zeigt, in welchem der Kugel-Störungsverhinderer, der in die Kugelumlaufspindel aus **Fig.** 16 aufgenommen ist, in dem Kugelzirkulationspfad zirkuliert.

AUSFÜHRLICHE BESCHREIBUNG DER BEVORZUGTEN AUSFÜHRUNGSFORMEN

[0041] Die bevorzugten Ausführungsformen der vorliegenden Erfindung werden nachfolgend unter Bezugnahme auf die begleitenden Zeichnungen beschrieben.

Erste Ausführungsform

[0042] **Fig.** 1 bis 6 zeigen einen Walzen-Störungsverhinderer RC gemäß einer ersten Ausführungsform der Erfindung und ein linear gleitendes Walzenlager, in das der Walzen-Störungsverhinderer RC eingebaut ist.

[0043] Dieser Walzen-Störungsverhinderer RC schließt einen flexiblen Harzverbinder **12** ein, der eingelegte Abschnitte **12**a besitzt, die zwischen jeder einer Anzahl von Walzen **11** eingelegt sind, welche aus Lagerstahl (SUJ2) hergestellt und unter gleichmäßigen Abständen angeordnet sind, und besitzt ein Paar von verbindenden Abschnitten **12**b, die jeden eingelegten Abschnitt **12**a verbinden und eine Anzahl von Walzen **11** im linearen Zustand und wälzbar trägt, wie insbesondere in **Fig.** 3 bis 6 gezeigt. An beiden Enden des Harzverbinders **12** ist ein abgeschrägter Führungsabschnitt **13** gebildet, der eine annähernd ähnliche Form einer Walze besitzt, um die Walze **11**a, die an dem Ende angeordnet ist, zu umgeben, wie in **Fig.** 6 gezeigt.

[0044] Das linear gleitende Walzlager, in das der Walzen-Störungsverhinderer RC eingebaut ist, schließt im wesentlichen eine metallische Schiene (eine Lagerlauffläche) **14**, die Steifigkeit besitzt, eine metallische Gleitplatte (andere Lagerlauffläche) **15**, die Steifigkeit besitzt, ein Walzführungselement **16**, das aus synthetischen Harz hergestellt ist und in ein Loch **15**b befestigt ist, das entlang der Längsrichtung in der Gleitplatte **15** gestanzt ist, befestigt ist, einen Deckel **17**, der aus synthetischem Harz hergestellt ist und an der Gleitplatte **15** zusammen mit dem Walzenführungselement **16** befestigt ist, und eine Anzahl von Walzen **11**, die kettenartig durch den Harzverbinder **12** wie in **Fig.** 1 und 2 gezeigt getragen sind, ein.

[0045] In dieser ersten Ausführungsform ist die Führungsschiene **14** mit einem glattflächigen Wälzpfad **14**a für die Walze **11** an jedem Schulterabschnitt gebildet, und die Gleitplatte **15** ist mit einem Lastwalzen-Wälzpfad **15**a für die Walze **11**, die eine Belastung aufbringt, gebildet. Darüber hinaus ist das Walzenführungselement **16** mit einer Nicht-Last-Walzenführungsbohrung **16**a zum Führen der Walze **11**, die in einem nicht belasteten Zustand walzt, gebildet, und der Deckel **17** ist mit einem Richtungsänderungspfad, nicht gezeigt, gebildet, der den kontinuierlichen Zirkulationspfad der Walze **11** durch Verbinden des Belastungswalzen-Wälzpfades **15**a der Gleitplatte **15** und der Nicht-Belastungswalzen-Führungsbohrung **16**a des Walzenführungselements **16** darstellt.

Zweite Ausführungsform

[0046] **Fig.** 7 zeigt einen Walzen-Störungsverhinderer RC gemäß einer zweiten Ausführungsform der Erfindung. Dieser Walzen-Störungsverhinderer RC schließt einen flexiblen Harzverbinder **22** ein, der plattenartige, eingelegte Abschnitte **22**a besitzt, die zwischen dem jeweiligen einer Anzahl von Walzen **21** eingelegt sind, welche aus Lagerstahl (SUJ2) hergestellt und unter gleichmäßigen Abständen angeordnet sind, und schließt ein Paar von verbindenden Abschnitten **22**b ein, die jeweils die eingelegten Abschnitte **22**a auf beiden Seiten der Walze **21** verbinden, und eine Anzahl von Walzen **21** in linearen Zustand und wälzbar anordnet. Auf beiden Enden des Harzverbinders **22** ist ein abgeschrägter Führungsabschnitt **23** gebildet, der eine halbzylindrische Form und etwa denselben Krümmungsradius wie die Walze **21**a besitzt.

[0047] Der Walzen-Störungsverhinderer RC gemäß der zweiten Ausführungsform trägt die Walzen **21** nicht durch Verwenden des Harzverbinders **22**, sondern ist in den kontinuierlichen Zirkulationspfad des linear gleitenden Walzenlagers auf dieselbe Weise wie die der Walzen-Störungsverhinderer RC der ersten Ausführungsform eingebaut, wodurch verhindert wird, dass die Walzen **21** einander berühren und einander stören.

Dritte Ausführungsform

[0048] **Fig.** 8 bis 11 zeigen einen Kugel-Störungsverhinderer BC gemäß einer dritten Ausführungsform der Erfindung. Dieser Kugel-Störungsverhinderer BC schließt ein einen flexiblen Harzverbinder **32**, der eingelegte Abschnitte **32**a besitzt, die zwischen den jeweiligen einer Anzahl von Kugeln **31** eingelegt sind, welche aus Lagerstahl (SUJ2) hergestellt und in gleichmäßigen Abständen angeordnet sind, und ein Paar von verbindenden Abschnitten **32**b zu verbinden der jeweiligen eingelegten Abschnitte **32**a und zum Tragen einer Anzahl von Kugeln **21** in linearem Zustand und wälzbar. Auf beiden Enden des Harzverbinders **32** ist ein abgeschrägter Führungsabschnitt **33** gebildet, der etwa dieselbe Form wie die Kugel **31**a besitzt, und die Kugel **31**a, die an dem Ende angeordnet ist, zu umgeben.

[0049] Dieser Kugel-Störungsverhinderer BC ist ebenso in dem kontinuierlichen Zirkulationspfad des linear gleitenden Kugellagers auf dieselbe Weise wie die der Walzen-Störungsverhinderer RC der ersten Ausführungsform eingebaut.

Vierte Ausführungsform

[0050] **Fig.** 12 bis 15 zeigen ein Kugel-Störungsverhinderer BC gemäß einer vierten Ausführungsform der Erfindung und eine Kugelumlaufspindel BS, in welche der Kugel-Störungsverhinderer BC eingebaut ist.

[0051] Dieser Kugel-Störungsverhinderer BC schließt eine Anzahl von Abstandhaltern **42** ein, die einen kugelförmigen, konkaven Abschnitt **42** zum Aufnehmen einer Kugel **41** teilweise auf der Frontfläche und der Rückfläche besitzen. Der Kugel-Störungsverhinderer BC ist in einen kontinuierlichen Zirkulationspfad der Kugelumlaufspindel eingebaut, die einschließt eine Spindelachse (eine Lagerlauffläche) **44**, die einen spiralförmigen Wälzpfad **44** für die Kugel **41** besitzt, eine Mutter (andere Lagerlauffläche) **45** mit einer spiralförmigen Wälzrille **45**a, die dem spiralförmigen Wälzpfad gegenüberliegt, und eine Anzahl von Kugeln **41**, die zwischen dem spiralförmigen Wälzpfad **44**a der Spindelachse **44** und der spiralförmigen Wälzrille **45**a der Mutter **45** bei aufgebrachter Belastung wälzen, und ist zwischen benachbarten Kugeln **41** angeordnet, um zu verhindern, dass die Kugeln **41** einander berühren und einander stören.

[0052] In dieser vierten Ausführungsform besitzt die Mutter **45** ein annähernd U-förmiges Rückführrohr **46**, das an einer Klemmfläche **45**b angebracht ist, die durch Abschneiden eines Teils des äußeren Umfangsabschnitts gebildet ist. Beide Endabschnitte des Rückführrohres **46** durchdringen eine Umfangswand der Mutter **44**, um sich in die spiralförmige Wälzrille **45**a, die dem spiralförmigen Wälzpfad **44**a der Spindelachse **44** gegenüberliegt, zu öffnen. Darüber hinaus sind an beiden Enden Kugelaufnahmeabschnitte **46**a gebildet, um die Kugeln **41**, die zwischen dem spiralförmigen Wälzpfad **44**a und der spiralförmigen Wälzrille **45**a bei aufgebrachter Belastung in das Rückführrohr **46** wälzen, aufzunehmen, und um die Kugeln **41**, die durch das Rückführrohr **46** wälzen, zwischen den spiralförmigen Wälzpfad **44**a und die spiralförmige Wälzrille **45**a zuzuführen. Der kontinuierliche Zirkulationspfad der Kugeln **41** wird durch die Spindelachse **44**, die Mutter **45** und das Rückführrohr **46** gebildet.

[0053] Der Abstandhalter **42**, der den Kugel-Störungsverhinderer BC der vierten Ausführungsform darstellt, ist zwischen benachbarten Kugeln **41**, die in den kontinuierlichen Zirkulationspfad der Kugelumlaufspindel eingebaut sind, angeordnet, zirkuliert in diesem Zirkulationspfad zusammen mit den Kugeln **41**, und verhindert, dass die Kugeln **41** einander berühren und einander stören.

Fünfte Ausführungsform

[0054] **Fig.** 16 bis 18 zeigen einen Kugel-Störungsverhinderer BC, der in eine Kugelumlaufspindel BS auf dieselbe Weise wie in der vierten Ausführungsform der Erfindung eingebaut ist.

[0055] Dieser Kugel-Störungsverhinderer BC schließt, anders als derjenige der vierten Ausführungsform, jedoch wie derjenige der dritten Ausführungsform, einen flexiblen Harzverbinder **52**, der eingelegte Abschnitte **52**a, die zwischen den jeweiligen einer Anzahl von Kugeln **51**, die in gleichmäßigen Abständen angeordnet sind, eingelegt ist, und einen verbindenden Abschnitt **52**b, der jeden eingelegten Abschnitt **52**a verbindet und eine Anzahl von Kugeln **41** wälzbar trägt, ein. Auf beiden Enden des Harzverbinders **52** ist jeweils ein abgeschrägter Führungsabschnitt **53** gebildet, um die Kugel **51**a, die an dem Ende angeordnet ist, zu umgeben.

[0056] In **Fig.** 16 bis 18 ist die Kugelwälzrille **54**a in der Spindelachse **54** gebildet, und die Nicht-Belastungswälzrille **55**a ist in der Mutter **55** gebildet. Darüber hinaus ist ein Ablenker **56**, der an der Mutter **54** befestigt ist und den kontinuierlichen Zirkulationspfad zwischen der Spindelachse **54** und der Mutter **55** bildet, mit einer Kugelrückführrille **56**a gebildet, wodurch eine Anzahl von Kugeln, die durch den Harzverbinder **52** verbunden sind, in dem durch die Kugelwälzrille **54**a der Spindelachse **54**, die Nicht-Belastungswälzrille **55**a der Mutter **55** und die Kugelrückführrille **56**a des Ablenkers **56** gebildeten Zirkulationspfades wälzen können, bei aufgebrachter Belastung.

[0057] Dieser Kugel-Störungsverhinderer BC der fünften Ausführungsform verhindert, dass die Kugeln **51** einander berühren und einander stören, wie der Kugel-Störungsverhinderer BC der vierten Ausführungsform.

Beispiele

[0058] Die vorliegende Erfindung wird nachfolgend genauer auf der Grundlage einiger experimenteller Beispiele (Beispiele und Vergleichsbeispiele) beschrieben.

Experimentelle Beispiele 1 bis 4

[0059] Unter Verwendung von Polyesterharzelastomer (Handelsname Perplene EN1000, EN2000, EN3000 und EN5000, hergestellt durch TOYOBO Co., Ltd.) wie in Tabelle 1 angegeben als Elastomer aus thermoplastischem Harz wurden 75 aus Lagerstahl (SUJ2) hergestellte Rollen mit einer Größe von 5 mm $\varnothing \times 7$ mm als ein Kern durch Spritzgießen hergestellt, von der Form gelöst, zusammen mit einer Anzahl von Walzen, wodurch der Walzen-Störungsverhinderer gegossen wurde, der eine Länge von etwa 340 mm und eine wie in **Fig.** 3 bis 6 für die erste Ausführungsform gezeigte Form besitzt.

[0060] Die erhaltenen Walzen-Störungsverhinderer der jeweiligen Vergleichsbeispiele 1 bis 4 wurden im Hinblick auf Dauerhaftigkeit, Gleiteigenschaften, Verschleißwiderstand, Wasserabsorptionsvermögen, Schwelleigenschaften und Wasserwiderstand untersucht.

[0061] Die Ergebnisse sind unten in Tabelle 1 aufgelistet.

Dauerhaftigkeit

[0062] Wie in **Fig.** 1 und 2 gezeigt, wurde der Walzen-Störungsverhinderer der jeweiligen experimentellen Beispiele 1 bis 4 in den kontinuierlichen Zirkulationspfad des linear gleitenden Walzenlagers eingebaut, mit dessen Schiene im befestigten Zustand, und die Gleitplatte wurde unter den Bedingungen mit einer Geschwindigkeit f von 2000 m/min hin und her bewegt, bei einem Hub St von 2500 mm, und einer Beschleunigung von 1 G. Die Dauerhaftigkeit wurde mit drei Stufen bewertet, in denen ○ keine Abnormalität nach Durchlaufen von 30 000 km anzeigt, Δ einige teilweise Beschädigung nach Durchlaufen von 30 000 km, jedoch keine Abnormalität beim Durchlaufen anzeigt, und X eine Abnormalität anzeigt, wie ein Brechen nach Durchlaufen von weniger als 30 000 km.

Gleiteigenschaften

[0063] Auf dieselbe Weise wie die Messung der Dauerhaftigkeit, wurde der Walzen-Störungsverhinderer der jeweiligen experimentellen Beispiele 1 bis 4 in den kontinuierlichen Zirkulationspfad des linear gleitenden Walzenlagers eingebaut, mit dessen Schiene im befestigten Zustand, und die Gleitplatte wurde durch eine Kraftmessdose geschoben, um den Wälzwiderstand der Gleitplatte in der Schiene bei einer Messfrequenz von 500 Hz für diese Kraftmessdose zu messen. Die Gleiteigenschaften wurden mit drei Stufen bewertet, in denen ○ bedeutet, dass sie für den Betrieb geeignet sind, da die Widerstandsvariation 25% oder weniger des Wälzwiderstandes beträgt, Δ ist für den Betrieb verwendbar obwohl die Widerstandsvariation teilweise weniger als 25% des Messwiderstandes beträgt, und X ist nicht verwendbar, da die Widerstandsvariation vollständig unterhalb 25% des Messwiderstandes liegt.

Verschleißwiderstand

[0064] Auf dieselbe Weise wie die Messung der Dauerhaftigkeit wurde der Walzen-Störungsverhinderer der jeweiligen experimentellen Beispiele 1 bis 4 in den kontinuierlichen Zirkulationspfad des linear gleitenden Walzenlagers eingebaut, mit dessen Schiene im befestigten Zustand, und die Gleitplatte wurde unter den Bedingungen mit einer Geschwindigkeit f von 200 m/min. einem Hub St von 2500 mm und einer Beschleunigung von 1 G hin und her bewegt, um den Verschleißbetrag an der Ecke am oberen Ende des Harzverbinders für den Walzen-Störungsverhinderer zu messen. Der Verschleißwiderstand wurde mit drei Stufen bewertet, in denen ○ keine Abnormalität des Verschleißes anzeigt, Δ zeigt etwas anfänglichen Verschleiß, jedoch keinen progressiven Verschleiß an, und X bedeutet progressiven (fortschreitenden) Verschleiß an dem oberen Ende während des Laufens, was zu einem Brechen führt.

Wasserabsorptionsvermögen

[0065] Unter Verwendung von vier Arten von Polyesterharzelastomer, das in jeden der experimentellen Beispiele 1 bis 4 wie in Tabelle 1 aufgelistet eingesetzt wurde, wurde ein Hantelprobekörper vom Typ JIS 3 in Übereinstimmung mit JIS K6251 hergestellt, und die Abmessungsvariation des Hantelprobekörpers wurde gemessen in einer Umgebung eines Gleichgewichtsfeuchtigkeitsgehalts bei 23°C von 65% RH, und das Wasserabsorptionsvermögen wurden mit drei Stufen bewertet, in denen O 0,5% oder weniger ist, Δ von 5% bis 1,5% ist, und X mehr als 1,5% ist.

Schwelleigenschaften

[0066] Auf dieselbe Weise wie in dem Test des Wasserabsorptionsvermögens wurde ein Hantelprobekörper vom Typ JIS 3 hergestellt, und der Hantelprobekörper wurde in das Versuchsöl bei einer Temperatur von 85°C für 672 Stunden eingetaucht, unter Anwendung eines synthetischen Kühlmittels (Synthylo hergestellt durch Castorol), eines löslichen Kühlmittels (Microcut 3850-LH hergestellt durch Japan Quakerchemical) und eines Emulsionskühlmittels (Yushiroken EC50T-3 hergestellt durch Yushiro Chemical Industries) als Versuchsöle, und unter Verwendung einer Umweltprüfmaschine (hergestellt von KATO: sse740RA). Der Schwellfaktor wurde anhand der Werte der Abmessungsvariation des Hantelprobekörpers infolge Schwellens berechnet und mit drei Stufen bewertet, in denen ○ 1,5% oder weniger ist, Δ von 1,5% bis 3% ist, und X mehr als 3% ist.

Wasserwiderstand

[0067] Auf dieselbe Weise wie der Test des Wasserabsorptionsvermögens und der Schwelleigenschaften wurde ein Hantelprobekörper vom Typ JIS3 hergestellt, und in kochendes Wasser bei 100°C für zehn Tage eingetaucht, um die Veränderung der Zugfestigkeit (Zugfestigkeit: 500 mm/min) des Hantelprobekörpers zu messen. Die Aufrechterhaltung der Zugfestigkeit wurde anhand der Veränderung der Zugfestigkeit berechnet und mit drei Stufen bewertet, in denen O eine Aufrechterhaltung der Zugfestigkeit von 80% oder mehr nach zehn Tagen ist, Δ ist eine Aufrechterhaltung der Zugfestigkeit von 70% bis 80% nach zehn Tagen, und X ist eine Aufrechterhaltung der Zugfestigkeit von weniger als 70% nach zehn Tagen.

TABELLE 1

Walzen-Störungsverhinderer					
Experimentelles Beispiel Nr.		1	2	3	4
Polester-harz-elastomer	Elastomer-Handelsname	Perplene			
	Typ	EN1000	EN2000	EN3000	EN5000
	Spannung bei 10% Verlängerung (kgf/cm^2)	69	80	158	193
	Zugfestigkeit (kgf/cm^2)	360	370	430	455
	Biege-Elastizitätsmodul (kgf/cm^2)	1200	1600	2700	4800
	Wert von (AxB)÷C	20,7	18,5	25,2	18,2
Bewertung	Dauerhaftigkeit	O	Δ	O	O
	Gleiteigenschaften	O	O	O	Δ
	Verschleisswiderstand	O	O	O	Δ
	Wasserabsorptionsvermögen	O	O	O	O
	Schwelleigenschaften	Δ	O	O	O
	Wasserwiderstand	Δ	O	O	O

Experimentelle Beispiele 5 bis 9

[0068] Unter Verwendung von Polyesterharzelastomer (Handelsname Perplene EN1000, EN2000, EN3000 und EN5000, hergestellt durch TOYOBO Co., Ltd.) wie in Tabelle 2 aufgelistet als thermoplastisches Harzelastomer, einer Spannung bei 10% Verlängerung A von 54 kgf/cm^2, einer Zugfestigkeit B von 220 kgf/cm^2, einem Biegeelastizitätsmodul C von 1100 kgf/cm^2, einer Beziehung $(A \times B) \div C = 10.8$, wurden 34 Kugeln aus Lagerstahl (SUJ2) mit einer Größe von 3,969 mm ∅ hergestellt als ein Kern durch Spritzgießen, und von der Form gelöst, zusammen mit einer Anzahl von Kugeln, wodurch die Kugel-Störungsverhinderer mit einer Form wie in **Fig.** 8 bis 11 gezeigt geformt wurden.

[0069] Die erhaltenen Kugel-Störungsverhinderer der jeweiligen experimentellen Beispiele 5 bis 9 wurden im Hinblick auf die Dauerhaftigkeit, Gleiteigenschaften, den Verschleißwiderstand, das Wasserabsorptionsvermögen, die Schwelleigenschaften und den Wasserwiderstand auf dieselbe Weise wie in den vorhergehenden experimentellen Beispielen 1 bis 4 untersucht.

[0070] Die Ergebnisse sind nachstehend in Tabelle 2 aufgelistet.

TABELLE 2

Kugel-Störungsverhinderer						
Experimentelles Beispiel Nr.		5	6	7	8	9
Polester-harz-elastomer	Elastomer-Handelsname	Perplene				
	Typ	EN 1000	EN 2000	EN 3000	EN 5000	-
	Spannung bei 10% Verlängerung (kgf/cm^2)	69	80	158	193	54
	Zugfestigkeit (kgf/cm^2)	360	370	430	455	220
	Biege-Elastizitätsmodul (kgf/cm^2)	1200	1600	2700	4800	1100
	Wert von (AxB)÷C	20,7	18,5	25,2	18,2	10,8
Bewertung	Dauerhaftigkeit	Δ	O	O	Δ	Δ
	Gleiteigenschaften	O	O	Δ	Δ	O
	Verschleisswiderstand	O	O	O	Δ	O
	Wasserabsorptionsvermögen	O	O	O	O	Δ
	Schwelleigenschaften	Δ	O	O	O	×
	Wasserwiderstand	O	O	O	O	Δ

[0071] Mit dem Wälzelement-Störungsverhinderer der vorliegenden Erfindung ist es möglich, mit der Führungsvorrichtung, in die dieser eingebaut ist, in ausgezeichneter Weise geringes Geräusch, Wartungsfreiheit für lange Zeit, hohe Geschwindigkeit und Gleiteigenschaften, und gleichzeitig ausgezeichnete Dauerhaftigkeit und Verschleißwiderstand aufzuweisen, wodurch die Führungsvorrichtung stabil über eine lange Zeit eingesetzt werden kann, um der Verminderung der Abmessungen und der Erhöhung der Geschwindigkeit zu begegnen.

Patentansprüche

1. Wälzelement-Störungsverhinderer für eine Führungsvorrichtung, die einen kontinuierlichen Zirkulationspfad und eine Vielzahl von Wälzelementen besitzt, die unter gleichmäßigen Abständen in dem kontinuierlichen Zirkulationspfad wälzen, worin der Wälzelement-Störungsverhinderer verhindert, dass die Wälzelemente einander stören, und
worin der Wälzelement-Störungsverhinderer aus einem Elastomer aus thermoplastischen Harz gebildet ist, das physikalische Eigenschaften in Übereinstimmung mit einem Ausdruck $(A \times B) \div C \geq 18$ besitzt, wobei A eine Spannung bei 10% Verlängerung darstellt, B eine Zugfestigkeit darstellt, und C einen Biege-Elastizitätsmodul darstellt.
2. Wälzelement-Störungsverhinderer nach Anspruch 1, worin das Elastomer aus thermoplastischen Harz eine Spannung bei 10% Verlängerung A von 60 bis 200 kgf/cm^2 besitzt, eine Zugfestigkeit B von 340 bis 460 kgf/cm^2 und einen Biege-Elastizitätsmodul C von 3000 bis 5000 kgf/cm^2 besitzt.
3. Wälzelement-Störungsverhinderer nach Anspruch 1, worin ein Wasserabsorptionskoeffizient für das Elastomer aus thermoplastischen Harz nicht mehr als 1,5 Gewichts-% beträgt.
4. Wälzelement-Störungsverhinderer nach Anspruch 1, worin ein Schwellfaktor des Elastomers aus thermoplastischem Harz nicht mehr als 3% beträgt.
5. Wälzelement-Störungsverhinderer nach Anspruch 1, worin eine Aufrechterhaltung der Zugfestigkeit des Elastomers aus thermoplastischem Harz nicht weniger als 70% nach zehn Tagen in einem Eintauchversuch in kochendem Wasser bei 100°C beträgt.
6. Führungsvorrichtung, die aufweist:
eine Schiene, die einen Wälzpfad besitzt;
eine Gleitplatte, die eine dem Wälzpfad gegenüberliegende Wälzrille besitzt und sich entlang der Schiene bewegt;
eine Vielzahl von Wälzelementen, die bei einer aufgebrachten Belastung zwischen dem Wälzpfad und der Wälzrille wälzen;
einen Wälzelement-Störungsverhinderer, der einen flexiblen Harzverbinder einschließt, welcher eine Vielzahl eingelegter Abschnitte besitzt, die zwischen den jeweiligen Wälzelementen eingelegt sind, und einen Verbindungsabschnitt zum Verbinden der jeweiligen eingelegten Abschnitte besitzt,
worin der Wälzelement-Störungsverhinderer aus einem Elastomer aus thermoplastischen Harz gebildet ist, das physikalische Eigenschaften in Übereinstimmung mit einem Ausdruck $(A \times B) \div C \geq 18$ besitzt, wobei A eine Spannung bei 10% Verlängerung darstellt, B eine Zugfestigkeit darstellt, und C einen Biege-Elastizitätsmodul darstellt.

7. Führungsvorrichtung nach Anspruch 6, worin der Harzverbinder die Wälzelemente in einem angeordneten Zustand und wälzbar mittels der eingelegten Abschnitte und des verbindenden Abschnitts trägt.

8. Führungsvorrichtung nach Anspruch 6, worin die Wälzelemente Kugeln sind, und das Elastomer aus thermoplastischem Harz besitzt eine Spannung bei 10% Verlängerung A von 60 bis 100 kgf/cm^2, eine Zugfestigkeit B von 340 bis 400 kgf/cm^2, und einen Biege-Elastizitätsmodul C von 1000 bis 2000 kgf/cm^2.

9. Führungsvorrichtung nach Anspruch 6, worin die Wälzelemente Walzen sind, und das Elastomer aus thermoplastischem Harz besitzt eine Spannung bei 10% Verlängerung A von 80 bis 200 kgf/cm^2, eine Zugfestigkeit B von 380 bis 400 kgf/cm^2, und einen Biege-Elastizitätsmodul C von 2000 bis 5000 kgf/cm^2.

10. Führungsvorrichtung, die aufweist:
eine Kugelumlaufspindel, die einen spiralförmigen Wälzpfad besitzt;
eine Mutter, die eine spiralförmige Wälzrille besitzt, die dem spiralförmigen Wälzpfad gegenüberliegt;
eine Vielzahl von Kugeln, die zwischen dem spiralförmigen Wälzpfad und der spiralförmigen Wälzrille wälzen; und
einen Kugel-Störungsverhinderer,
worin der Kugel-Störungsverhinderer eine Vielzahl von Abstandhaltern aufweist, die zwischen den jeweiligen Kugeln eingelegt sind, und
worin der Kugel-Störungsverhinderer aus einem Elastomer aus thermoplastischem Harz gebildet ist, das physikalischen Eigenschaften in Übereinstimmung mit einem Ausdruck $(A \times B) \div C \geq 18$ besitzt, wobei A eine Spannung bei 10% Verlängerung darstellt, B eine Zugfestigkeit darstellt, und C einen Biege-Elastizitätsmodul darstellt.

Hierzu 8 Seite(n) Zeichnungen

Nummer: DE 102 36 225 A1
Int. Cl.[7]: F 16 H 29/06
Offenlegungstag: 13. März 2003

FIG. 1

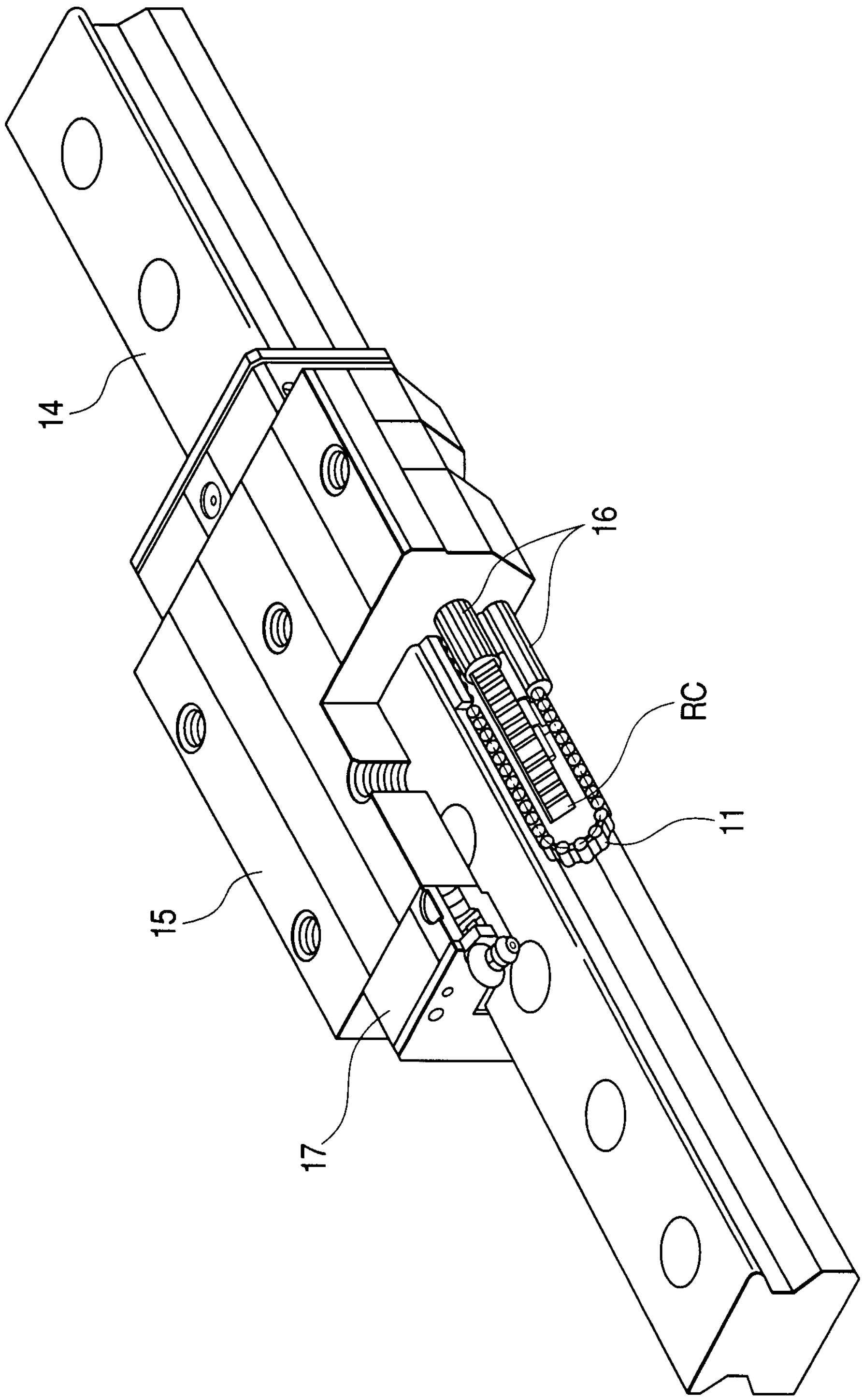


FIG. 2

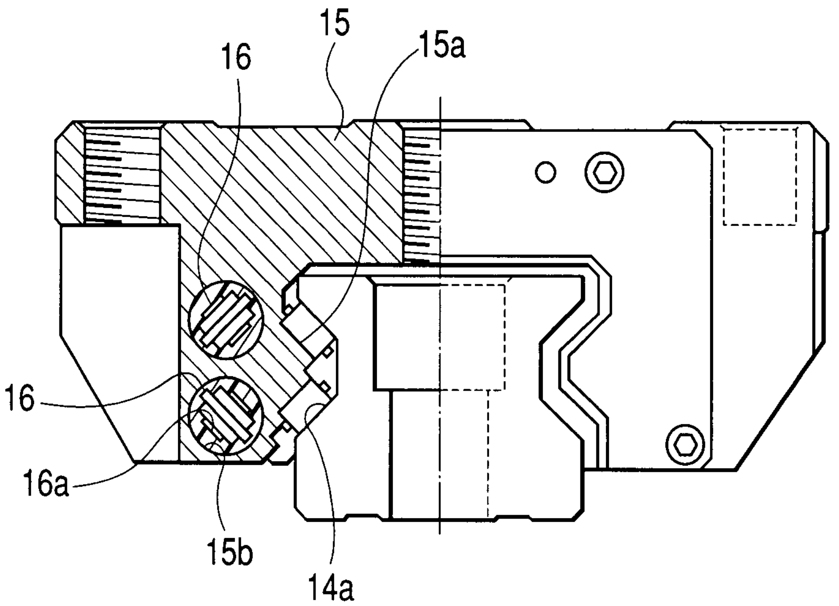


FIG. 3

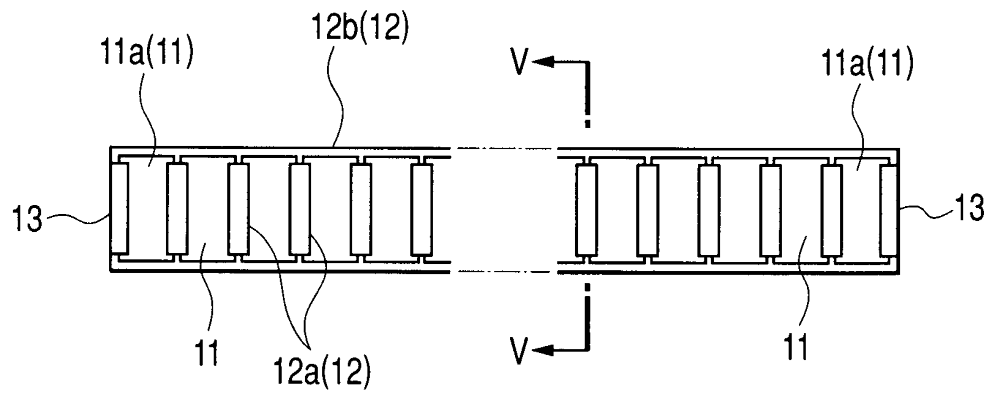
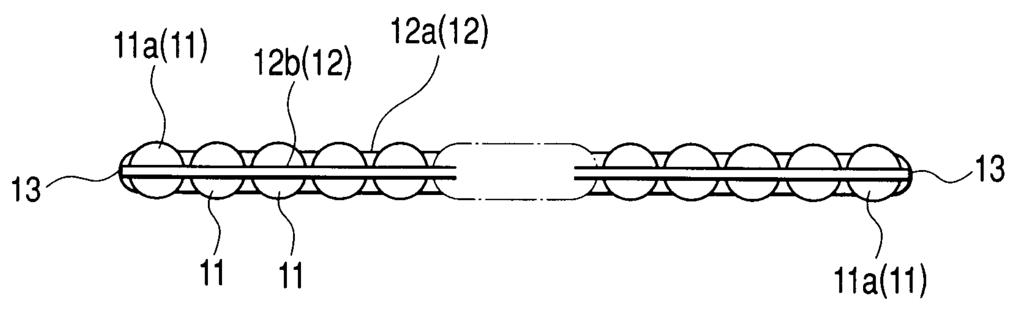


FIG. 4



Nummer: DE 102 36 225 A1
Int. Cl.7: F 16 H 29/06
Offenlegungstag: 13. März 2003

FIG. 5

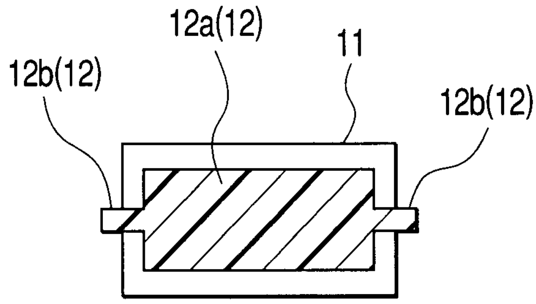


FIG. 6

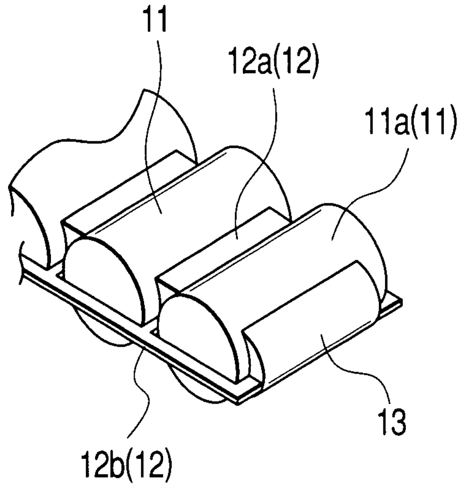
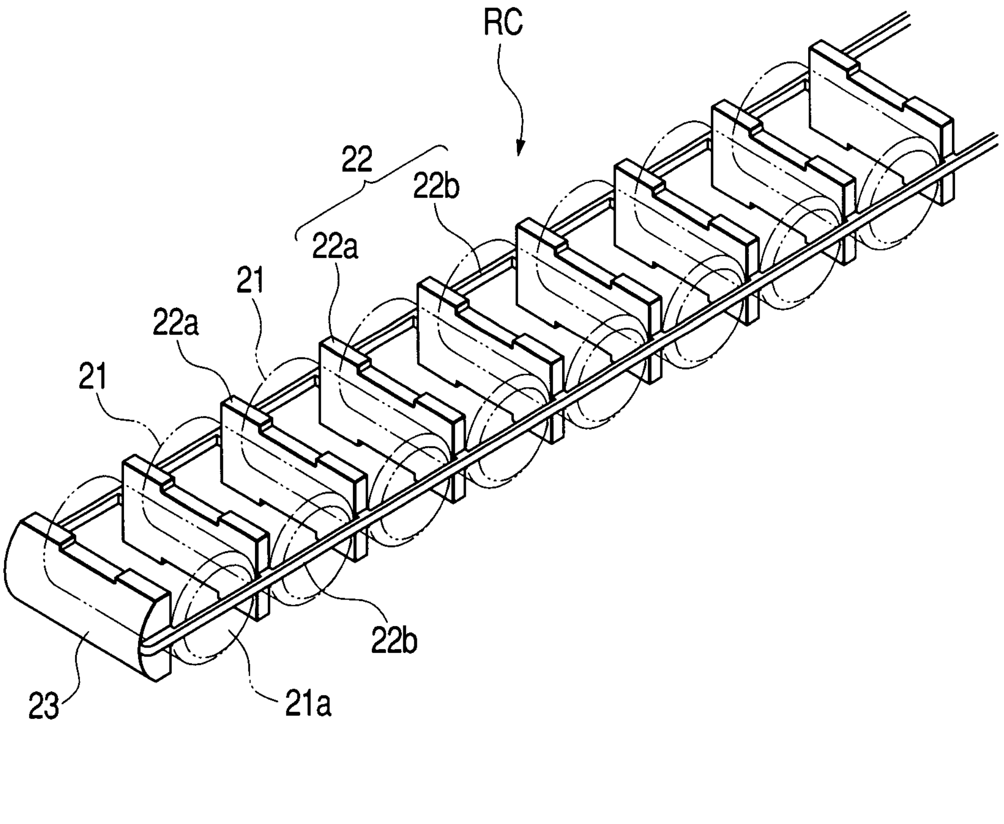


FIG. 7



Nummer: DE 102 36 225 A1
Int. Cl.[7]: F 16 H 29/06
Offenlegungstag: 13. März 2003

FIG. 8

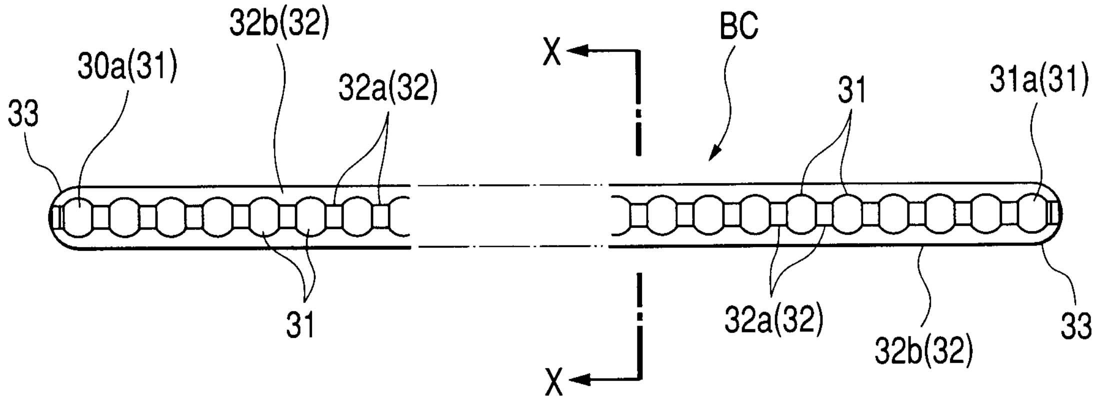


FIG. 9

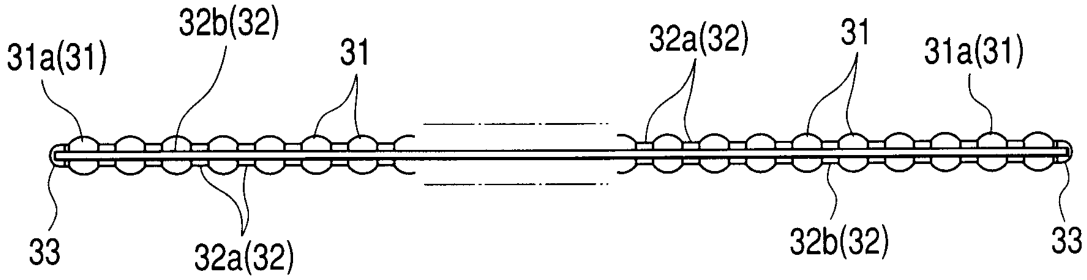


FIG. 10

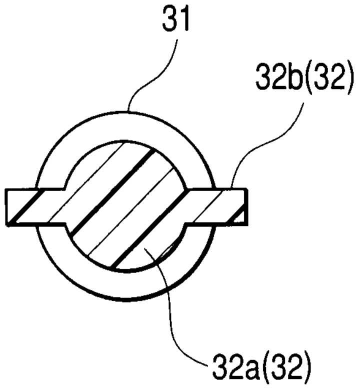
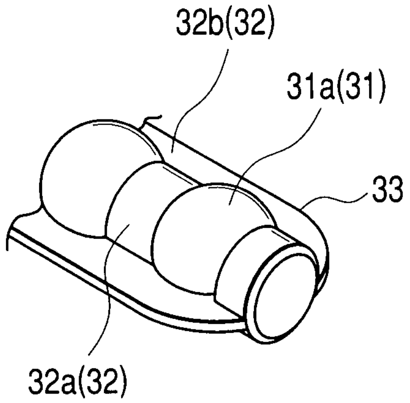


FIG. 11



Nummer: DE 102 36 225 A1
Int. Cl.[7]: F 16 H 29/06
Offenlegungstag: 13. März 2003

FIG. 12

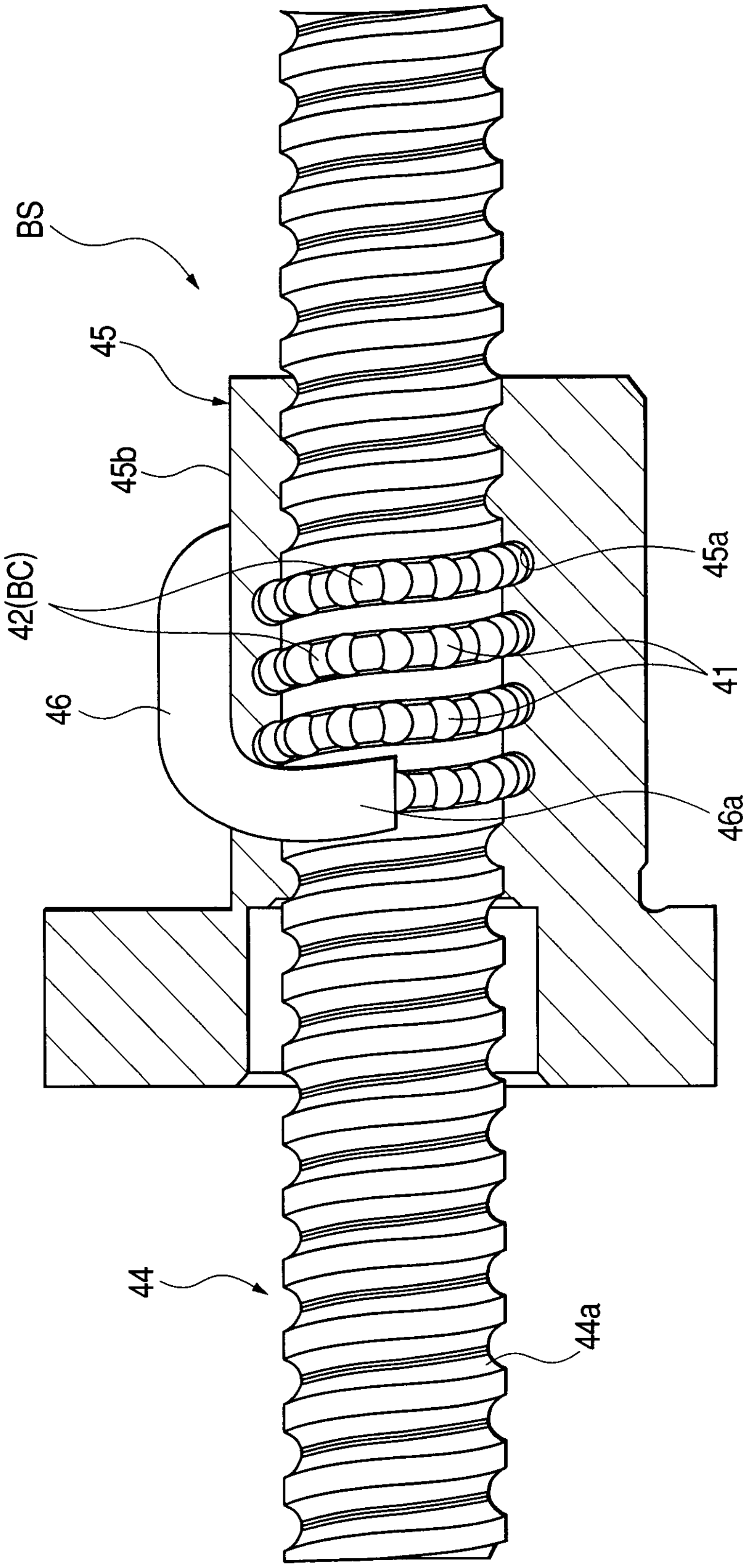


FIG. 13

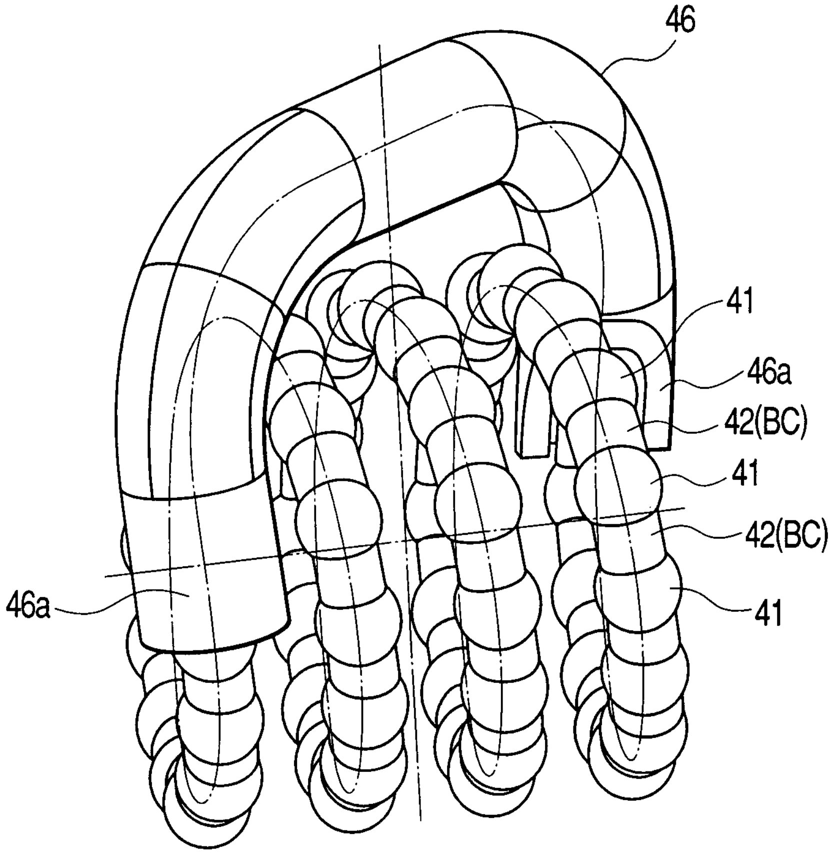


FIG. 14

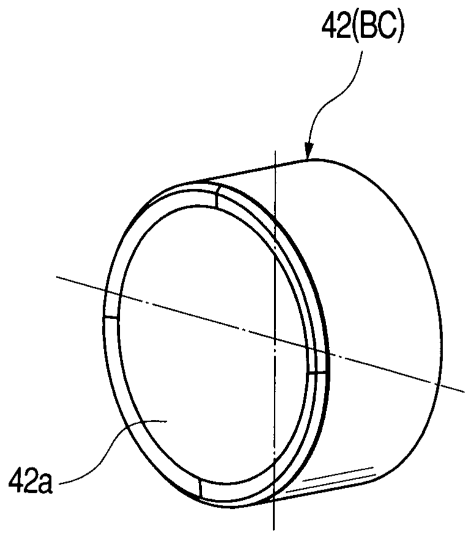
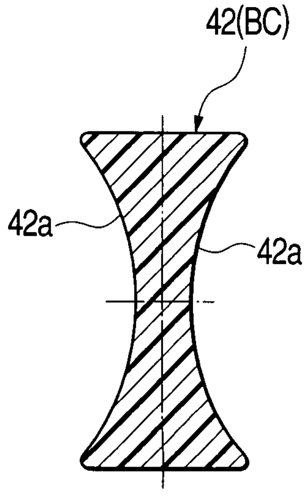


FIG. 15



Nummer: **DE 102 36 225 A1**
Int. Cl.[7]: **F 16 H 29/06**
Offenlegungstag: 13. März 2003

FIG. 16

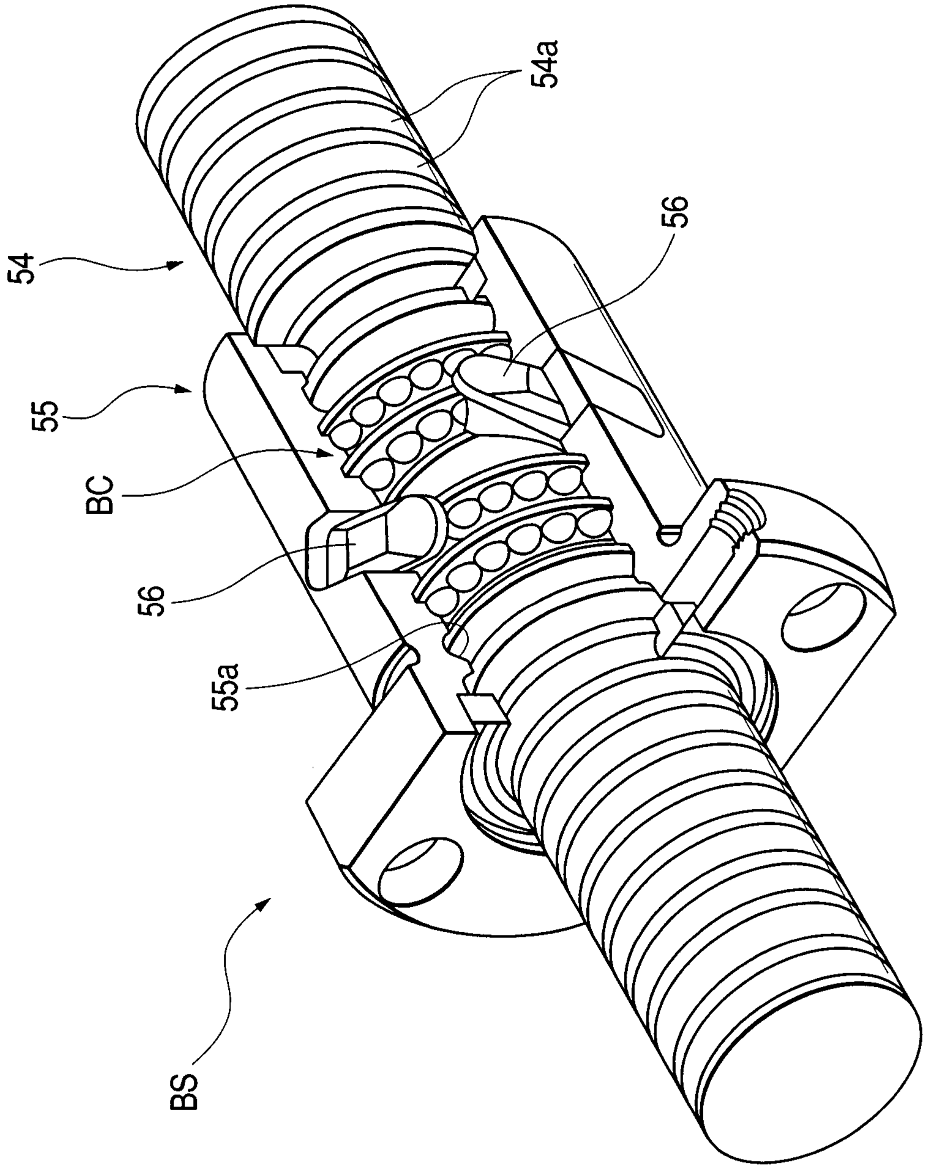


FIG. 17

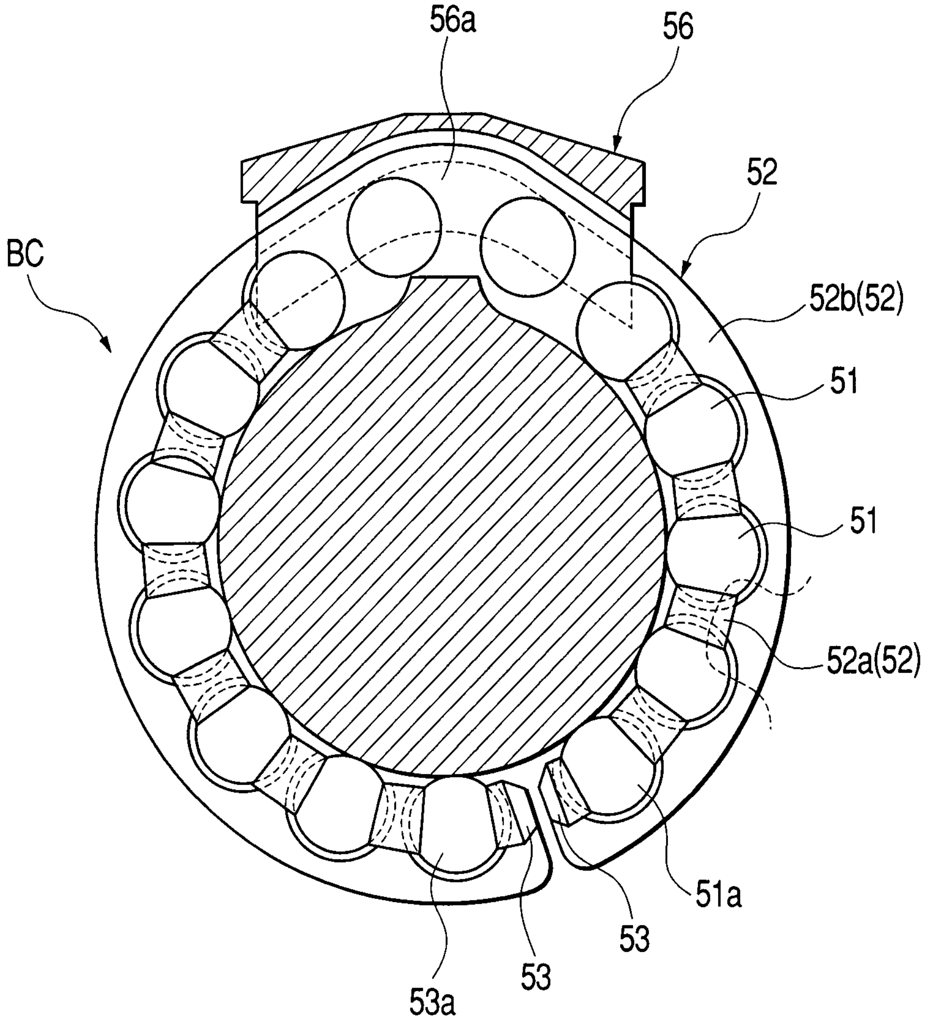
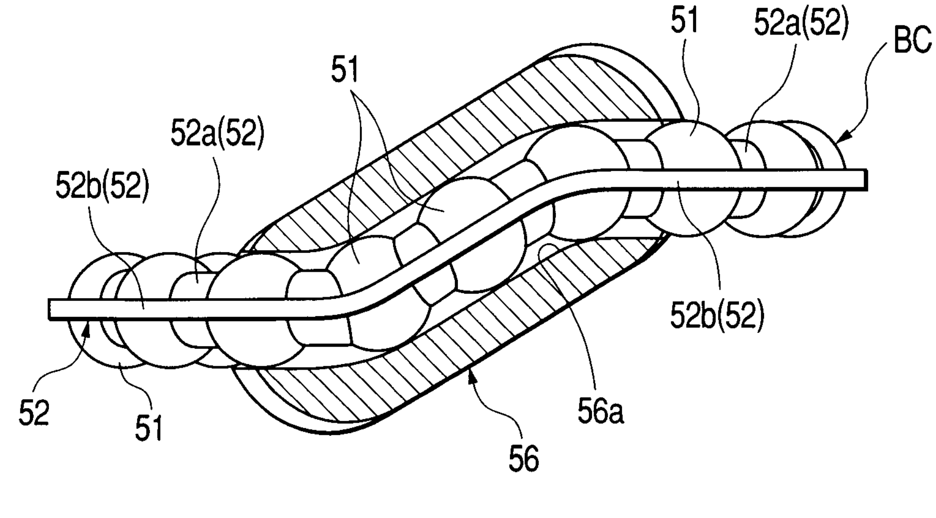

56a
56
52
BC
52b(52)
51
51
52a(52)
51a
53
53
53a

FIG. 18


51
52a(52)
BC
51
52a(52)
52b(52)
52b(52)
52
51
56a
56

(19) **BUNDESREPUBLIK DEUTSCHLAND**

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 102 15 766 A 1**

(51) Int. Cl.[7]:
F 16 C 29/04

(21) Aktenzeichen: 102 15 766.9
(22) Anmeldetag: 10. 4. 2002
(43) Offenlegungstag: 13. 2. 2003

DE 102 15 766 A 1

(30) Unionspriorität:
2001113120 11. 04. 2001 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

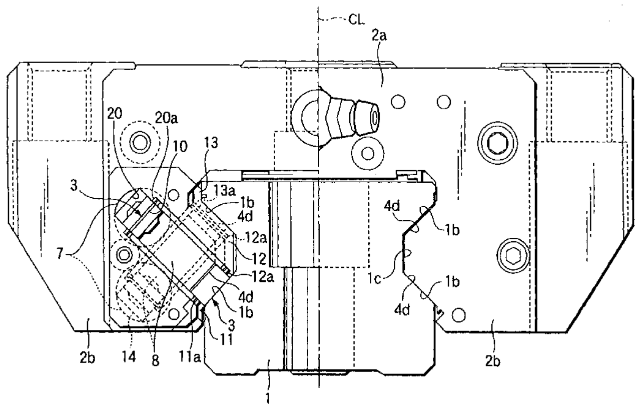
(74) Vertreter:
HOFFMANN · EITLE, 81925 München

(72) Erfinder:
Shirai, Takeshi, Tokyo/Tokio, JP; Mochizuki, Hiroaki, Yamanashi, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Wälzführungsvorrichtung und Walzenverbindungskörper

(57) Eine Wälzführungsvorrichtung schließt ein eine Schiene, die Walzenlaufflächen besitzt, und einen Walzenzirkulationspfad, der Lastwalzenlaufflächen entsprechend zu den Walzenlaufflächen besitzt, einschließt, und eine Vielzahl von Walzen, die in dem Walzenzirkulationspfad angeordnet und aufgenommen sind und in Assoziation mit einer Bewegung eines beweglichen Blocks gegenüber der Schiene zirkulieren. Jede Walze besitzt ein Verhältnis von näherungsweise 1,5 < L/Da < näherungsweise 3. Durch Einstellen des Verhältnisses der Walzenlänge zum Walzendurchmesser auf einen Wert von näherungsweise 1,5 < L/Da wird die grundlegende statische Belastungsbewertung einer Wälzführungsvorrichtung des Walzentyps größer als diejenige einer Wälzführungsvorrichtung des Kugeltyps, wenn die Teile der Vorrichtungen vom selben Modell sind. Durch Einstellen des Verhältnisses auf einen Wert von L/Da < näherungsweise 3, wird das Auftreten einer Schrägstellung ohne Ausfall verhindert, ohne Anwenden einer strengen Abmessungskontrolle des Axialspalts.



DE 102 15 766 A 1

Beschreibung

HINTERGRUND DER ERFINDUNG

1. Technisches Gebiet der Erfindung

[0001] Die vorliegende Erfindung bezieht sich auf eine Wälzführungsvorrichtung, die Walzen besitzt, welche eine Wälzbewegung ausführen und zwischen einer Laufringwelle und einem beweglichen Element eingelegt sind, sowie auf ein Walzenverbindungselement zum Halten der Walzen in rotierbarer und gleitbarer Weise.

2. Beschreibung des Standes der Technik

[0002] Eine Wälzführungsvorrichtung weist auf eine Schiene; einen beweglichen Block, der beweglich entlang der Schiene über eine Vielzahl von Wälzelementen vorgesehen ist; und eine Vielzahl von Walzen, die zwischen der Schiene und dem beweglichen Block eingelegt sind. **Fig.** 1 zeigt eine Wälzführungsvorrichtung, die Walzen darin aufgenommen besitzt. Wenn sich ein beweglicher Block **101** gegenüber einer Schiene **104** bewegt hat, führen Walzen **100**, die in einem zwischen zwei Walzenlaufringflächen **102** definierten Lastbereich angeordnet sind, eine Wälzbewegung aus, um dabei in einem nicht belasteten Bereich B angeordnete Walzen **100** zu schieben. Dann werden die in dem nicht belasteten Bereich B angeordneten Rollen **100** in den Lastbereich A auf der verbleibenden Seite geschoben. Somit zirkulieren die Walzen **100** durch einen Walzenzirkulationspfad, der entlang des beweglichen Blocks **101** definiert ist.

[0003] Ein Ball besitzt die Form einer Kugel und enthält eine unendliche Anzahl von Rotationsachsen. Daher kann sich der Ball in jegliche Richtung bewegen, je nachdem wie es die Umstände erfordern. Da die Walzen **100** zylindrisch sind, besitzt jede Walze **100** lediglich eine Rotationsachse, und daher ist die Bewegungsrichtung der Walze **100** auf lediglich eine Richtung begrenzt. Die Rotationsachse der Walze und die Bewegungsrichtung derselben müssen einen rechten Winkel aufrechterhalten. In Bezug auf eine Linearbewegungsführungsvorrichtung, welche die Walzen **100** verwendet, falls die Walzenlaufringfläche **102** des beweglichen Blocks **100** aus der Parallelen mit der Walzenlaufringfläche **102** der Schiene **104** geraten ist oder falls eine Aufsetz-Belastung auf den beweglichen Block **100** gewirkt hat, kann eine Möglichkeit entstehen, dass die Rotationsachse **105** der Walze **100** und die Bewegungsrichtung derselben aus einem rechten Winkel herausfallen, wie in **Fig.** 2 dargestellt. Ein derartiges Phänomen, in welchem die Walzen **100** gegenüber der normalen Rotationsachse geneigt sind, wird als "Schrägstellung" ("skew") bezeichnet. In dem Fall einer Linearbewegungsführungseinrichtung eines Typs ausschließlich mit Walzen, in welcher eine Vielzahl von ausschließlich Walzen **100** in dem Walzenzirkulationspfad eingeschlossen sind, kommen die Endflächen der entsprechend Walzen **100**, die in der Richtung der Rotationsachse liegen, in Kontakt mit einem Flansch **103**, der auf dem beweglichen Block **101** gebildet ist, wodurch das Auftreten eines Schrägstellens der Walzen **100** verhindert wird.

[0004] Falls Belastung auf die Linearbewegungs-Wälzelemente wirkt, werden der bewegliche Block **101** oder die Schiene **104** elastisch verformt. Das Ausmaß, in welchem die Wälzelemente, der bewegliche Block **101** oder die Schiene **104** Verformung widerstehen, wird als Steifigkeit der Linearbewegungsführungseinrichtung bezeichnet. Eine Linearbewegungsführungseinrichtung, in welcher Walzen als Wälzelemente aufgenommen sind, besitzt im allgemeinen eine größere Steifigkeit als die Linearführungseinrichtung, in welcher Kugeln als Wälzelemente eingesetzt sind. Die Steifigkeit der Linearbewegungsführungseinrichtung, die Walzen darin aufgenommen besitzt, wird anhand der Walzen **100** und der axialen Länge derselben bestimmt. Je größer die Anzahl von Walzen **100** und je länger ihre axiale Länge ist, desto größer ist die Steifigkeit der Linearbewegungsführungsvorrichtung. In anderen Worten, die Aufnahme einer großen Anzahl langgestreckter Rollen in die Linearbewegungsführungsvorrichtung ist effektiv zum Erhöhen der Steifigkeit derselben.

[0005] Wenn langgestreckte Walzen zum Verbessern der Steifigkeit verwendet werden, kann kein großer Kontaktbereich zwischen der Endfläche der Walze **100** und dem Flansch **103** in Bezug auf die Länge der Walze **100** in einer Rotationsrichtung davon sichergestellt werden. Daher kann eine Schrägstellung in den Walzen **100** auftreten. Dementsprechend können Probleme entstehen; das heißt, ein Phänomen, dass Walzen nicht mehr rotieren können (d. h. ein Blokkierphänomen), ein Erhitzungsphänomen, oder ein Phänomen eines Tischoszillierens aus Gründen von Vibration, das auftritt, wenn die Walzen in dem belasteten Bereich angeordnet sind (d. h. ein Wellenphänomen).

ZUSAMMENFASSUNG DER ERFINDUNG

[0006] Die vorliegende Erfindung dient zum Bereitstellen einer Wälzführungsvorrichtung und eines Walzenverbindungselements, die zuverlässig das Auftreten einer Schrägstellung der Walzen verhindern können und die Steifigkeit verbessern. Zum Lösen der obigen Aufgabe wird gemäß einer Zielrichtung der Erfindung eine Wälzführungsvorrichtung bereitgestellt, die aufweist:
eine Laufringwelle, die Walzlaufringflächen besitzt,
ein bewegliches Element, das Walzenzirkulationspfade besitzt, die Lastwalzenlaufringflächen entsprechend den jeweiligen Walzenlaufringflächen einschließen und an der Laufringwelle in relativ beweglicher Weise befestigt sind; und
eine Vielzahl von Walzen, die in den Walzenzirkulationspfaden angeordnet und aufgenommen sind und in Assoziation mit einer Bewegung der beweglichen Elemente gegenüber der Laufringwelle zirkulieren,
worin die Walzen derart gebildet sind, um eine Beziehung von näherungsweise $1{,}5 < L/Da <$ näherungsweise 3 zu erfüllen, wobei der Durchmesser der Walze als Da definiert ist, und die Länge der Walze entlang einer Richtung einer Rotationsachse davon als L angenommen ist.

[0007] Gemäß einer zweiten Zielrichtung der Erfindung sind in der Wälzführungsvorrichtung gemäß der ersten Zielrichtung die Vielzahl von Walzen derart angeordnet, dass die Rotationsachsen der Walzen parallel zueinander gebracht sind; die Wälzführungsvorrichtung besitzt einen Walzenhalter zum rotierbaren und gleitbaren Halten der Vielzahl von Walzen; und der Walzenhalter besitzt eine Vielzahl von Abstandhaltern, die jeweils zwischen den Walzen eingelegt sind, und flexible Verbindungsabschnitte zum gegenseitigen Verbinden der Abstandhalter.

[0008] Gemäß einer dritten Zielrichtung der Erfindung ist in der Wälzführungsvorrichtung gemäß der zweiten Zielrichtung eine mit Vertiefungen versehene Oberfläche, die zu der Geometrie der äußeren Oberfläche jeder der Walzen passt, auf jeder Seite der Abstandhalter gebildet.

[0009] Gemäß einer vierten Zielrichtung der Erfindung ragen in der Wälzführungsvorrichtung gemäß der zweiten Zielrichtung die Verbindungsabschnitte seitlich von den Endflächen der Walzen in Bezug auf die Richtung der Rotationsachsen heraus.

[0010] Gemäß einer fünften Zielrichtung der Erfindung sind in der Wälzführungsvorrichtung gemäß dem zweiten Aspekt die Führungsabschnitte entlang der Walzenzirkulationspfade des beweglichen Elements gebildet.

[0011] Gemäß einer sechsten Zielrichtung der Erfindung wird ein Walzenverbindungselement bereitgestellt, das aufweist:

einen Walzenhalter, der einschließt:

eine Vielzahl von Walzen, die derart anzuordnen sind, dass die Rotationsachsen der Walzen parallel zueinander gebracht sind; und

einen Walzenhalter, der eine Vielzahl von Abstandhaltern besitzt, die jeweils zwischen den Walzen eingelegt sind, und flexible Verbindungsabschnitte zum gegenseitigen Verbinden der Abstandhalter, worin die Walzen derart gebildet sind, um eine Beziehung von näherungsweise 1,5c L/Da < näherungsweise 3 zu erfüllen, wobei der Durchmesser der Walze als Da definiert ist, und die Länge der Walze entlang einer Richtung einer Rotationsachse als L angenommen ist.

[0012] Gemäß einer siebten Zielrichtung der Erfindung ist in dem Walzenverbindungselement gemäß der sechsten Zielrichtung eine mit Vertiefungen versehene Oberfläche auf jede Seite der Abstandhalter gebildet, die zu der Geometrie der äußeren Oberfläche jeder der Walzen passt.

[0013] Gemäß einer achten Zielrichtung der Erfindung ragen in dem Walzenverbindungselement die Verbindungsabschnitte seitlich von den Endflächen der Walzen in Bezug auf die Richtung der Rotationsachsen heraus.

KURZE BESCHREIBUNG DER ZEICHNUNGEN

[0014] **Fig.** 1 ist eine Querschnittsansicht, welche eine Linearbewegungsführungsvorrichtung zeigt, die Walzen des Standes der Technik darin aufgenommen besitzt;

[0015] **Fig.** 2 ist eine schematische Darstellung, welche Walzen zeigt, die eine Schrägstellung aufweisen;

[0016] **Fig.** 3 ist eine Ansicht, die einen Zustand zeigt, in welchem eine effektive Länge L der Walzen derart eingestellt ist, um im wesentlichen gleich einem Durchmesser Db einer Kugel unter Anforderung 1 zu sein;

[0017] **Fig.** 4 ist eine Querschnittsansicht, welche eine Wälzführungsvorrichtung des Kugeltyps zeigt, die ein Vergleichsobjekt unter Anforderung 2 ist;

[0018] **Fig.** 5 ist ein Graph, der eine grundlegende statische Belastungsbewertung Co einer Wälzführungsvorrichtung des Walzentyps und eine grundlegende statische Belastungsbewertung Co einer Wälzführungsvorrichtung des Kugeltyps zeigt, wenn L/Da auf ein Wert von 1,5 eingestellt ist;

[0019] **Fig.** 6a und 6b sind Veranschaulichungen, welche Werte zeigt, die in einem Ausdruck zum Berechnen eines Schrägstellungswinkels verwendet werden (worin **Fig.** 6a eine Seitenansicht einer Walze ist; und **Fig.** 6b eine Draufsicht der Walze ist);

[0020] **Fig.** 7 ist ein Graph, dessen horizontale Achse durch $\Delta L/L(=\zeta)$ und dessen vertikale Achse durch einen Schrägstellungswinkel β dargestellt ist;

[0021] **Fig.** 8 ist eine perspektivische Explosionsansicht, die eine Linearbewegungsführungsvorrichtung gemäß einer ersten Ausführungsform der Erfindung zeigt;

[0022] **Fig.** 9 ist eine Seitenansicht der Linearbewegungsführungsvorrichtung, welche teilweise eine Querschnittsansicht derselben senkrecht zu der Längsrichtung einschließt;

[0023] **Fig.** 10a und 10b zeigen eine Walze, die durch einen Walzenzirkulationspfad zirkuliert, worin **Fig.** 10a einen in dem belasteten Bereich angeordneten Walzenzirkulationspfad zeigt, und **Fig.** 10b einen in den nicht belasteten Bereich angeordneten Walzenzirkulationspfad zeigt;

[0024] **Fig.** 11a und 11b zeigen ein Verhältnis des Walzendurchmessers zu der Walzenlänge, worin **Fig.** 11a einen Zustand zeigt, in welchem L/Da einen Wert von 1,5 annimmt, und **Fig.** 11b einen Zustand zeigt, in welchem L/Da einen Wert von 3 annimmt;

[0025] **Fig.** 12a und 12b zeigen einen Schrägstellungswinkel einer Walze, worin **Fig.** 12a eine Walze gemäß der Ausführungsform zeigt, und **Fig.** 12b eine nadelförmige Walze zeigt; und

[0026] **Fig.** 13a bis 13c sind Ansichten, die einen Walzenhalter zeigen, worin **Fig.** 13a eine Draufsicht ist, **Fig.** 13b eine Seitenansicht ist, und **Fig.** 13c eine Frontansicht ist.

AUSFÜHRLICHE BESCHREIBUNG BEVORZUGTER AUSFÜHRUNGSFORMEN

[0027] Nachfolgend wird eine ausführlichere Beschreibung bevorzugter Ausführungsformen der Erfindung unter Bezugnahme auf die begleitenden Zeichnungen gegeben.

[0028] Um ein besseres Verständnis der vorliegenden Erfindung zu ermöglichen, sind die in den begleitenden Zeichnungen vorgesehenen Bezugszeichen mit Elementen assoziiert und in der Beschreibung in Klammern angegeben. Allerdings begrenzen die Bezugszeichen die Erfindung nicht auf die veranschaulichten Ausführungsformen.

[0029] Der Erfinder hat festgestellt, dass das Auftreten einer Schrägstellung von Walzen zuverlässig verhindert werden kann und dass die Steifigkeit einer Wälzbewegungsführungsvorrichtung verbessert werden kann mittels Festlegens eines Verhältnisses der Länge einer Walze in einer Rotationsrichtung davon zu dem Durchmesser der Walze in einen vorbestimmten Bereich.

[0030] Genauer gesagt weist eine Wälzführungsvorrichtung gemäß einer ersten Zielrichtung der Erfindung auf:

eine Laufringwelle **1**, die Walzenlaufringflächen **1**b besitzt, und ein bewegliches Element **2**, das Walzenzirkulationspfade besitzt, die Lastwalzenlaufringflächen **4**d entsprechend den jeweiligen Walzenlaufringflächen **1**b einschließen und an der Laufringwelle **1** in relativ beweglicher Weise befestigt sind; und

eine Vielzahl von Walzen **3**, die in den Walzenzirkulationspfaden angeordnet und aufgenommen sind und in Assoziation mit einer Bewegung des beweglichen Elements **2** gegenüber der Laufringwelle **1** zirkulieren. Die Walzen **3** sind hier derart gebildet, um ein Verhältnis von näherungsweise 1,5 < L/Da < näherungsweise 3 zu erfüllen, wobei der Durchmesser der Walzen **3** als Da definiert ist und die Länge der Walze **3** in einer Richtung der Rotationsachse davon als L angenommen ist.

[0031] Die Gründe für das Definieren eines Verhältnisses der Walzenlänge zu dem Walzendurchmesser auf einen Wert von näherungsweise 1,5 < L/Da werden nachfolgend beschrieben. Eine grundlegende statische Belastungsbewertung einer Wälzführungsvorrichtung, die Walzen als Wälzelemente verwendet (d. h. eine Wälzführungsvorrichtung des Walzentyps) und diejenige einer Wälzführungsvorrichtung, die Kugeln als Wälzelemente verwendet, wird bestimmt, während L/Da auf verschiedene Werte verändert wird, vorausgesetzt, dass beide Wälzführungsvorrichtungen vom selben Modell sind. Hier bezieht sich die grundlegende statische Belastungsbewertung auf eine Last, bei welcher der Gesamtbetrag der Verformung, der in den Wälzelementen auftritt, der in dem beweglichen Element auftritt und der in der Laufringwelle auftritt, eine Toleranzgrenze erreicht. Eine Berechnungsgleichung für die Wälzführungsvorrichtung des Walzentyps und eine Berechnungsgleichung für die Wälzführungsvorrichtung des Kugeltyps werden angewendet, und Anforderungen für die Gleichungen sind wie folgt.

Anforderung 1

[0032] In Bezug auf die Wälzführungsvorrichtung des Walzentyps und die Wälzführungsvorrichtung des Kugeltyps wird die effektive Länge L der Walze derart eingestellt, um im wesentlichen gleich zu dem Durchmesser Db der Kugel zu sein, wie in **Fig.** 3 dargestellt. Der allgemeine Grund für dies ist wie folgt. Die Abmessung des beweglichen Blocks, der als bewegliches Element dient, wird auf einen vorbestimmten Wert für jedes Modell ungeachtet der Art des Wälzelements (d. h. Walze oder Kugel) eingestellt. In dem Fall einer Kugel wird der Durchmesser Db der Kugel innerhalb eines Bereichs der Abmessungen des beweglichen Blocks auf eine maximale Abmessung eingestellt, bei welcher eine Bewegung der Kugel, wie eine Richtungsänderung, möglich wird. Weiter sind in dem Fall einer Walze die Länge L und der Durchmesser Da der Walze auf maximale Abmessungen eingestellt, bei welchen eine Bewegung der Walze, wie eine Richtungsänderung, möglich wären. Falls ein Versuch unternommen wird, die Kugel und die Walze maximaler Abmessungen in den beweglichen Block des identischen Modells einzufügen, wird ein Verhältnis von $L \approx Db$ unvermeidlich erhalten.

Anforderung 2

[0033] Es wurde eine Wälzführungsvorrichtung des Walzentyps beschrieben in Verbindung mit einer in **Fig.** 8 und 9 gezeigten Ausführungsform verwendet. Als zu vergleichende Wälzführungsvorrichtungen des Kugeltyps wurde eine Wälzführungsvorrichtung mit einer Struktur wie der in **Fig.** 4 dargestellten verwendet. Die Wälzführungsvorrichtung ist von Kugeltyp und wurde vom Anmelder entwickelt (vom Anmelder als Modell NRS bezeichnet), um dieselbe Steifigkeit wie diejenige einer Wälzführungsvorrichtung des Walzentyps aufzuweisen. Von allen Teilen handelsüblich erhältlicher Wälzführungsvorrichtungen, einschließlich der Produkte anderer Herstellungsfirmen, besitzt die Wälzführungsvorrichtung die maximale grundlegende statische Belastungsbewertung.

[0034] Die schematische Konstruktion der Wälzführungsvorrichtung des Kugeltyps wird nachfolgend beschrieben. Zwei Reihen von Kugeln **112** sind zwischen einer unteren Fläche des beweglichen Blocks **110** und einer oberen Fläche der Schiene **111** definiert. Weiter ist eine Gesamtheit von zwei Reihen von Kugeln **113** auf den jeweiligen Seiten der Schiene **111** vorgesehen und ist definiert zwischen einer inneren Seitenfläche des beweglichen Blocks **110** und einer äußeren Seitenfläche der Schiene **111**. Die Wälzführungsvorrichtung ist dadurch gekennzeichnet, dass eine Kugellaufrille **110**a des beweglichen Blocks **110** und eine Kugellaufrille **111**a der Schiene **111** mit ausreichender Tiefe gebildet sind, um die schwere Last aufzunehmen. Eine Kontaktlinie **116** ist definiert durch Verbinden des Mittelpunkts der Kugel **114** mit einem Kontaktpunkt, der zwischen der Kugel **114** und der Kugellaufrille **110**a des beweglichen Blocks **110** vorhanden ist. In ähnlicher Weise ist eine Kontaktlinie **117** definiert durch Verbinden des Mittelpunkts der Kugel **114** mit einem Kontaktpunkt, der zwischen der Kugel **114** und der Kugellaufrille **111**a der Schiene **111** vorhanden ist. Die Kontaktlinien **116** und **117** sind jeweils so eingestellt, um einen Winkel von 45° gegenüber ein horizontalen Linie einzunehmen. Somit können die Kugel **114** gleichzeitig radiale Belastung, umgekehrt radiale Belastung und horizontale Belastung aufnehmen.

[0035] Die grundlegende statische Belastungsbewertung der Wälzführungsvorrichtung des Walzentyps wird bestimmt durch Verwendung einer Berechnungsgleichung für den Kugeltyp, während L/Da auf verschiedene Werte verändert wird. Weiter wird die grundlegende statische Belastungsbewertung der Wälzführungsvorrichtung des Kugeltyps bestimmt durch Verwendung einer Berechnungsgleichung für den Kugeltyp während L/Da auf verändert wird. Dementsprechend wird festgestellt, dass die grundlegende statische Belastungsbewertung der Wälzführungsvorrichtung des Walzentyps diejenige der Wälzführungsvorrichtung des Kugeltyps an einer Grenze überschreitet, bei welcher L/Da 1,5 ist.

[0036] **Fig.** 5 ist ein Graph, der ein Vergleich zwischen der grundlegenden statischen Belastungsbewertung Co der Wälzführungsvorrichtung des Walzentyps und der grundlegenden statischen Belastungsbewertung Co der Wälzführungsvorrichtung des Kugeltyps zeigt, wenn L/Da einen Wert von 1,5 erreicht hat. Wie anhand von **Fig.** 5 ersichtlich ist, vorausgesetzt, dass L/Da einen Wert von 1,5 annimmt, überschreitet die grundlegende statische Belastungsbewertung Co der Wälzführungsvorrichtung des Walzentyps diejenige der Wälzführungsvorrichtung des Kugeltyps unter Berücksichtigung aller Modelle. Im Gegensatz hierzu, wenn L/Da zu einem Wert von 1,5 oder weniger angenommen wird, ist festzustellen, dass die grundlegende statische Beanspruchungsbewertung Co der Wälzführungsvorrichtung des Walzentyps geringer ist als diejenige der Wälzführungsvorrichtung des Kugeltyps, was die Verwendung von Walzen bedeutungslos macht.

[0037] Somit wird durch Einstellen des Verhältnisses der Walzenlänge zu dem Walzendurchmesser auf einen Wert von näherungsweise 1,5 < L/Da die grundlegende statische Belastungsbewertung Co der Wälzführungsvorrichtung des Walzentyps größer als diejenige der Wälzführungsvorrichtung des Kugeltyps, wenn die Teile der Vorrichtungen von demselben Modell sind. Somit wird die Eignung der Verwendung von Walzen, d. h. eine Erhöhung der Steifigkeit der Walzen, erzielt.

[0038] Als nächstes werden die Gründe für das Einstellen des Verhältnisses der Walzenlänge zu dem Walzendurchmesser auf einen Wert von L/Da < näherungsweise 3 beschrieben. Unter Berücksichtigung, dass die Walzen angeschrägt worden sind, ist ein Schrägstellungswinkel β, bei welchem die Walzen gegenüber der normalen Rotationsachse geneigt sind, durch nachstehende Gleichung 1 definiert

$$\beta = \sin^{-1}\left[\frac{2bL(1+\xi) - \sqrt{(2bL(1+\xi))^2 - 8\xi L^2(L^2+b^2)}}{2(L^2+b^2)}\right] \qquad (1)$$

[0039] Wie in **Fig.** 6a und 6b dargestellt, bezeichnet L die Länge einer Walze; L + ΔL bezeichnet die Breite einer Rille; b bezeichnet die Breite eines Kontaktbereichs, der zwischen der Walze und einem Flansch vorhanden ist, wenn die Walze im engen Kontakt mit dem Flansch gebracht wird; und ξ = ΔL durch L ≈ 0,01 bis 0,1. Durch Verwendung der oben beschriebenen Gleichung zum Berechnen eines Winkels kann ein Graph aufgetragen werden, dessen horizontale Achse ΔL durch L (= ζ) darstellt und dessen vertikale Achse einen Schrägstellungswinkel Δ darstellt, während L/Da auf verschiedene Werte verändert wird, wie in **Fig.** 7 dargestellt (wobei Da = 2b). Der Wert von L/Da wurde auf 1,5, 3 und 4 verändert.

[0040] Wie anhand von **Fig.** 7 ersichtlich ist, wird die Veränderungsrate von ΔL/L-β plötzlich hoch bei einem Bremswert von L/Da ≈ 3. Wenn L/Da einen Wert von 4 annimmt, verändert sich der Schrägstellungswinkel stark von einem Winkel von etwa 6° auf ein Winkel von etwa 10°, wenn ΔL/L von einem nominalen Wert von etwa 0,02 auf einen Wert von etwa 0,025, d. h. um einen Wert von 0,005 anwächst. Somit muss, um den Schrägstellungswinkel zu unterdrücken, der axiale Spalt ΔL sehr streng gesteuert werden, wodurch ein Problem eines Kostenanstieges entsteht. Dem gegenüber, falls L/Da auf einen Wert von näherungsweise 3 oder weniger eingestellt ist, wird eine Veränderungsrate von ΔL/L-β vergleichsweise niedrig ausfallen. Selbst wenn eine geringfügige Abweichung beim Einstellen von ΔL entsteht, wird der Schrägstellungswinkel nicht allzu stark beeinflusst. In anderen Worten, die Genauigkeit der Dimensionssteuerung des axialen Spalts ΔL kann vermindert werden, indem L/Da auf einen Wert von näherungsweise 3 oder weniger eingestellt wird.

[0041] Das Auftreten einer Schrägstellung kann zuverlässig verhindert werden, ohne Anwendung eines sehr genauen Abmessungsmanagements des axialen Spalts ΔL mittels Einstellen von L/Da auf weniger als näherungsweise 3. Weiterhin gibt es keine Notwendigkeit einer sehr strengen Dimensionsüberwachung des axialen Spalts ΔL. Somit können die Kosten der Wälzführungsvorrichtung begrenzt werden.

[0042] Gemäß einer zweiten Zielrichtung der Erfindung ist die Vielzahl von Walzen **3** derart angeordnet, dass die Rotationsachsen der Walzen parallel zueinander gebracht sind. Die Wälzführungsvorrichtung besitzt einen Walzenhalter **10** zum rotierbaren und gleitbaren Halten der Vielzahl von Walzen **3**. Weiter besitzt der Walzenhalter **10** eine Vielzahl von Abstandhaltern **46**, die jeweils zwischen den Walzen **3** eingelegt sind, und flexible Verbindungsabschnitte **47** zum gegenseitigen Verbinden der Abstandhalter **46**.

[0043] Gemäß der Erfindung, da die Walzenhalter **10** die Walzen in einer vorbestimmten Position ausrichten, kann das Auftreten einer Schrägstellung der Walzen **3** verhindert werden. Selbst wenn eine Schrägstellung entstanden ist korrigiert der Walzenhalter **10** die Schrägstellung der Walzen **3** derart, dass jede der Walzen **3** wiederum eine vorbestimmte Rotationsachse einnimmt mittels einer elastischen Rückstellkraft der Verbindungsabschnitte **47**. Somit besitzt der Walzenhalter **10** die Wirkung des Ausrichtens der Walzen **3** in eine vorbestimmte Position und die Wirkung des Verhinderns der Akkumulation der Schrägstellung der Walzen **3**. Die Kooperation mit der Wirkung, die durch Einstellen des Verhältnisses des Walzendurchmessers zu der Walzenlänge auf L/Da < näherungsweise 3 erzielt wird, verhindert die Verwendung des Walzenhalters **10** zuverlässig das Auftreten einer Schrägstellung der Walzen **3**.

[0044] Gemäß einer dritten Zielrichtung der Erfindung ist eine mit Vertiefungen versehene Oberfläche **49**, die zu der Geometrie der äußeren Oberfläche jeder der Walzen **3** passt, auf jeder Seite der Abstandhalter **46** gebildet.

[0045] Gemäß der Erfindung, als Ergebnis der mit Vertiefungen versehenen Oberflächen **49**, welche die Walzen **3** halten, kann ein Entfernen der Walzen **3** aus dem Walzenhalter **10** verhindert werden; d. h. ein bewegliches Element **2**, das andernfalls veranlasst sein würde, wenn das bewegliche Element **2** von der Laufringwelle **1** entfernt wird. Weiterhin wird eine ausreichende Menge von Schmiermittel in einem zwischen der mit Vertiefungen versehenen Oberfläche **49** und der Walze **3** definierten Raum gesammelt, wodurch eine ausreichende Schmierwirkung erzielt wird.

[0046] Gemäß einer vierten Zielrichtung der Erfindung ragen die Verbindungsabschnitte **47** seitlich von den Endflächen der Walzen **3** in Bezug auf die Richtung der Rotationsachse hervor.

[0047] Gemäß einer fünften Zielrichtung der Erfindung sind Führungsabschnitte (**11**a, **12**a, **13**a und **20**a) entlang der Walzenzirkulationspfade des beweglichen Elements **2** gebildet.

[0048] In dieser Beschreibung bezieht der Begriff "Führung" bevorzugt auf den folgenden Zustand.

[0049] Ein Spalt geringer Abmessung ist zwischen den Verbindungsabschnitten **47** des Walzenhalters **10** und den Führungsabschnitten **11**a, **12**a, **13**a und **20**a gebildet. Falls der Walzenhalter **10** sich verzogen hat oder seine Richtung geringfügig geändert hat, geraten die Verbindungsabschnitte **47** in Kontakt mit einer Wandfläche der Führungsabschnitte **11**a, **12**a, **13**a und **20**a. In anderen Worten, bleiben die Verbindungsabschnitte **47** nicht die gesamte Zeit in Kontakt mit den Führungsabschnitten **11**a, **12**a, **13**a und **20**a. Die Wälzführungsvorrichtung kann derart konstruiert sein, dass die Verbindungsabschnitte **47** stets in Kontakt mit den Führungsabschnitten **11**a, **12**a, **13**a und **20**a bleiben. Allerdings unterdrückt der Spalt, der zwischen den Verbindungsabschnitten **47** und den Führungsabschnitten **11**a, **12**a, **13**a und **20**a vorhanden ist, den Kontaktwiderstand, der dazwischen auftreten wird, wodurch der Bewegungswiderstand des beweglichen Elements **2** vermindert wird.

[0050] Gemäß der Erfindung ist der Walzenhalter **10** derart geführt, um einen vorbestimmten Pfad in dem Walzenzirkulationspfad mittels der Führungsabschnitte **11**a, **12**a, **13**a und **20**a aufrechtzuerhalten. Dementsprechend halten die durch den Walzenhalter **10** gehaltenen Walzen ebenso einen vorbestimmten Pfad ein, und somit kann das Auftreten einer Schrägstellung der Walzen **3** mit wesentlich größerer Zuverlässigkeit verhindert werden.

[0051] Gemäß einer sechsten Zielrichtung der Erfindung kann die Erfindung als Walzenverbindungselement gebildet sein. Das Walzenverbindungselement besitzt einen Walzenhalter **10**, welcher Halter aufweist:
eine Vielzahl von Walzen **3**, die derart angeordnet sind, dass die Rotationsachsen der Walzen parallel zueinander gebracht sind;
eine Vielzahl von Abstandhaltern **46**, von denen jeder zwischen den Walzen **3** eingelegt ist und auf jeder Seite davon eine mit Vertiefungen versehene Oberfläche **49** besitzt, die zu der Geometrie der äußeren Umfangsfläche einer benachbarten Walze **3** passt; und
flexible Verbindungsabschnitte **47** zum miteinander verbinden der Abstandshalter **46**, wobei die Walzen **3** derart gebildet sind, um keine Beziehung von näherungsweise 1,5 < L/Da < näherungsweise 3 zu erfüllen, wobei der Durchmesser der Walze **3** als Da definiert ist und die Länge der Walze **3** in einer Richtung der Rotationsachse davon als L angenommen ist.

[0052] Gemäß einer siebten Zielrichtung der Erfindung ist eine mit Vertiefungen versehene Oberfläche **49**, die zu der Geometrie der äußeren Oberfläche jeder der Walzen **3** passt, auf beiden Seiten der Abstandshalter **46** gebildet.

[0053] Gemäß einer achten Zielrichtung der Erfindung ragen die Verbindungsabschnitte **47** seitlichen von den Endflächen der Walzen in Bezug auf die Richtung der Rotationsachsen hervor.

[0054] Nachfolgend wird eine ausführlichere Beschreibung bevorzugter Ausführungsformen der Erfindung unter Bezugnahme auf die begleitenden Zeichnungen gegeben.

[0055] **Fig.** 8 und 9 zeigen Linearbewegungsführungsvorrichtungen, die als Wälzführungsvorrichtungen gemäß einer ersten Ausführungsform der Erfindung dienen. **Fig.** 8 ist eine perspektivische Explosionsansicht der Linearbewegungsführungsvorrichtung, und **Fig.** 9 stellt eine Seitenansicht einer zusammengesetzten Linearbewegungsführungsvorrichtung und eine Querschnittsansicht der Vorrichtung in einem Schnitt entlang einer Richtung senkrecht zu der Längsrichtung der Schiene bereit. Die Linearbewegungsführungsvorrichtung besitzt eine Schiene **1**, die als sich linear erstreckende Schiene dient, und einen beweglichen Block **2**, der als bewegliches Element dient, das beweglich mit der Schiene **1** über eine Vielzahl von Walzen **3**, die als Wälzelemente wirken, verbunden ist.

[0056] Die Schiene **1** ist schmal und länglich, um ein rechteckiges Querschnittsprofil anzunehmen. Eine Rille **1**a, die ein v-förmiges Querschnittsprofil besitzt, ist auf beiden Seitenflächen der Schiene **1** gebildet, um sich in Längsrichtung zu erstrecken. Wie in **Fig.** 9 dargestellt besitzt die Rille **1**a Seitenflächen **1**b, und eine Bodenfläche **1**c. Die Wandflächen **1**b, **1**b der Rille **1**a kreuzen einander unter einem Winkel von 90°. Hier werden obere und untere Wandflächen **1**b als Walzenlaufflächen **1**b, **1**b verwendet, auf welchen die Walzen **3** wälzen sollen. Die Walzenlaufflächen **1**b, **1**b sind vertikal auf beiden Seiten der Schiene **1** vorgesehen; insgesamt sind vier Walzenlaufflächen **1**b auf der Schiene **1** gebildet.

[0057] Der bewegliche Block **2** besitzt einen horizontalen Abschnitt **2**a, der einer oberen Fläche der Schiene **1** gegenüberliegt, und Hülsenabschnitte **2**b, die sich nach unten von entsprechenden Seiten der horizontalen Abschnitte **2**a erstrecken und der rechten und linken Seitenfläche der Schiene **1** gegenüberliegen. Zwei Walzenzirkulationspfade, die vertikal in einer Reihe angeordnet sind, sind in jedem des rechten und linken Hülsenabschnitts **2**b gebildet. Insgesamt sind vier Walzenzirkulationspfade gebildet (siehe **Fig.** 9).

[0058] Zunächst werden die Walzenzirkulationspfade beschrieben. Wie in **Fig.** 9 dargestellt, sind zwei Lastwalzenlaufflächen **4**d, die vertikal in einer Reihe angeordnet sind, in jedem der Hülsenabschnitte **2**b des beweglichen Blocks **2** gebildet. Ein zwischen den Lastwalzenlaufflächen **4**d und den Walzenlaufflächen **1**b definierter Raum bildet einen Lastbereich der Walzenzirkulationspfade.

[0059] Zwei Walzenstützpfade **7**, die vertikal in einer Reihe angeordnet sind, sind in entsprechenden Hülsenabschnitten **2**b derart gebildet, um unter einem vorbestimmten Abstand von und parallel zu den Lastwalzenlaufflächen **4**d beabstandet zu sein. Die Walzenstützpfade **7** bilden einen nicht belasteten Bereich der Walzenzirkulationspfade.

[0060] U-förmige Umkehrpfade **8**, welche die Lastwalzenlauffläche **4**d, **4**d mit beiden Enden der entsprechenden Walzenstützpfade **7** verbinden und die Walzen **3** zirkulieren sind in den entsprechenden Hülsenabschnitten **2**b vorgesehen. Ein Umkehrpfad **8** verbindet die obere Lastwalzenlauffläche **4**d mit dem unteren Walzenstützpfad **7**, und der andere Umkehrpfad **8** verbindet die untere Lastwalzenlauffläche **4** mit dem oberen Walzenstützpfad **7**. Somit besteht ein höhengleicher Übergang zwischen einem Paar von Umkehrpfaden **8**. Die Umkehrpfade **8** bilden auch nicht belastete Bereiche der Walzenzirkulationspfade.

[0061] Ringförmige Walzenzirkulationspfade sind durch die Lastwalzenlaufflächen **4**d, einem Paar der Umkehrpfade **8** und die Walzenstützenpfade **7** gebildet. Jeder der Walzenzirkulationspfade ist in einer einzelnen Ebene gebildet, und die Walzen **3** zirkulieren zweidimensional innerhalb jedem der Walzenzirkulationspfade. Eine Ebene, in welcher ein Walzenzirkulationspfad vorhanden ist, kreuzt unter einem rechten Winkel eine andere Ebene, in welcher ein anderer Walzenzirkulationspfad existiert. Hier ist ein Walzenzirkulationspfad innerhalb des anderen Walzenzirkulationspfades vorhanden.

[0062] Wie in **Fig.** 8 dargestellt, weist der bewegliche Block **2** auf ein Stahlblockelement **4**, Kunststoff-Zirkulationspfad-bildende Elemente aus Kunststoff **11**, **12**, **13**, **15**a, **15**b und **20**, die in den Blockhauptkörper **4** aufzunehmen sind, und ein Paar von Seitenabdeckungen **5**, die an den entsprechenden Endflächen des Hauptblockkörpers **4**, der die Zirkulationspfad-bildenden Elemente aus Kunststoff **11**, **12**, **13**, **15**a, **15**b und **20** darin aufgenommen hat, zu befestigen sind. Vorsprünge **4**c, die zu der Geometrie der Rillen **1**a passen, sind den entsprechenden Hülsenabschnitten **4**b des Blockhauptkörpers **4** gebildet. Die zweiten Lastwalzenlaufflächen **4**d, die als Lastwälzelement Laufabschnitte entsprechend zu den Wälzlaufflächen **1**b dienen, sind auf jedem der Vorsprünge **4**c gebildet (siehe **Fig.** 9). Zwei Lastwalzenlaufflächen **4**d sind in den entsprechend Hülsenabschnitten **4**b des Blockhauptkörpers **4** gebildet; namentlich insgesamt vier Lastwalzenlaufflächen. In der vorliegenden Ausführungsform sind die zwei Walzenlaufflächen **1**b und die zwei Lastwalzenlaufflächen **4**d auf beiden Seiten des Blockhauptkörpers **4** gebildet. Die Anzahl der Walzenlaufflächen **2**b und die Anzahl der Lastwalzenlaufflächen **4**d können auf verschiedene Werte in Abhängigkeit vom Typ der Linearbewegungsführungsvorrichtung eingestellt sein.

[0063] Die Zirkulationspfad-bildenden Elemente aus Kunststoff weisen alle Elemente **11**, **12** und **13** auf, die sich entlang seitlicher Kanten der entsprechenden Lastwalzenlaufflächen **4**d erstrecken und das Entfernen der Walzen **3** aus den Lastwalzenlaufflächen **4**d verhindern, wenn der bewegliche Block **2** von der Schiene **1** entfernt wird; Stützpfadsbildungselemente **14** zum Zurückführen der Walzen **3**; und Innenradiusführungsabschnitts-bildende Elemente **15**a und **15**b zum Bilden von Innenradiusführungsabschnitten der Umkehrpfade **8**. Die Halteelemente **11**, **12**, **13**, die Stützpfads-bildenden Elemente **14**, ein Paar der Innenradiusführungsabschnitts-bildenden Elemente **15**a, und ein Paar der Innenradiusführungsabschnitts-bildenden Elemente **15**b sind aus Harz getrennt von dem Blockhauptkörper **4** gebildet. Sie sind in den Hauptkörper **4** eingeschlossen.

[0064] Wie in **Fig.** 9 dargestellt, sind die Halteelemente in erste Halteelemente **11** zum Halten unterer Abschnitte der unteren Walzen **3** und untere Abschnitte der oberen Walzen **3**; und dritte Halteelemente **13** zum Halten oberer Abschnitte der oberen Walzen **3** aufgeteilt. Diese Halteelemente wirken als Flansche zum Führen der Walzen **3** in axialer Richtung.

[0065] Wie in **Fig.** 8 dargestellt, sind die ersten Halteelemente **11** aus langen, dünnen Kunststoffformprodukten gebildet. Mittels des Einschließens der ersten Halteelemente **11** in dem Blockhauptkörper **4** sind Führungsrillen **11**a (siehe **Fig.** 9) gebildet, die als Führungsabschnitte zum Führen eines Verbindungsriemens des Rollenhalters **10** dienen, was später zu beschreiben ist. Als Ergebnis daraus, dass die ersten Halteelemente **11** zwischen dem Paar von Seitenabdeckungen **5** eingelegt sind, sind die ersten Halteelemente **11** an dem beweglichen Block **2** befestigt, während beide Enden gelagert sind.

[0066] Die zweiten Halteelemente **12** sind aus langen, dünnen Kunststoffformprodukten gebildet. Führungsrillen **12**a (siehe **Fig.** 9) sind auf beiden Seiten jedes zweiten Halteelements **12** zum Führen des Verbindungsriemens des Rollenhalters **10** gebildet. Als Ergebnis daraus, dass die zweiten Halteelemente **12** zwischen dem Paar von Seitenabdeckungen **5** eingelegt sind, sind die zweiten Halteelemente **5** an dem beweglichen Block **2** befestigt, während beide Enden gelagert sind.

[0067] Die dritten Halteelemente **13** sind aus langen, dünnen Kunststoffformprodukten gebildet. Mittels Einschließens der dritten Halteelemente **13** in den Blockhauptkörper **4** sind Führungsrillen **13**a (siehe **Fig.** 9) gebildet, die als Führungsabschnitte zum Führen eines Verbindungsriemens des Rollenhalters **10** dienen, was später zu beschreiben ist. Als Ergebnis daraus, dass die dritten Halteelemente **13** zwischen dem Paar von Seitenabdeckungen **5** eingelegt sind; sind die dritten Halteelemente **13** an dem beweglichen Block **2** befestigt, während beide Enden gelagert sind, wie in dem Fall der ersten Halteelemente **11**.

[0068] Jede dieser Stützpfad-bildenden Elemente **14** ist aus halbrohrförmigen Elementen **14**a, **14**b gebildet, die durch Trennen eines Rohres in zwei Teile in der Richtung der Rotationsachse gebildet sind. Jedes der halbrohrförmigen Elemente **14**a, **14**b besitzt eine Rille **20**, die zu der Geometrie der Walzen **3** sich in Längsrichtung erstreckend passt; eine Führungsrille **20**a (siehe **Fig.** 9), die als Führungsabschnitt zum Führen des Verbindungsriemens des Walzenhalters **10** dient; und ein Flansch **19**, der sich in Längsrichtung entlang beiden Seiten der Rille **20** erstreckt. Die Walzenstützpfade **7** sind durch die Stützpfad-bildenden Elemente **14** gebildet.

[0069] Die Innenradiusführungsabschnitt-bildenden Elemente **15**a sind in zwei Teile in Längsrichtung der Schiene **1** geteilt. Mittels Zusammensetzens der zwei Innenradiusführungsabschnitt-bildenden Elemente **15**a wird ein Umkehrpfad der höhengleichen Verbindung gebildet. Weiterhin ist eine Führungsrille, die als Führungsabschnitt zum Führen des Verbindungsriemens des Walzenhalters **10** dient, in dem Umkehrpfad gebildet. Ein Innenradiusführungsabschnitt **21** für einen innenradiusseitigen Walzenzirkulationspfad ist in einem geteilten Element **15**a gebildet, das dem beweglichen Block **2** (d. h. dem inneren) zugewandt ist. Der Innenradiusführungsabschnitt **21** ist in der Form eines im wesentlichen halbkreisförmigen Bogens gebildet. Ein Außenradiusführungsabschnitt **31** für den innenradiusseitigen Walzenzirkulationspfad und ein Innenradiusführungsabschnitt **32** für den außenradiusseitigen Walzenzirkulationspfad sind in einem geteilten Element **15**b, das der Seitenabdeckung **5** (d. h. dem Äußeren) zugewandt ist.

[0070] Der innenradiusseitige Führungsabschnitt **32** und der außenradiusseitige Führungsabschnitt **31** sind in der Form eines im wesentlichen halbkreisförmigen Bogens gebildet.

[0071] Jede der Seitenabdeckungen **5** ist im Querschnittsprofil an den Blockhauptkörper **4** angepasst. Die Seitenabdeckung **5** besitzt einen horizontalen Querschnitt **5**a und ein Paar von Hülsenabschnitten **5**b. Die Außenradiusführungsabschnitte **36** für die außenradiusseitigen Walzenzirkulationspfade sind in den Hülsen **5**b gebildet. Weiterhin sind die Innenradiusführungs-bildenden Elemente **15**a, **15**b, die zusammen kombiniert sind, an die entsprechenden Hülsen **5**d angepasst.

[0072] Wie in **Fig.** 8 dargestellt, sind die Seitenabdeckungen **5** an den entsprechenden längsseitigen Enden des Blockhauptkörpers **4** befestigt. Bolzen sind in Bolzeneinfügelöchern, die in den Seitenabdeckungen **5** gebildet, eingefügt, und die Bolzen sind in Schraubeneingriff mit Schraubenlöchern, die in den Endflächen des Blockhauptkörpers **4** gebildet sind, wodurch die Seitenabdeckungen **5** an den Blockhauptkörper **4** befestigt sind. Daraus ergibt sich, dass die Innenradiusführungsabschnitte **15**a, **15**b an dem Blockhauptkörper **4** befestigt sind. Weiterhin ist eine dekorative Platte **38** an dem äußeren jeder der Seitenabdeckungen **5** befestigt.

[0073] **Fig.** 10A und 10B zeigen die Walzen **3**, die durch die Walzenzirkulationspfade zirkulieren. **Fig.** 10A zeigt die Walzen **3**, die durch den belasteten Bereich rotieren, der zwischen der Walzenlauffläche **1**b der Schiene **1** und dem beweglichen Block **2** definiert ist; und **Fig.** 10B zeigt die Walzen **3**, die sich durch den Stützpfad bewegen, der als nicht belasteter Bereich dient.

[0074] Wie in **Fig.** 10A dargestellt, ist der Walzenzirkulationspfad in dem Lastbereich derart gebildet, um ein rechteckiges Querschnittsprofil anzunehmen, das zu dem Querschnittsprofil der Walze **3** passt. Führungsflansche **41** sind in dem beweglichen Block **2** mittels der Halteelemente **11**, **12** und **13** zum Führen der Endflächen der Walzen **3** gebildet, die in der Richtung der Rotationsachse davon angeordnet sind. Ein Abstand L+ΔL zwischen den Flanschen **41** ist derart eingestellt, um etwas länger zu sein als die Länge L der Walzen **3**, die in der Richtung der Rotationsachse davon derart platziert sind, dass ein Axialspalt ΔL entsteht. Hier ist $\xi = \Delta L/L$ derart eingestellt, um in einem Bereich von beispielsweise 0,02 bis 0,07 zu liegen. Führungsrillen **11**a, **12**a und **13**a sind in den entsprechenden Flanschen **41** zum Führen eines Paars von Verbindungsriemen des Walzenhalters **10** gebildet, was später zu beschreiben ist.

[0075] Wie in **Fig.** 10B dargestellt, ist der Walzenzirkulationspfad in den nicht belasteten Bereich ebenso derart gebildet, um ein rechteckiges Querschnittsprofil anzunehmen, das zu dem Querschnittsprofil der Walze **3** passt. Führungsflansche **43** sind in dem beweglichen Block **2** von den Stützpfad-bildenden Elementen **14** zum Führen der Endflächen der Walzen **3** gebildet, angeordnet in der Richtung einer Rotationsachse davon. Ein Abstand L+ΔL zwischen den Flanschen **43** ist derart eingestellt, um etwas länger zu sein als die Länge L der Walze **3**, die in der Richtung einer Rotationsachse davon derart angeordnet ist, dass dort ein Axialspalt ΔL entsteht. Führungsrillen **20**a zum Führen eines Paares von Verbindungsriemen des Walzenhalters **10**, wie später beschrieben, sind in den entsprechenden Flanschen **43** gebildet. Eine Abmessung zwischen der Innenradiusführungsfläche **51** und der Außenradiusführungsfläche **52** des Walzenzirkulationspfades im nicht belasteten Bereich ist derart eingestellt, um etwas größer zu sein als der Durchmesser der Walze **3**, so dass ein schmaler Spalt entsteht zwischen dem äußeren Umfang der Walze **3** und den Innenradius- und Außenradiusführungsflächen **51**, **52**.

[0076] **Fig.** 11A und 11B zeigen ein Verhältnis des Durchmessers Da der Walze **3** zu der Länge L derselben. **Fig.** 11A zeigt die Walze **3** unter der Annahme L/Da gleich 1,5, und **Fig.** 11B zeigt die Walze **3** unter Annahme L/Da gleich 3. Das Verhältnis des Durchmessers Da der Walze **3** zu der Länge L der Walze **3** ist beliebig eingestellt, um innerhalb dieses Bereichs zu liegen.

[0077] In der vorliegenden Ausführungsform durch Einstellen des Verhältnisses auf näherungsweise 1,5 < L/Da, besitzt die Wälzführungsvorrichtung des Walzentyps eine größere grundlegende statische Belastungsbewertung Co als die Wälzführungsvorrichtung des Kugeltyps in vorstehend beschriebener Weise. Die Angemessenheit der Verwendung der Walze **3**, d. h. eine Wirkung erhöhter Steifigkeit, wird erzielt. Wie in **Fig.** 12A dargestellt, wird der Durchmesser Da der Walze **3** größer als die Länge L derselben in der Richtung einer Rotationsachse mittels Einstellens des Verhältnisses der Walzenlänge zu dem Walzendurchmesser auf L/Da < näherungsweise 3. Wie oben erwähnt kann das Auftreten einer Schrägstellung und Ausfall verhindert werden, ohne Anwendung einer strengen Abmessungskontrolle des axialen Spalts ΔL. Wie in **Fig.** 12B dargestellt, falls das Verhältnis auf L/Da > 3 eingestellt ist, nehmen die Walzen **3** die Form einer Nadel an. Somit wird ein Schrägstellungswinkel α unvermeidlich ansteigen, sofern nicht die Abmessungen des Axialspalts ΔL streng kontrolliert werden.

[0078] **Fig.** 13A bis 13C zeigen ein Walzenverbindungselement, das die Walzen **3** darin aufgenommen besitzt. **Fig.** 13A ist eine Draufsicht des Walzenverbindungselements. **Fig.** 13B ist eine Seitenansicht des Walzenverbindungselements, und **Fig.** 13C ist eine Frontansicht desselben. Die Walzen **3** sind miteinander verbunden in der Form einer Kette mittels der Walzenhalter **10**. Ein Walzenverbindungselement ist in jedem der vier Walzenzirkulationspfade aufgenommen. Der Walzenhalter **10** ist integral durch die Abstandhalter **46** und die Verbindungsriemen **47** unter Verwendung der Verbindungsstücke **48** gebildet. Somit bildet der gesamte Walzenhalter **10** einen Streifen, der Erden besitzt. Um das Befestigen des Rollenhalters **10** an dem beweglichen Block **2** zu erleichtern sind vordere Enden **10**a des Rollenhalters **10** abgerundet.

[0079] Die Abstandhalter **46** sind in der Form eines im wesentlichen rechtwinkligen Würfels gebildet. Mit Vertiefungen versehene Oberflächen **59**, die zu der Geometrie des äußeren Umfangs der benachbarten Walzen **3** passen, sind in jedem der Abstandhalter **46** gebildet. Die mit Vertiefungen versehene Oberflächen **49** kommen in gleitbaren Kontakt mit den äußeren Umfangsflächen der Walzen **3**. Die Breite des Abstandshalters **46** ist etwas kürzer ausgeführt als die Länge der Walze **3** in der Richtung einer Rotationsachse davon.

[0080] Das Paar von Verbindungsriemen **47** ist mit Seitenflächen **50** der entsprechenden Abstandhalter **46** in der Richtung der Rotationsachse der Walzen **3** verbunden. Die Verbindungsriemen **47** ragen seitlich von den Endflächen der Walzen **3** in Bezug auf die Richtung der Rotationsachsen hervor. Die Verbindungsriemen **47** sind innerhalb einer Ebene gelegen, welche die Rotationsachsen der Walzen **3** einschließt. Darüber hinaus sind die Verbindungsriemen **47** dünn ausgeführt, um flexibel in Übereinstimmung mit dem Walzenzirkulationspfad zu sein.

[0081] Wie in **Fig.** 13 dargestellt, stimmt die Breite W2 des Verbindungsstücks **48** in der Längsrichtung des Verbindungsriemens **47** mit dem geringsten Abstand zwischen den mit Vertiefungen versehenen Oberflächen **49** überein. Die Breite W3 des Verbindungsstücks **48** in der Richtung einer Rotationsachse der Walze **3** ist auf einen solchen Wert eingestellt, dass die Abstandhalter **46** sich gegenüber den Verbindungsriemen **47** neigen können. Wie in **Fig.** 13C dargestellt, ist eine Verstärkungsrippe **53** in jedem der Verbindungsstücke **48** gebildet. Die Verstärkungsrippen **53** verhindern, dass sich die Verbindungsriemen **47** in einer Richtung **2** in Bezug auf die Abstandshalter **46** senkrecht zu der Ebene bewegen, welche die Rotationsachse der Walzen **3** einschließt. Umgekehrt verhindern die Verstärkungsrippen **53**, dass die Abstandhalter **46** und, durch Ausdehnung, die Walzen **3** sich in Richtung (2) senkrecht zu der Ebene, welche die Rotationsachsen der Walzen **3** einschließt, und in Richtung (1) gegenüber den Verbindungsriemen **47** bewegen. Die Verbindungsriemen **47** sind durch die Führungsrille derart geführt, um sich entlang eines vorbestimmten Pfades zu bewegen. Somit können die Walzen **3** entlang eines vorbestimmten Pfades ohne Ausfall bewegt werden, mittels Verhinderns, dass die Walzen **3** sich in einer Richtung (2) gegenüber den Verbindungsriemen **47** bewegen.

[0082] Da der Walzenhalter **10** die Walzen **3** in eine vorbestimmte Position ausrichtet kann das Auftreten einer Schrägstellung der Walzen **3** verhindert werden. Selbst wenn eine Schrägstellung entstanden ist kann die Schrägstellung der Walzen **3** derart korrigiert werden, dass die Walzen **3** erneut vorbestimmte Rotationsachsen einnehmen, mittels der elastischen Rückstellkraft des Paares von Verbindungsriemen **47**. Somit besitzt der Walzenhalter **10** die Wirkung des Ausrichtens der Walzen **3** in eine vorbestimmte Position und die Wirkung des Verhinderns der Akkumulation einer Schrägstellung der Walzen **3**. Weiterhin kann der Schrägstellungswinkel vermindert werden mittels des Einstellens des Verhältnisses des Walzendurchmessers zur Walzenlänge auf L/Da < näherungsweise 3. Dementsprechend in Zusammenwirken der Wirkungen des Walzenhalters **10**, der die Walzen **3** in eine vorbestimmte Position ausrichtet und die Akkumulation der Schrägstellung verhindert, kann eine Schrägstellung der Rollen ohne Ausfall verhindert werden. Da der Rollenhalter **10** durch die Führungsrillen **11**a, **12**a, **13**a und **20**a derart geführt ist, um einen vorbestimmten Pfad in dem Walzenzirkulationspfad aufrecht zu erhalten. Somit halten die Walzen **3**, die durch den Walzenhalter **10** gehalten sind, auch einen vorbestimmten Pfad ein, und die Walzen **3** können geeigneter ausgerichtet werden.

[0083] Obwohl die vorstehende Ausführungsform die Wälzführungsvorrichtung als Linearbewegungswälzführungsvorrichtung zum Führen einer Linearbewegung angewendet hat, ist die Erfindung nicht auf Linearbewegung begrenzt. Ebenso kann eine Kurvenbewegungsführungsvorrichtung zum Führen einer gekrümmten Bewegung angewendet werden. Alternativ kann ebenso eine sogenannte Walzentyp-Wälzführungsvorrichtung angewendet werden, die nicht mit einem Halter ausgestattet ist.

[0084] Wie beschrieben worden ist, wird mittels des Einstellens eines Verhältnisses der Walzenlänge zum Walzendurchmesser auf einen Wert von näherungsweise 1,5 < L/Da die grundlegende statische Belastungsbewertung Co der Wälzführungsvorrichtung des Walzentyps größer als diejenige der Wälzführungsvorrichtung des Kugeltyps, wenn die Teile der Vorrichtungen vom selben Modell sind. Somit wird die Eignung der Verwendung von Walzen, d. h. eine Erhöhung der Steifigkeit der Walzen, erzielt. Mittels Einstellens des Verhältnisses auf einen Wert von L/Da < näherungsweise 3, kann das Auftreten einer Schrägstellung ohne Ausfall verhindert werden, ohne Anwenden einer strengen Abmessungskontrolle des Axialspalts ΔL. Somit kann das Auftreten einer Schrägstellung von Rollen und eine Erhöhung der Steifigkeit ohne Ausfall erzielt werden.

[0085] Der Walzenhalter richtet die Walzen in eine vorbestimmte Position aus und verhindert das Auftreten einer Schrägstellung der Walzen. Selbst wenn eine Schrägstellung aufgetreten ist, kann die Schrägstellung der Walzen derart korrigiert werden, dass die Walzen wieder ihre vorbestimmten Rotationsachsen einnehmen, mittels der elastischen Rückstellkraft der Verbindungsabschnitte. Somit besitzt der Walzenhalter die Wirkung des Ausrichtens der Walzen in eine vorbestimmte Position und die Wirkung des Verhinderns der Akkumulation der Schrägstellung der Walzen. Weiterhin kann ein Schrägstellungswinkel vermindert werden mittels des Einstellens des Verhältnisses des Walzendurchmessers zur Walzenlänge auf L/Da < näherungsweise 3. Dementsprechend kann in Zusammenwirkung mit den dargelegten Wirkungen des Walzenhalters eine Schrägstellung der Walzen ohne Ausfall verhindert werden.

Patentansprüche

1. Wälzführungsvorrichtung, die aufweist:
eine Laufringwelle, die Walzenlaufringflächen besitzt,
ein bewegliches Element, das Walzenzirkulationspfade besitzt, die Lastwalzenlaufringflächen entsprechend den jeweiligen Walzenlaufringflächen einschließen und an der Laufringwelle in relativ beweglicher Weise befestigt sind; und
eine Vielzahl von Walzen, die in den Walzenzirkulationspfaden angeordnet und aufgenommen sind und in Assoziation mit einer Bewegung der beweglichen Elemente gegenüber der Laufringwelle zirkulieren,
worin die Walzen derart gebildet sind, um ein Verhältnis von näherungsweise 1,5 < L/Da < näherungsweise 3 zu erfüllen, wobei der Durchmesser der Walze als Da definiert ist und die Länge der Walze entlang einer Richtung einer Rotationsachse als L angenommen ist.

2. Wälzführungsvorrichtung nach Anspruch 1, worin die Vielzahl von Walzen derart angeordnet ist, dass die Rotationsachsen der Walzen parallel zueinander gebracht sind; die Wälzführungsvorrichtung besitzt einen Walzenhalter zum rotierbaren und gleitbaren Halten der Vielzahl von Walzen; und der Walzenhalter besitzt eine Vielzahl von Abstandhaltern, die jeweils zwischen den Walzen eingelegt sind, und flexible Verbindungsabschnitte zum gegenseitigen Verbinden der Abstandhalter.

3. Wälzführungsvorrichtung nach Anspruch 2, worin eine mit Vertiefungen versehene Oberfläche, die zu der Geometrie der äußeren Oberfläche jeder der Walzen passt, auf beiden Seiten der Abstandhalter gebildet ist.

4. Wälzführungsvorrichtung nach Anspruch 2, worin die Verbindungsabschnitte seitlich von den Endflächen der Walzen in Bezug auf die Richtung der Rotationsachsen herausragen.

5. Wälzführungsvorrichtung nach Anspruch 2, worin Führungsabschnitte entlang der Walzenzirkulationspfade des beweglichen Elements gebildet sind.

6. Walzenverbindungselement, das aufweist:
einen Walzenhalter, der einschließt:
eine Vielzahl von Walzen, die derart angeordnet sind, dass die Rotationsachsen der Walzen parallel zueinander gebracht sind; und
einen Walzenhalter, der eine Vielzahl von Abstandhaltern besitzt, die jeweils zwischen den Walzen eingelegt sind, und flexible Verbindungsabschnitte zum gegenseitigen Verbinden der Abstandhalter, worin die Walzen derart gebildet sind, um eine Beziehung von näherungsweise 1,5 < L/Da < näherungsweise 3 zu erfüllen, wobei der Durchmesser der Walzen als Da definiert ist und die Länge der Walzen in einer Richtung der Rotationsachse davon als L angenommen ist.

7. Walzenverbindungselement nach Anspruch 6, worin eine mit Vertiefungen versehene Oberfläche, die zu der Geometrie der äußeren Oberfläche jeder der Walzen passt, auf beiden Seiten der Abstandhalter gebildet ist.

8. Walzenverbindungselement nach Anspruch 6, worin die Verbindungsabschnitte seitlich von den Endflächen der Walzen in Bezug auf die Richtung der Rotationsachsen herausragen.

Hierzu 10 Seite(n) Zeichnungen

- Leerseite -

Nummer: **DE 102 15 766 A1**
Int. Cl.[7]: **F 16 C 29/04**
Offenlegungstag: 13. Februar 2003

FIG.1

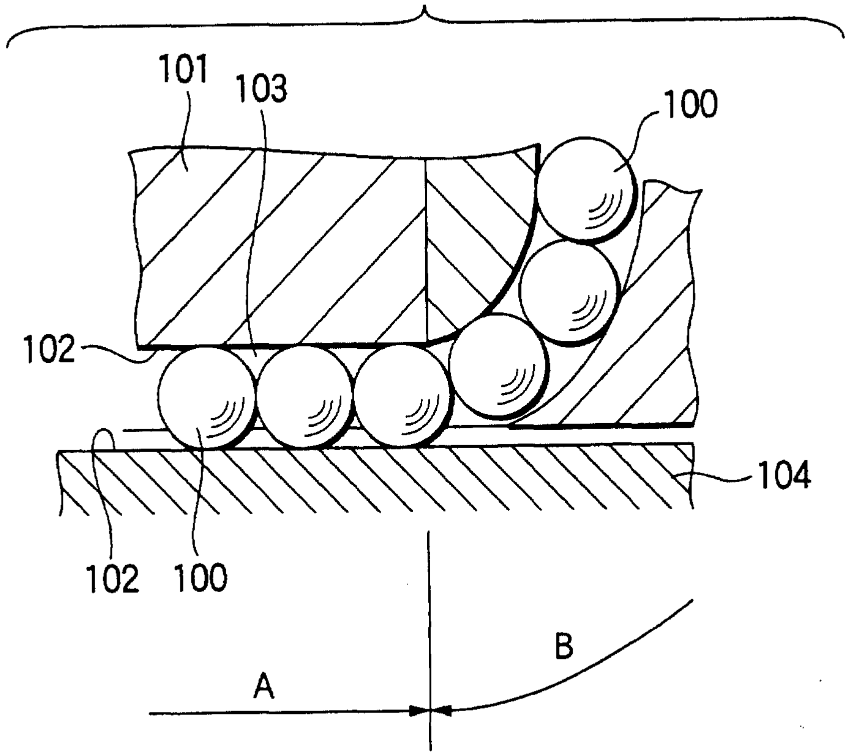


FIG.2

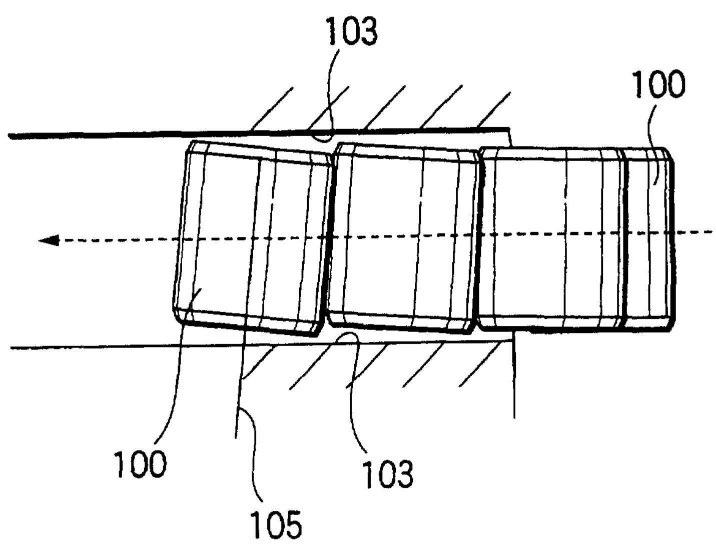


FIG.3

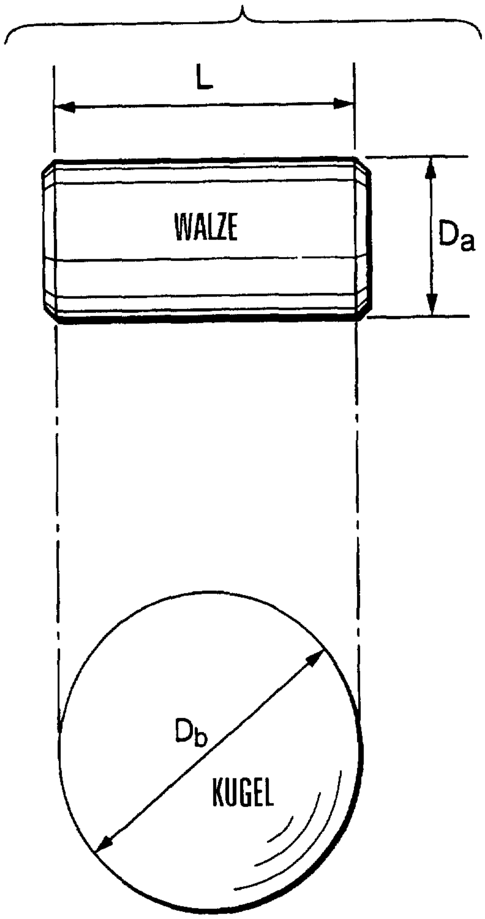
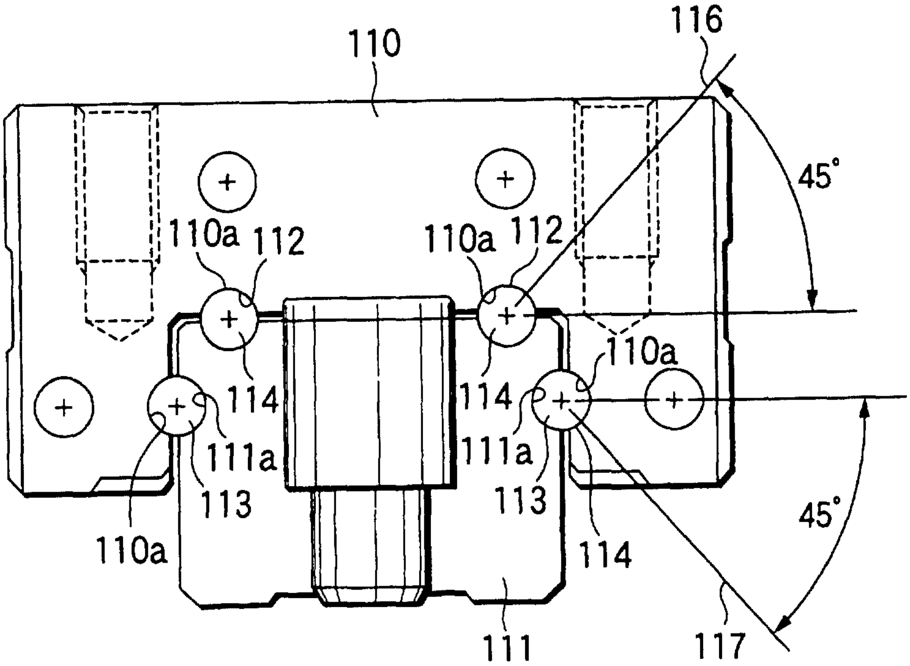

L
WALZE
Da
Db
KUGEL

FIG.4


110
116
45°
110a
112
110a
112
114
114
110a
111a
111a
113
113
110a
114
45°
111
117

Nummer: DE 102 15 766 A1
Int. Cl.[7]: F 16 C 29/04
Offenlegungstag: 13. Februar 2003

FIG.5

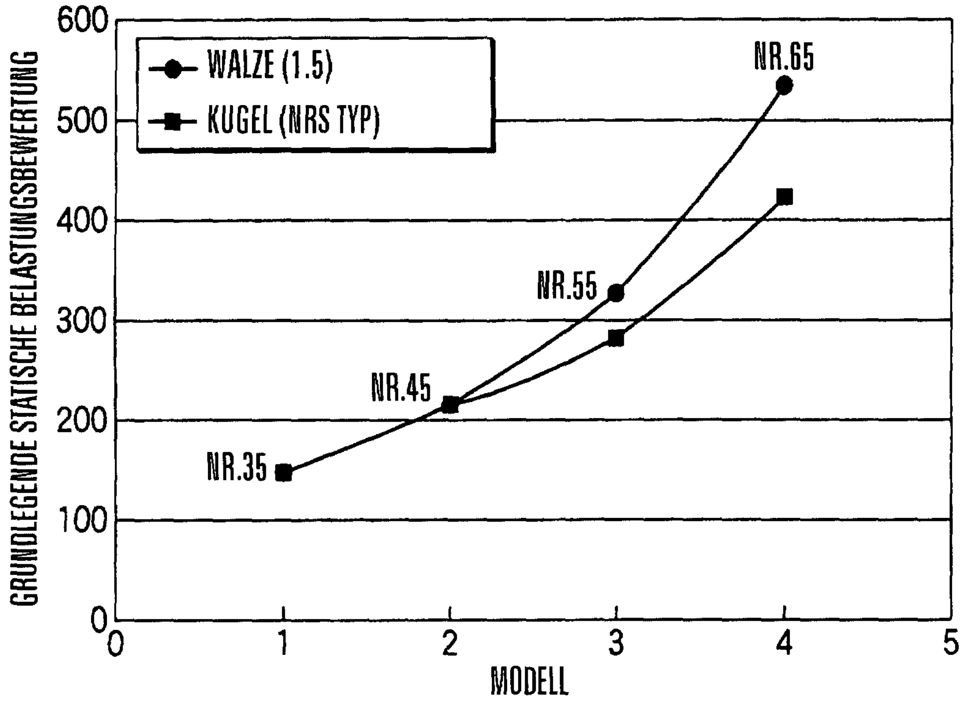


FIG.6A

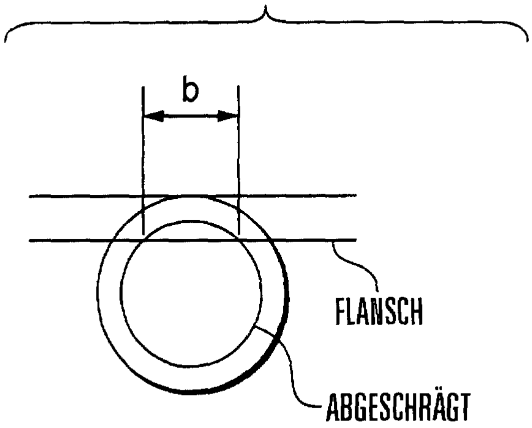


FIG.6B

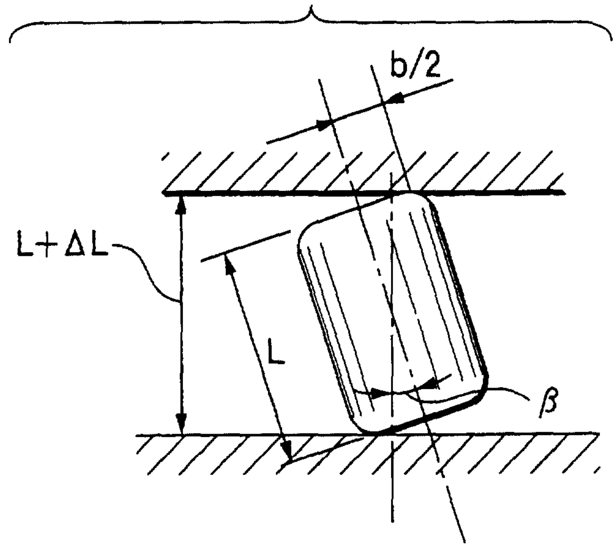
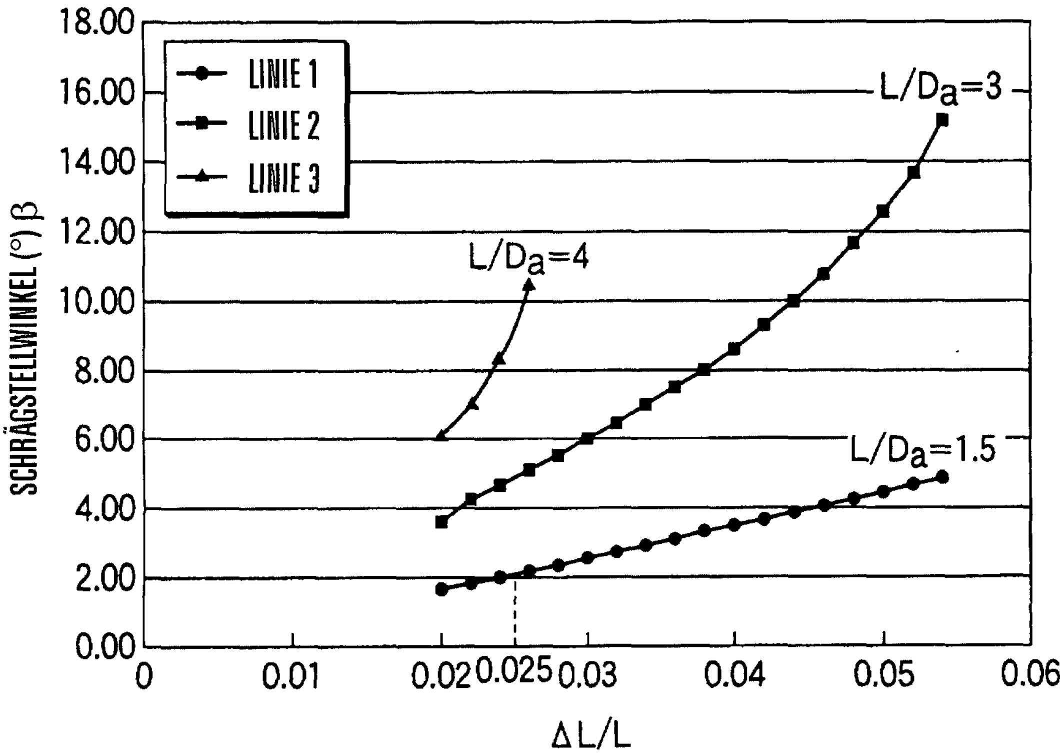
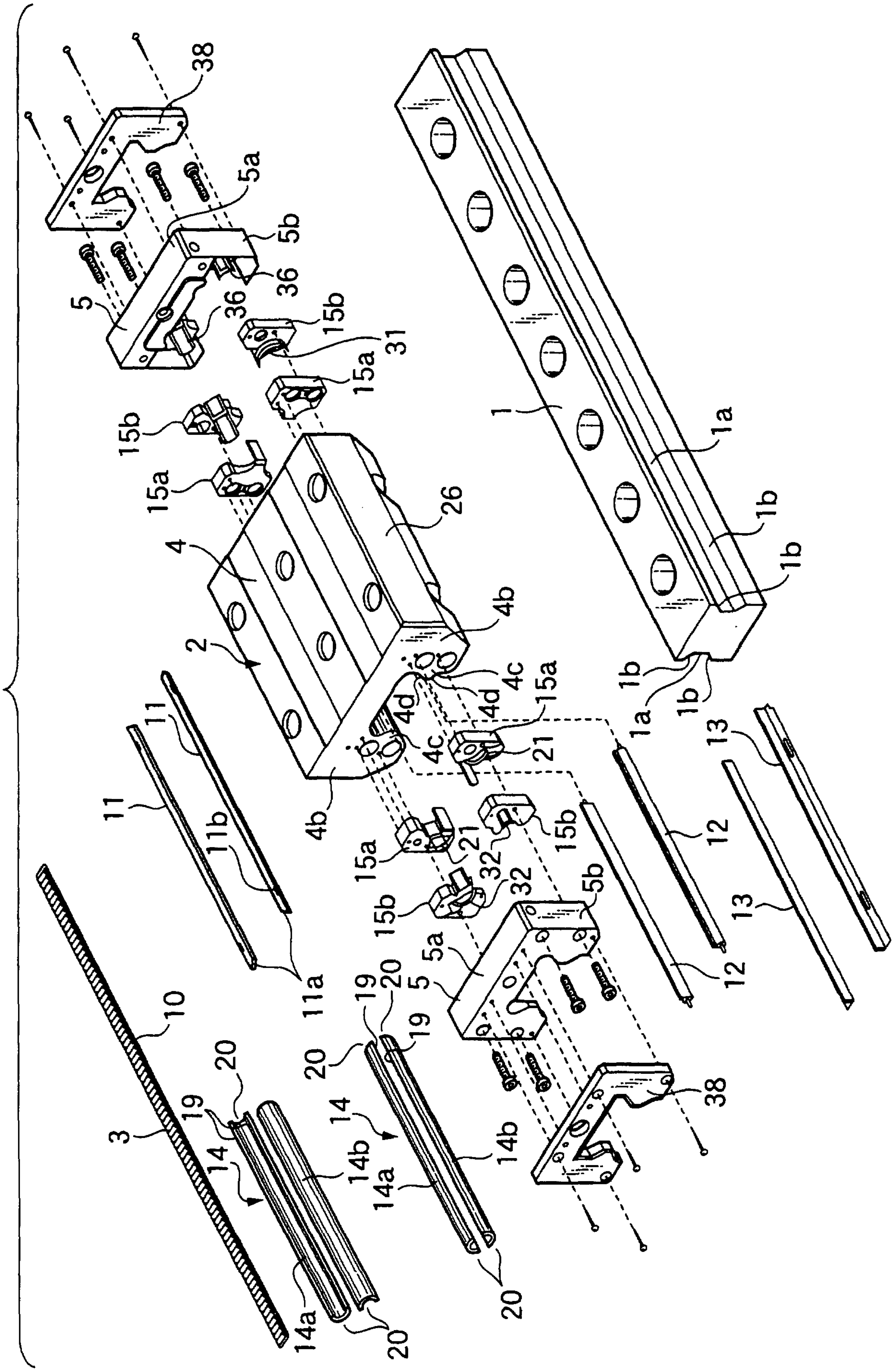


FIG.7


LINIE 1
LINIE 2
LINIE 3
L/Da=3
L/Da=4
L/Da=1.5
SCHRÄGSTELLWINKEL (°) β
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
0.01
0.02
0.025
0.03
0.04
0.05
0.06
ΔL/L

Nummer: **DE 102 15 766 A1**
Int. Cl.[7]: **F 16 C 29/04**
Offenlegungstag: 13. Februar 2003

FIG.8



Nummer: **DE 102 15 766 A1**
Int. Cl.^{7}: **F 16 C 29/04**
Offenlegungstag: 13. Februar 2003

FIG.9

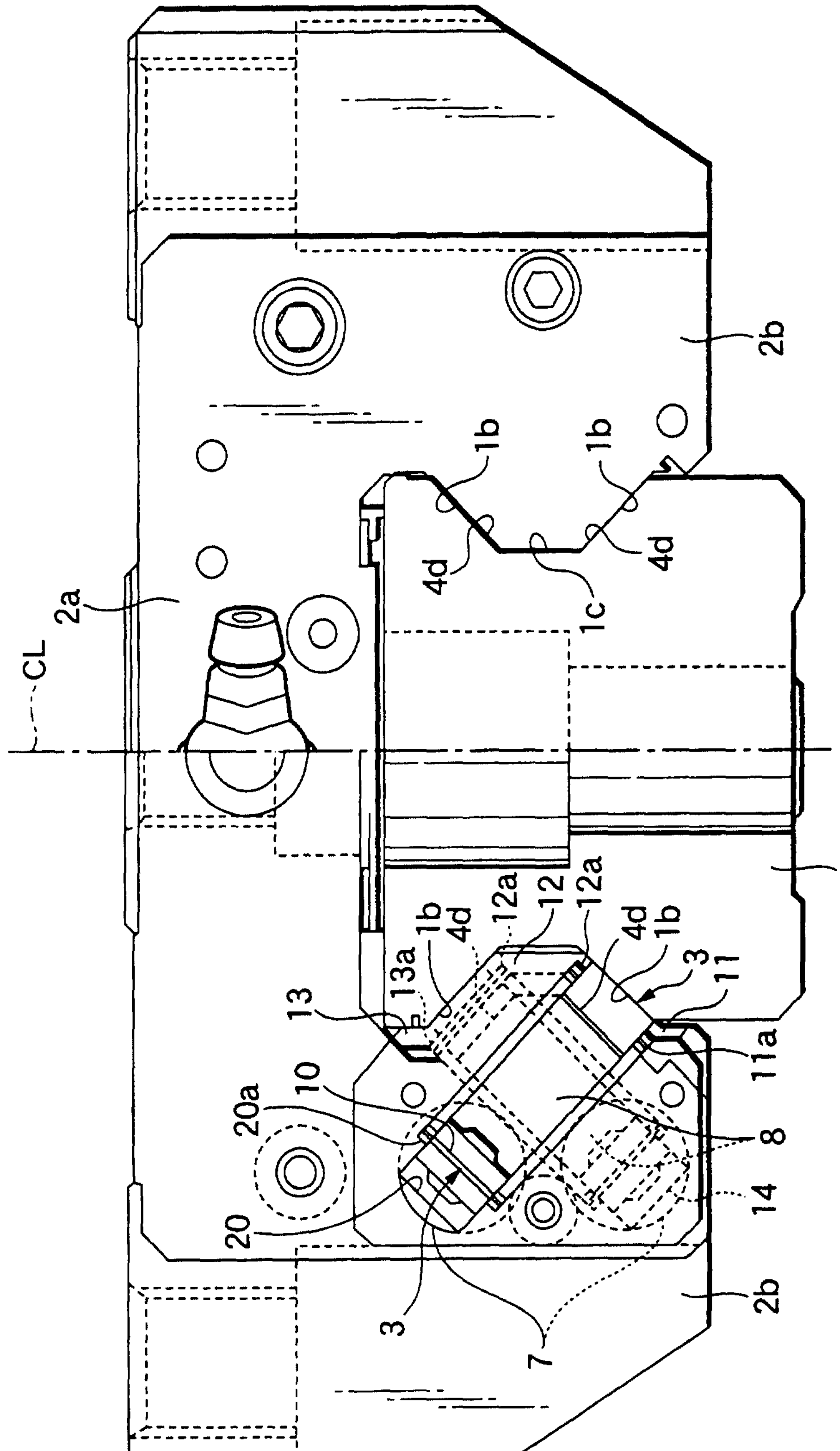


FIG.10A

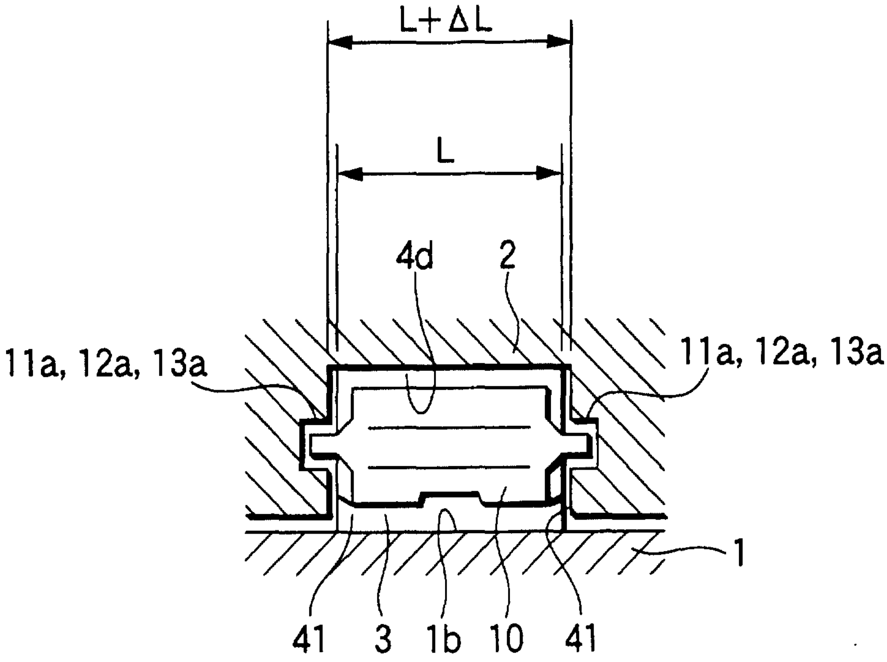


FIG.10B

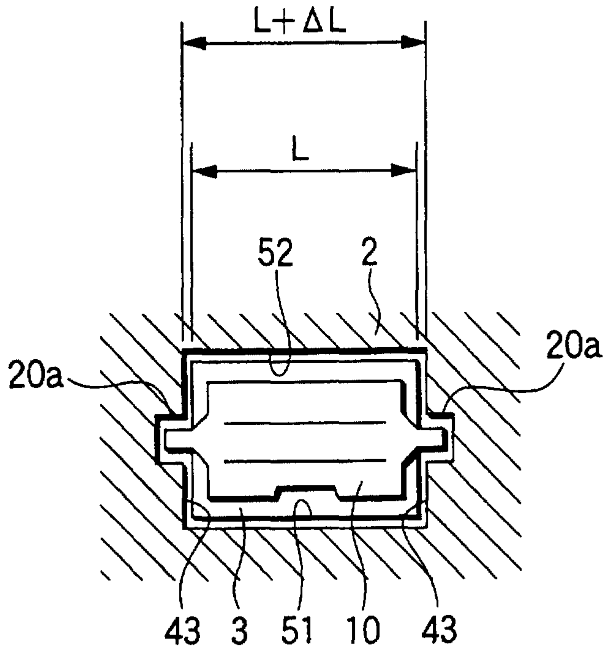


FIG.11A

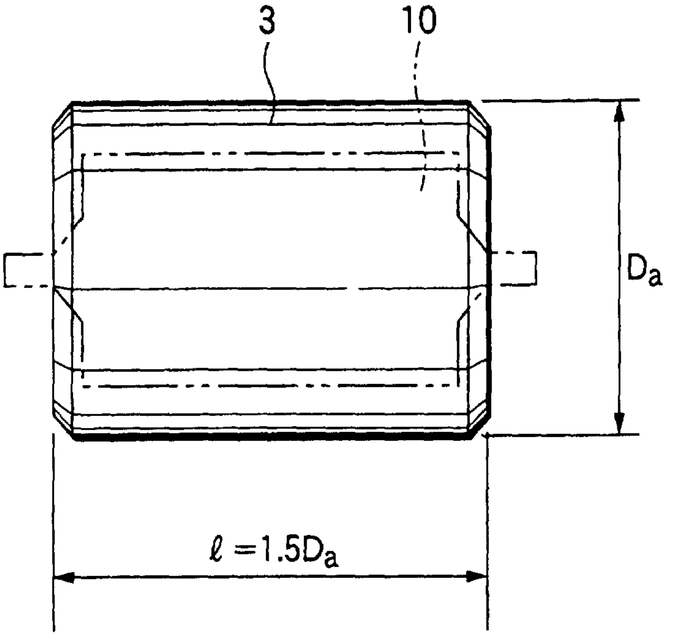
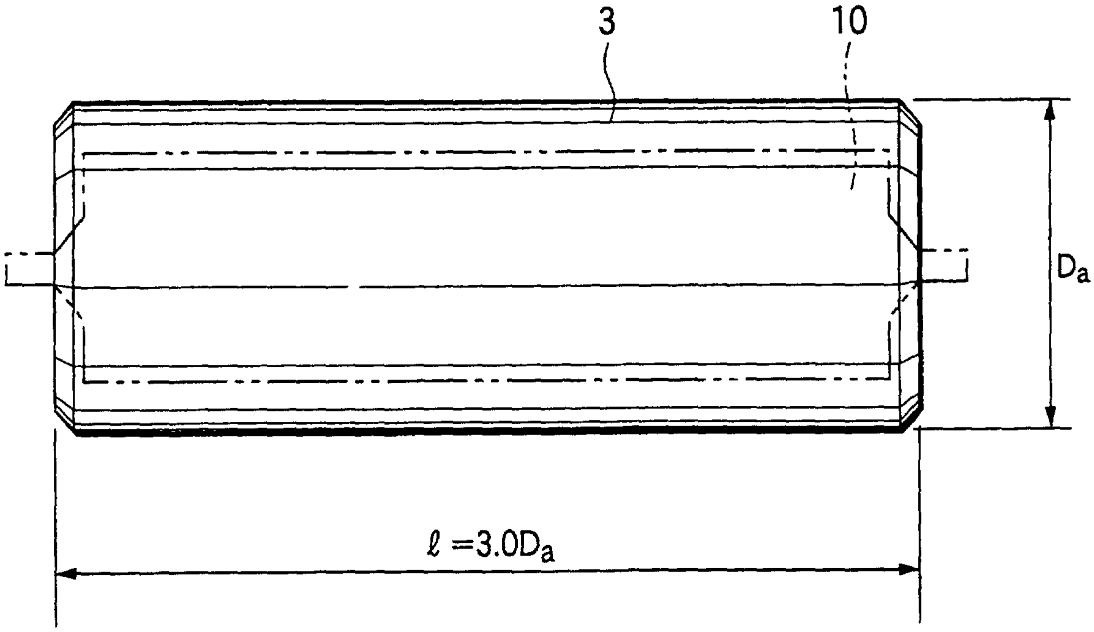


FIG.11B



Nummer: **DE 102 15 766 A1**
Int. Cl.[7]: **F 16 C 29/04**
Offenlegungstag: 13. Februar 2003

FIG.12A

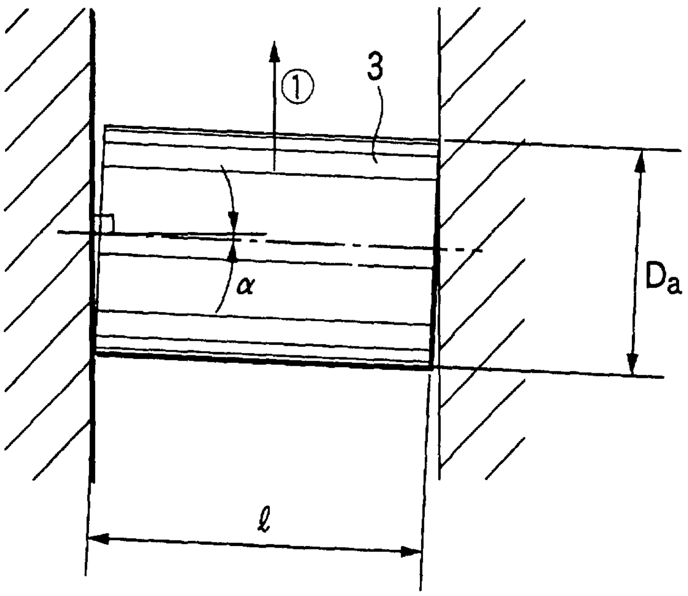
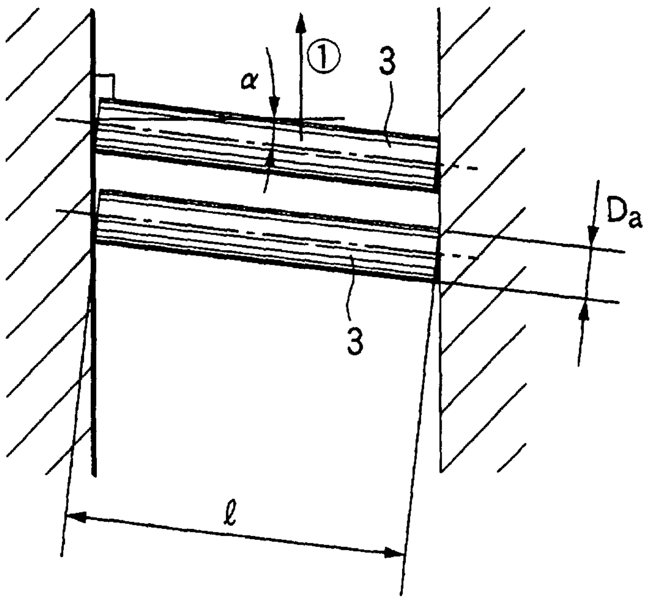


FIG.12B



Nummer: DE 102 15 766 A1
Int. Cl.[7]: F 16 C 29/04
Offenlegungstag: 13. Februar 2003

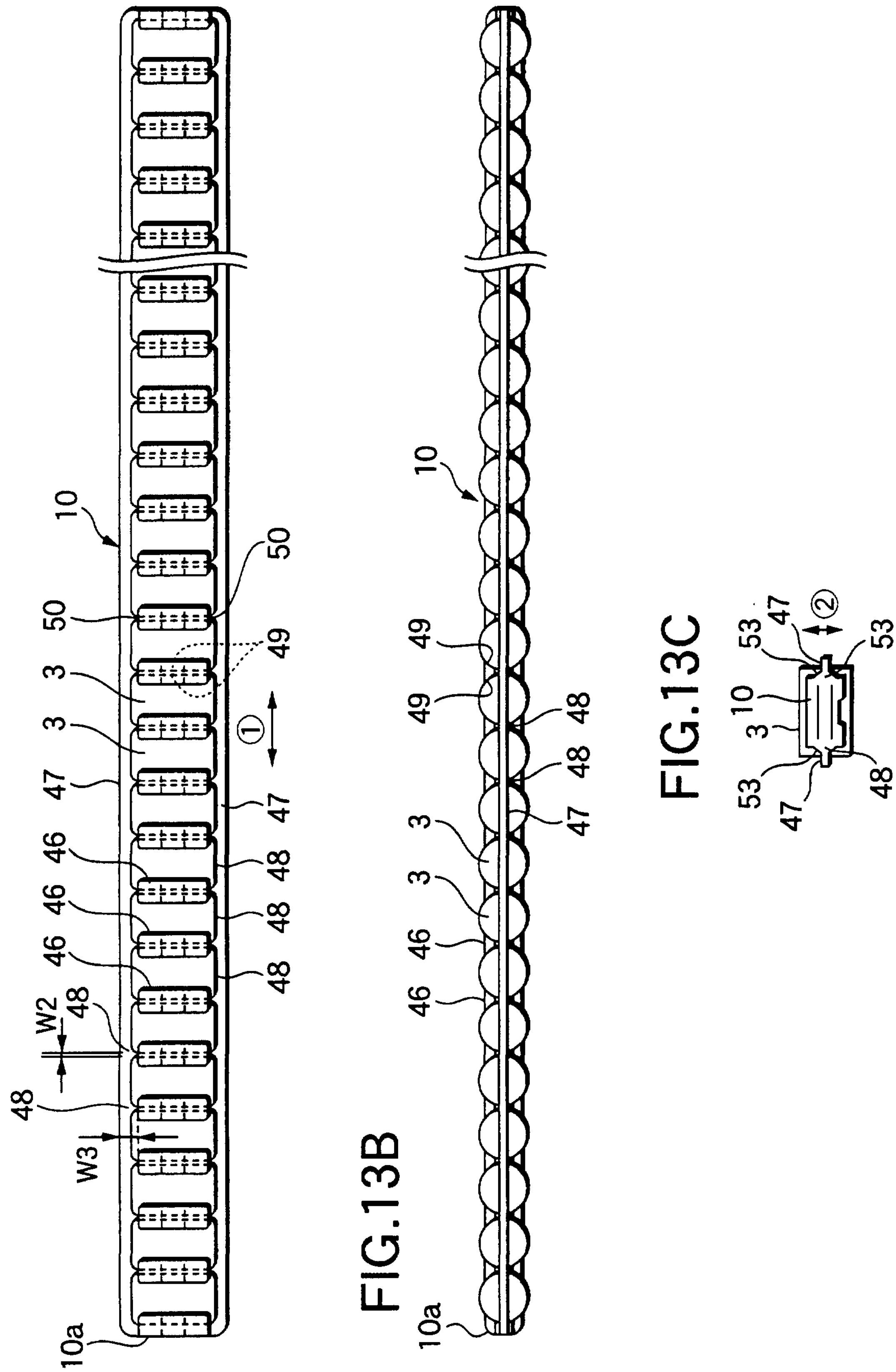


FIG.13A

FIG.13B

FIG.13C

(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 101 56 339 A 1**

(51) Int. Cl.[7]: **F 16 C 29/06**

(21) Aktenzeichen: 101 56 339.6
(22) Anmeldetag: 16. 11. 2001
(43) Offenlegungstag: 23. 5. 2002

DE 101 56 339 A 1

(30) Unionspriorität:
2000-351200 17. 11. 2000 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
HOFFMANN · EITLE, 81925 München

(72) Erfinder:
Michioka, Hidekazu, Tokyo, JP; Murata, Tomozumi, Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Führungsvorrichtung

(57) Eine Führungsvorrichtung umfasst eine Spurschiene, die Laufringoberflächen für Wälzkörper in Längsrichtung gebildet hat, ein Gleitstück, das eine Lastlaufringoberfläche gegenüber der Laufringoberfläche hat und einen Rückkehrweg für Wälzkörper, der parallel zu der Lastlaufringoberfläche angebracht ist, und das ein Paar von Richtungsumkehrwegen hat, die einen endlosen Umkehrweg für die Wälzkörper durch Verbinden der Lastlaufringoberfläche mit beiden Enden des Rückkehrwegs vervollständigen, und das an der Spurschiene angebracht ist, so dass deren Relativbewegung ermöglicht wird, und mehrere Wälzelemente, die für Last in einer Position zwischen einer Lastlaufringoberfläche des Gleitstücks und der Laufringoberfläche der Spurschiene empfänglich sind und in dem endlosen Umlaufweg umlaufen. Eine Stufe, bei der die Lastlaufringoberfläche niedriger als eine Seitenwandoberfläche an einem inneren Durchmesser des Richtungsumkehrwegs wird, ist an einem Ort gebildet, an dem der Richtungsumkehrweg mit der Lastlaufringoberfläche verbunden ist.

DE 101 56 339 A 1

Beschreibung

HINTERGRUND DER ERFINDUNG

1. Gebiet der Erfindung

[0001] Die vorliegende Erfindung bezieht sich auf eine Führungsvorrichtung, die in einem linearen Führungsabschnitt von beispielsweise einer Werkzeugmaschine oder einem ähnlichen Werkzeug verwendet wird, um ein bewegbares Element, wie einen Tisch, über einen stationären Abschnitt, wie ein Bett, zu führen, und bei der ein Gleitstück, das mit mehreren Wälzelementen ausgerüstet ist, die endlos umlaufen, frei nach vorne und hinten entlang einer Führungsschiene läuft.

[0002] Insbesondere bezieht sich die vorliegende Erfindung auf eine Verbesserung hinsichtlich der Hochgeschwindigkeitsbewegung eines Gleitstücks auf der Laufringschiene.

2. Beschreibung des Stands der Technik

[0003] Als Führungsvorrichtung dieser Art ist bislang eine Führungsvorrichtung bekannt, die eine auf einem stationären Abschnitt, wie einem Bett, angebrachte Spurschiene umfasst und eine Laufringoberfläche für Wälzelemente, wie Laufrollen, hat, die darauf geformt ist; und ein Gleitstück, das an der Spurschiene durch eine Vielzahl von Wälzelementen angebracht ist und entlang der Spurschiene läuft, wobei es ein bewegliches Element, wie einen Tisch, stützt.

[0004] Das Gleitstück hat eine Lastlaufringoberfläche, die gegenüber einer Laufringoberfläche einer Spurschiene in bezug auf Wälzelemente ist, und einen Rückkehrweg, der parallel zu der Lastlaufringoberfläche angebracht ist. Ferner umfasst das Gleitstück einen Gleitblock, der entlang der Spurschiene in Verbindung mit dem Abwälzen der Wälzelemente bewegbar ist, und ein Paar von Endkappen. Die Endkappen sind an jeweiligen Endflächen des Gleitblocks befestigt und haben einen U-förmigen Kehrenweg (genannt ein U-Kehrenweg). Der U-Kehrenweg führt Wälzelemente in Richtung auf den Rückkehrweg, die an einer Position zwischen der Lastlaufringoberfläche des Gleitblocks und der Lastlaufringoberfläche der Spurschiene angelangt sind. Die Endkappen sind an den jeweiligen Endflächen des Gleitblocks befestigt, als Folge dessen die Lastlaufringoberfläche mit dem Ende des Rückkehrwegs durch den U-förmigen Weg verbunden ist. Somit entsteht ein endloser Umlaufweg innerhalb des Gleitstücks.

[0005] Die Wälzkörper, die um den endlosen Umlaufweg des Gleitstücks umlaufen, rollen durch einen Ort zwischen der Lastlaufringoberfläche des Gleitblocks und dem Laufring der Spurschiene. Insbesondere rollen die Wälzelemente durch ein Lastgebiet, wobei sie die Last aufnehmen, die auf den Gleitblock ausgeübt wird. In einem Nichtlastgebiet wird die Last auf die Wälzelemente gelöst und sie rollen in einem Nichtlastzustand, in dem keine Last auf die Wälzkörper aufgebracht wird. **Fig.** 7 ist eine vergrößerte Querschnittansicht, die eine Verbindung zwischen dem Nichtlastgebiet und dem Lastgebiet zeigt. Insbesondere zeigt die Zeichnung, dass die Wälzkörper **101**, die durch einen U-förmigen Weg **100** gerollt sind, ohne eine Last aufzunehmen, in eine Position zwischen einer Laufringoberfläche **103** einer Spurschiene **102** und einem Lastlaufring **105** eines Gleitblocks **104** gelangen. Die Lastlaufringoberfläche **105** des Gleitblocks **104** und die Wälzkörper **100**, wie Kugeln oder Zylinder, sind aus Stahl gefertigt, aber keine vollständig steifen Körper und habe eine leichte Elastizität. In dem Lastgebiet erfahren die Lastlaufringoberfläche **105** und die Wälzkörper **101** eine leichte elastische Deformation aufgrund von Last, und in dem Nichtlastgebiet nehmen die Wälzkörper ihre ursprünglichen Gestalten wieder ein, wenn die Last entfernt wird. Aus diesem Grund sind der innere Durchmesser des Rückkehrwegs und derjenige des U-Kehrenwegs **100**, die das Nichtlastgebiet bilden, größer als der Durchmesser des Wälzkörpers **101**. Ein Intervall zwischen der Lastlaufringoberfläche **105** des Gleitblocks **104** in dem Lastgebiet und der Laufringoberfläche **103** der Spurschiene **102** ist jedoch kleiner als der Durchmesser des Wälzkörpers **101**. Wenn somit die Wälzkörper **101**, die durch das Nichtlastgebiet gerollt sind, abrupt in das Lastgebiet gelangen, werden die Wälzkörper **101** einer abrupten Kompression am Eingang des Lastgebiets ausgesetzt. Als Folge entsteht ein höherer Widerstand bei der Zirkulation der Wälzkörper **101** und das Geräusch, das mit der Zirkulation der Wälzkörper **101** verbunden ist, wird stärker. Aus diesen Gründen wurde, um gleichmäßig und elastisch die Wälzkörper **101** zu deformieren, die in das Lastgebiet aus dem Nichtlastgebiet gelangen, bislang jedes Ende in Längsrichtung der Lastlaufringoberfläche **105** keilförmig gestaltet. Jedes Ende des Lastgebiets ist leicht verbreitert, in der Form eines Glockenbodens, in Richtung auf das Nichtlastgebiet. Durch solche ein Verbreiterung des Lastgebiets rollen die Wälzkörper **101**, die in das Lastgebiet aus den Nichtlastgebiet gerollt sind, in die Tiefe des Lastgebiets, so dass der Zirkulationswiderstand und das Geräusch der Wälzkörper **101** verringert wird.

[0006] Wie oben beschrieben, wird der U-Kehrenweg **100**, der das Nichtlastgebiet bildet, durch die Endkappe **107** definiert, die sich von dem Gleitblock **104** unterscheidet, der die Lastlaufringoberfläche **105** darauf gebildet hat. Um einen glatten Übergang der Wälzkörper **101** zwischen dem Nichtlastgebiet und dem Lastgebiet zu bewirken, muss die Endkappe **107** genau in bezug auf den Gleitblock **104** positioniert werden. Im Stand der Technik wurde ein Versuch unternommen, die positionale Genauigkeit beim Anbringen der Endkappe **107** an dem Gleitblock **104** zu verbessern, indem ein Vorsprung, der von der Endkappe **107** vorsteht, in ein ausgespartes Loch eingepasst wird, das in der Endfläche des Gleitblocks **104** geformt ist, wodurch der Rand der ballig gedrehten Lastlaufringoberfläche **105** mit einer Seitenwandoberfläche **106** am inneren Umriss des U-Kehrenwegs **100** vollständig in Übereinstimmung gebracht wird.

[0007] Selbst wenn die positionale Genauigkeit beim Montieren der Endkappe **107** relativ zu dem Gleitblock **104** verbessert worden ist, wird die Seitenwandoberfläche **106** am Innendurchmesser des U-Kehrenwegs **100** niedriger als der Rand der Lastlaufringoberfläche **105** durch das Verhältnis zwischen der Genauigkeit beim Ausbilden der Lastlaufringoberfläche **105** und der Genauigkeit beim Ausbilden der Kunststoffendkappe **107**, wie es durch gestrichelte Linien angegeben ist, die in **Fig.** 7 gezeigt sind. Möglicherweise kann ein Fall auftreten, in dem der Rand der Lastlaufringoberfläche **105** leicht an einer Verbindung zwischen der Lastlaufringoberfläche **105** und dem U-Kehrenweg **100** vorsteht. Auf diese Weise kollidieren die Wälzkörper **101** mit dem Rand der so vorspringenden Lastlaufringoberfläche **105**, wenn die Wälzkörper **101** in das Lastgebiet aus dem U-Kehrenweg **100** eindringen. Solch eine Kollision bildet kein ernsthaftes Problem, wenn das Gleitstück entlang der Spurschiene mit einer geringen Geschwindigkeit läuft; die Kollision bildet jedoch ein bemerkenswertes Problem, wenn die Geschwindigkeit erhöht werden muss, mit der das Gleitstück entlang der Spurschiene laufen soll. Wenn die Geschwindigkeit, mit der das Gleitstück entlang der Spurschiene läuft, erhöht wird, kommen somit innerhalb einer vorgegebenen Zeitdauer eine größere Anzahl von Kugeln zur Kollision mit der Lastlaufringoberfläche. Als Folge wird der Widerstand, der hinsichtlich der Zirkulation der Wälzkörper auferlegt wird, oder die Geräuschbildung merklich. Da ferner die Aufprallenergie proportional zum Quadrat der Geschwindigkeit ist, wird der Rand der vorspringenden Lastlaufringoberfläche hinsichtlich einer Beschädigung anfällig.

[0008] Ein halbkreisförmiger Führungsabschnitt, der am Innendurchmesser des U-Kehrenwegs **100** positioniert ist, ist bislang an einer Endkappe oder einem Gleitblock angebracht worden. Um jedoch die Genauigkeit beim Ausbilden eines endlosen Umlaufwegs zu erhöhen, wurde kürzlich das direkte Ausbilden des halbkreisförmigen Führungsabschnitts an der Endfläche des Gleitblocks durch Spritzgießen von Kunststoff (Kunstharz) durchgeführt (wie es in der japanischen offengelegten Patentanmeldung Nr. 317762/1995 beschrieben ist). Selbst in diesem Fall ist es schwierig, den Rand der Lastlaufringoberfläche mit der inneren Seitenoberfläche des U-Kehrenwegs in Übereinstimmung zu bringen, der einen halbkreisförmigen Führungsabschnitt hat, ohne dass sich eine Stufe ausbildet. Die Hochgeschwindigkeitszirkulation von Wälzkörpern ist mit den vorher beschriebenen Problemen verbunden.

ZUSAMMENFASSUNG DER ERFINDUNG

[0009] Die vorliegende Erfindung wurde im Hinblick auf diese Nachteile getätigt und strebt danach, eine lineare Führungsvorrichtung vorzusehen, die das Auftreten von Kollisionen von Wälzkörpern vermeidet, die andernfalls auftreten würde, wenn die Wälzkörper in ein Lastgebiet aus einem Nichtlastgebiet rollen, so dass ein Gleitwiderstand und Geräusche verringert werden, die andernfalls auftreten würden, wenn sich ein Gleitstück mit hoher Geschwindigkeit relativ zu einer Spurschiene bewegt.

[0010] Um die Aufgabe zu erzielen, stimmt idealer Weise die Lastlaufringoberfläche vollständig mit der Seitenwandoberfläche überein und geht kontinuierlich in sie am inneren Durchmesser des U-Kehrenwegs über, wenn die lineare Führungsvorrichtung zusammengefügt wird. Vorgegebene Toleranzen sind jedoch im Rahmen der Fertigungsgenauigkeit einzelner Komponenten oder einer Positioniergenauigkeit vorhanden. Um eine ideale Übereinstimmung zwischen der Lastlaufringoberfläche und der Seitenwandoberfläche zu erzielen, müssen ein Gleitstückhauptkörper und Endkappen mit einem beträchtlich hohen Maß an Genauigkeit gefertigt werden und die so hergestellten Komponenten müssen mit einem beträchtlich hohen Maß an Präzision zusammengefügt werden. Daher ist es äußerst schwierig, eine solche hochgenaue Herstellung und ein solches Zusammenfügen von Teilen zu erreichen.

[0011] Bei der linearen Führungsvorrichtung gemäß der vorliegenden Erfindung sind die Seitenwandoberfläche am inneren Durchmesser des U-Kehrenwegs und die Lastlaufringoberfläche nicht mit der Absicht gebildet, dass sie an dem Ort kontinuierlich werden, an dem der U-Kehrenweg mit der Lastlaufringoberfläche verbunden ist; stattdessen ist es beabsichtigt, einen gestuften Abschnitt zu bilden, so dass der Rand eines Eingangs der Lastlaufringoberfläche niedriger als die Seitenwandoberfläche wird.

[0012] Durch solche technischen Einrichtungen ist der Längsrand der Lastlaufringoberfläche im Vergleich zur Seitenwandoberfläche am inneren Durchmesser des U-Kehrenwegs vertieft. Damit kollidieren die Wälzkörper, die ein Lastgebiet aus dem U-Kehrenweg betreten möchten, nicht mit dem Rand der Lastlaufringoberfläche und die Wälzkörper können glatt an das Lastgebiet aus dem Nichtlastgebiet abgegeben werden. Ferner hat der U-Kehrenweg ursprünglich einen inneren Durchmesser der größer als der Durchmesser der Wälzkörper ist. Selbst wenn die Seitenwandoberfläche am inneren Radius des U-Kehrenwegs über den Rand des Eingangs der Lastlaufringoberfläche vorsteht, werden somit die Wälzkörper, die in den U-Kehrenweg aus dem Lastgebiet eindringen wollen, nicht durch einen Winkel der Seitenwandoberfläche gebremst. Somit können die Wälzkörper gleichmäßig an das Nichtlastgebiet aus dem Lastgebiet abgegeben werden.

[0013] Der gestufte Abschnitt hat eine Größe von etwa 5% des Durchmessers des Wälzkörpers. Der gestufte Abschnitt mit solch einer Größe kann direkt durch Justieren einer Toleranz ausgebildet werden, die mit dem Fertigen der Lastlaufringoberfläche oder der Endkappe verbunden ist. Ferner ist ein erlaubbarer Bereich für die Größe des gestuften Abschnitts verfügbar. Das Fertigen des gestuften Abschnitts ist somit beträchtlich einfacher als das Erreichen einer vollständigen Übereinstimmung zwischen der Seitenwandoberfläche und der Lastlaufringoberfläche.

[0014] Selbst wenn es unmöglich ist, eine Übereinstimmung zwischen der Lastlaufringoberfläche und der Seitenwandoberfläche am inneren Durchmesser des U-Kehrenwegs zu erreichen, indem lediglich die Genauigkeit beim Fertigen der Komponenten oder lediglich das Zusammenfügen von genauen Komponenten festgelegt wird, kann das Erreichen einer Übereinstimmung zwischen der Lastlaufringoberfläche und der Seitenwandoberfläche durch Herstellen der linearen Führungsvorrichtung nach dem Zusammenfügen implementiert werden. Insbesondere wird durch gleichzeitiges Schleifen der Lastlaufringoberfläche und der Seitenwandoberfläche, die einander benachbart sind, ein Vorstehen des Rands des Eingangs der Lastlaufringoberfläche relativ zur Seitenwandoberfläche vermieden, wodurch die Oberflächen so endbearbeitet werden, dass sie ohne Stufe kontinuierlich werden. Damit kann eine ideale Kontinuität zwischen dem Lastgebiet und dem Nichtlastgebiet sichergestellt werden, wobei dies nur wenig Arbeit umfasst, so dass eine gleichmäßige Zirkulation der Wälzkörper erreicht wird.

[0015] Die vorliegende Erfindung kann auf einen endlosen Umlaufweg einer Kugelkeilwelle angewendet werden, die aus einer Keilwelle und einem Mutterelement besteht, das entlang der Welle läuft, ebenso wie auf einen endlosen Kugelumlaufweg einer linearen Führungsvorrichtung, die aus einer Spurschiene und einem Gleitstück besteht.

KURZE BESCHREIBUNG DER ZEICHNUNGEN

[0016] **Fig.** 1 ist eine perspektivische Ansicht, die ein Beispiel einer linearen Führungsvorrichtung zeigt, auf die die vorliegende Erfindung angewendet wird;

[0017] **Fig.** 2 ist eine Vorderquerschnittsansicht, die eine lineare Führungsvorrichtung gemäß der Ausführungsform zeigt;

[0018] **Fig.** 3 ist eine Querschnittsansicht entlang der Linie III-III aus **Fig.** 2;

[0019] **Fig.** 4 ist eine perspektivische Ansicht, die aufgereihte Kugeln zeigt, die in einen endlosen Umlaufweg eines Gleitstücks gemäß der Ausführungsform eingebaut werden sollen;

[0020] **Fig.** 5 ist eine vergrößerte Querschnittsansicht, die ein Beispiel einer Verbindung zwischen einem Lastgebiet und einem U-Kehrenweg einer linearen Führungsvorrichtung gemäß der Ausführungsform zeigt;

[0021] **Fig.** 6 ist eine vergrößerte Querschnittsansicht, die ein anderes Beispiel einer Verbindung zwischen einem Lastgebiet und einem U-Kehrenweg einer linearen Führungsvorrichtung gemäß der Ausführungsform zeigt; und

[0022] **Fig.** 7 ist eine vergrößerte Querschnittsansicht, die ein Beispiel einer Verbindung zwischen einem Lastgebiet und einem U-Kehrenweg einer linearen Führungsvorrichtung des Stands der Technik zeigt.

DETAILLIERTE BESCHREIBUNG DER BEVORZUGTEN AUSFÜHRUNGSFORMEN

[0023] Es wird nun eine Beschreibung von bevorzugten Ausführungsformen der Erfindung unter Verweis auf die beigefügten Zeichnungen gegeben.

[0024] Eine lineare Führungsvorrichtung gemäß der vorliegenden Erfindung wird im einzelnen untenstehend unter Verweis auf die beigefügten Zeichnungen beschrieben.

[0025] **Fig.** 1 ist eine perspektivische Ausschnittsansicht, die ein Beispiel einer linearen Führungsvorrichtung zeigt, auf die die vorliegende Erfindung angewendet wird. Die lineare Führungsvorrichtung umfasst eine Spurschiene **1**, die einen Kugellaufring **11** in einer Längsrichtung von ihr gebildet hat; ein Gleitstück **2**, das in Eingriff mit der Spurschiene **1** über eine Vielzahl von Kugeln **3** ist, die als Wälzkörper dienen; und ein Dichtelement **5**, das an einer Endfläche an beiden Enden des Gleitstücks **2** in dessen Bewegungsrichtung angebracht ist und das in direktem Kontakt mit der oberen und Seitenoberfläche der Spurschiene **1** gebracht wird.

[0026] Wie es in **Fig.** 2 gezeigt ist, ist die Spurschiene **1** so konstruiert, dass sie ein im wesentlichen rechteckiges Querschnittsprofil einnimmt, wenn man einen Querschnitt entlang der Richtung senkrecht zur Längsrichtung der Schiene **1** betrachtet. Ein Montageloch **10** zum Einführen eines Verankerungsbolzens ist unter geeigneten Intervallen in der Längsrichtung so geformt, dass es durch die Spurschiene **1** durchdringt. Zwei Kugellaufringnuten **11** sind in einer oberen Oberfläche der Spurschiene **1** so geformt, dass die Montagelöcher **10** zwischen die Kugellaufringnuten **11** zwischengeschaltet sind. Ferner ist eine Kugellaufringnut **11** auf jeder Seitenoberfläche **11** der Spurschiene **1** geformt. Jede der vier Kugellaufringnuten ist in der Gestalt eines tiefen Schlitzes so geformt, der eine Krümmung einnimmt, die etwas größer ist als diejenige einer kugelförmigen Oberfläche der Kugel **3**.

[0027] Das Gleitstück **2** umfasst einen metallischen Gleitblock **21**, der mit einer Montageoberfläche **20** ausgebildet ist, die zum Montieren eines verschiebbaren Elements (nicht gezeigt), wie eines Tischs, verwendet wird, und mit einem Paar von Kunststoffendkappen **22, 22**, die an beiden Endflächen des Gleitblocks **21** befestigt sind. Eine Vertiefung ist in der unteren Oberfläche des Gleitstücks **2** so geformt, dass ein oberer Teil der Spurschiene **1** in die Vertiefung mit Spiel passt. Somit ist das Gleitstück **2** so konstruiert, dass es ein im wesentlichen sattelartiges Querschnittsprofil hat.

[0028] Der Gleitblock **21** hat einen Basisabschnitt **21**a mit der darauf gebildeten Montageoberfläche **20**, und ein Paar von Einfassungen **21**b, **21**b, die sich nach unten von den jeweiligen Seiten des Basisabschnitts **21**a erstreckt. Somit ist der Gleitblock **21** so konstruiert, dass er ein im wesentlichen sattelartiges Querschnittsprofil einnimmt. Mehrere Gewindelöcher **20**a zur Verwendung zum Sichern eines bewegbaren Elements mit Bolzen sind in der Montageoberfläche **20** geformt. Zwei Lastlaufringnuten **23** sind in der unteren Oberfläche des Basisabschnitts **21**a geformt, und eine Lastlaufringnut **23** ist in einer inneren Seitenoberfläche jeder der Einfassungen **21**b geformt. Somit sind eine Gesamtzahl von vier Lastlaufringnuten **23** so gebildet, dass sie entsprechenden Kugellaufringnuten **11** gegenüber sind, die in der Spurschiene **1** geformt sind. Die Kugeln **3** laufen unter Last an einem Ort, der zwischen der Lastlaufringnut **23** und der Kugellaufringnut **11** der Spurschiene **1** definiert wird; insbesondere in einem Lastgebiet. Somit läuft das Gleitstück **2** über die Spurschiene **1**.

[0029] Zwei Kugelrückkehrwege **24** sind in dem Basisabschnitt **21**a des Gleitblocks **21** durch Bohren gebildet, und ein Kugelrückkehrweg **24** ist in jeder der Einfassungen **21**b durch Bohren geformt. Die Kugelrückkehrwege **24** sind parallel zu jeweiligen Lastlaufringnuten **23** angebracht. **Fig.** 3 ist eine Querschnittsansicht, die einen endlosen Kugellaufweg zeigt, der in dem Gleitstück **2** geformt ist. Jeder der Kugelrückkehrwege **24** steht mit einer entsprechenden Lastlaufringnut **23** durch zwei im wesentlichen U-förmige Richtungsumkehrwege **25** (einfach als "U-Kehrenwege" bezeichnet) in Verbindung, die durch die jeweiligen Endkappen **22** definiert werden. Insbesondere führt ein U-Kehrenweg **25** die Kugeln **3** nach oben, die das Rollen durch die Lastlaufringnut **23** des Gleitblocks **21** beendet haben, und liefert die Kugeln **3** an den Kugelrückkehrweg **23**, und der andere U-Kehrenweg **25** liefert die Kugeln **3** aus dem Kugelrückkehrweg **24** zur Lastlaufringnut **23**. Durch Befestigen der Endkappen **23** an dem Gleitblock **21** durch nicht dargestellte Montagebolzen wird ein endloser Umlaufweg für die Kugeln **3** in dem Gleitstück **2** gebildet.

[0030] Wie es in **Fig.** 3 gezeigt ist, ist eine Endfläche auf beiden Seiten des Gleitblocks **21** in der Bewegungsrichtung davon mit einem Kappenbefestigungsabschnitt **40** bedeckt, der zum Verwenden der Endkappe **22** verwendet wird. Ein gestufter Positionierabschnitt **41** zum Aufpassen einer inneren Seitenoberfläche der Endkappe **22** ist in dem Kappenbefestigungsabschnitt **40** geformt. Wenn die Endkappe **22** an dem Gleitblock **21** befestigt wird, positioniert der gestufte Positionierabschnitt **41** die Endkappe **22** genau. Der Kappenbefestigungsabschnitt **40** ist integral mit dem Gleitblock **21** durch ein sogenanntes Einsatzgussverfahren geformt, bei dem geschmolzenes Harz durch Einspritzen in eine Form gegossen wird, die den Gleitblock **21** darin vorgesehen hat. Es kann ein Fall auftreten, in dem der Kappenbefestigungsabschnitt **40** durch Druckgießen von Leichtmetall, wie Aluminium, anstatt von Kunststoff gebildet wird. Das Gießverfahren ist nicht auf das Einsatzgießen beschränkt; der Gleitblock **21** und der Kappenbefestigungsabschnitt **40** können getrennt gebildet werden und später zusammengefügt werden.

[0031] Ein halbkreisförmiger Führungsabschnitt **42** – der eine Seitenwandoberfläche am inneren Durchmesser des U-Kehrenwegs bildet – steht von dem Kappenbefestigungsabschnitt **40** vor. Der Führungsabschnitt **42** bildet den U-Kehrenweg **25** in Verbindung mit der Endkappe **22**. Eine halbkreisförmige Führungsnut **43** ist in der Endkappe **22** geformt und bildet eine Seitenwandoberfläche am äußeren Durchmesser des U-Kehrenwegs **25**. Wenn die Endkappe **22** an dem Kappenbefestigungsabschnitt **40** befestigt ist, ist der Führungsabschnitt **42** des Kappenbefestigungsabschnitts **40** an der Führungsnut **43** der Endkappe **22** befestigt, so dass dadurch der U-Kehrenweg **25** gebildet wird.

[0032] Die Kappenmontageabschnitte **40**, die an beiden Endflächen des Gleitblocks **21** angebracht sind, werden miteinander durch den Kugelrückkehrweg **24** verbunden. Insbesondere ist der Kugelrückkehrweg **24** durch Beschichten der inneren Umfangsoberfläche des Durchgangslochs **44**, das in dem Gleitblock **21** gebildet ist, mit einem röhrenartigen Körper **45** aus Kunststoff gebildet. Solch ein röhrenartiger Körper **45** verbindet das Paar von Kappenbefestigungsabschnitten **40, 40**, die die Endflächen des Gleitblocks **21** bedecken. Der röhrenartige Körper **45** wird durch Einsatzgießen gleichzeitig mit dem Ausbilden des Kappenbefestigungsabschnitts **40** geformt, wodurch die inneren Umfangsoberfläche des Gleitblocks **21** beschichtet wird. Entsprechend sind die Kappenbefestigungsabschnitte **40**, die an den Endflächen des Gleitblocks **21** geformt sind, miteinander integral durch den röhrenartigen Körper **45**, der durch den Gleitblock **21** durchdringt. Die Kappenbefestigungsabschnitte **40** sind fest an dem metallischen Gleitblock **21** befestigt.

[0033] Ein Hülsenabschnitt **46**, der aus Kunstharz gefertigt ist, ist über der unteren Oberfläche des Basisabschnitts **21**a des Gleitblocks **21** ebenso wie über den inneren Oberflächen der Einfassungen **21**b geformt, so dass dadurch das Paar von Kappenbefestigungsabschnitten **40**, **40** verbunden wird. Der Hülsenabschnitt **46** wird ebenfalls durch Einsatzgießen gleichzeitig mit dem Ausbilden der Kappenbefestigungsabschnitte **40** und der röhrenartigen Körper **45** geformt. Zusammen mit dem röhrenartigen Körper **45** befestigt der Hülsenabschnitt **46** das Paar von Kappenbefestigungsabschnitten **40**, **40** fest an dem Gleitblock **21**. Der Hülsenabschnitt **46** ist so geformt, dass er von der Lastlaufringnut **23** für die Kugeln **3** entfernt bleibt, die in dem Gleitblock **21** gebildet ist. Der Hülsenabschnitt **46** hat die Funktion des Führens eines Riemenabschnitts eines Kugelverbindungselements, das später beschrieben wird.

[0034] Bei der linearen Führungsvorrichtung werden die Kugeln **3** nicht in einer vorliegenden Formen in den endlosen Umlaufweg des Gleitstücks **2** eingeführt; vielmehr werden eine Vielzahl von Kugeln **3** in den endlosen Zirkulationsweg als Kugeln auf einer Kette **6** eingebaut, die aus einer Reihe von Kugeln besteht. **Fig.** 4 zeigt ein Beispiel der Kugeln auf einer Kette **6**. Die Kugeln auf einer Kette **6** werden aus mehreren Kugeln **3** gebildet, die in einer Reihe unter vorbestimmten Intervallen auf einen Verbindungsriemen **60** aufgefädelt werden. Der Verbindungsriemen **60** hat eine Vielzahl von Abstandshalterabschnitten **61**, die jeweils zwischen benachbarte Kugeln **3** gelegt werden. Die Abstandshalterabschnitte **61** sind miteinander durch einen Riemenabschnitt **62** verbunden. Auf beiden Seiten jedes der Abstandshalterabschnitte **61** ist ein kugelförmiger Sitz **63** geformt, der in Kontakt mit einer kugelförmigen Oberfläche der angrenzenden Kugel **3** zu bringen ist. Jede Kugel **3** wird drehbar durch ein Paar von Abstandshalterabschnitten **61** umfasst, die sich an den jeweiligen Seiten der Kugelreihe befinden. In solch einem Zustand werden mehrere Kugeln **3** miteinander durch den Verbindungsriemen **60** verbunden. Wie es in **Fig.** 3 gezeigt ist, werden die Kugeln **3** in jeden endlosen Umlaufweg des Gleitstücks **2** in der Form einer einzelnen Kugelkette **6** eingeführt. Um das Auftreten eines Knicks in dem Verbindungsriemen **60** zu vermeiden, während die Kugeln **3** in dem Zirkulationsweg umlaufen, ist ein Paar von Stützen **67** in der inneren Umfangsoberfläche des röhrenartigen Körpers **45** aus Kunststoff gebildet, der den Rückkehrweg **24** bildet, in der Richtung, in der die Kugeln **3** laufen. Der Riemenabschnitt **62** des Verbindungsriemens **60** wird entlang der Schlitze **47** geführt. Ähnliche Schlitze **48** sind in den Gebieten des Hülsenabschnitts **46** geformt, die auf beiden Seiten jeder Lastlaufringnut **23** des Gleichrings **21** positioniert sind.

[0035] **Fig.** 5 ist eine vergrößerte Querschnittsansicht, die eine Verbindung zwischen dem Lastgebiet und dem U-Kehrenweg **25** innerhalb des endlosen Umlaufwegs zeigt. Nachdem sie durch den U-Kehrenweg **25** in einem Nichtlastzustand gerollt sind, in dem keine Last auf die Kugeln **3** aufgebracht wird, rollen die Kugeln **3** in ein Lastgebiet zwischen der Lastlaufringnut **23** des Gleitstücks **2** und der Laufringnut **11** der Spurschiene **1**. In dem Lastgebiet rollen die Kugeln, wobei sie die Last aufnehmen, die auf das Gleitstück **2** aufgebracht wird. Der innere Durchmesser des U-Kehrenwegs **25**, der ein Nichtlastgebiet ist, ist so festgelegt, dass er etwas größer als der Durchmesser der Kugel **3** ist. Selbstverständlich ist auch der Eingang des U-Kehrenwegs **25**, insbesondere ein Abstand d1, zwischen der Seitenwandoberfläche **50** am inneren Durchmesser des U-Kehrenwegs **25** und der Laufringnut **11** der Spurschiene **1** ebenfalls so festgesetzt, dass er etwas größer ist als der Durchmesser der Kugel **3**. Im Gegensatz dazu sind im Lastgebiet die Kugeln **3** zwischen der Lastlaufringnut **23** des Gleitstücks **2** und der Laufringnut **11** der Spurschiene **1** eingeschlossen, wobei sie eine Last aufnehmen. Ein maximaler Abstand d2 zwischen der Lastlaufringnut **23** und der Laufringnut **11** ist im wesentlichen identisch zum Durchmesser der Kugel **3**. Wenn Last auf das Gleitstück **2** ausgeübt wird oder eine Vorlast auf die Kugeln **3** auferlegt wurde, wird der Abstand d2 kleiner als der Durchmesser der Kugel **3**. Wenn somit die Lastlaufringnut **23** vollständig parallel zur Spurschiene **1** über die gesamte Länge des Lastgebiets geformt ist, werden die Kugeln **3**, die aus dem Nichtlastgebiet in das Lastgebiet eintreten, in einem Grenzgebiet zwischen den Gebieten komprimiert, wodurch eine gleichmäßige Zirkulation der Kugeln **3** behindert wird. Wie es in **Fig.** 5 gezeigt ist, ist ein Keilgebiet A in der Lastlaufringnut **23** an beiden Enden des Lastgebiets vorgesehen. Der Abstand zwischen der Lastlaufringnut **23** und der Laufringnut **11** ist so festgesetzt, dass er sich graduell verbreitert mit Annäherung auf den U-Kehrenweg **25**. Durch das Vorhandensein des Keilgebiets A in der Lastlaufringnut **23** werden die Kugeln **3**, die in das Lastgebiet von dem Nichtlastgebiet eingetreten sind, graduell komprimiert, wobei sie sich vorwärts bewegen, und können Last aufnehmen, so dass dadurch eine gleichmäßige Zirkulation der Kugeln **3** erreicht wird und Geräusche verringert werden.

[0036] Eine Führung nach oben **49** ist am Ende der Führungsnut **43** der Endkappe **22** benachbart zum Ende der Spurschiene **1** zum Führen der Kugeln **3** geformt, so dass sie von der Laufringnut **11** der Spurschiene **1** ausgeht. Nachdem sie aus der Last beim Eintritt in den U-Kehrenweg **25** aus dem Lastgebiet freigegeben sind, entfernen sich die Kugeln **3** aus der Laufringnut **11** der Spurschiene **1** durch die Führung nach oben **49** und rollen in der Tiefe des im wesentlichen U-kehrenförmigen Wegs **25**.

[0037] Der halbkreisförmige Führungsabschnitt **42**, der am inneren Durchmesser des U-Kehrenwegs **25** positioniert ist, ist an dem Gleitblock **21** durch Spritzguss auf die oben beschriebene Weise befestigt. Es ist schwierig, vollständig den Längsrand der Lastlaufringnut **23** mit der Seitenwandoberfläche **50** des U-Kehrenwegs **25** auszurichten, der in dem Führungsabschnitt **42** geformt ist. Wenn keine vollständige Übereinstimmung zwischen der Lastlaufringnut **23** und dem U-Kehrenweg **25** vorhanden ist und wenn die Lastlaufringnut **23** von der Seitenwandoberfläche **50** in Richtung auf die Spurschiene **1** vorsteht, kommen die Kugeln **3**, die in das Lastgebiet aus dem U-Kehrenweg **25** gelangt sind, zur Kollision mit dem Rand der Lastlaufringnut **23**, selbst wenn das Keilgebiet A auf die oben beschriebene Weise vorgesehen wird. Wie es oben beschrieben worden ist, wird eine gleichmäßige Zirkulation der Kugeln **3** behindert und möglicherweise treten Geräusche als Folge der abrupten Kollision der Kugel **3** mit der Lastlaufringnut **23** auf.

[0038] Wie es in **Fig.** 5 gezeigt ist, ist es beabsichtigt, die lineare Führungsvorrichtung gemäß der vorliegenden Erfindung mit dem gestuften Abschnitt **51** zu versehen, so dass der Rand der Lastlaufringnut **23** niedriger wird als die Seitenwandoberfläche **50** am inneren Durchmesser des U-Kehrenwegs **25**. Selbst wenn Fehler beim Ausbilden des Führungsabschnitts **42** oder beim Ausbilden der Lastlaufringnut **23** vorhanden sind, wird verhindert, dass die Lastlaufringnut **23** von der Seitenwandoberfläche **50** der U-Kehrenwegs **25** in Richtung auf die Spurschiene **1** vorsteht. Die Größe des gestuften Abschnitts **51** ist etwa 5% des Durchmessers der Kugel **3**. Als Folge kann verhindert werden, dass die Kugeln **3**, die das Lastgebiet aus dem U-Kehrenweg **25** betreten, mit dem Rand der Lastlaufringnut **23** kollidieren, so dass dadurch eine gleichmäßige Zirkulation der Kugeln **3** erreicht wird. Eine solche Konstruktion ist in einem Fall effektiv, in dem die Kugeln **3** mit beträchtlich hoher Geschwindigkeit innerhalb des endlosen Umlaufwegs laufen. Selbst wenn das Gleitstück **2** mit einer hohen Geschwindigkeit relativ zur Spurschiene **1** läuft, kann eine lineare Führungsvorrichtung, die solche eine Konstruktion anwendet, bewirken, dass das Gleitstück **2** sich mit beträchtlich geringem Widerstand bewegt und sie kann das Erzeugen von Geräuschen minimieren, die andernfalls beim Bewegen der Kugeln **3** hervorgerufen würden.

[0039] Wenn der gestufte Abschnitt **51**, wie der oben beschriebene, vorhanden ist, steht der Rand der Seitenwandoberfläche **50** des U-Kehrenwegs **25** über die Lastlaufringnut in Richtung auf die Spurschiene **1** vor. Eine Breite d1 des Eingangs des U-Kehrenwegs **25** ist größer als der Durchmesser der Kugel **3**, wie es oben erwähnt wurde. Wenn die Kugeln den U-Kehrenweg **25** aus dem Lastgebiet betreten, werden die Kugeln **3** somit nicht durch den gestuften Abschnitt **51** gebremst. Der Führungsabschnitt **49** nach oben, der in der Endkappe **22** geformt ist, ist in einer Position vorgesehen, in der die Kugel **3** in Kontakt mit dem Führungsabschnitt **49** gelangt, nachdem sie aus der Last beim Eingang in den U-Kehrenweg **25** freigegeben wurde. Selbst nachdem sie aus der Last freigegeben wurde, rollt die Kugel **3** über die Laufringnut **11** der Spurschiene **1**, bis sie den oberen Führungsabschnitt **49** erreicht. Selbst in diesem Bezug besteht keine Möglichkeit, dass die Kugel **3**, die in das Nichtlastgebiet aus dem Lastgebiet gelangt, durch den gestuften Abschnitt **51** gefangen wird.

[0040] Wenn es nicht beabsichtigt wird, den gestuften Abschnitt **51** zu formen, wird das Keilgebiet A der Lastlaufringnut **23** wieder geschliffen, nachdem der Führungsabschnitt **42** auf der Endfläche des Gleitblocks **21** durch Spritzgießen geformt worden ist, so dass der Rand der Lastlaufringnut **23** justiert werden kann, so dass er mit der Seitenwandoberfläche **50** des Führungsabschnitts **42** übereinstimmt. Diese Arbeiten werden durch Verwendung eines Fräsgeräts durchgeführt. Wenn das Keilgebiet A der Lastlaufringnut **23** wieder geschliffen wird, kann eine vollständige Übereinstimmung zwischen der Lastlaufringnut **23** und der Seitenwandoberfläche **50** am inneren Durchmesser des U-Kehrenwegs **25** erreicht werden, ohne dass eine Stufe vorhanden wäre, wie es in **Fig.** 6 gezeigt ist. Somit können die Lastlaufringnut **23** und die Seitenwandoberfläche **50** kontinuierlich gestaltet werden. Somit kann eine gleichmäßige Zirkulation der Kugeln **3** sichergestellt werde, wie im Fall, in dem der gestufte Abschnitt **51** gebildet wird.

[0041] Die Ausführungsform wurde unter Verwendung der Zeichnungen beschrieben, die ein Beispiel zeigen, in dem der · Führungsabschnitt **42** am inneren Durchmesser des U-Kehrenwegs integral mit einem metallischen Gleitblock gegossen ist. Selbst im Fall einer linearen Führungsvorrichtung, bei der der Führungsabschnitt an dem Gleitblock in Verbindung mit der Endkappe befestigt ist, kann jedoch eine glatte Zirkulation der Kugeln durch Anwenden der vorliegenden Erfindung erreicht werden. Bei der Ausführungsform ist die Spurschiene **1** linear geformt. Die Spurschiene **1** kann jedoch in der Gestalt einer Kurve mit einer Krümmung gebildet werden.

[0042] Wie es beschrieben worden ist, gelangen bei der linearen Führungsvorrichtung gemäß der vorliegenden Erfindung Wälzkörper, die in ein Lastgebiet aus einem U-Kehrenweg gelangen sollen, gleichmäßig in das Lastgebiet aus einem Nichtlastgebiet und umgekehrt, ohne dass sie durch den Rand einer Lastlaufringoberfläche gebremst werden. Wenn die Wälzkörper mit einer hohen Geschwindigkeit innerhalb eines endlosen Umlaufwegs rollen, kann somit das Auftreten von Widerstand oder Geräuschen verhindert werden, was andernfalls durch das Rollen hervorgerufen würde. Es kann eine beträchtlich gleichmäßige und ruhige Hochgeschwindigkeitsrelativbewegung zwischen einem Gleitstück und einer Spurschiene erreicht werden.

Patentansprüche

1. Führungsvorrichtung, umfassend:
eine Spurschiene, die Laufringoberflächen für Wälzkörper in einer Längsrichtung von ihr geformt hat;
ein Gleitstück, das eine Lastlaufringoberfläche gegenüber der Laufringoberfläche und einen Rückkehrweg für Wälzkörper hat, der parallel zur Lastlaufringoberfläche angebracht ist; das ein Paar von Richtungsumkehrwegen hat, die einen endlosen Zirkulationsweg für Wälzkörper durch Verbinden der Lastlaufringoberfläche mit beiden Enden des Rückkehrwegs vervollständigen; und das an der Spurschiene so angebracht ist, dass eine Relativbewegung dazwischen möglich ist; und
mehrere Wälzkörper, die Last in einer Position zwischen einer Lastlaufringoberfläche des Gleitstücks und der Laufringoberfläche der Spurschiene aufnehmen können und die in dem endlosen Umlaufweg umlaufen;
wobei ein gestufter Abschnitt, bei dem die Lastlaufringoberfläche niedriger als eine Seitenwandoberfläche an einem inneren Durchmesser des Richtungsumkehrwegs wird, an einem Ort gebildet ist, an dem der Richtungsumkehrweg mit der Lastlaufringoberfläche verbunden ist.

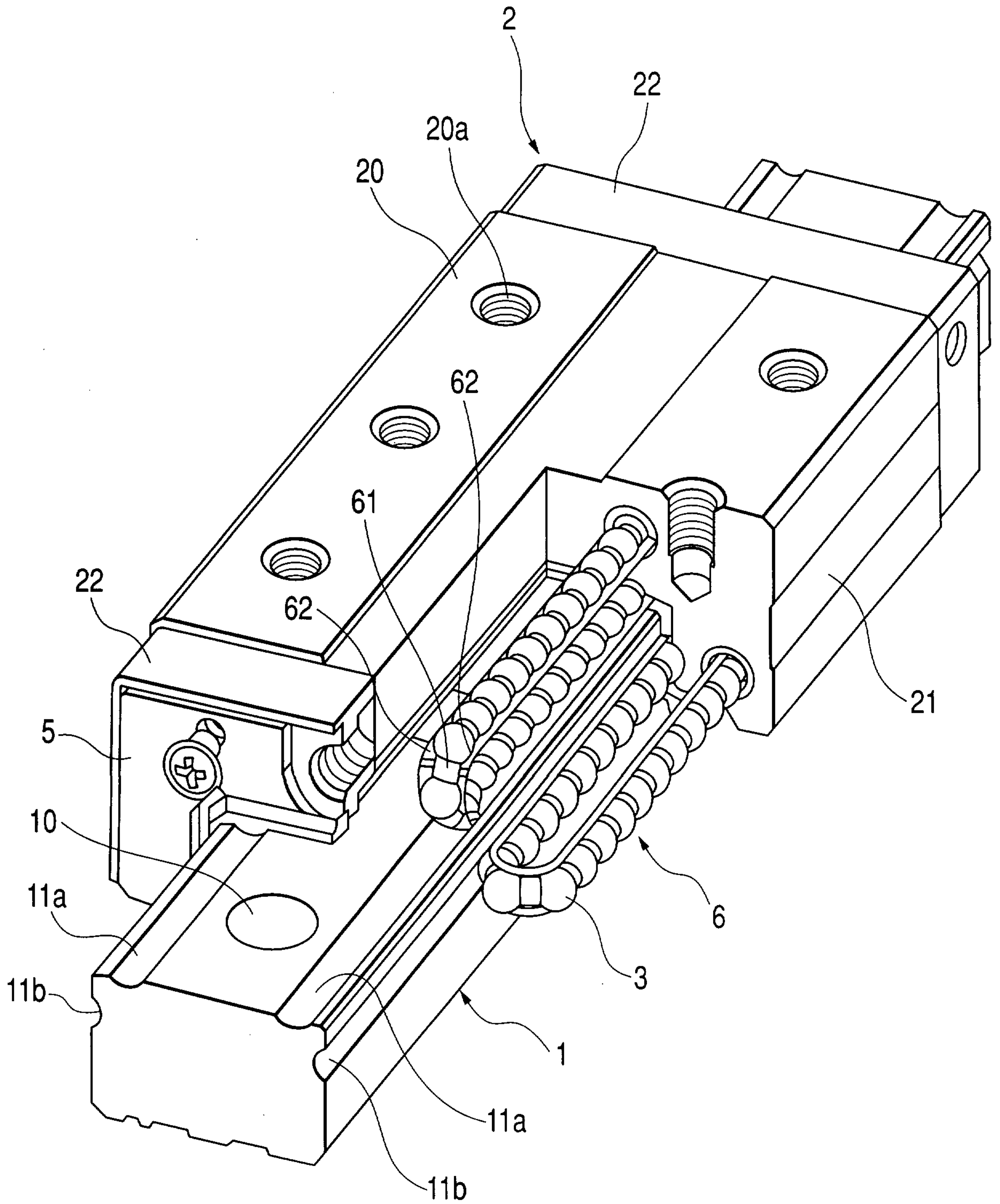
2. Führungsvorrichtung, umfassend:
eine Spurschiene, die Laufringoberflächen für Wälzkörper in einer Längsrichtung von ihr gebildet hat;
ein Gleitstück, das eine Lastlaufringoberfläche gegenüber der Laufringoberfläche und einen Rückkehrweg für Wälzkörper hat, der parallel zur Lastlaufringoberfläche angebracht ist, wobei das Gleitstück ein Paar von Richtungsumkehrwegen hat, die einen endlosen Umlaufweg für Wälzkörper durch Verbinden der Lastlaufringoberfläche mit beiden Enden des Rückkehrwegs vervollständigen, und wobei das Gleitstück an der Spurschiene so angebracht ist, dass eine Relativbewegung dazwischen ermöglicht wird; und
mehrere Wälzkörper, die Last in einer Position zwischen einer Lastlaufringoberfläche des Gleitstücks und der Laufringoberfläche der Spurschiene aufnehmen können und die in dem endlosen Umlaufweg umlaufen;
wobei ein Ort, an dem der Richtungsumkehrweg mit der Lastlaufringoberfläche verbunden ist, so geschliffen ist, dass eine Seitenwandoberfläche an einem inneren Durchmesser der Richtungsumkehrwegs kontinuierlich zur Lastlaufringoberfläche wird.

3. Führungsvorrichtung nach Anspruch 1 oder 2, wobei das Gleitstück umfasst:
einen metallischen Gleitblock, der die Lastlaufringoberfläche und den Rückkehrweg darauf gebildet hat; und
ein Paar von Kunststoffendkappen, die an den jeweiligen Enden des Gleitblocks befestigt sind und jeweils den Richtungsumkehrweg darin gebildet haben.

Hierzu 7 Seite(n) Zeichnungen

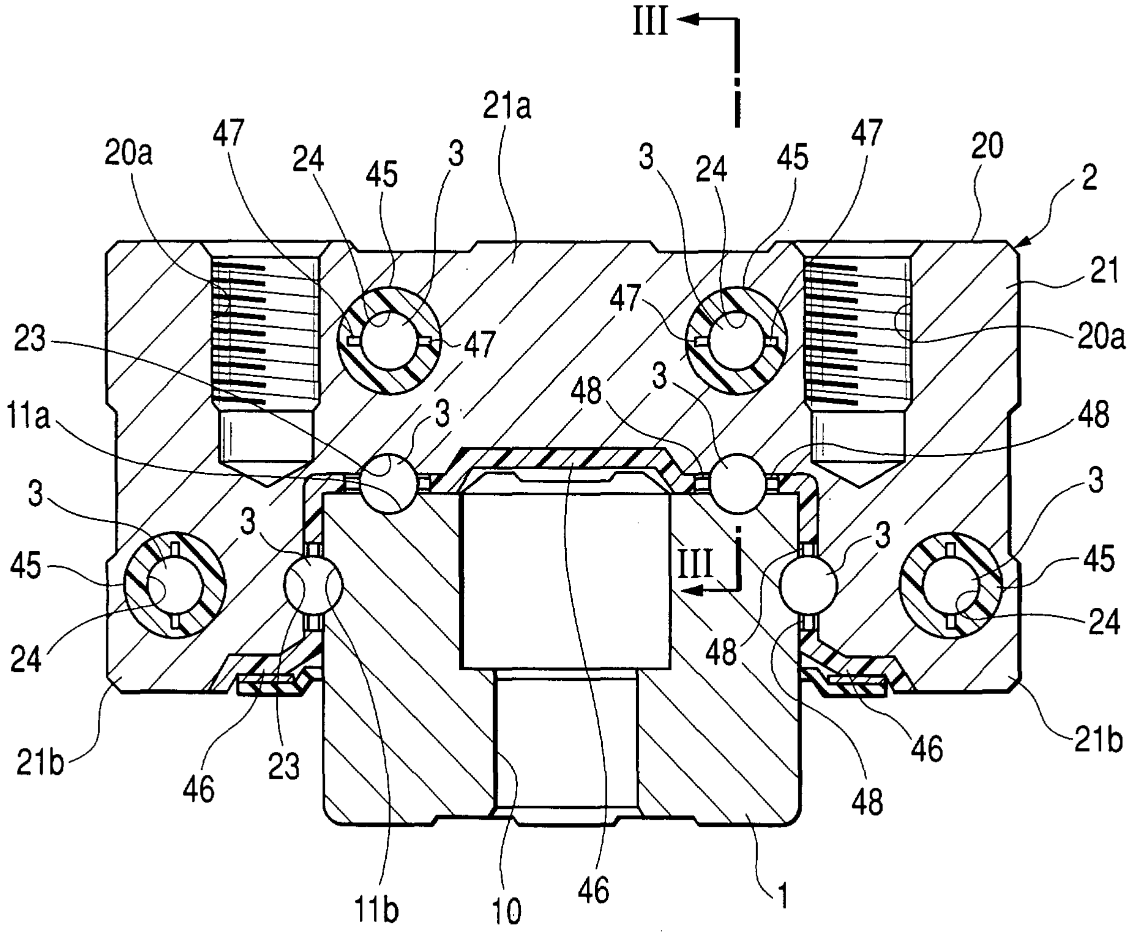
- Leerseite -

FIG. 1



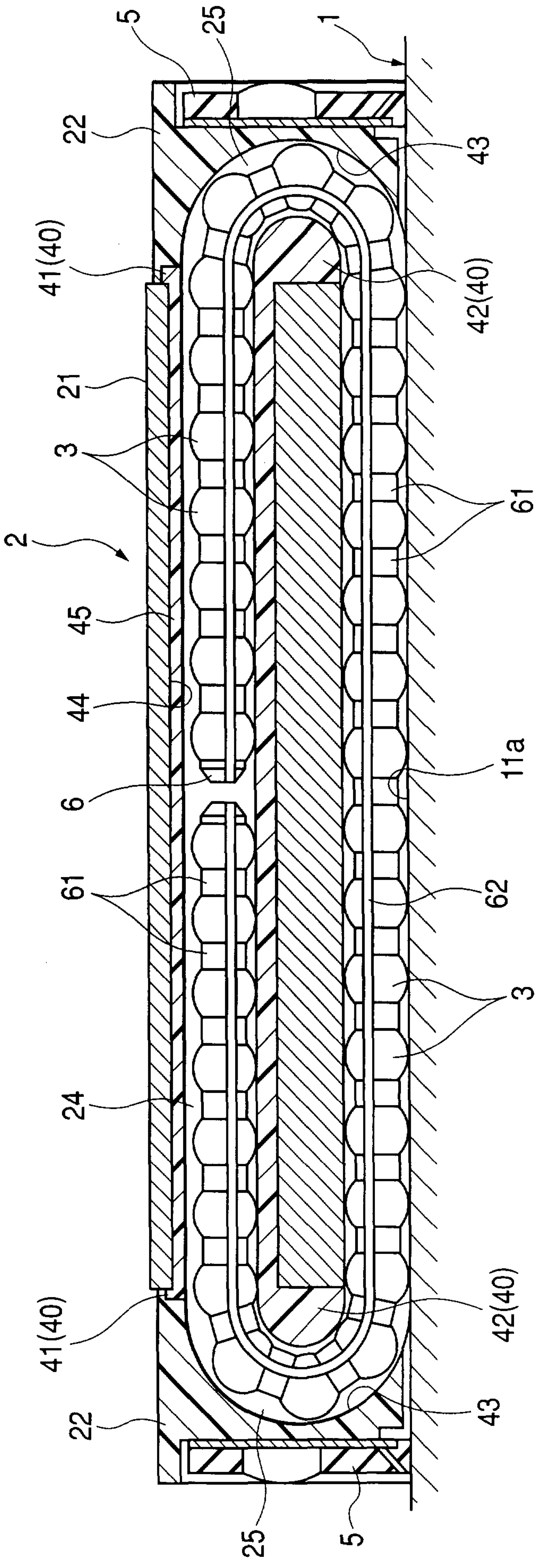
Nummer: DE 101 56 339 A1
Int. Cl.[7]: F 16 C 29/06
Offenlegungstag: 23. Mai 2002

FIG. 2



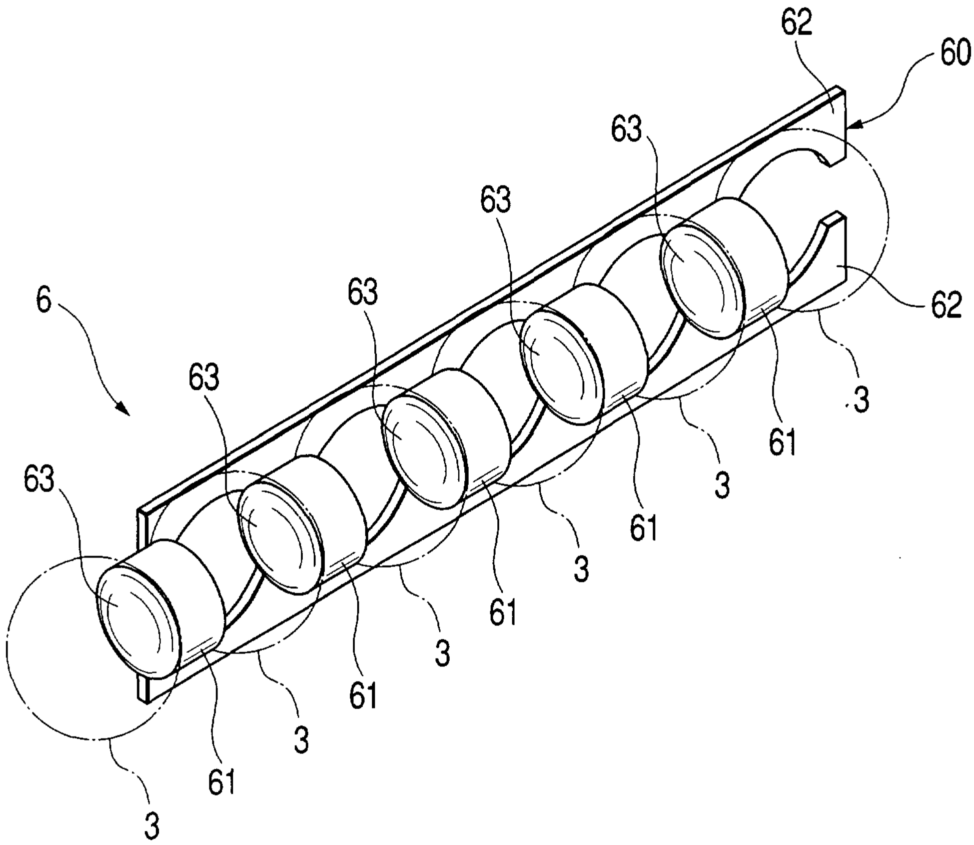
Nummer: **DE 101 56 339 A1**
Int. Cl.⁷: **F 16 C 29/06**
Offenlegungstag: 23. Mai 2002

FIG. 3



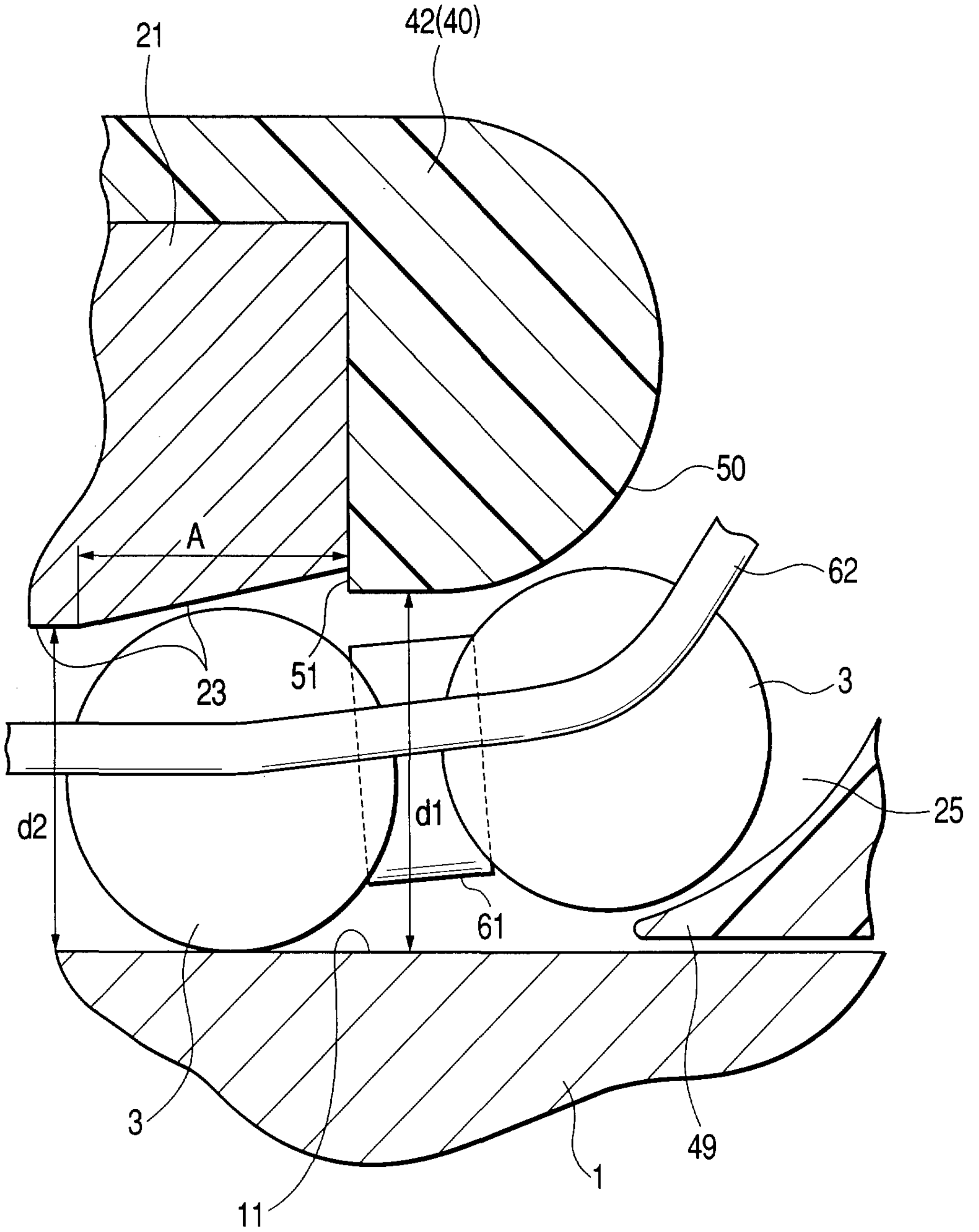
Nummer: **DE 101 56 339 A1**
Int. Cl.[7]: **F 16 C 29/06**
Offenlegungstag: 23. Mai 2002

FIG. 4



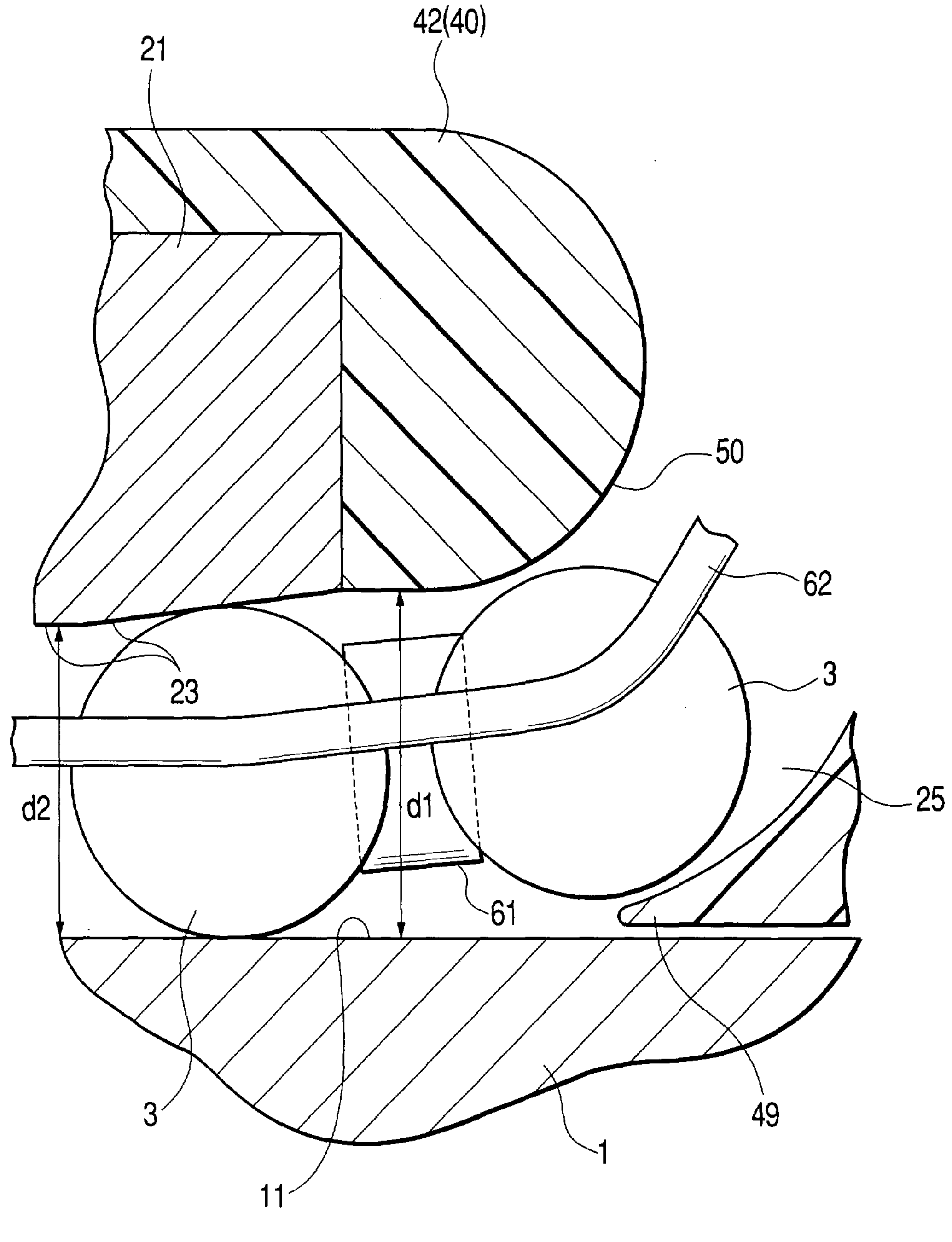
Nummer: DE 101 56 339 A1
Int. Cl.[7]: F 16 C 29/06
Offenlegungstag: 23. Mai 2002

FIG. 5



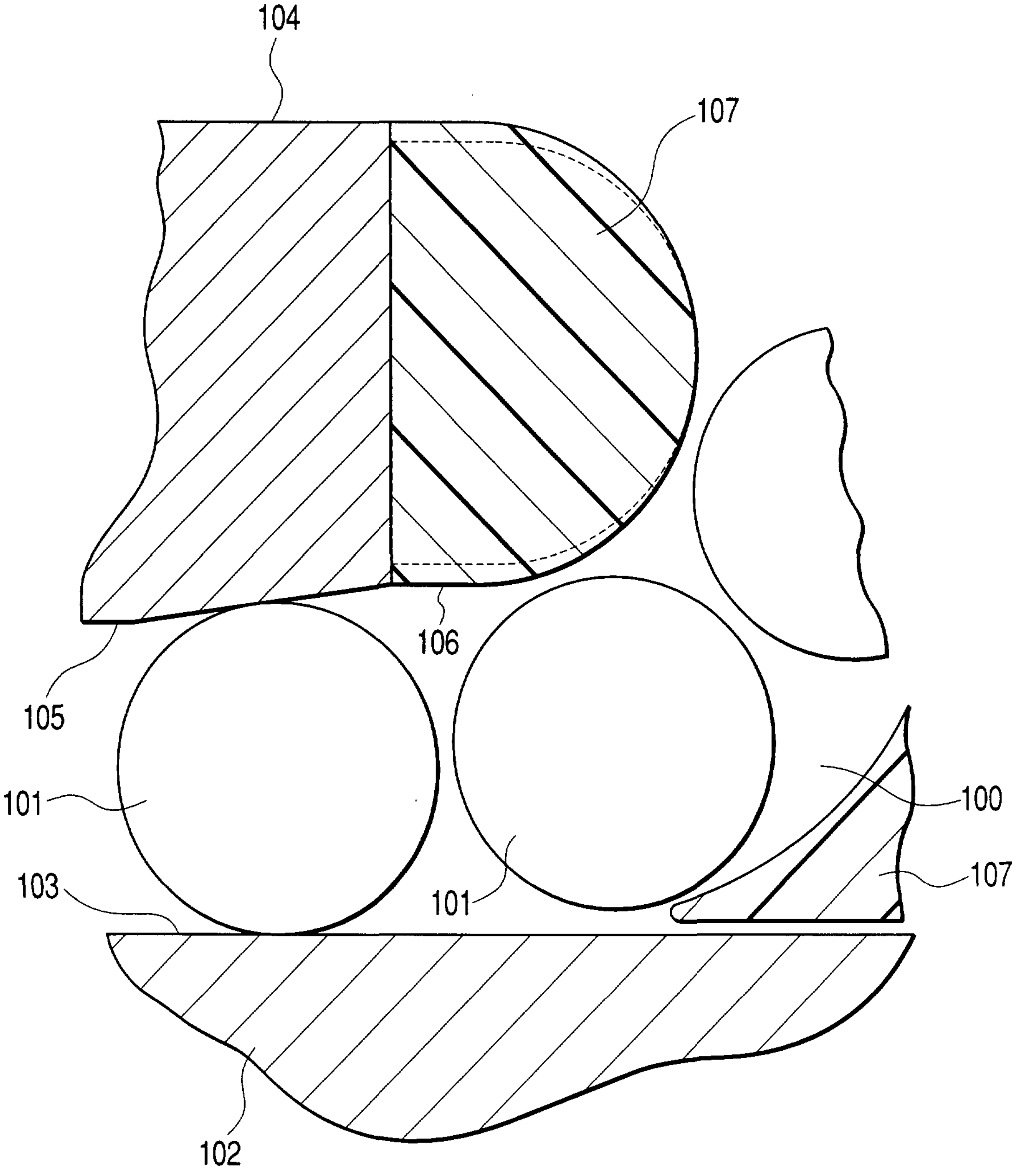
Nummer: DE 101 56 339 A1
Int. Cl.[7]: F 16 C 29/06
Offenlegungstag: 23. Mai 2002

FIG. 6



Nummer: DE 101 56 339 A1
Int. Cl.[7]: F 16 C 29/06
Offenlegungstag: 23. Mai 2002

FIG. 7



(19) **BUNDESREPUBLIK DEUTSCHLAND**

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 101 44 917 A 1**

(51) Int. Cl.[7]:
F 16 C 29/06

(21) Aktenzeichen: 101 44 917.8
(22) Anmeldetag: 12. 9. 2001
(43) Offenlegungstag: 18. 4. 2002

(30) Unionspriorität:
2000-282259 18. 09. 2000 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

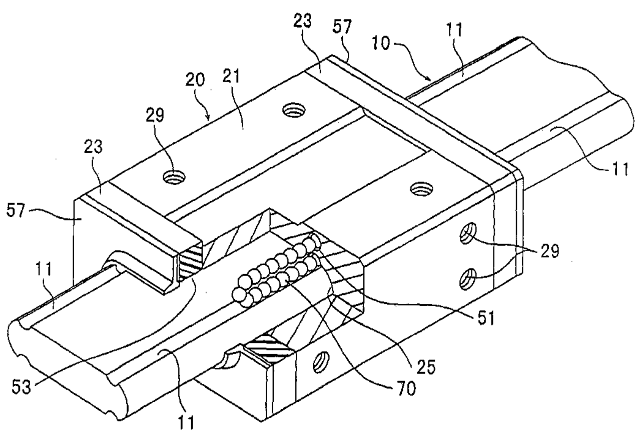
(74) Vertreter:
Tiedtke, Bühling, Kinne & Partner, 80336 München

(72) Erfinder:
Teramachi, Akihiro, Tokio, JP; Uesugi, Masakazu, Tokio, JP; Shirai, Takeki, Tokio, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Rollführungsvorrichtung und Herstellungsverfahren für diese sowie Antriebsvorrichtung mit der Rollführungsvorrichtung

(57) Es ist eine Schiene 10 vorgesehen, an der eine Rollelementrollfläche 11 entlang der längsgerichteten Richtung ausgebildet ist, ein Block 20, an dem eine Lastrollelementrollfläche 27 an einer Öffnung 25 mit einem Durchgangsloch ausgebildet ist, eine Vielzahl von Kugeln 70 zwischen der Rollelementrollfläche 11 und der Lastrollelementrollfläche 27 angeordnet und eingefasst ist, die gemäß der relativen Bewegung der Schiene 10 und 11 des Blocks 20 zirkulieren. Eine Schnittgestalt an rechten Winkeln zu der längsgerichteten Richtung der Schiene 10 und eine Schnittgestalt der Öffnung 25 sind in einer wechselseitig geometrisch ähnlichen längsgerichteten Gestalt ausgebildet. Der Block 20 ist eine Kastenbauart mit einer hohen Steifigkeit. Ein Berührwinkel der Kugel 70 kann durch Ändern der Position einzig der Rollelementrollfläche 11 und der Lastrollelementrollfläche 27 geändert werden, die an einer Bauart des Blocks 20 und der Schiene 10 bearbeitet werden sollen.



DE 101 44 917 A 1

DE 101 44 917 A 1

Beschreibung

[0001] Die vorliegende Erfindung betrifft eine Rollführungsvorrichtung, bei der ein Block und eine Schiene relativ linear im Eingriff miteinander über Reihen von endlos zirkulierenden Rollelementen bewegbar sind, deren Herstellungsverfahren und eine Antriebsvorrichtung mit der Rollführungsvorrichtung.

[0002] Bisher war eine Rollführungsvorrichtung bekannt, bei der ein Block und eine Schiene linear bewegbar im Eingriff miteinander über ein Vielzahl von Rollelementen mit endlos zirkulierenden Kugeln und Rollen sind. Wie in **Fig.** 8 gezeigt ist, hat die Rollführungsvorrichtung genauer gesagt eine Schiene **80**, einen Block **90** mit einem Einschnitt **93**, der an einer unteren Fläche davon ausgebildet ist, an die die Schiene **80** passt, und eine Anzahl von Rollelementen **100**, die zwischengesetzt sind, um eine Reihe zwischen einer Rollelementrollfläche **81** und der Schiene **80** auszubilden, und eine Lastrollelementrollfläche **91** des Blocks **90**.

[0003] Hier ist der Block **90** mit Rollelementauslasslöchern **94** versehen, durch die die Rollelemente **100**, die zwischen jedem Paar der Rollelementrollfläche **81** und der Lastrollelementrollfläche **91** hindurchgetreten sind, ausgelassen werden und zu einer Ursprungsposition erneut zurückgeführt werden, um einen endlosen Zirkulationsdurchgang der Rollelemente **100** auszubilden.

[0004] Wenn des weiteren der Block **90** linear relativ entlang der Schiene **80** belegt wird, werden die Rollelemente **100** linear bewegt, während sie zwischen der Rollelementrollfläche **81** und der Lastrollelementrollfläche **91** rollen, treten zwischen der Rollelementrollfläche **81** und der Lastrollelementrollfläche **91** hindurch, werden zu dem Rollelementauslassloch **94** durch einen Rückführdurchgang zurückgeführt, der an einer nicht gezeigten Endplatte vorgesehen ist, und dann wieder zwischen der Rollelementrollfläche **81** und der Lastelementrollfläche **91** zugeführt. Für den Fall jedoch, dass der Block **90** feststehend ist und die Schiene **80** bei der vorstehend genannten Rollführungsvorrichtung bewegt wird und wenn ein schweres Stück an einem Schienenspitzenabschnitt der nach vorn gerichteten Seite der Schiene **80** in **Fig.** 8 installiert wird und ein Lastmoment darauf aufgebracht wird, trägt die Last zu einer ungleichmäßigen Verformung an dem Block **90** bei, so dass ein Verformungsbetrag (ein Öffnungsbetrag des Einschnitts **93**) an der nach vorn gerichteten Seite und der nach hinten gerichteten Seite des Blocks **90** in **Fig.** 8 variiert wird, was zu einem Problem dahingehend führt, dass die Positionsgenauigkeit der Schiene **80** verschlechtert wird.

[0005] Um dieses Problem zu lösen, kann anstelle des Einschnitts **93** ein Durchgangsloch an der Mitte des Blocks **90** vorgesehen werden, um die Schiene **80** durch das Innere des Durchgangslochs hindurchzuführen. Im Falle dieses Aufbaus wird auch für den Fall, dass eine ungleichmäßige Last auf eine Seite der Schiene **80** aufgebracht wird und das Lastmoment erzeugt wird, der Einschnitt **93** nicht geöffnet werden, so dass die Schiene **80** ständig sicher gehalten werden kann.

[0006] Sogar bei der Rollführungsvorrichtung jedoch, die so aufgebaut ist, ist es erforderlich, dass Bearbeitungspositionen der gegenüberliegenden Rollelementrollfläche **81** und der Lastrollelementrollfläche **91** auf verschiedene Positionen (verschiedene Berührwinkelpositionen) gemäß dem Verwendungszweck geändert werden, und daher muss die Gestalt einer Öffnung **25** des Blocks **90** und die äußere Gestalt der Schiene **80** ebenso gemäß der vorstehend genannten Änderung geändert werden, wobei sich dadurch ein kompliziertes Problem ergibt.

[0007] Daher ist es eine Aufgabe der vorliegenden Erfindung, eine Rollführungsvorrichtung zu schaffen, bei der auch dann, wenn ein großes Moment auf eine Schiene aufgebracht wird, ein Block nicht verformt wird, und auch wenn Bearbeitungspositionen einer Rollelementrollfläche **81** und einer Lastrollelementrollfläche **91** gleichzeitig geändert werden, es nicht erforderlich ist, die Gestalt des Blocks und der Schiene selbst zu ändern, ein Herstellungsverfahren davon und eine Antriebsvorrichtung mit der Rollführungsvorrichtung zu schaffen.

[0008] Ein erster Gesichtspunkt der vorliegenden Erfindung ist auf eine Rollführungsvorrichtung gerichtet, die eine Schiene hat, bei der eine Rollelementrollfläche entlang ihrer längsgerichteten Richtung ausgebildet ist, einen Block, bei dem eine Öffnung mit einem Durchgangsloch ausgebildet ist, wobei die Schiene an diese Öffnung angepasst ist, und ein Rollelementzirkulationsdurchgang mit einer Lastrollelementrollfläche entsprechend der Rollelementrollfläche der Schiene ausgebildet ist, und einer Vielzahl von Rollelementen, die in dem Rollelementzirkulationsdurchgang angeordnet und eingefasst sind und gemäß der relativen Bewegung der Schiene und des Blocks zirkulieren, wobei eine Schnittgestalt an rechten Winkeln zu der längsgerichteten Richtung der Schiene und eine Schnittgestalt der Öffnung des Blocks in wechselseitig geometrisch ähnlicher Längsgestalt ausgebildet sind. Auf diese Weise ist die Öffnung des Blocks zu einem Durchgangsloch ausgebildet, und daher ist der Block eine Kastenbauart einer hohen Steifigkeit, der nicht verformt wird, so dass es möglich ist, eine befriedigende Positionsgenauigkeit der Schiene ausreichend aufrechtzuerhalten, auch wenn ein großes Moment darauf aufgebracht wird. Außerdem wird es gemäß der vorliegenden Erfindung durch geeignetes Ändern der Bearbeitungspositionen einzig der Rollelementrollfläche und der Lastrollelementrollfläche möglich, einen Berührwinkel der Rollelemente durch eine Bauart eines Blocks und einer Schiene optional zu ändern. Daher ist es auch für den Fall, dass der Zweck der Verwendung und die Bedingung der Verwendung durch den Anwender verschieden sind, möglich, diese Situationen zu bewältigen, wobei dadurch die Herstellung der Rollführungsvorrichtung einfach und bei niedrigen Kosten ermöglicht wird.

[0009] Ein zweiter Gesichtspunkt der vorliegenden Erfindung ist auf die Rollführungsvorrichtung gerichtet, bei der die Schnittgestalt bei rechten Winkeln zu der längsgerichteten Richtung der Schiene und die Schnittgestalt der Öffnung des Blocks wechselweise in einer gekrümmten Linie bezüglich eines Teils ausgebildet sind, an dem die Rollelementrollfläche und die Lastelementrollfläche ausgebildet sind. Auf diese Weise ist es durch Ausbilden des Teils von beiden Schnittgestalten in eine gekrümmte Linie möglich, den Berührwinkel einfach durch Ändern der Positionen der Rollelementrollfläche und der Lastrollelementrollfläche zu ändern, wie vorstehend beschrieben ist.

[0010] Darüber hinaus ist es ein dritter Gesichtspunkt der vorliegenden Erfindung bei der Rollführungsvorrichtung, einen Aufbau zu schaffen, bei dem die gekrümmte Linie ein Teil einer runden Gestalt ist. Wenn die gekrümmte Linie eine runde Gestalt ist, wird die Beziehung zwischen der Position und dem Berührwinkel der vorstehend genannten Rollelementrollfläche und der Lastrollelementrollfläche am wichtigsten, da die Position von jeder Rollfläche mit einer hohen Genauigkeit geändert werden kann, wobei es damit möglich wird, den Berührwinkel mit einer hohen Genauigkeit zu ändern und festzusetzen.

[0011] Ein vierter Gesichtspunkt der vorliegenden Erfindung ist auf die Rollführungsvorrichtung gerichtet, bei der die gekrümmte Linie ein Teil einer Ellipse ist. Wenn die gekrümmte Linie eine Ellipse ist, ist die Beziehung der vorstehend genannten Rollelementrollfläche und der Lastrollelementrollfläche zu dem Berührwinkel nicht einfach, wie für den Fall der vorstehend genannten runden Gestalt, wobei es somit möglich ist, den Berührwinkel in Proportion zu der runden Gestalt einfach zu ändern.

[0012] Darüber hinaus ist ein fünfter Gesichtspunkt der vorliegenden Erfindung auf ein Herstellungsverfahren einer Rollführungsvorrichtung gerichtet, die einen Prozess des Ausbildens einer Rollelementrollfläche an einer Schiene entlang der längsgerichteten Richtung, einen Prozess des Ausbildens eines Rollelementzirkulationsdurchgangs mit einer Lastrollelementrollfläche entsprechend der Rollelementrollfläche der Schiene an einem Block, an dem eine Öffnung mit einem Durchgangsloch bearbeitet wird und einem Prozess des Einsetzens der Schiene in die Öffnung des Blocks und Anordnen sowie Einfassen einer Vielzahl von Rollelementen in den Rollelementzirkulationsdurchgang, die gemäß der relativen Bewegung der Schiene und des Blocks zirkulieren, wobei eine Schnittgestalt an rechten Winkeln zu der längsgerichteten Richtung der Schiene und eine Schnittgestalt der Öffnung des Blocks im voraus in eine wechselseitig geometrisch ähnliche längsgerichtete Gestalt bearbeitet werden, und wobei Bearbeitungspositionen von sowohl der Lastrollelementrollfläche des Blocks und der Rollelementrollfläche der Schiene geeignet geändert werden, wodurch der Berührwinkel der Rollelemente zu dem Block und der Schiene optional geändert wird.

[0013] Darüber hinaus ist ein sechster Gesichtspunkt der vorliegenden Erfindung auf eine Antriebsvorrichtung mit einer Rollführungsvorrichtung gerichtet, die eine Schiene hat, an der eine Rollelementrollfläche entlang der längsgerichteten Richtung ausgebildet ist; einem Block, an dem eine Öffnung mit einem Durchgangsloch ausgebildet ist, wobei die Schiene an diese Öffnung passt und ein Rollelementzirkulationsdurchgang einschließlich einer Lastrollelementrollfläche entsprechend der Rollelementrollfläche der Schiene ausgebildet ist; und einer Vielzahl von Rollelementen, die in dem Rollelementzirkulationsdurchgang angeordnet sowie eingefasst sind und die gemäß der relativen Bewegung der Schiene und des Blocks zirkulieren; wobei eine Schnittgestalt an rechten Winkeln zu der längsgerichteten Richtung der Schiene und eine Schnittgestalt der Öffnung des Blocks in eine wechselseitig geometrisch ähnliche längsgerichtete Gestalt ausgebildet sind, und ein Linearmotor mit einer Sekundärseite, die an den beiden Hauptseiten der Schiene angeordnet ist, und einer Primärseite, die an der Öffnung des Blocks entsprechend dieser Sekundärseite angeordnet ist, angeordnet ist.

[0014] **Fig.** 1 ist eine perspektivische schematische Teilschnittansicht einer Rollführungsvorrichtung gemäß einem Ausführungsbeispiel der vorliegenden Erfindung.

[0015] **Fig.** 2 zeigt eine Rollführungsvorrichtung gemäß einem Ausführungsbeispiel der vorliegenden Erfindung, und **Fig.** 2(a) ist eine schematische Querschnittsseitenansicht und **Fig.** 2(b) ist eine Draufsicht.

[0016] **Fig.** 3 ist eine Querschnittsansicht einer Rollführungsvorrichtung gemäß einem Ausführungsbeispiel der vorliegenden Erfindung.

[0017] **Fig.** 4 ist eine Querschnittsansicht einer Rollführungsvorrichtung, bei der Bearbeitungspositionen einzig von einer Rollelementrollfläche **11** und einer Lastrollelementrollfläche **27** geändert werden.

[0018] **Fig.** 5 ist eine Querschnittsansicht der Rollführungsvorrichtung, bei der Bearbeitungspositionen einzig von der Rollelementrollfläche **11** und der Lastrollelementrollfläche **27** geändert werden.

[0019] **Fig.** 6 ist eine Querschnittsansicht, die eine Antriebsvorrichtung gemäß der vorliegenden Erfindung zeigt.

[0020] **Fig.** 7 ist eine Querschnittsansicht, die eine andere Antriebsvorrichtung gemäß der vorliegenden Erfindung zeigt.

[0021] **Fig.** 8 ist eine Querschnittsansicht, die eine herkömmliche Rollführungsvorrichtung zeigt.

[0022] Im Folgenden werden Ausführungsbeispiele der vorliegenden Erfindung genau unter Bezugnahme auf die Zeichnungen beschrieben.

[0023] **Fig.** 1 bis **Fig.** 3 zeigen eine Rollführungsvorrichtung gemäß einem Ausführungsbeispiel der vorliegenden Erfindung, wobei **Fig.** 1 eine teilweise geschnittene perspektivische Ansicht ist, **Fig.** 2(a) eine schematische Seitenschnittansicht ist, **Fig.** 2(b) eine Draufsicht ist, und **Fig.** 3 eine Querschnittsansicht ist. Wie in diesen Zeichnungen gezeigt ist, ist die Rollführungsvorrichtung aus einer Schiene **10**, einem Block **20** und einer Kugel (Rollelement) **70** aufgebaut.

[0024] Ein Querschnitt der Schiene **10** ist eine längsgerichtete Gestalt, und obere und untere Flächen sind genauer gesagt im Wesentlichen parallele Ebenen, bei denen beide Seiten in einer im Wesentlichen elliptischen Gestalt ausgebildet sind, die mit einer bogenförmigen Gestalt vorstehen. Darüber hinaus sind oben und unten an der Schiene **10** zwei vertiefungsähnliche Rollelementrollflächen **11** rechts und links ausgebildet und daher sind vier vertiefungsähnliche Rollelementrollflächen **11** insgesamt ausgebildet.

[0025] Der Block **20** hat einen Blockkörper **21** und Endplatten **23**, die an beiden Endseiten des Blockkörpers **21** eingebaut sind. Der Blockkörper **21** ist mit einer Öffnung **25** versehen, in die die Schiene **10** eingesetzt ist, und an oberen und unteren Flächen dieser Öffnung **25** sind vier vertiefungsähnliche Lastrollelementrollflächen **27** entsprechend den jeweiligen Rollelementrollflächen **11** der Schiene **10** ausgebildet. Zwischen jeder der wechselseitig gegenüberliegenden Rollelementflächen **11** und der Lastrollelementrollfläche **27** ist eine Vielzahl von Kugeln (Rollelemente) **70**, . . . bewegbar zwischengesetzt.

[0026] Die Öffnung **25** ist ein Durchgangsloch und ihr Querschnitt ist eine längsgerichtete Gestalt, und genauer gesagt sind obere und untere Flächen im Wesentlichen parallele Ebenen, an denen beide Seiten in einer im Wesentlichen elliptischen Gestalt ausgebildet sind, die wie eine bogenförmige Gestalt vorstehen. Das heißt, dass eine Schnittgestalt an rechten Winkeln zu der längsgerichteten Richtung der Schiene **10** und eine Schnittgestalt der Öffnung **25** in einer wechselseitig geometrisch ähnlichen längsgerichteten Gestalt ausgebildet sind, für den Fall dieses Ausführungsbeispiels eine elliptische Gestalt. Daher sind die äußere Umfangsfläche der Schiene **10** und die innere Umfangsfläche der Öffnung **25** parallel und Zwischenraumabmessungen von beiden Flächen sind ungefähr die gleichen an jedem Teil.

[0027] An dem Blockkörper **21** sind zwei Rollelementauslasslöcher **51** zum Auslassen der Kugeln bei einem Lastbereich entsprechend den jeweiligen Lastrollelementrollflächen **27** oben beziehungsweise unten von der Öffnung **25** ausgebildet, und daher sind vier Löcher **51** insgesamt ausgebildet. Andererseits sind an oberen und unteren Flächen und an beiden Seiten des Blocks **21** Schraubenlöcher **29** zum Befestigen dieses Blockkörpers **21** mit anderen Elementen vorgesehen.

[0028] Die Endplatte **23** ist aus einem rechteckigen Element gebildet, das ungefähr die gleiche Gestalt hat wie die Endfläche des Blockkörpers **21**. An seiner Mitte ist eine Öffnung **53** zum Hindurchführen der Schiene **10** und ein Rückführdurchgang **55** zum Vorwärtsleiten der Kugeln **70**, die zwischen dem Blockkörper **21** und der Schiene **10** zwischengesetzt sind, in ein Rollelementauslassloch **51** in dem

Lastbereich zum erneuten Rückführen der Kugeln zu dem Lastbereich vorhanden. Außerdem ist an der äußeren Endseite der Endplatte **23** ein Abdichtungselement **57** vorgesehen, um zu verhindern, dass Schmutz in das Innere eintritt und um zu verhindern, dass Schmiermittel nach außen austritt.

[0029] Des weiteren ist ein Rollelementzirkulationsdurchgang durch die Lastrollelementrollfläche **27** entsprechend der Rollelementrollfläche **11** der Schiene **10**, das Rollelementauslassloch **51** und den Rückführdurchgang **55** definiert.

[0030] Als ein Verfahren zum Herstellen der Lastrollelementrollfläche **27** an dem Block **20** kann beispielsweise ein Verfahren verwendet werden, bei dem die Öffnung **25** an dem Block **20** durch Drahtschneiden (Erodieren) und dergleichen perforiert wird und eine Vertiefung dann an der inneren Fläche davon lediglich durch Schleifen ausgebildet wird, um die Lastrollelementrollfläche **27** zu bearbeiten.

[0031] Wenn die Schiene **10** dann linear in ihrer längsgerichteten Richtung zu dem Block **20** bewegt wird, bewegt sich die Schiene **10** sanft, wenn die Kugel **70** zwischen der Rollelementrollfläche **11** der Schiene **10** und der Lastrollelementrollfläche **27** des Blocks **20** sich bewegt, während es rollt.

[0032] Da bei der vorliegenden Erfindung die Öffnung **25** an dem Block **20** vorgesehen ist und die Schiene durch das Innere davon geleitet ist, wie beispielsweise in **Fig.** 2(a) gezeigt ist, ist der Block **20** an einem Befestigungsseitenelement **25** befestigt, auch wenn andererseits ein Bewegungsseitenelement **77** an dem Spitzenabschnitt der Schiene **10** befestigt ist und ein Lastmoment auf die Schiene aufgebracht wird, tritt ein Problem, bei dem die Öffnung **25** geöffnet und verformt wird, nicht auf und die Schiene **10** bewegt sich ständig sanft zu der gleichen Position wie für den Fall, bei dem das Bewegungsseitenelement **77** nicht verwendet wird, so dass es möglich ist, eine befriedigende Positionsgenauigkeit des Bewegungsseitenelements **77** ständig zu erhalten.

[0033] Da andererseits bei der vorliegenden Erfindung, wie vorstehend beschrieben ist, die Schnittgestalt an rechten Winkeln zu der längsgerichteten Richtung der Schiene **10** und die Schnittgestalt der Öffnung **25** in eine wechselseitig geometrisch ähnliche Ellipse ausgebildet sind, das heißt eine längsgerichtete Gestalt, ist die Zwischenraumabmessung der äußeren Umfangsfläche der Schiene **10** und der inneren Umfangsfläche der Öffnung **25** an jedem Teil ungefähr gleich. Wie in **Fig.** 4 und **Fig.** 5 gezeigt ist, können daher auch dann, wenn die gleiche Schiene und der gleiche Block wie die Schiene **10** und der Block **20** verwendet werden, die Bearbeitungspositionen der Rollelementrollfläche **11** und der Lastrollelementrollfläche **27** zu verschiedenen Positionen (verschiedenen Positionen eines Berührwinkels θ) gemäß dem Verwendungszweck geändert werden. Eine Vertiefungsbearbeitung der Rollelementrollfläche **11** und der Lastelementrollfläche **27** ist einfach, da sie lediglich durch Schleifen erzielt werden kann. Das heißt, dass gemäß dem Verwendungszweck durch Ändern der Bearbeitungspositionen von sowohl der Rollelementrollfläche **11** als auch der Lastelementrollfläche **27** auf eine geeignete Weise es ermöglicht wird, den Berührwinkel θ (θ1, θ2) der Kugel **70**, der Schiene **10** und des Blocks **20** optional zu ändern.

[0034] Jedoch sind bei dem vorliegenden Ausführungsbeispiel die rechtwinklige Schnittgestalt zu der längsgerichteten Richtung der Schiene **10** und die Schnittgestalt der Öffnung **25** des Blocks **20** wechselseitig in eine bogenförmige Gestalt ausgebildet, das heißt eine gekrümmte Linie bezüglich eines Teils, an dem die Rollelementrollfläche **11** und die Lastrollelementrollfläche **27** ausgebildet sind.

[0035] Auf diese Weise ist es durch Ausbilden des Teils von beiden Schnittgestalten in eine gekrümmte Linie möglich, den Berührwinkel einfach durch Ändern der Positionen der Rollelementrollfläche **11** und der Lastelementrollfläche **27** zu ändern, wie vorstehend beschrieben ist. Außerdem sind beide oder einer von dem Teil der Schienenschnittgestalt und der Blockschnittgestalt einer geraden Linie, wobei Ändern des Berührwinkels nicht immer einfach ist.

[0036] Bei dem vorliegenden Ausführungsbeispiel ist die vorstehend genannte gekrümmte Linie eine bogenförmige Gestalt, das heißt ein Teil einer runden Gestalt. Wenn die gekrümmte Linie eine runde Gestalt ist, wird die Beziehung der Position und des Berührwinkels der vorstehend genannten Rollelementrollfläche **11** und der Lastrollelementrollfläche **27** am wichtigsten, da die Position jeder Rollfläche in hohem Maße genau geändert werden kann, wobei es auch möglich ist, den Berührwinkel mit einer hohen Genauigkeit zu ändern und festzusetzen.

[0037] Außerdem kann die vorstehend genannte gekrümmte Linie ein Teil einer elliptischen Gestalt sein. Für den Fall einer Ellipse ist jedoch die Beziehung der vorstehend genannten Rollelementrollfläche **11** und der Lastrollelementrollfläche **27** zu dem Berührwinkel nicht so einfach wie für den Fall der vorstehend genannten runden Gestalt, wobei es somit möglich ist, den Berührwinkel in Proportion zu der runden Gestalt zu ändern.

[0038] **Fig.** 6 ist eine quergerichtete Schnittansicht, die eine Antriebsvorrichtung gemäß der vorliegenden Erfindung zeigt. Diese Antriebsvorrichtung ist so aufgebaut, dass Magneten (Sekundärseite (Sekundärkonduktor)) **60**, **60** eingebaut sind, um jeweils an oberen und unteren Flächen (prinzipiell an beiden Flächen) der Schiene **10** der Rollführungsvorrichtung desselben Aufbaus eingebettet zu sein, der in **Fig.** 4 gezeigt ist, und andererseits sind Elektromagneten (Primärseite (Stator)) **61**, **61** eingebaut, um an oberen und unteren Flächen des inneren Umfangs der Öffnung **25** des Blocks **20** eingebettet zu sein. Ein Linearmotor, der durch ein Paar aus einem Magneten **60** und einem Magneten **61** der oberen Seite ausgebildet ist, und ein Linearmotor, der durch ein Paar aus einem Magneten **60** und einem Magneten **61** der unteren Seite ausgebildet ist, sind an einer Position vorgesehen, die vertikal zu der Mitte der Schiene **10** symmetrisch ist. Als Linearmotor können Motoren von verschiedenem Aufbau, wie zum Beispiel ein linearer Direktstrommotor und ein linearer Impulsmotor, angewendet werden. Durch eine Durchströmung von Strom zu den Elektromagneten **61**, **61** wird die Schiene **10** angetrieben, um sich zu dem Block **20** vorzuschieben und zurückzuziehen.

[0039] Da bei diesem Ausführungsbeispiel die Schiene **10** durch die Öffnung **25**, die an dem Block **20** vorgesehen ist, abgedeckt ist, ist es möglich, eine Position zum Einbauen des Magneten **60** und des Elektromagneten **16** nicht nur an der Seite der oberen Fläche einzubauen, sondern auch an der Seite der unteren Fläche, das heißt an prinzipiell beiden Seiten der Schiene **10**. Daher ist es möglich, eine Verformung eines Strukturelements in radiale Richtung aufgrund der Magnetanziehung zu beschränken, so dass eine Drucklast durch Raumeinsparung aufgrund der Verwendung von zwei Paaren von Motoren erhöht wird.

[0040] **Fig.** 7 zeigt ein Ausführungsbeispiel, bei dem die Magneten **60**, **60** von der Innenseite und der Außenseite der Schiene **10**, die in **Fig.** 6 gezeigt ist, in einen Magneten integriert sind. Wenn die Befestigung zwischen der Schiene **10** und dem Magnet **60** sicher durch Verklebung oder Verschraubung und dergleichen vorgesehen werden kann, vereinfacht eine derartige Einrichtung den Aufbau und verringert die Kosten.

[0041] Ausführungsbeispiele der vorliegenden Erfindung sind vorstehend beschrieben, aber die vorliegende Erfindung ist nicht auf die vorstehenden Ausführungsbeispiele beschränkt, und verschiedene Abwandlungen sind innerhalb des Anwendungsbereichs der Ansprüche und des Anwendungsbereichs der technischen Idee möglich, die in der Beschreibung und den Zeichnungen angegeben ist. Auch für den Fall von jeder Gestalt oder einer Konstruktion oder einer Qualität eines Materials oder eines Verfahrens einer Verwendung, die nicht direkt in der Beschreibung und den Zeichnungen angegeben sind, liegen sie außerdem innerhalb des Anwendungsbereichs der technischen Idee der vorliegenden Erfindung, solange sie die Funktion und die Wirkung der vorliegenden Erfindung demonstrieren.

[0042] Beispielsweise wird bei den vorstehenden Ausführungsbeispielen der Block **20** als die feststehende Seite und die Schiene **10** als die bewegbare Seite verwendet, wobei der Block **20** umgekehrt als die bewegbare Seite und die Schiene **10** als die feststehende Seite verwendet werden kann.

[0043] Desweiteren sind bei den vorstehenden Ausführungsbeispielen die Schnittgestalt an rechten Winkeln zu der längsgerichteten Richtung der Schiene **10** und die Schnittgestalt der Öffnung **25** des Blocks **20** wechselweise in eine runde Gestalt oder einen Teil einer elliptischen Gestalt ausgebildet, d. h. eine gekrümmte Linie, aber andere gekrümmte Linien sind anwendbar.

[0044] Desweiteren ist bei den vorstehenden Ausführungsbeispielen ein Fall gezeigt, bei dem Kugeln als Rollelemente verwendet werden, aber die vorliegende Erfindung kann auf den Fall angewendet werden, bei dem Rollen bzw. Walzen bei einem ähnlichen Aufbau verwendet werden.

[0045] Somit ist die Schiene **10** vorgesehen, an der die Rollelementrollfläche **11** entlang der längsgerichteten Richtung ausgebildet ist, der Block **20**, an dem die Lastrollelementrollfläche **27** an der Öffnung **25** mit dem Durchgangsloch ausgebildet ist, der Vielzahl von Kugeln **70** zwischen der Rollelementrollfläche **11** und der Lastelementrollfläche **27** angeordnet und eingefasst ist, die gemäß der relativen Bewegung der Schiene **10** und **11** des Blocks **20** zirkulieren. Die zu der längsgerichteten Richtung der Schiene **10** rechtwinklige Schnittgestalt und die Schnittgestalt der Öffnung **25** sind in einer wechselseitig geometrisch ähnlichen längsgerichteten Gestalt ausgebildet. Der Block **20** ist eine Kastenbauart mit hoher Steifigkeit. Ein Berührwinkel der Kugel **70** kann durch Ändern der Position einzig der Rollelementrollfläche **11** und der Lastrollelementrollfläche **27** geändert werden, die an der Bauart des Blocks **20** und der Schiene **10** bearbeitet werden sollen.

Patentansprüche

1. Rollführungsvorrichtung mit:
einer Schiene, an der eine Rollelementrollfläche entlang ihrer längsgerichteten Richtung ausgebildet ist,
einem Block, an dem eine Öffnung mit einem Durchgangsloch ausgebildet ist, wobei die Schiene an diese Öffnung angepasst ist, und ein Rollelementzirkulationsdurchgang mit einer Lastrollelementrollfläche entsprechend der Rollelementrollfläche der Schiene ausgebildet ist, und
einer Vielzahl von Rollelementen, die in dem Rollelementzirkulationsdurchgang angeordnet und eingefasst sind und die gemäß der relativen Bewegung der Schiene und des Blocks zirkulieren, wobei
eine zu der längsgerichteten Richtung der Schiene rechtwinklige Schnittgestalt und eine Schnittgestalt der Öffnung des Blocks in eine wechselseitig geometrisch ähnliche längsgerichtete Gestalt ausgebildet sind.

2. Rollführungsvorrichtung gemäß Anspruch 1, dadurch gekennzeichnet, dass die zu der längsgerichteten Richtung der Schiene senkrechte Schnittgestalt und die Schnittgestalt der Öffnung des Blocks wechselseitig in eine gekrümmte Linie bezüglich eines Teils ausgebildet sind, an dem die Rollelementrollfläche und die Lastrollelementrollfläche ausgebildet sind.

3. Rollführungsvorrichtung gemäß Anspruch 2, dadurch gekennzeichnet, dass die gekrümmte Linie ein Teil einer runden Gestalt ist.

4. Rollführungsvorrichtung gemäß Anspruch 2, dadurch gekennzeichnet, dass die gekrümmte Linie ein Teil einer Ellipse ist.

5. Herstellungsverfahren einer Rollführungsvorrichtung mit:
einem Schritt des Ausbildens einer Rollelementrollfläche an einer Schiene entlang der längsgerichteten Richtung,
einem Schritt des Ausbildens eines Rollelementzirkulationsdurchgangs mit einer Lastrollelementrollfläche entsprechend der Rollelementrollfläche der Schiene an einem Block, an dem eine Öffnung mit einem Durchgangsloch bearbeitet ist, und
einem Schritt des Einsetzens der Schiene in die Öffnung des Blocks und des Anordnens sowie Einfassens einer Vielzahl von Rollelementen in den Rollelementzirkulationsdurchgang, die gemäß der relativen Bewegung der Schiene und des Blocks zirkulieren, wobei
eine zu der längsgerichteten Richtung der Schiene senkrechte Schnittgestalt und eine Schnittgestalt der Öffnung des Blocks im Voraus in einer wechselseitig geometrisch ähnlichen längsgerichteten Gestalt bearbeitet werden und Bearbeitungspositionen von sowohl der Lastrollelementrollfläche des Blocks als auch der Rollelementrollfläche der Schiene geeignet geändert werden, wodurch der Berührwinkel der Rollelemente zu dem Block und der Schiene optional geändert wird.

6. Antriebsvorrichtung mit einer Rollführungsvorrichtung, die Folgendes aufweist:
eine Schiene, an der eine Rollelementrollfläche entlang der längsgerichteten Richtung ausgebildet ist,
einen Block, an dem eine Öffnung mit einem Durchgangsloch ausgebildet ist, wobei die Schiene an diese Öffnung passt, und ein Rollelementzirkulationsdurchgang einschließlich einer Lastrollelementrollfläche entsprechend der Rollelementrollfläche der Schiene ausgebildet ist, und
eine Vielzahl von Rollelementen, die in dem Rollelementzirkulationsdurchgang angeordnet und eingefasst sind und die gemäß der relativen Bewegung der Schiene und des Blocks zirkulieren, wobei
eine zu der längsgerichteten Richtung der Schiene rechtwinklige Schnittgestalt und eine Schnittgestalt der Öffnung des Blocks in eine wechselseitig geometrisch ähnliche längsgerichtete Gestalt ausgebildet sind, und
ein Linearmotor mit einer Sekundärseite, die an beiden Hauptseiten der Schiene angeordnet ist, und einer Primärseite, die an der Öffnung des Blocks entsprechend dieser Sekundärseite angeordnet ist, vorgesehen ist.

Hierzu 8 Seite(n) Zeichnungen

- Leerseite -

Nummer: **DE 101 44 917 A1**
Int. Cl.[7]: **F 16 C 29/06**
Offenlegungstag: 18. April 2002

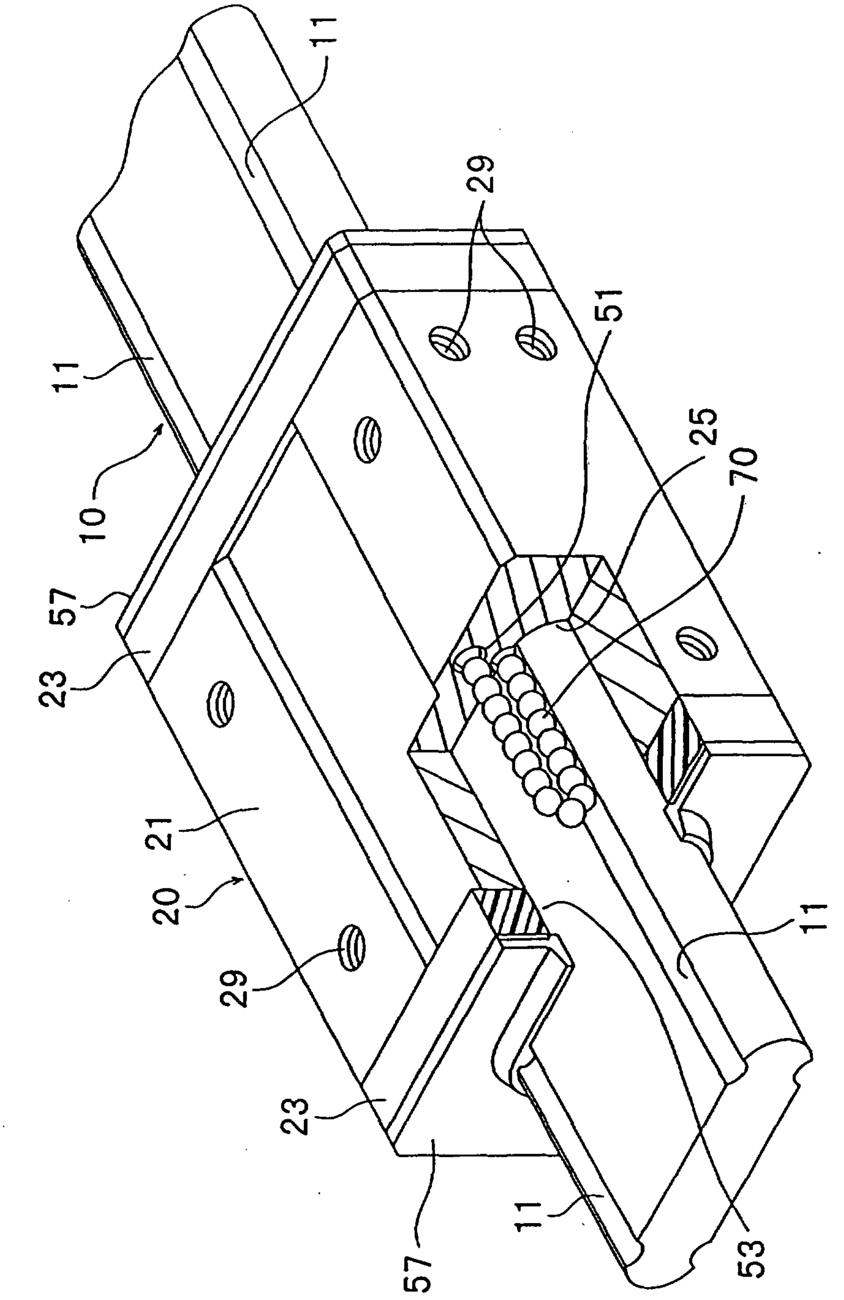


Fig 1

Nummer: DE 101 44 917 A1
Int. Cl.[7]: F 16 C 29/06
Offenlegungstag: 18. April 2002

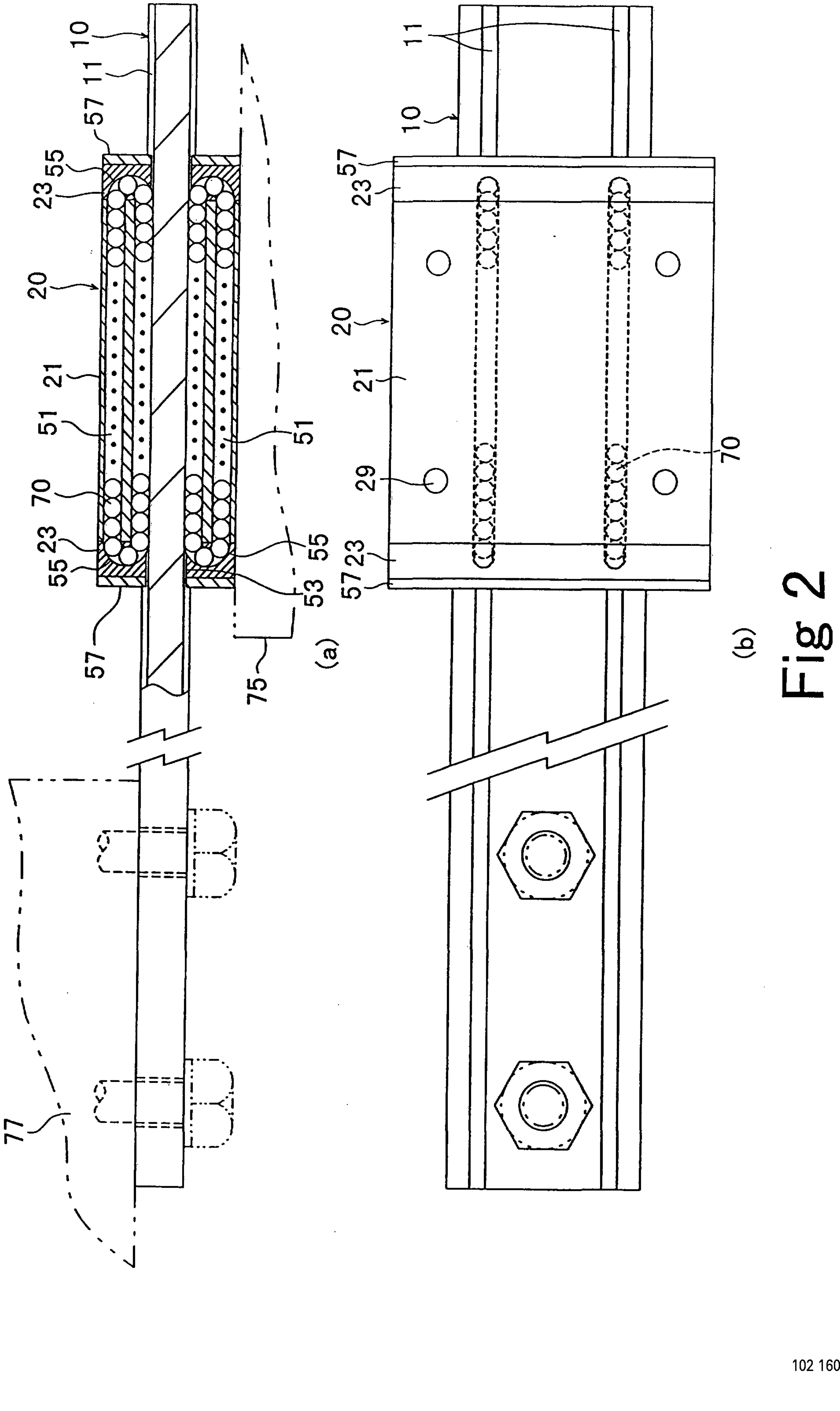


Fig 2

Nummer: **DE 101 44 917 A1**
Int. Cl.^{7}: **F 16 C 29/06**
Offenlegungstag: 18. April 2002

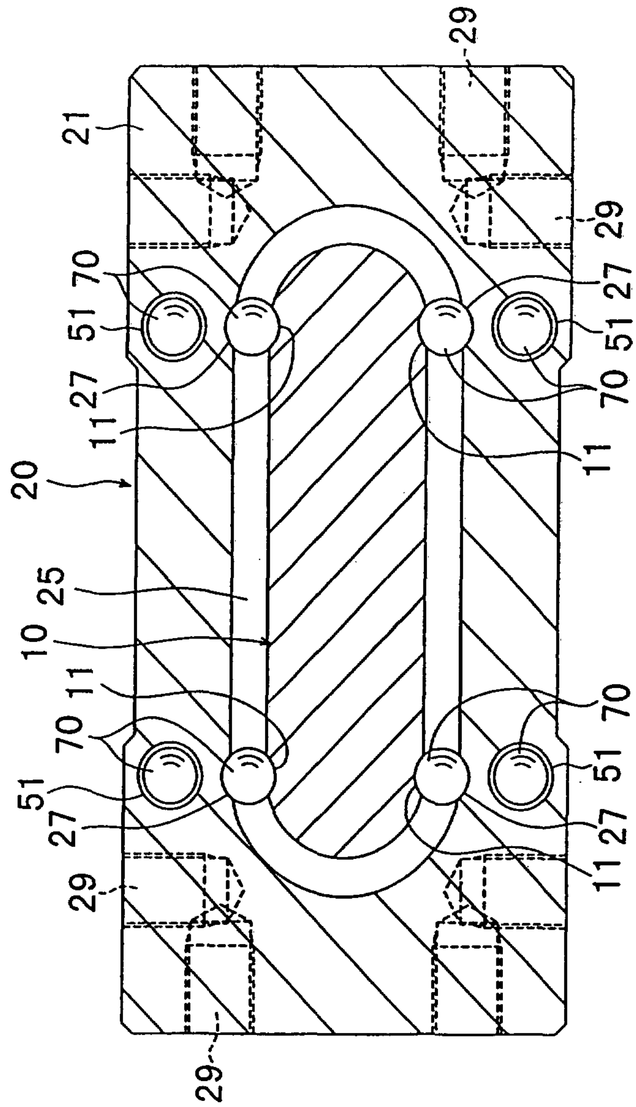


Fig 3

Nummer: DE 101 44 917 A1
Int. Cl.[7]: F 16 C 29/06
Offenlegungstag: 18. April 2002

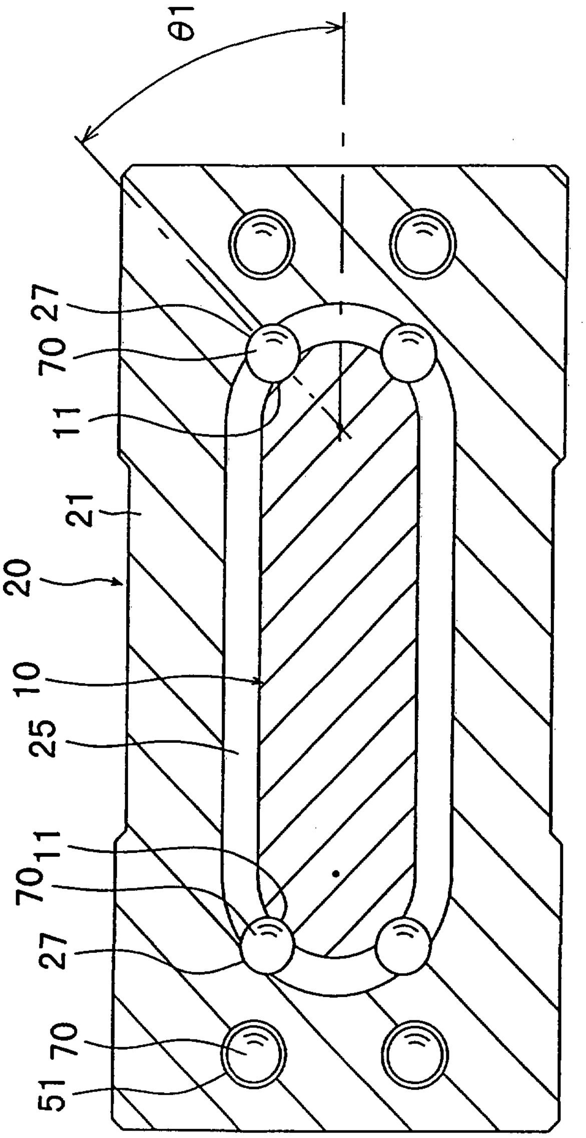


Fig 4

Nummer: **DE 101 44 917 A1**
Int. Cl.[7]: **F 16 C 29/06**
Offenlegungstag: 18. April 2002

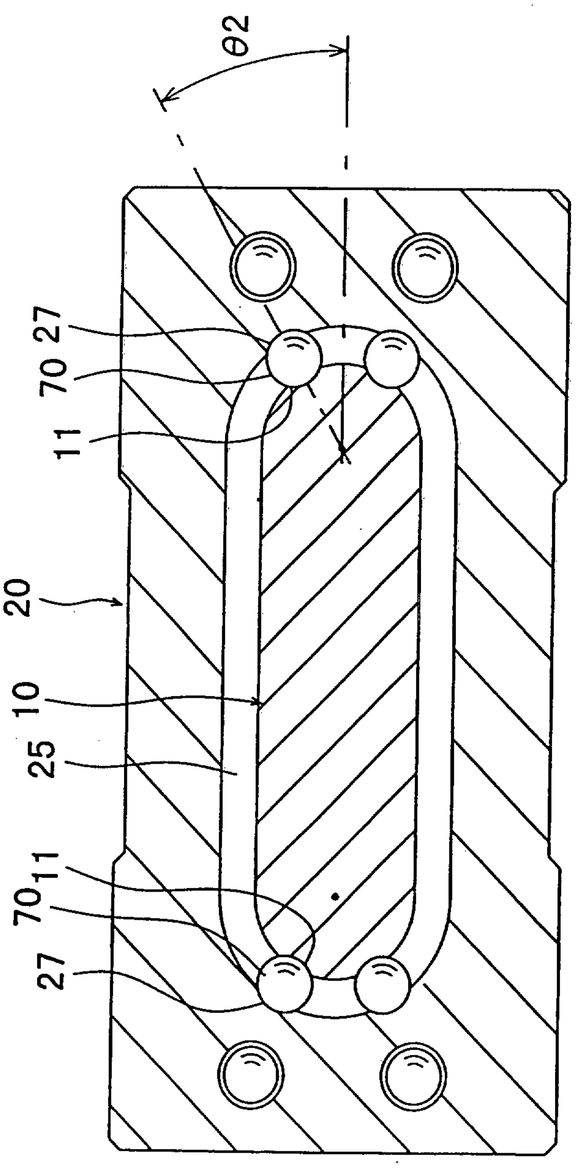


Fig 5

Nummer: **DE 101 44 917 A1**
Int. Cl.^{7}: **F 16 C 29/06**
Offenlegungstag: 18. April 2002

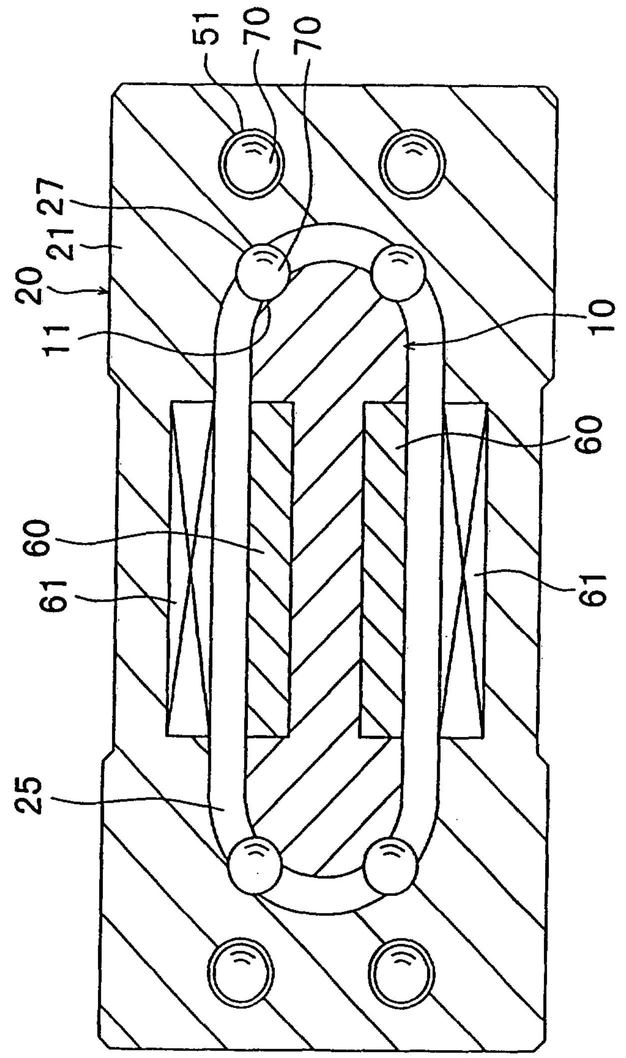


Fig 6

Nummer: **DE 101 44 917 A1**
Int. Cl.^{7}: **F 16 C 29/06**
Offenlegungstag: 18. April 2002

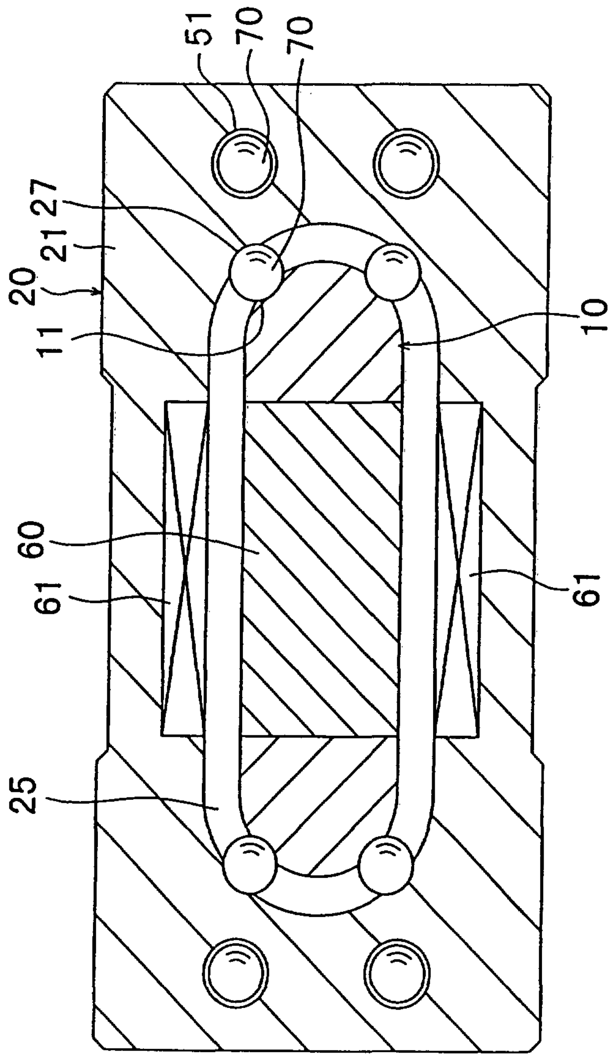
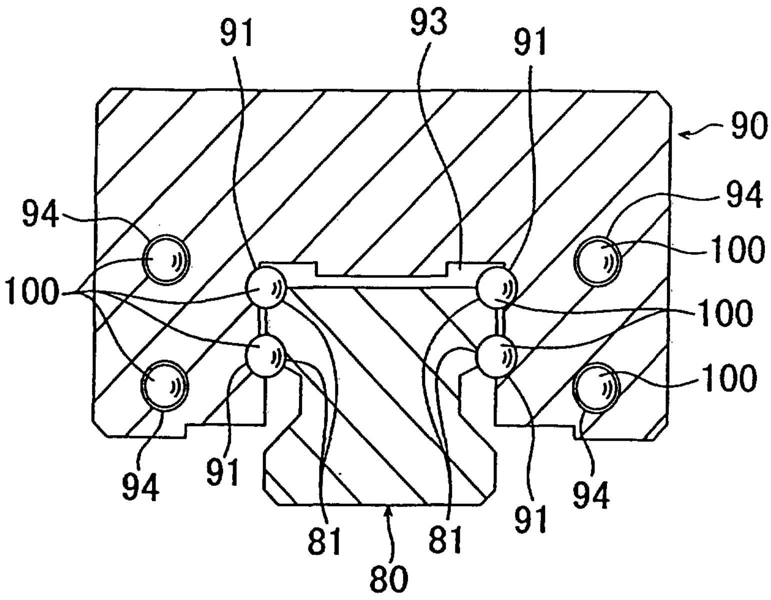


Fig 7

Nummer: DE 101 44 917 A1
Int. Cl.[7]: F 16 C 29/06
Offenlegungstag: 18. April 2002



STAND DER TECHNIK

Fig 8

(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 101 21 311 A 1**

(51) Int. Cl.[7]:
F 16 H 25/24

(21) Aktenzeichen: 101 21 311.5
(22) Anmeldetag: 2. 5. 2001
(43) Offenlegungstag: 6. 12. 2001

(30) Unionspriorität:
00-133266 02. 05. 2000 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Vossius & Partner, 81675 München

(72) Erfinder:
Niwa, Hiroshi, Tokyo, JP; Nishimura, Kentarou, Tokyo, JP; Abe, Yasuyuki, Tokyo, JP; Tamura, Kiyomi, Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Wälzkörper-Abstandshalter in einer Rollführungsvorrichtung

(57) Es wird ein Wälzkörper-Abstandshalter bereitgestellt, der in einer Rollführungsvorrichtung mit einer endlosen Kugelumlaufbahn eingesetzt wird und der in der endlosen Umlaufbahn abwechselnd mit vielen Kugeln angeordnet ist und zusammen mit den Kugeln in der endlosen Umlaufbahn umläuft. Er weist ein Paar Kugelpfannen auf, die jeweils in einer konkaven Kugelflächenform ausgebildet sind, die eine Kugelfläche der Kugel gut annähert und sich im Gleitkontakt mit der Kugel befindet, und um die Kugelpfanne herum ist ein ringförmiger Käfigabschnitt ausgebildet, der in Richtung der Kugelanordnung über einen Randabschnitt der Kugelpfanne vorsteht und außer Kontakt mit der auf der Kugelpfanne aufliegenden Kugel gehalten wird.

DE 101 21 311 A 1

DE 101 21 311 A 1

Beschreibung

[0001] Die Erfindung betrifft einen Wälzkörper-Abstandshalter, der in verschiedenen Rollführungsvorrichtungen mit einer endlosen Umlaufbahn, wie z. B. einer Linearführung und einer Kugelspindel, zwischen den aneinandergrenzenden Kugeln in der endlosen Umlaufbahn eingesetzt ist und die Reibung zwischen den Kugeln sowie die Wärmeentwicklung vermindert, um dadurch deren Rollbewegung zu glätten.

[0002] Als Rollführungsvorrichtung, in der ein Elementepaar fortlaufend eine Relativbewegung durch eine endlos umlaufende Kugelreihe ausführt, sind bisher Vorrichtungen bekannt, wie z. B. eine Linearführung, die als Linearführungsabschnitt in einer Werkzeugmaschine, einer Transportvorrichtung und dergleichen eingesetzt wird und die einen beweglichen Körper, wie z. B. einen Tisch, auf einem ruhenden Abschnitt führt, wie z. B. auf einem Bett oder Support, und eine Kugelspindel, die zusammen mit dieser Linearführung verwendet wird und dem beweglichen Körper einen linearen Hub erteilt, der einem Drehungsbetrag eines Motors entspricht.

[0003] Die erstere Linearführung weist eine Lagerlaufschiene auf, die auf dem ruhenden Abschnitt angeordnet ist und in der in Längsrichtung eine Laufrille für die Kugeln ausgebildet ist, sowie ein Gleitbett, das eine Lastlaufrille aufweist, die der Laufrille der Lagerlaufschiene mit vielen dazwischen angeordneten Kugeln gegenüberliegt, und in dem eine endlose Umlaufrille für die in der Lastlaufrille rollenden Kugeln ausgebildet ist, und ist so gestaltet, daß das den beweglichen Körper tragende Gleitbett zusammen mit dem endlosen Umlauf der Kugeln fortlaufend die Linearbewegung entlang der Lagerlaufschiene ausführt. Umgekehrt gibt es ferner einen Fall, wo die Linearführung so gestaltet ist, daß die Lagerlaufschiene relativ zu dem festen Gleitbett bewegt wird.

[0004] Andererseits weist die letztere Kugelspindel eine Spindelwelle auf, in der eine spiralförmige Kugellaufrille mit vorgegebener Steigung ausgebildet ist, sowie ein Gewinderingelement mit einer Lastlaufrille, die der Kugellaufrille mit vielen dazwischen angeordneten Kugeln gegenüberliegt, wobei in dem Gewinderingelement eine endlose Umlaufbahn für die in der Lastlaufrille rollenden Kugeln ausgebildet ist, wobei die Kugelspindel so gestaltet ist, daß zusammen mit einer Relativbewegung zwischen der Spindelwelle und dem Gewinderingelement die Kugeln in der endlosen Umlaufbahn umlaufen und das Gewinderingelement und die Spindelwelle sich relativ zueinander in axialer Richtung bewegen.

[0005] Da andererseits in einer derartigen Rollführungsvorrichtung die einzelne Kugel, die in der endlosen Umlaufbahn umläuft, in Kontakt mit den vor und nach ihr angeordneten Kugeln kommt, war es bei hoher Laufgeschwindigkeit der Kugel möglich, daß abgesehen vom Verschleiß der Kugeln innerhalb relativ kurzer Zeit, z. B. durch Reibung zwischen den Kugeln, ein Nachteil derart entsteht, daß die Kugel oder die Lastlaufrille infolge der Reibungswärme blokkieren bzw. sich festfressen. Ferner wird bei einer Umkehr der Bewegungsrichtung, d. h. bei einer Umkehr der Umlaufrichtung, eine Anordnung der Kugeln in der endlosen Umlaufbahn wahrscheinlich gestört, und in einem Extremfall entsteht eine sogenannte Blockierungserscheinung, bei der sich die Kugeln in der endlosen Umlaufbahn stauen, so daß die Möglichkeit besteht, daß der Betrieb der Linearführung selbst unmöglich wird. Zur Beseitigung derartiger Nachteile wird daher in JP-A-315 853/1999 eine Linearführung offenbart, in der ein Wälzkörper-Abstandshalter zwischen den aneinandergrenzenden Kugeln in der endlosen Umlaufbahn eingefügt ist.

[0006] Die in der obigen Patentschrift offenbarte Linearführung ist so angepaßt, daß ein aus Kunstharz hergestellter Wälzkörper-Abstandshalter, der als Trennstück bzw. Abstandshalter bezeichnet wird, abwechselnd mit der Kugel in der endlosen Umlaufbahn angeordnet ist und dadurch eine gegenseitige Berührung der Kugeln verhindert. Ein solcher Abstandshalter ist in einer scheibenartigen Form ausgebildet, deren äußerer Durchmesser kleiner als ein Kugeldurchmesser ist, und an seiner Vorder- und Rückseite, die beide mit den Kugeln in Kontakt kommen, sind Kugelpfannen ausgebildet, deren Krümmungen größer sind als die Krümmung einer Kugelfläche der Kugel. Bei abwechselnder Anordnung der Kugel und des Abstandshalters ohne Zwischenraum in der endlosen Umlaufbahn wird dadurch jede Kugel zwischen einem Paar vor bzw. hinter der Kugel angrenzender Abstandshalter angeordnet, so daß sie zusammen mit den Abstandshaltern in der endlosen Umlaufbahn umläuft, ohne eine Kugelreihe zu stören, auch wenn die Umlaufrichtung umgekehrt wird.

[0007] Wenn jedoch, wie bei dem in JP-A-315 853/1999 dargestellten Wälzkörper-Abstandshalter, die im Gleitkontakt mit der Kugel befindliche Kugelpfanne als konkav gekrümmte Fläche ausgebildet ist, deren Krümmung größer als die der Kugelfläche der Kugel ist, dann schaukelt bzw. wackelt die Kugel in dem Wälzkörper-Abstandshalter, da zwischen einem Randabschnitt am Umfang der Kugelpfanne und der Kugel ein Zwischenraum entsteht, so daß sich das Problem ergibt, daß eine Mäanderbewegung der Kugeln in der endlosen Umlaufbahn unmöglich völlig auszuschließen ist.

[0008] Andererseits ist es unter dem Gesichtspunkt der Verhinderung der Mäanderbewegung der Kugeln in der endlosen Umlaufbahn notwendig, daß sich die Kugel auf der Kugelpfanne des Wälzkörper-Abstandshalters ohne Schaukeln einspielt, und daher muß die Kugelpfanne in einer konkaven Kugelflächenform ausgebildet sein, welche die Kugelfläche der Kugel gut annähert. Falls jedoch die Kugelpfanne in einer solchen konkaven Kugelflächenform ausgebildet ist, entsteht eine große Kontaktfläche zwischen der Kugel und der Kugelpfanne, so daß eine Zunahme des Gleitkontaktwiderstands zwischen dem Wälzkörper-Abstandshalter und der Kugel, ein vorzeitiger Verschleiß des Wälzkörper-Abstandshalters und dergleichen möglich sind.

[0009] Falls ferner die Kugelpfanne mit kleinem Durchmesser konstruiert ist, um die Zunahme des Gleitkontaktwiderstands bezüglich der Kugel zu vermeiden, dann ergibt sich der Nachteil, daß der Wälzkörper-Abstandshalter aus dem Zwischenraum zwischen den aneinandergrenzenden Kugeln herausfällt, auch wenn nur ein geringer Zwischenraum zwischen der Kugel und dem Wälzkörper-Abstandshalter entsteht.

[0010] Die Erfindung ist im Hinblick auf ein solches Problem entwickelt worden, und ihre Aufgabe besteht darin, einen Wälzkörper-Abstandshalter bereitzustellen, der einen guten Sitz der Kugel auf der Kugelpfanne ermöglicht, wodurch die Ausrichtung der Kugeln und der Wälzkörper-Abstandshalter in der endlosen Umlaufbahn stabilisiert werden soll, und der den auf die Kugel wirkenden Gleitkontaktwiderstand verringern und ein Herausfallen des Wälzkörper-Abstandshalters aus dem Zwischenraum zwischen den Kugeln wirksam verhindern kann.

[0011] Diese Aufgabe wird mit den Merkmalen der Ansprüche gelöst.

[0012] Da bei einer solchen technischen Einrichtung die Kugelpfanne, mit der sich die Kugel im Gleitkontakt befindet, in der konkaven Kugelflächenform ausgebildet ist, welche die Kugelfläche der Kugel gut annähert, entsteht kaum ein Zwischenraum zwischen der Kugelfläche der Kugel und der Kugelpfanne, so daß der Sitz der Kugel auf der Kugelpfanne stabilisiert wird. Falls daher die Wälzkörper-Abstandshalter und die Kugeln abwechselnd in der endlosen Umlaufbahn der Rollführungsvorrichtung angeordnet sind, soll die Ausrichtung der Kugeln und der Wälzkörper-Abstandshalter stabilisiert werden, so daß es möglich wird, eine Mäanderbewegung der Kugeln in der endlosen Umlaufbahn zu verhindern.

[0013] Da ferner rund um die Kugelpfanne der ringförmige Rückhalte- bzw. Käfigabschnitt (wörtlich: Abschnitt zur Verhinderung des Herausfallens) ausgebildet ist, der außer Kontakt mit der Kugel gehalten wird, und der Käfigabschnitt in Richtung der Kugelanordnung über den Randabschnitt der Kugelpfanne vorsteht, wird es möglich, ein Herausfallen des Wälzkörper-Abstandshalters von vornherein dadurch zu verhindern, daß der Käfigabschnitt mit der Kugel in Eingriff kommt, selbst wenn ein Zwischenraum zwischen der Kugel und dem Wälzkörper-Abstandshalter entsteht und daher ein Herausfallen des Wälzkörper-Abstandshalters aus dem Zwischenraum zwischen aneinandergrenzenden Kugeln wahrscheinlich wird. Da ein Durchmesser der Kugelpfanne ohne Rücksicht auf das Herausfallen des Wälzkörper-Abstandshalters festgelegt werden kann und daher die Kugelpfanne so klein wie nötig ausgebildet werden kann, wird es dementsprechend möglich, eine kleine Kontaktfläche zwischen der Kugelpfanne und der Kugel herzustellen, wodurch der auf die Kugel wirkende Gleitkontaktwiderstand verringert wird. Da ferner der Käfigabschnitt bei auf der Kugelpfanne aufliegender Kugel außer Kontakt mit der Kugel gehalten wird, nimmt der auf die Kugel wirkende Gleitkontaktwiderstand in keinem Fall durch die Bereitstellung des Käfigabschnitts zu.

[0014] Falls die Kugelpfanne in der konkaven Kugelflächenform ausgebildet ist, welche die Kugelfläche der Kugel gut annähert, wird ein an der Kugel anhaftendes Schmiermittel durch einen Randabschnitt am Umfang der Kugelpfanne abgeschabt, da der Umfangsrandabschnitt in Kontakt mit der Kugelfläche der Kugel kommt, so daß die Kugel wahrscheinlich einen Zustand mit unzureichender Schmierung annimmt. Da jedoch bei dem erfindungsgemäßen Wälzkörper-Abstandshalter der rund um die Kugelpfanne vorgesehene Käfigabschnitt außer Kontakt mit der Kugelfläche der Kugel gehalten wird, tritt das Schmiermittel wahrscheinlich in den Zwischenraum zwischen dem Käfigabschnitt und der Kugel ein, so daß auch dann ein guter Schmierungszustand der Kugel aufrechterhalten werden kann, wenn die Kugelpfanne in der konkaven Kugelflächenform ausgebildet ist, welche die Kugelfläche der Kugel gut annähert. Dementsprechend ist es im Hinblick auf die Aufrechterhaltung eines guten Schmierungszustands des erfindungsgemäßen Wälzkörper-Abstandshalters vorzuziehen, wenn zwischen der Kugelpfanne und dem sie umgebenden Käfigabschnitt eine ringförmige Rille ausgebildet wird und diese ringförmige Rille als Schmiermittelsumpf verwendet wird. Da bei einem derartigen Aufbau das Schmiermittel, das in den Zwischenraum zwischen der Kugel und dem Käfigabschnitt fließt, in der ringförmigen Rille gespeichert wird, kann immer Schmiermittel auf die Kugeloberfläche aufgebracht werden.

[0015] Da es andererseits schwierig ist, in der endlosen Umlaufbahn der Rollführungsvorrichtung einen Zwischenraum zwischen der Kugel und dem Wälzkörper-Abstandshalter völlig zu beseitigen, folgt daraus, daß der Wälzkörper-Abstandshalter und die Kugel während eines Umlaufs der Kugeln immer wieder ein wenig zusammenstoßen. Im Hinblick darauf, eine Ermüdung und ein Stoßgeräusch der Kugeln zu vermindern, die auf derartige Stöße zurückzuführen sind, sollte die Kugelpfanne, mit der sich die Kugel im Gleitkontakt befindet, vorzugsweise aus einem entsprechend weichen Material bestehen. Dagegen darf sich der Käfigabschnitt, da er das Herausfallen des Wälzkörper-Abstandshalters aus dem Zwischenraum zwischen aneinandergrenzenden Kugeln verhindern soll, beim Auftreten einer solchen Situation nicht ohne weiteres durch Stöße der Kugel verformen, so daß er vorzugsweise aus einem harten Material bestehen sollte. Unter diesem Gesichtspunkt sollten dementsprechend die Kugelpfanne und der Käfigabschnitt, die in dem erfindungsgemäßen Wälzkörper-Abstandshalter vorgesehen sind, vorzugsweise aus verschiedenen Harzmaterialien geformt werden, wobei der Käfigabschnitt vorzugsweise aus einem härterem Harzmaterial als die Kugelpfanne geformt wird.

[0016] Übrigens kann der Käfigabschnitt in einer fugenlosen Ringform ausgebildet werden, kann aber auch mit einem in der Ringform durch einen Schlitz abgetrennten Vorsprung hergestellt werden.

[0017] Da, wie oben erläutert, bei dem erfindungsgemäßen Wälzkörper-Abstandshalter jedes Kugelpfannenpaar, mit dem sich die Kugeln im Gleitkontakt befinden, in der konkaven Kugelflächenform ausgebildet wird, welche die Kugelfläche der Kugel gut annähert, und da rund um jede Kugelpfanne der ringförmige Käfigabschnitt ausgebildet ist, der in Richtung der Kugelanordnung über den Randabschnitt der Kugelpfanne vorsteht und außer Kontakt mit der auf der Kugelpfanne aufliegenden Kugel gehalten wird, ist es möglich, die Ausrichtung der Kugeln und der Wälzkörper-Abstandshalter in der endlosen Umlaufbahn zu stabilisieren und dabei einen guten Sitz der Kugel auf der Kugelpfanne zu erreichen, um den auf die Kugel wirkenden Gleitkontaktwiderstand zu verringern, und außerdem wird es möglich, das Herausfallen des Wälzkörper-Abstandshalters aus dem Zwischenraum zwischen den Kugeln wirksam zu verhindern.

[0018] **Fig.** 1 zeigt eine seitliche Schnittansicht, die eine Ausführungsform einer Kugelspindelvorrichtung darstellt, in der erfindungsgemäße Wälzkörper-Abstandshalter zusammen mit Kugeln in einer endlosen Umlaufbahn angeordnet sind;

[0019] **Fig.** 2 zeigt eine Schnittansicht von vorn der in **Fig.** 1 dargestellten Kugelspindelvorrichtung;

[0020] **Fig.** 3 zeigt eine perspektivische Ansicht, die eine erste Ausführungsform des erfindungsgemäßen Wälzkörper-Abstandshalters darstellt;

[0021] **Fig.** 4 zeigt eine Vorderansicht, die den Wälzkörper-Abstandshalter nach der ersten Ausführungsform darstellt;

[0022] **Fig.** 5 zeigt eine Schnittansicht entlang einer Linie V-V in **Fig.** 4;

[0023] **Fig.** 6 zeigt eine vergrößerte Schnittansicht, die eine Beziehung zwischen dem Käfigabschnitt des Wälzkörper-Abstandshalters nach der ersten Ausführungsform und einer Kugel darstellt;

[0024] **Fig.** 7 zeigt eine Schnittansicht, die einen Zustand darstellt, in dem die Kugeln auf den Kugelpfannen des Wälzkörper-Abstandshalters nach der ersten Ausführungsform aufliegen;

[0025] **Fig.** 8 zeigt eine Schnittansicht, die einen Zustand darstellt, in dem die Kugeln in den Kugelpfannen des Wälzkörper-Abstandshalters nach der ersten Ausführungsform Spiel haben;

[0026] **Fig.** 9 zeigt eine Schnittansicht, die ein Beispiel des Wälzkörper-Abstandshalters nach der ersten Ausführungsform darstellt, bei dem die ringförmige Rille und der Schmierölsumpf weggelassen wurden;

[0027] **Fig.** 10 zeigt eine vergrößerte Schnittansicht, die eine Beziehung zwischen dem Käfigabschnitt des in **Fig.** 9 dargestellten Wälzkörper-Abstandshalters und der Kugel darstellt; und

[0028] **Fig.** 11 zeigt eine Schnittansicht, die eine zweite Ausführungsform des erfindungsgemäßen Wälzkörper-Abstandshalters darstellt.

[0029] Nachstehend wird ein erfindungsgemäßer Wälzkörper-Abstandshalter anhand der Zeichnungen näher erläutert.

[0030] **Fig.** 1 und **Fig.** 2 zeigen eine Ausführungsform einer Kugelspindelvorrichtung, in der die erfindungsgemäßen Wälzkörper-Abstandshalter zusammen mit Kugeln in einer endlosen Umlaufbahn angeordnet sind. In diesen Zeichnungen bezeichnet das Bezugszeichen **1** eine Spindelwelle, das Bezugszeichen **2** eine Kugel und das Bezugszeichen **3** ein Gewinderingelement, wobei das Gewinderingelement **3** über viele Kugeln **2** mit der Spindelwelle **1** im Eingriff ist.

[0031] In einer äußeren Umfangsfläche der Spindelwelle **1** ist eine spiralförmige Kugellaufrille **10** ausgebildet, während in einer inneren Umfangsfläche des Gewinderingelements **3** eine spiralförmige Lastlaufrille **30** ausgebildet ist, die der Kugellaufrille **10** der Spindelwelle **1** gegenüberliegt, und die Kugellaufrille **10** und die Lastlaufrille **30** bilden eine spiralförmige Lastkugelbahn zwischen der Spindelwelle **1** und dem Gewinderingelement **3**. Das heißt, wenn zwischen der Spindelwelle **1** und dem Gewinderingelement **3** eine relative Drehbewegung auftritt, rollt die Kugel **2** spiralförmig in der Lastkugelbahn und trägt dabei eine Last. Ferner ist an dem Gewinderingelement **3** ein Rücklaufrohr **4** angebracht, das beide Enden der Lastkugelbahn miteinander verbindet, um dadurch die endlose Umlaufbahn für die Kugeln **2** zu bilden, so daß die Kugel **2**, nachdem sie durch die Lastkugelbahn hindurchgerollt und von der Last befreit worden ist, einen lastfreien Zustand annimmt und in dem Rücklaufrohr **4** zu einem Einlaß der Lastkugelbahn zurückrollt, wobei sie mehrere Windungen der Kugellaufrille **10** überspringt. Wenn dementsprechend die Spindelwelle **1** und das Gewinderingelement **3** gegeneinander gedreht werden, folgt daraus, daß die Kugel **2** von der Lastkugelbahn zum Rücklaufrohr **4** und vom Rücklaufrohr **4** zur Lastkugelbahn rollt und innerhalb der endlosen Umlaufbahn, die durch die Lastkugelbahn und das Rücklaufrohr **4** gebildet wird, umläuft.

[0032] Um bei dieser Kugelspindelvorrichtung zu verhindern, daß die in der endlosen Umlaufbahn untergebrachten Kugeln **2** einander berühren, wird zwischen den aneinandergrenzenden Kugeln **2**, **2** ein Wälzkörper-Abstandshalter **5** eingefügt. Wie in **Fig.** 3 bis **Fig.** 5 dargestellt, wird der Wälzkörper-Abstandshalter **5** geformt, indem ein Kunstharz annähernd in Scheibenform gebracht und an seinen vorderen und hinteren Flächen jeweils Kugelpfannen **50** ausgebildet werden, mit denen sich die Kugeln **2** im Gleitkontakt befinden. Die Kugeln **2** und der Wälzkörper-Abstandshalter **5** sind in der endlosen Umlaufbahn abwechselnd angeordnet. Dadurch wird verhindert, daß die in der endlosen Umlaufbahn rollenden Kugeln **2** einander berühren, wodurch ein stoßfreier Umlauf der Kugel und dadurch eine Glättung der Drehbewegung des Gewinderingelements **3** relativ zur Spindelwelle **1** erreicht werden sollen, und außerdem wird eine Geräuschentwicklung infolge von Stößen zwischen den Kugeln während des Betriebs der Kugelspindelvorrichtung vermindert.

[0033] Die Kugelpfanne **50** ist in einer konkaven Kugelflächenform ausgebildet, welche die Kugelfläche der Kugel **2** gut annähert, und ist so gestaltet, daß die angrenzende Kugel **2** fast ohne Zwischenraum mit der Kugelpfanne **50** in Kontakt kommt. Ferner ist in der Kugelpfanne **50** ein ringförmiger Schmierölsumpf **51** ausgebildet und so angepaßt, daß eine beabsichtigte Schmierung zwischen der Kugelpfanne **50** und der Kugel **2** erfolgt. Ferner ist rund um die Kugelpfanne **50** ein ringförmiger Käfigabschnitt **52** so ausgebildet, daß er die Kugelpfanne **50** umgibt. Eine Spitze des Käfigabschnitts **52** steht in Anordnungsrichtung der Kugeln **2** (horizontale Richtung in **Fig.** 5) über einen Randabschnitt der Kugelpfanne **50** vor. Wie in **Fig.** 6 dargestellt, ist der Käfigabschnitt jedoch so angepaßt, daß bei auf der Kugelpfanne **50** aufliegender Kugel **2** ein Zwischenraum zwischen der Kugel **2** und der Spitze des Käfigabschnitts **52** ausgebildet ist. Außerdem ist zwischen dem Käfigabschnitt **52** und der Kugelpfanne **50** eine ringförmige Rille **53** ausgebildet, welche die Kugelpfanne von dem Käfigabschnitt trennt und so angepaßt ist, daß die ringförmige Rille **53** als Schmierölsumpf funktioniert.

[0034] **Fig.** 7 zeigt einen Zustand, in dem die Kugeln **2** auf den Kugelpfannen **50** des Wälzkörper-Abstandshalters **5** aufliegen. Da die Kugelpfanne **50**, wie weiter oben erwähnt, in der konkaven Kugelflächenform ausgebildet ist, welche die Kugelfläche der Kugel **2** gut annähert, berührt die aufliegende Kugel **2** die Kugelpfanne nahezu ohne Zwischenraum, wie in dieser Zeichnung dargestellt. Falls die Kugeln **2** und die Wälzkörper-Abstandshalter **50** ohne Zwischenräume in der endlosen Umlaufbahn der Kugelspindelvorrichtung angeordnet sind, führen dadurch die Kugeln **2** auf den Kugelpfannen **50** der Wälzkörper-Abstandshalter **5** keine instabile Schaukelbewegung aus, so daß die Kugeln **2** und die Wälzkörper-Abstandshalter **5** ohne Mäander- bzw. Schlängelbewegung in der endlosen Umlaufbahn umlaufen können.

[0035] Da ferner der rund um die Kugelpfanne **50** ausgebildete Käfigabschnitt **52** nicht in Kontakt mit der auf der Kugelpfanne **50** aufliegenden Kugel **2** kommt, folgt daraus, daß ein an der Kugel **2** anhaftendes Schmiermittel, wie z. B. Fett, von einem Zwischenraum zwischen dem Käfigabschnitt **52** und der Kugelfläche der Kugel **2** in die ringförmige Rille **53** eintritt und in der ringförmigen Rille **53** aufgefangen wird. Daher wird das Schmiermittel wahrscheinlich zwischen die Kugel **2** und die Kugelpfanne **50** gezogen, die miteinander im Gleitkontakt sind, so daß eine sichere Schmierung zwischen der Kugel **2** und dem Wälzkörper-Abstandshalter **5** möglich ist und außerdem das Schmiermittel wahrscheinlich auch an einer Oberfläche der Kugel **2** anhaftet, die sich nach dem Passieren der ringförmigen Rille **53** nach außen bewegt, so daß eine sichere Schmierung zwischen der Kugel **2** und der Laufrille **10** der Kugelspindelvorrichtung möglich wird.

[0036] Andererseits zeigt **Fig.** 8 einen Zustand, in dem ein Zwischenraum zwischen den aneinandergrenzenden Kugeln **2** sich während des Umlaufs in der endlosen Umlaufbahn vergrößert und daher die Kugeln **2** in den Kugelpfannen **50** des Wälzkörper-Abstandshalters **5** Spiel haben. Ein derartiger Zustand tritt irgendwo in der endlosen Umlaufbahn auf, da es schwierig ist, die Kugeln **2** und die Wälzkörper-Abstandshalter **5** beispielsweise ohne Zwischenräume bezüglich der endlosen Umlaufbahn der Kugelspindelvorrichtung anzuordnen, und weil die Kugel **2** und der Wälzkörper-Abstandshalter **5** bei langdauernder Nutzung verschleißen. Wenn die Kugeln **2** auf die obige Weise in den Kugelpfannen **50** Spiel haben, verliert außerdem der zwischen den Kugeln **2** angeordnete Wälzkörper-Abstandshalter **5** seinen Halt und versucht, aus dem Zwischenraum zwischen den Kugeln **2** herauszufallen. Da jedoch bei dem Wälzkörper-Abstandshalter **5** nach der vorliegenden Ausführungsform die Spitze des Käfigabschnitts **52** in Anordnungsrichtung der Kugeln **2** über den Randabschnitt der Kugelpfanne **50** vorsteht, kommt der bis zu diesem Zeitpunkt kontaktfreie Käfigabschnitt **52** in Eingriff mit den Kugeln **2**, wenn ein Herausfallen des Wälzkörper-Abstandshalters **5** aus dem

Zwischenraum zwischen den aneinandergrenzenden Kugeln **2** wahrscheinlich wird, und verhindert dadurch das Herausfallen des Wälzkörper-Abstandshalters **5** aus dem Zwischenraum zwischen den Kugeln **2**. Dementsprechend ist es bei dem Wälzkörper-Abstandshalter **5** nach der vorliegenden Ausführungsform nicht notwendig, einen unnötig großen Durchmesser der Kugelpfanne **50** festzusetzen, um das Herausfallen aus dem Zwischenraum zwischen den Kugeln **2** zu verhindern, so daß die Kugelpfanne **50** in der kleinsten notwendigen Größe ausgebildet werden kann. Daher kann die Kontaktfläche zwischen der Kugel **2** und der Kugelpfanne **50** verkleinert werden, so daß der Gleitkontaktwiderstand zwischen der Kugel **2** und dem Wälzkörper-Abstandshalter **5** entsprechend verringert werden kann. Im Hinblick auf die Kugelspindelvorrichtung, in der die Wälzkörper-Abstandshalter **5** in der endlosen Umlaufbahn angeordnet sind, führt dies dazu, daß eine stoßfreie Bewegung mit geringer Drehmomentschwankung erzielt wird.

[0037] Übrigens ist bei dem Wälzkörper-Abstandshalter **5** nach der obenerwähnten ersten Ausführungsform die ringförmige Rille **53** zwischen der Kugelpfanne **50** und dem Käfigabschnitt **52** ausgebildet, und der ringförmige Schmierölsumpf **51** ist in der Kugelpfanne **50** ausgebildet, aber wie in **Fig.** 9 dargestellt, können die ringförmige Rille **53** und der Schmierölsumpf **51** bei der Erfindung weggelassen werden. Selbst in diesem Fall kommt jedoch, wie in **Fig.** 10 dargestellt, der Käfigabschnitt **52** nicht in Kontakt mit der Kugelfläche der Kugel **2**, die auf der Kugelpfanne **50** aufliegt, und zwischen dem Käfigabschnitt **52** und der Kugelfläche der Kugel **2** ist ein Zwischenraum ausgebildet. Da das an der Kugel **2** anhaftende Schmiermittel, wie z. B. Fett, in den Zwischenraum eintritt, wird durch das Schmiermittel wahrscheinlich zwischen die Kugel **2** und die Kugelpfanne **50** gezogen, die miteinander im Gleitkontakt sind, so daß eine sichere Schmierung zwischen der Kugel **2** und dem Wälzkörper-Abstandshalter **5** möglich wird, wobei allerdings die im Zwischenraum enthaltene Schmiermittelmenge geringer ist als in dem Fall mit Ausbildung der ringförmigen Rille **53**.

[0038] **Fig.** 11 zeigt eine zweite Ausführungsform des erfindungsgemäßen Wälzkörper-Abstandshalters.

[0039] Bei dem Wälzkörper-Abstandshalter **5** nach der obenerwähnten ersten Ausführungsform werden die Kugelpfanne **50** und der Käfigabschnitt **52** im Spritzgußverfahren in einem Stück aus einem einzigen Kunstharz hergestellt. Bei einem Wälzkörper-Abstandshalter **6** nach der zweiten Ausführungsform werden jedoch die Kugelpfanne **50** und der Käfigabschnitt **52** jeweils aus verschiedenen Kunstharzen geformt. Da übrigens die anderen Konstruktionsmerkmale die gleichen sind wie beim Wälzkörper-Abstandshalter **5** nach der ersten Ausführungsform, werden in **Fig.** 11 die gleichen Bezugszeichen wie bei der ersten Ausführungsform zugeordnet, und ausführliche Erläuterungen der Merkmale werden hier weggelassen.

[0040] Da der Wälzkörper-Abstandshalter die Funktion eines Polsters bzw. Stoßdämpfers zwischen den aneinandergrenzenden Kugeln **2** ausübt, um dadurch die Ermüdung und Geräuschentwicklung der Kugeln **2** infolge von Stößen zu vermindern, wird die Kugelpfanne **50** vorzugsweise aus einem entsprechend weichen Material geformt, um diese Funktion in ausreichendem Maße aufweisen zu können. Da jedoch der Käfigabschnitt **52**, wenn sich ein Zwischenraum zwischen den aneinandergrenzenden Kugeln **2** vergrößert, mit der Kugel **2** in Eingriff kommt, um dadurch das Herausfallen des Wälzkörper-Abstandshalters zu verhindern, wird er vorzugsweise aus einem harten Material geformt, damit er nicht leicht deformiert wird. Hierbei kann als Richtwert bei der Auswahl eines Harzmaterials zum Formen des Käfigabschnitts und der Kugelpfanne der Biegeelastizitätsmodul eines solchen Kunstharzes gewählt werden. Das heißt, es wird berücksichtigt, daß ein Material mit niedrigem Biegeelastizitätsmodul sich leicht verformen läßt, während ein Material mit hohem Biegeelastizitätsmodul sich schwer verformen läßt.

[0041] Dementsprechend kann bei dem Wälzkörper-Abstandshalter **6** nach der zweiten Ausführungsform der Käfigabschnitt **52** im Vergleich zur Kugelpfanne **50** aus einem harten Kunstharz geformt werden, so daß die entsprechenden Teile ihre Funktionen in höchstem Grade aufweisen können.

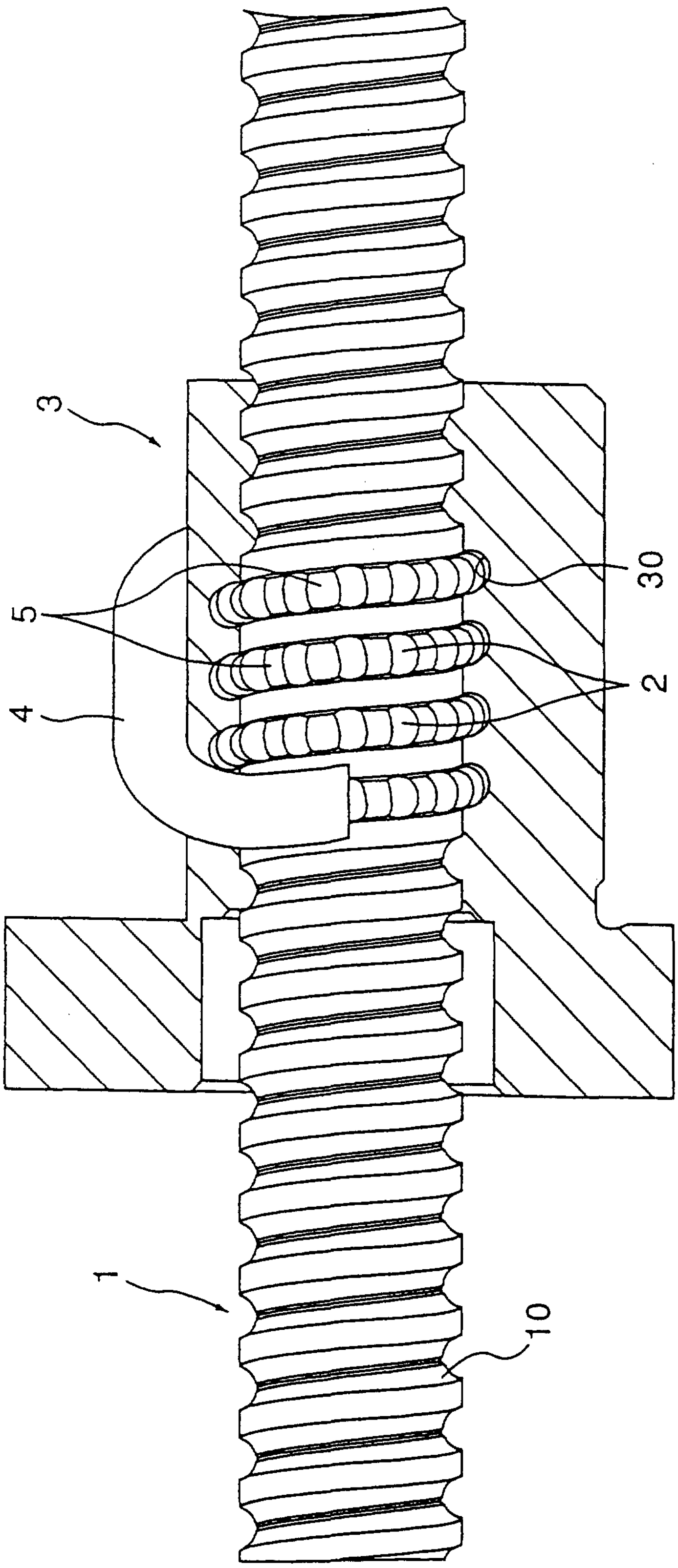
Patentansprüche

1. Wälzkörper-Abstandshalter, der in einer Rollführungsvorrichtung verwendet wird, in der ein Elementepaar eine kontinuierliche Relativbewegung durch eine endlos umlaufende Kugelreihe ausführt, wobei der Abstandshalter zwischen Kugeln eingefügt ist, die in ihrer endlosen Umlaufbahn aneinandergrenzen, und zusammen mit den Kugeln umläuft, **dadurch gekennzeichnet**,
daß der Wälzkörper-Abstandshalter ein Paar Kugelpfannen aufweist, die jeweils in einer konkaven Kugelflächenform ausgebildet sind, die eine Kugelfläche der Kugel gut annähert und sich im Gleitkontakt mit der Kugel befindet, und
daß um jede Kugelpfanne herum ein ringförmiger Käfigabschnitt ausgebildet ist, der in Richtung der Kugelanordnung über einen Randabschnitt der Kugelpfanne vorsteht und außer Kontakt mit der auf der Kugelpfanne aufliegenden Kugel gehalten wird.
2. Wälzkörper-Abstandshalter nach Anspruch 1, dadurch gekennzeichnet, daß zwischen der Kugelpfanne und dem Käfigabschnitt eine ringförmige Rille ausgebildet ist und daß die ringförmige Rille als Schmierölsumpf dient.
3. Wälzkörper-Abstandshalter nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß in der Kugelpfanne ein Schmierölsumpf ausgebildet ist.
4. Wälzkörper-Abstandshalter nach Anspruch 1, 2 oder 3, wobei die Kugelpfanne und der Käfigabschnitt aus verschiedenen Harz- oder Kunststoffmaterialien geformt werden und daß der Käfigabschnitt aus einem härteren Harz- oder Kunststoffmaterial als die Kugelpfanne geformt wird.
5. Rollführungsvorrichtung mit einem Wälzkörper-Abstandshalter nach einem der Ansprüche 1 bis 4.

Hierzu 7 Seite(n) Zeichnungen

Nummer: **DE 101 21 311 A1**
Int. Cl.^{7}: **F 16 H 25/24**
Offenlegungstag: 6. Dezember 2001

Fig. 1



Nummer: DE 101 21 311 A1
Int. Cl.⁷: F 16 H 25/24
Offenlegungstag: 6. Dezember 2001

Fig.2

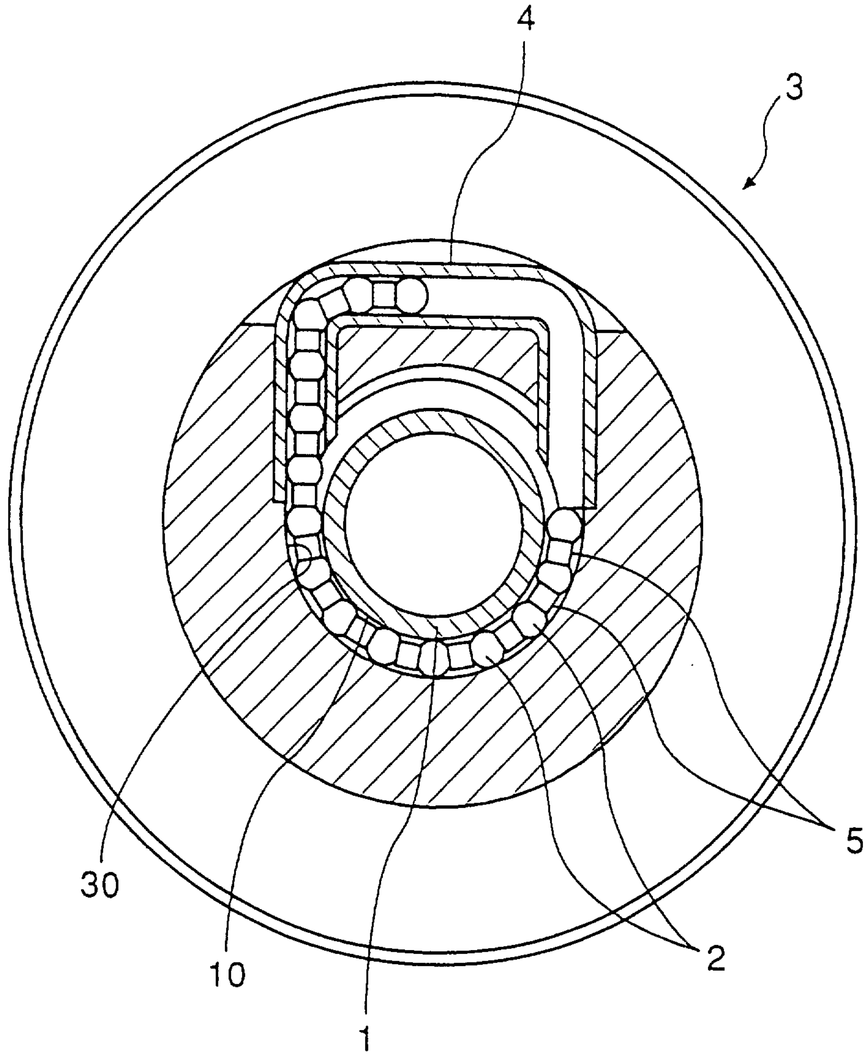


Fig.3

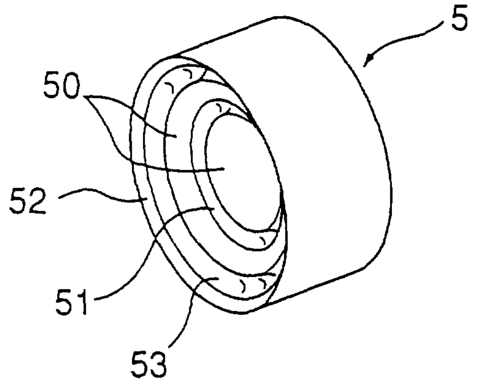
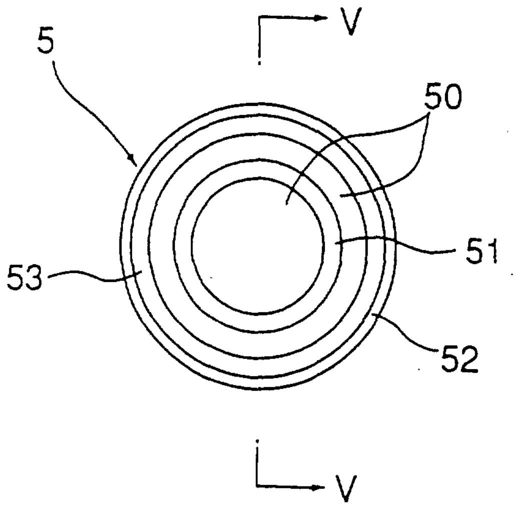


Fig.4



Nummer: **DE 101 21 311 A1**
Int. Cl.[7]: **F 16 H 25/24**
Offenlegungstag: 6. Dezember 2001

Fig.5

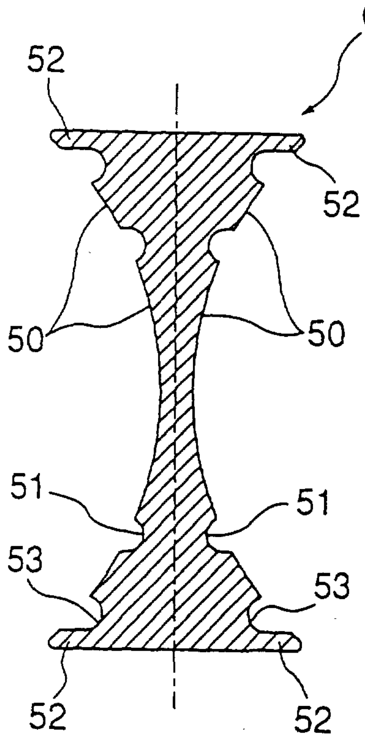


Fig.6

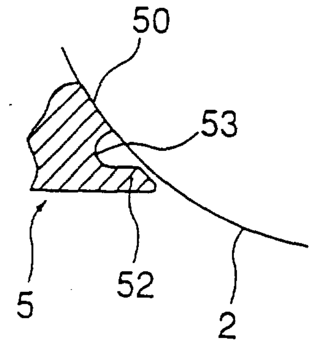


Fig.7

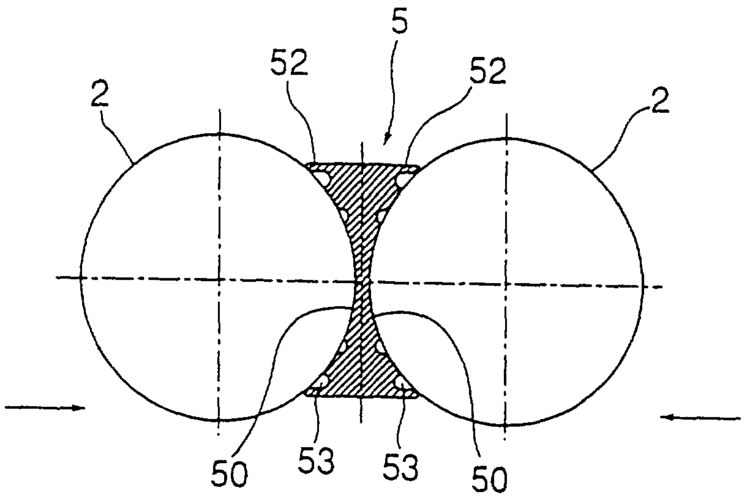
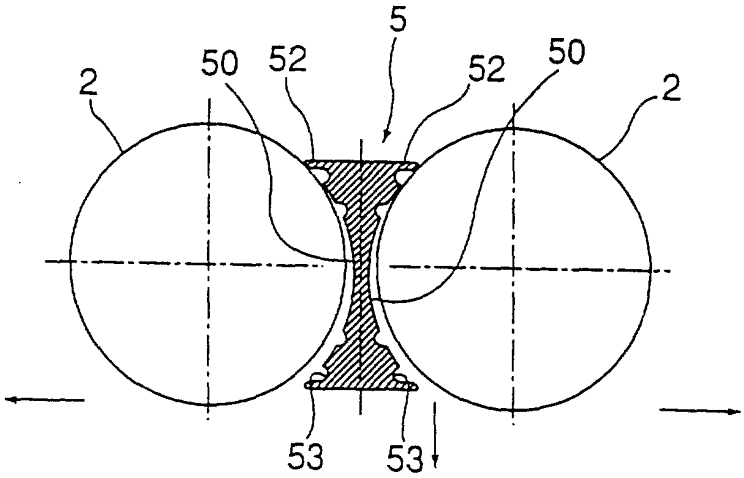


Fig.8



Nummer: **DE 101 21 311 A1**
Int. Cl.[7]: **F 16 H 25/24**
Offenlegungstag: 6. Dezember 2001

Fig.9

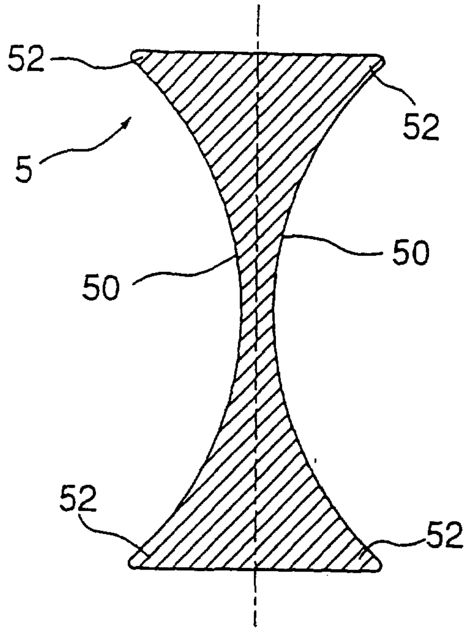
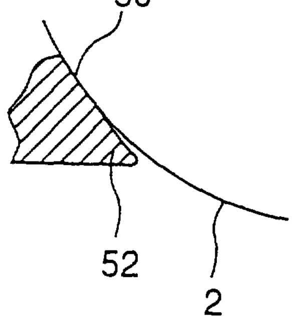
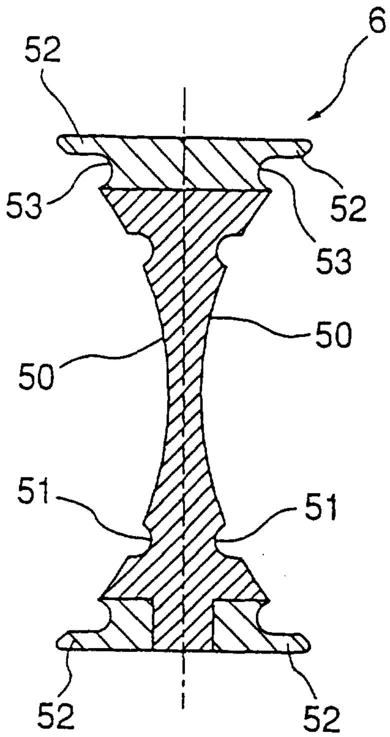


Fig.10



Nummer: **DE 101 21 311 A1**
Int. Cl.⁷: **F 16 H 25/24**
Offenlegungstag: 6. Dezember 2001

Fig.11



(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 101 15 943 A 1**

(51) Int. Cl.[7]:
F 16 H 25/22
B 23 Q 5/00

(21) Aktenzeichen: 101 15 943.9
(22) Anmeldetag: 30. 3. 2001
(43) Offenlegungstag: 25. 10. 2001

(30) Unionspriorität:
2000-95183 30. 03. 2000 JP
2000-334354 01. 11. 2000 JP

(71) Anmelder:
THK Co., Ltd., Tokyo/Tokio, JP

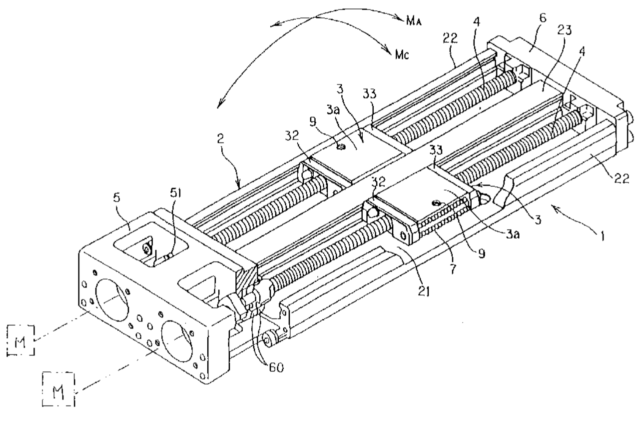
(74) Vertreter:
Klunker, Schmitt-Nilson, Hirsch, 80797 München

(72) Erfinder:
Takahashi, Kenji, Nakadate, JP; Michioka, Hidekazu, Tokyo, JP; Takamatsu, Hiroshi, Nakadate, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Antriebsvorrichtung

(57) Eine Antriebsvorrichtung enthält einen Führungstisch (2) mit einem flachen Teil (21), senkrechten Seitenteilen (22), die sich parallel zueinander entlang den Seitenrändern des flachen Teils erstrecken, und mindestens einem Teilungsabschnitt (23), der an dem flachen Teil (21) in einem Bereich zwischen den rechtwinkligen Seitenabschnitten (21) ausgebildet ist, wobei er sich parallel zu diesen erstreckt. Bewegungstische (3, 3) sind in jeweils einen Raum zwischen einem der rechtwinkligen Seitenteile und dem Teilungsabschnitt (23) eingesetzt. Die Bewegungstische besitzen an ihren Seitenflächen Laufflächen für belastete Kugeln zur Bildung von Kugelumlaufkanälen entsprechend Laufflächen an dem Führungstisch (2). In den Kugelumlaufkanälen sind mehrere Kugeln angeordnet und zirkulieren in den Kanälen entsprechend der Relativbewegung zwischen dem Führungstisch (2) und den Bewegungstischen. Eine antreibende Einheit dient zum relativen Antreiben von Führungstisch und Bewegungstisch.



DE 101 15 943 A 1

Beschreibung

[0001] Die Erfindung betrifft eine Antriebsvorrichtung mit großer Breite und beispielsweise einer Vorschubspindel sowie einer Linearführungseinrichtung.

[0002] Bekannt ist eine Antriebsvorrichtung mit einem Aufbau, der eine Vorschubspindel als Antriebseinrichtung enthält, zum Beispiel einen Kugelumlauf-Stellantrieb, eine Gleitspindel oder dergleichen, und außerdem eine Linearführungseinrichtung aufweist. Eine solche Antriebseinrichtung besteht im wesentlichen aus einer Spindel, die auf ihrer Außenfläche mit einer spiralförmigen Nut ausgestattet ist, einer linearen Führungsschiene als Längs-Führungstisch oder Spurtisch parallel zu der Spindel, und einem als Bewegungselement dienenden Block, der an der Linearführungsschiene in deren Längsrichtung beweglich gelagert ist, wobei der bewegliche Block mit einem Mutterelement ausgestattet ist, welches in Gewindeeingriff mit der Spindel steht.

[0003] Üblicherweise ist an einer solchen Antriebsvorrichtung eine Werkzeugmaschine, beispielsweise ein Maschinentisch, gelagert, wobei dieses Maschinenteil in eine gewünschte Stellung gebracht und dort angehalten wird. Diese Positionssteuerung der Werkzeugmaschine erfolgt zum Beispiel dadurch, daß man die Drehbewegung der Spindel beim Betreiben eines Motors oder einer anderen Antriebseinrichtung steuert. Wie erwähnt, kann man eine solche Antriebsvorrichtung als Kompaktvorschubeinheit mit guter Montierbarkeit und Einstellbarkeit bezeichnen. Aus diesem Grund wurde eine solche Antriebsvorrichtung bisher für verschiedene Industrieroboter, Transportanlagen und dergleichen verwendet.

[0004] Wie beispielsweise in dem japanischen offengelegten Gebrauchsmuster HEI 2-12554 dargestellt ist, umfassen Antriebsvorrichtungen der oben genannten Art grundsätzlich zwei verschiedene Bautypen: den Sattel- oder Überspreizungstyp, bei dem ein einen Bodenteil und daran in Längsrichtung verlaufende Seitenteile aufweisender beweglicher Tisch eine Führungsschiene überspreizt und an dieser entlang bewegbar ist; und einen Nuteinsatztyp, bei dem ein bewegliches Element mit rechteckigem Querschnitt beweglich in eine nutförmige Ausnehmung eines Spurelements eingepaßt ist, wobei das Spurelement kastenförmigen Querschnitt hat und damit das bewegliche Element in dem Spurelement in dessen Längsrichtung beweglich ist.

[0005] Vergleicht man die beiden Bautypen miteinander bezüglich der gleichen Nenn-Last, so läßt sich eine Linearführungseinrichtung vom Nuteinsatztyp mit geringerer Bauhöhe fertigen als der Überspreizungstyp, er kann also kompakter bauen, wobei er entsprechend weniger Platz einnimmt. In dieser Hinsicht läßt sich sagen, daß der Nuteinsatztyp vom Aufbau her effizienter eingesetzt werden kann bei Robotern oder Transporteinheiten, deren Einsatz für beschränkte oder enge Räume vorgesehen ist.

[0006] Der Nuteinsatztyp (idly groove-fitting type) soll im folgenden anhand der **Fig.** 7 und 8 näher erläutert werden.

[0007] Ein Spur- oder Führungstisch **90** mit kastenförmigem Querschnitt und einer gewissen Längserstreckung setzt sich zusammen aus einem horizontalen flachen Abschnitt, der einen Bodenteil **90**a bildet, und einem Paar seitlicher Abschnitte, die von dem Bodenteil **90**a aufrecht abstehen, wie in den **Fig.** 7 und 8 zu sehen ist, wodurch zwischen den genannten Teilen eine Ausnehmung gebildet wird. Die Seitenabschnitte sind mit inneren Seitenflächen **91**, **91** ausgestattet, in denen zwei Reihen (eine obere und eine untere) Kugellaufnuten **92**, **92** so ausgeformt sind, daß sich die Nuten parallel zueinander in Längsrichtung erstrecken. Außerdem ist in dem in Breitenrichtung gesehen mittleren Abschnitt des kastenförmigen Führungstisches **90** eine Spindel **93** für den Kugelumlauf-Stellantrieb angeordnet, parallel zu den Kugellaufflächen **92**, **92**.

[0008] Ein Bewegungstisch **94** ist ein Bauteil mit einer Oberseite, auf der ein Tisch T oder dergleichen gelagert wird, um ein Werkzeugmaschinenteil oder ein anderes Bauelement zu transportieren, oder um andere Artikel auf dem Tisch T anzuordnen. Der Bewegungstisch **94** besitzt Rechteck-Querschnitt und ist mit einem Mutterabschnitt **95** ausgestattet, der mit der Kugelumlaufspindel **93** zusammenwirkt. Der Bewegungstisch **94** besitzt eine Breitenabmessung, die etwas geringer ist als die Innenabmessung der Ausnehmung des Führungstisches **90**, wie aus **Fig.** 8 ersichtlich ist.

[0009] Der Bewegungstisch **94** ist lose in der Ausnehmung (Nut) des Führungstisches **90** aufgenommen. Der Bewegungstisch **94** ist mit Seitenflächen versehen, in denen Kugellaufflächen **94**a, **94**a für belastete Kugeln derart ausgebildet sind, daß sich die Laufflächen gegenüber den Kugellaufflächen **92**, **92** in den Seitenflächen **91**, **91** des Führungstisches **90** befinden. Außerdem sind Kugelrücklaufkanäle, jeweils bestehend aus einem geradlinigen Durchgangsloch, in einem massiven Abschnitt des Bewegungstisches ausgebildet, wobei sich die Kanäle parallel zu den Laufflächen **94**a für belastete Kugeln erstrecken, wobei außerdem U-förmige Laufrichtungs-Änderungskanäle an dem Bewegungstisch an dessen Längsenden ausgebildet sind, die die Laufflächen **94**a für belastete Kugeln mit den Kugelrücklaufkanälen **94**b verbinden, wodurch jeweils ein Endlos-Kugelumlaufkanal gebildet wird, in welchem eine Anzahl von Kugeln **97** als Wälzelemente aufgenommen ist, die entlang dem Kanal abrollen.

[0010] Wenn im Betrieb die Kugelumlaufwelle **93** durch Antreiben seitens eines nicht gezeigten Servomotors gedreht wird, bewegt sich der Bewegungstisch **94** im Verein mit der Drehbewegung der Kugelumlaufspindel **93** und wird entlang dem Führungstisch **90** in dessen Längsrichtung geführt. Bei diesem Vorgang läßt sich die Bewegung des Bewegungstisches **94** ruckfrei aufgrund der Rollbewegungen der Stahlkugeln B durchführen, welche zwischen dem Mutterelement **95** und der Kugelumlaufspindel **93** angeordnet sind, während die Kugeln **97** sich zwischen dem Führungstisch **90** und dem Bewegungstisch **94** befinden. Eine über den Tisch T auf den Bewegungstisch **94** einwirkende Last eines Gegenstands, beispielsweise eines Maschinenwerkzeugteils, eines Tisches oder dergleichen, oder eines auf dem Tisch T befindlichen Transportguts, wirkt direkt auf eine Anzahl von Kugeln **97** ein, die sich abrollend zwischen den Kugellaufflächen **92**, **92** und den Kugellaufflächen **94**a, **94**a für belastete Kugeln befinden. Darüber hinaus sind die Kugellaufflächen **92**, die Kugellaufflächen **94**a für belastete Kugeln und die Kugeln **97** derart angeordnet, daß sie die Abmessungen der Lücken zwischen jeder der Kugellaufflächen **92** und jeder der Kugeln **97** sowie zwischen jeder der Laufflächen **94**a für belastete Kugeln und jeder der Kugeln **97** kleiner zu machen trachten, wodurch auf die Kugeln **97** eine Vorspannung ausgeübt wird.

[0011] Bei einer herkömmlichen Antriebsvorrichtung mit dem oben beschriebenen Aufbau ist allerdings der Bodenteil **90**a des Führungstisches **90** von beträchtlicher Breite, so daß er die Neigung hat, sich durch ein Lastmoment Mc (**Fig.** 8) zu verformen oder durchzubiegen, welches in Abrollrichtung auf den Bewegungstisch einwirkt, wodurch die beiden Seitenabschnitte mit den Innenflächen **91**, **91**, in denen die Kugelaufnuten ausgebildet sind, nach außen geöffnet werden. Dies verursacht im Ergebnis eine Situation, in der der enge Kontakt zwischen den Kugeln **97**, der Kugellauffläche **92** und der Kugellauffläche **94**a für belastete Kugeln aufgehoben oder gelockert wird und es zu der Schwierigkeit kommt, auf die Kugeln **97** eine ausreichend starke Vorspannung aufzubringen. Bei einer Bewegung des Bewegungstisches **94** kommt es dann zu einer Gier- oder Nickbewegung aufgrund der verringerten Vorspannung, demzufolge man kein glattes und ruckfreies lineares Vorrücken des bewegten Teils erwartet werden kann. Dies ist von Nachteil.

[0012] Um den oben angesprochenen Mangel zu beheben, gab es die Idee, mehrere derartige Antriebsvorrichtungen Seite an Seite parallel zueinander anzuordnen. Allerdings erfordert eine solche seitliche Parallelanordnung beträchtlichen Platz in Breitenrichtung und eignet sich nicht zur Unterbringung in einem eng begrenzten Raum. Darüber hinaus erfordert eine solche Parallelanordnung eine hochgenaue Einstellung der parallelen Fluchtung und Arbeitsposition. Um außerdem den Betriebswiderstand der Anordnung minimal zu machen, ist beträchtlicher Zeit- und Arbeitsaufwand für eine Bedienungsperson erforderlich, wobei außerdem die Fertigungskosten für mehrere Antriebsvorrichtungen beträchtlich hoch sind.

[0013] Ziel der Erfindung ist es, die in dem oben erläuterten Stand der Technik anzutreffenden Unzulänglichkeiten oder Nachteile zu beheben und eine Antriebsvorrichtung mit breitem Aufbau zu schaffen, bei der es weniger Änderung der Vorspannung zwischen einem Wälzelement und einer Wälzelement-Lauffläche auch dann gibt, wenn eine Last, insbesondere ein Lastmoment in der Abrollrichtung relativ groß ist. Dabei sollen die Abmessungen in Breitenrichtung der Antriebsvorrichtung gering gehalten werden, ferner soll der Zusammenbau einfach und problemlos bei verringerten Fertigungskosten geschehen können.

[0014] Erreicht werden diese sowie weitere Ziele erfindungsgemäß durch eine Antriebsvorrichtung, insbesondere eine Antriebsvorrichtung mit beträchtlicher Breite, welche die Merkmale des Anspruchs 1 aufweist.

[0015] Vorteilhafte Weiterbildungen und Ausgestaltungen der Erfindung sind in den abhängigen Ansprüchen angegeben.

[0016] Gemäß diesen Weiterbildungen ist jeder der Bewegungstische mit Lagerteilen ausgestattet, um einen zu transportierenden Gegenstand zu lagern, wobei die Lagerteile an den beweglichen Tischen an einer Stelle ausgebildet sind, die in Bewegungsrichtung der Bewegungstische im wesentlichen zentral ist, wobei sie gleichzeitig in Richtung der Seitenabschnitte des Führungstisches versetzt sind.

[0017] Der Führungstisch ist eine Außenschiene, die Bewegungstische werden durch innere Blöcke gebildet.

[0018] Die Antriebsmittel umfassen ein Vorschubgewinde, eine Vorschubgewindewelle und eine Motoreinrichtung, die mit der Vorschubspindel betrieblich verbunden ist. Werden Kugeln als Wälz- oder Rollelemente verwendet, so ist das Vorschubgewinde vorzugsweise ein Kugelumlaufgewinde für jeden der Bewegungstische, wobei die Vorschubwelle eine Kugelumlaufspindel ist und mehrere Kugelumlaufspindeln synchron von mindestens einem Motor angetrieben werden.

[0019] Der flache Abschnitt, die dazu rechtwinkligen Seitenabschnitte und der Teilungsabschnitt des Führungstisches sind einstückig miteinander ausgebildet. Der Führungs- oder Spurtisch und die beweglichen Tische sind durch Zusammenbau als Linearführungsanordnung ausgebildet.

[0020] Da bei dem Aufbau mit den besonderen Merkmalen der vorliegenden Erindung der Teilungsabschnitt des Führungstisches vorhanden ist, kann sich der flache Abschnitt oder Bodenabschnitt des Führungstisches auch dann nicht durchbiegen, wenn er beträchtliche Abmessungen in Breitenrichtung besitzt. Aus diesem Grund läßt sich die Gegenmoment-Fähigkeit verbessern, wobei sich die Seitenabschnitte des Führungstisches nicht nach außen öffnen. Dementsprechend ändert sich die auf die Wälzelemente und die Wälzelement-Laufflächen aufgebrachte Vorspannung praktisch nicht, wodurch ein glattes und ruckfreies Bewegen des Bewegungstisches garantiert wird. Da es außerdem nicht notwendig ist, eine Mehrzahl von Führungsvorrichtungen Seite an Seite anzuordnen, läßt sich der Aufnahmeraum in Breitenrichtung reduzieren, außerdem können Zusammenbau in kürzerer Zeit und mit weniger Arbeitsaufwand und dementsprechend mit weniger Kosten durchgeführt werden.

[0021] Da sich ferner die Lagerabschnitte (Befestigungsbolzenlöcher) an dem Bewegungstisch an einer Stelle befinden, die im wesentlichen zentral an dem Bewegungstisch entlang dessen Bewegungsrichtung liegt, dabei aber in Richtung der Seitenabschnitte des Führungstisches versetzt ist, wird die Belastung durch den zu transportierenden Gegenstand gleichmäßig auf die jeweiligen rechtwinkligen Seitenabschnitte und den Zwischenabschnitt verteilt, demzufolge die Gegenmoment-Fähigkeiten für die Wälzelement-Laufflächen im wesentlichen gleich groß gehalten werden können, was eine ausgewogene Starrheit und Steifigkeit schafft. Der Bewegungstisch kann dementsprechend glatter bewegt werden. Die Ausbildung der Befestigungsbolzenlöcher als Lagerabschnitte ermöglicht ein einfaches und problemloses Anbringen und Lagern des zu transportierenden Gegenstands und macht die gesamte Struktur des Bewegungstisches einfach und kompakt.

[0022] Im folgenden werden Ausführungsbeispiele der Erfindung anhand der Zeichnung näher erläutert. Es zeigen:

[0023] **Fig.** 1 eine teilweise geschnittene perspektivische Ansicht einer Antriebsvorrichtung mit breitem Aufbau (großer Breitenabmessung) gemäß einer Ausführungsform der Erfindung;

[0024] **Fig.** 2 eine Draufsicht auf einen wesentlichen Teil der Antriebsvorrichtung nach **Fig.** 1;

[0025] **Fig.** 3 eine Schnittansicht entlang der Linie III-III in **Fig.** 2;

[0026] **Fig.** 4 eine perspektivische Ansicht eines wesentlichen Teils der Antriebsvorrichtung nach **Fig.** 1 in vergrößertem Maßstab;

[0027] **Fig.** 5 eine Draufsicht auf eine Antriebsvorrichtung gemäß einer weiteren Ausführungsform der Erfindung;

[0028] **Fig.** 6 ebenfalls eine Draufsicht auf eine Antriebsvorrichtung gemäß einer weiteren Ausführungsform der Erfindung;

[0029] **Fig.** 7 eine perspektivische Ansicht eines wesentlichen Teils einer Antriebsvorrichtung mit herkömmlichem Aufbau; und

[0030] **Fig.** 8 eine Schnittansicht der Antriebsvorrichtung nach **Fig.** 7.

[0031] Anhand der **Fig.** 1 bis 4 soll im folgenden eine erste bevorzugte Ausführungsform einer erfindungsgemäßen Antriebsvorrichtung erläutert werden.

[0032] Die Antriebsvorrichtung **1** gemäß der Erfindung ist eine solche mit besonders großen Abmessungen in Breitenrichtung (breiter lateraler Aufbau) und wird hier einfach als "Antriebsvorrichtung" bezeichnet. Nach **Fig.** 1 enthält die Antriebseinrichtung **1** eine Außenschiene **2** als Führungstisch mit einer gewissen Längserstreckung, zwei Innenblöcke **3**, **3** als Bewegungstisch (oder Bewegungstische), der sich entlang der Außenschiene **2** geführt verfahren läßt, Antriebsmittel in Form eines Kugelumlaufantriebs mit Kugelumlaufspindeln **4**, **4** zum Aufbringen einer Antriebskraft zur Relativbewegung zwischen der Außenschiene **2** und den Innenblöcken **3**, **3**, und Gehäuse **5** und **6**, die das vordere bzw. hintere Ende (die Längsenden) der Kugelumlaufspindeln **4**, **4** drehbar lagern.

[0033] Die Außenschiene **2** besteht gemäß **Fig.** 2 und 3 aus einem flachen Bodenteil **21** mit flacher Oberfläche, dazu rechtwinkligen Seitenteilen **22**, **22**, die sich parallel zueinander und an den Seiten des flachen Bodenteils **21** erstrecken, und einem Teilungsabschnitt **23**, der von dem flachen Bodenteil **21** ähnlich wie die Seitenteile **22**, **22** hochsteht und sich parallel zu diesen Seitenteilen **22**, **22** erstreckt. Bei diesem Aufbau wird die Außenschiene **2** in einen dargestellten Zustand (vertikal installierten Zustand) durch zwei Ausnehmungen mit oberen Öffnungen gebildet, untereinander abgetrennt durch den Teilungsabschnitt **23**, der sich in Längsrichtung der Ausnehmungen erstreckt. Der Bodenteil **21** der Außenschiene **2** enthält außerdem eine Mehrzahl von Bolzenlöchern **2**b, **2**b zum Befestigen der Antriebsvorrichtung als eine bauliche Komponente beispielsweise einer Werkzeugmaschine mit Hilfe von Bolzen oder dergleichen.

[0034] Bei einer bevorzugten Ausführungsform sind der flache Bodenteil **21**, die Seitenteile **22**, **22** und der Teilungsabschnitt **23** einstückig miteinander durch beispielsweise Spritzgießen gebildet. Die einstückige Ausbildung steigert die Festigkeit und Steifigkeit der gesamten Außenschiene **2** und verringert Arbeitsprozesse, was folglich bequem und wirtschaftlich ist. Allerdings können diese Teile auch unabhängig voneinander hergestellt und dann mit Hilfe von Bolzen und Muttern oder dergleichen zusammengebaut werden.

[0035] Beide senkrechten Seitenteile **22**, **22** besitzen Innenflächen **22**a, **22**a, an denen jeweils zwei vertikale Reihen von Kugellaufflächen (Wälzelement-Laufflächen) **24**a, **24**b ausgebildet sind. Es sind also insgesamt vier Kugellaufflächen **24**a, **24**a, **24**b und **24**b so angeordnet, daß sie sich in Längsrichtung der Innenflächen erstrecken. Außerdem sind an jeder der Seitenflächen **23**a, **23**a des Teilungsabschnitts **23** vertikal beabstandet zwei Reihen von Kugellaufflächen (Wälzelement-Laufflächen) **25**a, **25**b ausgebildet, die sich in Längsrichtung des Teilungsabschnitts erstrecken.

[0036] Die Innenblöcke **3**, **3** sind in die beiden Ausnehmungen **2**a, **2**a der Außenschiene **2** aufgenommen und werden von dieser über eine Anzahl von Kugeln **7**, **7**, . . . **7**, die Wälzelemente darstellen, gehaltert. Die Innenblöcke **3**, **3** besitzen Seitenflächen, an denen insgesamt acht Reihen von Laufflächen für belastete Kugeln (Laufflächen für belastete Wälzelemente) **34**a, **34**a, **34**b und **34**b derart ausgebildet ist, daß diese Laufflächen den acht Reihen von Kugellaufflächen **24**a, **24**a, **24**b, **24**b, **25**a, **25**a, **25**b bzw. **25**b der Außenschiene **2** entsprechen, das heißt im Zusammengebauten Zustand diesen Kugellaufflächen gegenüberstehen, wobei eine Reihe von Kugeln **7**, **7**, . . . **7** zwischen diesen Kugellaufflächen und Laufflächen für belastete Kugeln abrollbar angeordnet ist.

[0037] Jeder der Innenblöcke **3** ist an seinem mittleren Bereich mit einem Mutterabschnitt **31** ausgestattet, mit welchem die Spindelwelle **4** in Gewindeeingriff steht, wobei der Mutterabschnitt **31** sich zusammensetzt aus einem Kugelumlaufloch **31**a, welches direkt in den Innenblock **3** eingeformt ist. Das Kugelumlaufloch **31**a ist gemäß **Fig.** 1 in einem Bereich auf einer Linie ausgebildet, welche Mittellinien von Verbindungen zwischen oberen und unteren zwei Reihen von Kügellaufflächen **34**a, **34**b, **35**a und **35**b auf den beiden Seitenflächen des Innenblocks **3** verbindet. Außerdem kann der Mutterabschnitt **31** unabhängig von dem Innenblock **3** als einzelnes Element ausgebildet sein.

[0038] Darüber hinaus sind die Innenblöcke **3** mit Kugelrücklaufkanälen **36**c, **36**c, **36**d, **36**d, **37**c, **37**c, **37**d und **37**d zum Zurückführen der Kugeln **7** ausgestattet, welche den belasteten Kugellaufbereich in Abschnitten zwischen den jeweiligen Seitenflächen der Innenblöcke **3**, **3** und den Kugelumlauflöchern **31**a, **31**a passiert haben, wobei die Kugelrücklaufkanäle den Laufflächen für belastete Kugeln, **34**a, **34**a, **34**b, **34**b, **35**a, **35**a, **35b** bzw. **35b** entsprechen. Bei der dargestellten Ausführungsform sind diese Kugelrücklaufkanäle **36**c, **36**c, **36**d, **36**d, **37**c, **37**c, **37**d, **37**d derart angelegt, daß sie auf horizontalen Linien liegen, die durch die Mitten der jeweiligen Kugellaufflächen der Außenschiene **2** und der Kugellaufflächen für belastete Kugeln der Innenblöcke **3**, **3** gehen. Außerdem ist auf sämtliche Kugeln **7**, **7**, . . . **7** eine Vorspannung aufgebracht, wobei diese Vorspannung dadurch entsteht, daß die Abmessung der Lücken zwischen den jeweiligen Kugellaufflächen **24**a... und jeder der Kugeln **7** sowie zwischen jeder der Laufflächen für belastete Kugeln, 34a . . . und jeder der Kugeln **7** mit einem Minderbetrag (–) gefertigt ist.

[0039] Wie außerdem in den **Fig.** 1 bis 3 zu sehen ist, sind die Innenblöcke **3**, **3** mit Schraubenlöchern (Lagerabschnitten) **9**, **9** zur Anbringung eines zu transportierenden Gegenstands auf den Oberseiten der Innenblöcke **3**, **3** ausgestattet. Die Gewindelöcher **9**, **9** sind in Bereiche an den Seiten der Innenflächen **22**a, **22**a der rechtwinkligen Seitenteile **22**, **22** derart gebohrt, daß sie gegenüber der Stelle der Kugelrücklaufkanäle **36**c, **36**c, **36**d, **36**d, **37**c, **37**c, **37**d und **37**d entfernt sind.

[0040] Die Kugelumlauflöcher **31**a, die die Mittelbereiche der Innenblöcke **3**, **3** durchsetzen, sind auf der Hälfte ihrer Erstreckung (Zonen) in der in die Innenblöcke **3**, **3** eindringenden Richtung mit Gewindenuten ausgestattet, wie dies in **Fig.** 4 dargestellt ist, wobei für die Kugelumlauflöcher **31**a jeweils ein Rücklaufkanal **41** vorgesehen ist, so daß insgesamt durch diese Teile ein Kugelumlaufkanal gebildet wird. Außerdem erhalten auch die Kugeln B zwischen der Kugelumlaufspindel **4** und dem Kugelumlaufloch **31**a eine Vorspannung.

[0041] Wie in **Fig.** 1 und **Fig.** 2 zu sehen ist, sind die Innenblöcke **3**, **3** an ihren längsseitigen Enden mit Stirnplatten **32**, **33** ausgestattet, die vorzugsweise aus Kunststoffmaterial bestehen und jeweils etwa Rechteckform besitzen, etwa mit dem gleichen Grundriß wie der Innenblockkörper **3**a, der aus metallischem Material besteht. Die Stirnplatten **32** und **33** sind an den Innenblockkörpern **3**a, **3**a beispielsweise mittels Schrauben befestigt.

[0042] Die Stirnplatten **32** und **33** sind an ihren Lagerflächen bezüglich der Innenblockkörper **3**a, **3**a mit Laufrichtungs-Änderungskanälen **32**a, **32**a, **32**b, **32**b, **33**a, **33**a, **33**b und **33**b ausgestattet, um die Kugeln **7** aus den Belastungsbereichen zwischen den Innenblöcken **3**, **3** und der Außenschiene **2** aufzunehmen und sie in die Kugelrücklaufkanäle **36**c, **36**d, **37**c, **37**d und dann wieder in die belasteten Bereiche zu führen. Das heißt: an jeweils einer Stirnplatte sind vier Laufrichtungs-Änderungskanäle ausgebildet. Dementsprechend setzen sich die Kugelumlaufkanäle jeweils zusammen aus den Laufrichtungs-Änderungskanälen, den Kugelrücklaufkanälen und den Laufkanälen für belastete Kugeln. Die Kugeln **7**, **7**, ... **7** sind in den Kugelumlaufkanälen derart angeordnet und aufgenommen, daß sie entsprechend der Relativbewegung zwischen der Außenschiene **2** und den Innenblöcken **3**, **3** zirkulieren. Außerdem befinden sich offensichtlich die Laufflächen für die belasteten Kugeln auf den Außenseiten der jeweiligen Innenblöcke **3**, **3**.

[0043] Wie in **Fig.** 1 gezeigt ist, ist jede der Kugelumlaufspindeln **4**, **4** in das Kugelumlaufloch **31**a des jeweiligen Innenblocks **3**, **3** eingesetzt, ist mit einem Ende über einen nicht gezeigten Lagerteil im Gehäuse **6** an einem Ende der Außenschiene **2**, und ist mit dem anderen Ende ebenfalls drehbar durch ein Lagerteil **60** des Gehäuses **5** am anderen Ende der Außenschiene **2** gelagert. Diese Kugelumlaufspindeln **4**, **4** sind betrieblich mit Wellen von zwei nicht gezeigten Motoren gekoppelt, beispielsweise über Verbindungselemente.

[0044] Die Antriebsvorrichtung breiter Struktur gemäß obiger Beschreibung arbeitet folgendermaßen:

[0045] Wenn die erwähnten beiden Motoren synchron angetrieben werden, werden die Kugelumlaufspindeln **4**, **4** der Antriebsvorrichtung **1** gemeinsam gedreht, und diese Drehbewegungen werden über die Mutterabschnitte **31**, **31** auf die Innenblöcke **3**, **3** übertragen, die hierdurch entlang der Außenschiene **2** in dieselbe Richtung hin- und herbewegt werden.

[0046] Da bei diesem Vorgang die Schraubenlöcher oder Gewindelöcher, die zur Befestigung des zu transportierenden Gegenstands dienen, an Stellen ausgebildet sind, die zu den jeweiligen beiden Seiten der Außenschiene **2** versetzt sind und außerdem bezüglich der Bewegungsrichtung der Innenblöcke **3**, **3** mittig angeordnet sind, wird die durch den Gegenstand bedingte Last im wesentlichen gleichförmig auf beide rechtwinklige Seitenteile 22, 22 und den Teilungsabschnitt **23** der Außenschiene **2** verteilt. Aus diesem Grund lassen sich die Gegenmoment-Lastaufnahmefähigkeiten der jeweiligen Kugellaufflächen ausgleichen, demzufolge die Kugellaufflächen in seitlicher Richtung bezüglich der Last starr ausbalanciert sind. Damit sind die Innenblöcke **3**, **3** ruckfrei linear beweglich.

[0047] Da bei der beschriebenen Ausführungsform der Teilungsabschnitt **23** an der Außenschiene **2** ausgebildet ist, um die beiden Innenblöcke **3**, **3**, die Seite an Seite angeordnet sind, voneinander zu trennen oder aufzuteilen, ist es möglich, den horizontalen Teil **21** (den flachen Bodenteil) an einer Durchbiegung oder Auslenkung auch dann zu hindern, wenn die Außenschiene **2** eine sehr breite Struktur oder Abmessung besitzt, wodurch die Gegenmoment-Aufnahmefähigkeit verbessert und verhindert wird, daß die Seitenteile **22**, **22** nach außen geöffnet werden. Dies ist im Betrieb von Vorteil und zweckdienlich.

[0048] Aufgrund der obigen Umstände wird eine auf die Kugeln **7** und die Kugellaufflächen aufgebrachte Vorspannung nicht oder praktisch nicht geändert, demzufolge Fluktuationen der Innenblöcke **3**, **3** wirksam verhindert und mithin eine ruckfreie und glatte Bewegung der Innenblöcke **3**, **3** garantiert wird.

[0049] Das Verhindern des Biegens oder Durchbiegens des horizontalen Teils **21** der Außenschiene **2** durch die genannte Plazierung des Teilungsabschnitts **23** wird im folgenden näher erläutert.

[0050] Zunächst: bezüglich des Lastmoments MA in Nickrichtung gemäß **Fig.** 1 ist anzumerken, daß die Außenschiene **2** eine Schale darstellt, wobei der Trennabschnitt **23** die Funktion eines Kiels hat und dementsprechend eine äußerst hohe Steifigkeit für die Außenschiene **2** in dieser Belastungsrichtung gewährleisten kann.

[0051] Weiterhin: was die Verformung der Außenschiene **2** entsprechend einer pferdesattelähnlichen Aufspreizung angeht, so ist hier das Poisson-Verhältnis maßgeblich, demzufolge der Teilungsabschnitt **23** eine Durchbiegung der Außenschiene **2** bezüglich des Lastmoments MA in Nickrichtung unterdrücken kann, dementsprechend auch die Durchbiegung bezüglich des Lastmoments MC in Rollrichtung gemäß **Fig.** 1 verhindert werden kann.

[0052] Die Verbesserung hinsichtlich des Belastungs-Gegenmoments durch die Plazierung des Teilungsabschnitts **23** führt zu der Situation, daß die Antriebsvorrichtung ausreichende Festigkeit und Steifigkeit auch dann haben kann, wenn die Höhe der Außenschiene **2**, das heißt die Höhe der Gesamtstruktur der Antriebsvorrichtung, reduziert wird.

[0053] Um die Gegenmoment-Fähigkeit gegenüber Lastmomenten weiter zu verbessern, kann es zusätzlich zu den obigen Merkmalen wirksam sein, die Dicke des flachen Bodenteils **21** und der rechtwinkligen Seitenteile **22**, **22** der Außenschiene **2** zu verstärken und die Dicke der Querteile des flachen Bodenteils **21** und der rechtwinkligen Seitenteile **22**, **22** der Außenschiene **2** zu erhöhen.

[0054] Außerdem ist es gemäß der Ausführungsform der vorliegenden Erfindung nicht notwendig, mehrere Antriebsvorrichtungen Seite an Seite wie bei dem herkömmlichen Vorschlag anzuordnen, demzufolge der Unterbringungsraum in Breitenrichtung reduziert wird und die Antriebsvorrichtung einfach eingerichtet und eingestellt werden kann, demzufolge sich Arbeitsaufwand und Arbeitszeit für eine Bedienungsperson ebenso wie die Fertigungskosten verringern.

[0055] Bei einer modifizierten Ausführungsform kann eine Mehrzahl von Innenblöcken größer als zwei Seite an Seite parallel zueinander angeordnet sein. Bei einer solchen Ausgestaltung erhöht sich entsprechend die Anzahl der Teilungsabschnitte **23**. Beim dargestellten Ausführungsbeispiel befindet sich zwar der Teilungsabschnitt **23** zwischen einander benachbarten zwei inneren Blöcken **3**, **3**, die jeweils in einem von beiden Vertiefungen **2**a aufgenommen sind, alternativ können aber zwei oder mehr als zwei Innenblöcke **3**, **3** in jeweils einer Ausnehmung **2**a der Außenschiene **2** aufgenommen sein. Bei der dargestellten Ausführungsform sind zwar die Gewindelöcher in den Innenblöcken als Halteabschnitte an Stellen ausgebildet, die auf beiden Seiten der Außenschiene **2** versetzt sind; alternativ können die Innenblöcke aber auch mit dem zu transportierenden Gegenstand gekoppelt sein, wobei die Innenblöcke **3**, **3** dann als Bewegungstisch fungieren.

[0056] Bei der dargestellten Ausführungsform sind zwei Motoren an einer Stirnseite der Außenschiene **2** angeordnet. Statt dessen können aber auch zwei Motoren M, M an den beiden Enden der Außenschiene angeordnet sein, wie dies in **Fig.** 5 gezeigt ist. Bei dieser Anordnung werden zwei Motoren M, M synchron betrieben, so daß eine hohe Schubkraft erzielbar ist. Natürlich ist es auch möglich, diese beiden Motoren M, M unabhängig ohne synchronen Betrieb zu betreiben.

[0057] Außerdem kann entgegen der Ausführungsform nach **Fig.** 5, wo zwei Motoren endseitig an der Außenschiene **2** vorgesehen sind, ein Antrieb der Kugelumlaufspindeln mit Hilfe eines einzelnen Motors erfolgen, wobei **Fig.** 6 eine derartige Ausgestaltung zeigt.

[0058] Nach **Fig.** 6 ist eine Ausgangswelle (Antriebswelle) eines Motors M betrieblich mit einer der beiden Kugelumlaufspindeln **4**, **4** über eine Kupplung verbunden. Ein Antriebszahnrad **81** auf dieser Ausgangswelle kämmt mit einem angetriebenen Zahnrad **82**, welches mit der anderen Kugelumlaufspindel **4**, **4** gekoppelt ist, über ein Zwischenzahnrad **83**. Wenn bei diesem Aufbau der Motor M angetrieben wird, drehen sich die beiden Kugelumlaufspindeln **4**, **4** synchron und gleichsinnig, um die beiden Innenblöcke **3**, **3** synchron zu bewegen.

[0059] Bei der in **Fig.** 6 gezeigten Ausgestaltung kann das Antriebszahnrad **81** direkt mit dem angetriebenen Zahnrad **82** ohne Zwischenrad **83** kämmen, wobei dann von einer rechtsgängigen Spindel und einer linksgängigen Spindel Gebrauch gemacht wird, um die beiden Kugelumlaufspindeln **4**, **4** zu bilden, während bei Verwendung des Zwischenrads **83** gleichsinnige Kugelumlaufspindeln **4**, **4** benutzt werden können.

[0060] Außerdem kann man als Vorschubspindel anstelle der Kugelumlaufspindel der beschriebenen Ausführungsform eine Gleitspindel verwenden, und man kann außerdem anstelle der Kugeln **7** und B bei der beschriebenen Ausführungsform andere Wälzkörper, beispielsweise Rollen, verwenden.

[0061] Bei der dargestellten Ausführungsform wird zwar die Vorschubspindel als Antriebseinrichtung zur Ausführung der Relativbewegung zwischen der Außenschiene **2** und den Innenblöcken **3**, **3** verwendet, allerdings kann auch eine andere Antriebseinrichtung verwendet werden, so zum Beispiel ein Linearmotor. Bei einem Linearmotor kann ein zylindrischer Magnet als Stator und eine Ringspule an dem Magneten als Bewegungselement eingesetzt werden.

[0062] Gemäß obiger Beschreibung wurde die Linearbewegung zwischen der Außenschiene **2** und den Innenblökken **3**, **3** erwähnt, allerdings ist auch ein Aufbau denkbar, bei dem die Außenschiene **2** und die Innenblöcke **3**, **3** entlang einer gekrümmten Bahn relativ zueinander beweglich sind.

Patentansprüche

1. Antriebsvorrichtung, umfassend:
einen Führungstisch (**2**) mit einem flachen Teil (**21**), sich entlang der beiden Seitenränder des flachen Teils (**21**) in dessen Längsrichtung rechtwinklig erstreckenden, zueinander parallel verlaufenden Seitenteilen (**22**, **22**) und mindestens einem Teilungsabschnitt (**23**), der an dem flachen Teil (**21**) in einem Bereich zwischen den rechtwinkligen Seitenteilen (**22**, **22**) so ausgebildet ist, daß er sich parallel zu den Seitenteilen erstreckt, wobei die rechtwinkligen Seitenteile (**22**, **22**) auf ihren Innenseiten Wälzelement-Laufflächen (**24**a, **24**b, **25**a, **25**b) aufweisen, die sich in Längsrichtung der Seitenteile erstrecken, und der Teilungsabschnitt (**23**) auf beiden Seitenflächen Wälzelement-Laufflächen für belastete Wälzelemente (**34**a, **34**b, **35**a, **35**b) aufweist, die sich in Längsrichtung des Teilungsabschnitts erstrekken;
mehrere Bewegungstische (**3**, **3**), die jeweils in einen Raum eingesetzt sind, welcher zwischen einem der rechtwinkligen Seitenteile (**22**, **22**) und dem Teilungsabschnitt (**23**) oder zwischen mehreren Teilungsabschnitten (**23**) definiert ist, wobei die Bewegungstische (**3**, **3**) jeweils äußere Seitenflächen aufweisen, in denen Wälzelement-Laufflächen für belastete Wälzelemente (**34**a, **34**b, **35**a, **35**b) gebildet sind, wodurch Wälzelement-Umlaufkanäle gebildet werden, welche den Wälzelement-Laufflächen (**24**a, **24**b, **25**a, **25**b) des Führungstisches (**2**) entsprechen;
eine Anzahl von Wälzelementen (**7**), die in den Wälzelement-Umlaufkanälen beweglich angeordnet sind, um in diesen entsprechend der Relativbewegung zwischen dem Führungstisch (**2**) und den beweglichen Tischen (**3**, **3**) zu zirkulieren; und
Antriebsmittel zum Antreiben des Führungstisches (**2**) und/ oder des Bewegungstisches (**3**, **3**), um eine Relativbewegung zwischen ihnen hervorzurufen.
2. Vorrichtung nach Anspruch 1, bei der jeder der Bewegungstische (**3**, **3**) mit Lagerabschnitten (**9**, **9**) ausgestattet ist, um einen zu transportierenden Gegenstand zu lagern, wobei die Lagerabschnitte (**9**, **9**) an den beweglichen Tischen (**3**, **3**) an einer Stelle ausgebildet sind, die sich entlang der Bewegungsrichtung der beweglichen Tische (**3**, **3**) etwa in der Mitte der Tische befindet, während sie in Richtung der Seitenabschnitte des Führungstisches (**2**) versetzt sind.
3. Vorrichtung nach Anspruch 2, bei der die Lagerabschnitte (**9**, **9**) Gewindelöcher sind, die in den Bewegungstischen (**3**, **3**) ausgebildet sind.
4. Vorrichtung nach einem der Ansprüche 1 bis 3, bei der der Führungstisch (**2**) eine Außenschiene ist und die Bewegungstische (**3**, **3**) Innenblöcke sind.
5. Vorrichtung nach einem der Ansprüche 1 bis 4, bei der die Antriebsmittel ein Vorschubgewinde, eine Gewindespindelwelle (**4**, **4**) und eine Motoreinrichtung, die betrieblich mit der Gewindespindelwelle (**4**, **4**) gekoppelt ist, aufweisen.
6. Vorrichtung nach Anspruch 5, bei der die Wälzelemente (B) Kugeln sind, das Vorschubgewinde ein Kugelumlaufgewinde für jeden Bewegungstisch (**3**, **3**) ist, und die Gewindespindelwelle eine Kugelumlaufspindel für jedes Kugelumlaufgewinde ist, wobei mehrere Kugelumlaufspindeln synchron von mindestens einem Motor angetrieben werden.
7. Vorrichtung nach einem der Ansprüche 1 bis 6, bei der der flache Teil (**21**), die senkrechten Seitenteile (**22**, **22**) und der Teilungsabschnitt (**23**) des Führungstisches (**2**) einstückig miteinander ausgebildet sind.
8. Vorrichtung nach einem der Ansprüche 1 bis 7, bei der der Führungstisch (**2**) und die Bewegungstische (**3**, **3**) in zusammengebautem Zustand als Linearführungsvorrichtung ausgebildet sind.

Hierzu 5 Seite(n) Zeichnungen

- Leerseite -

Nummer: DE 101 15 943 A1
Int. Cl.[7]: F 16 H 25/22
Offenlegungstag: 25. Oktober 2001

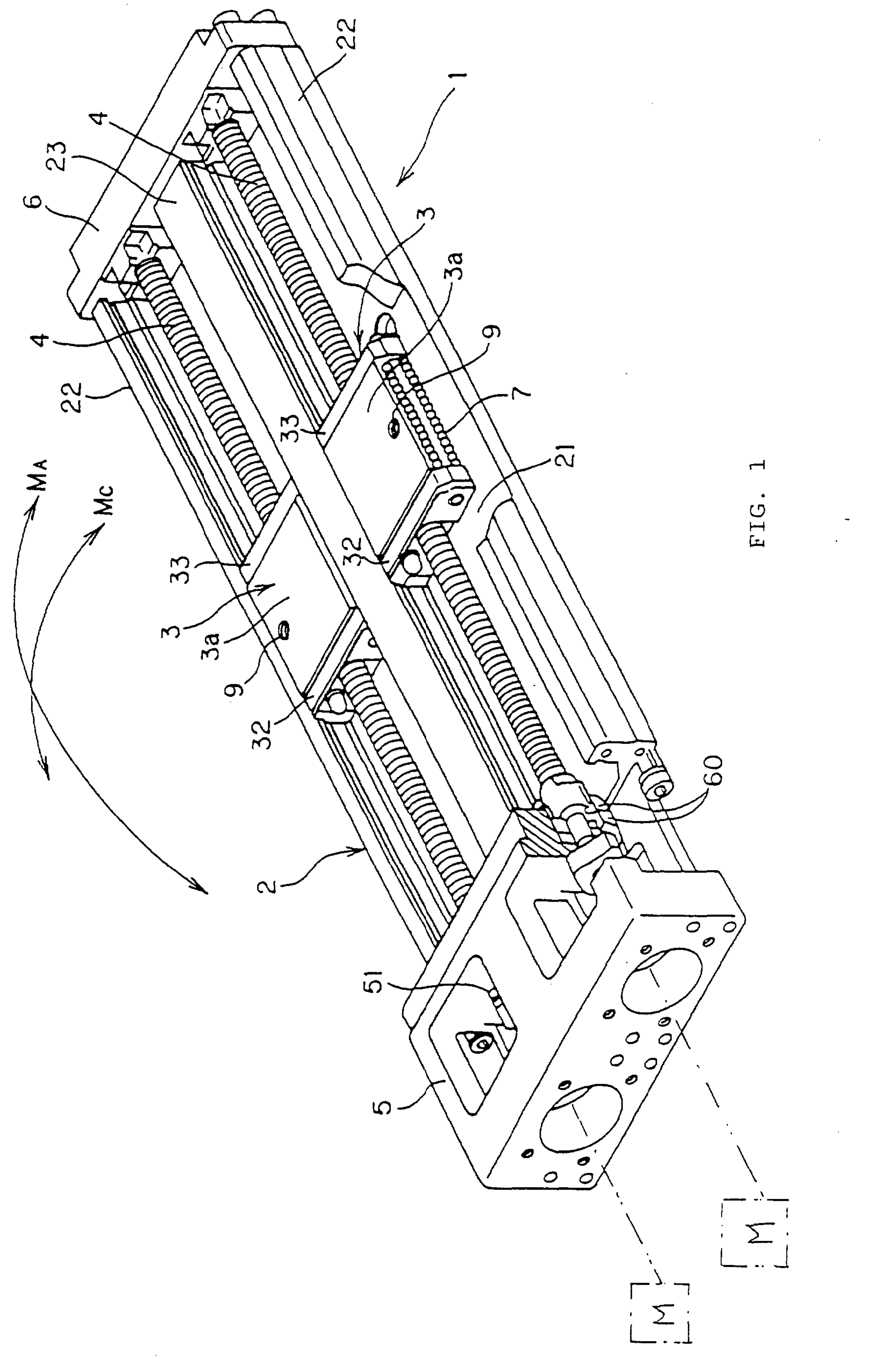


FIG. 1

Nummer: **DE 101 15 943 A1**
Int. Cl.[7]: **F 16 H 25/22**
Offenlegungstag: 25. Oktober 2001

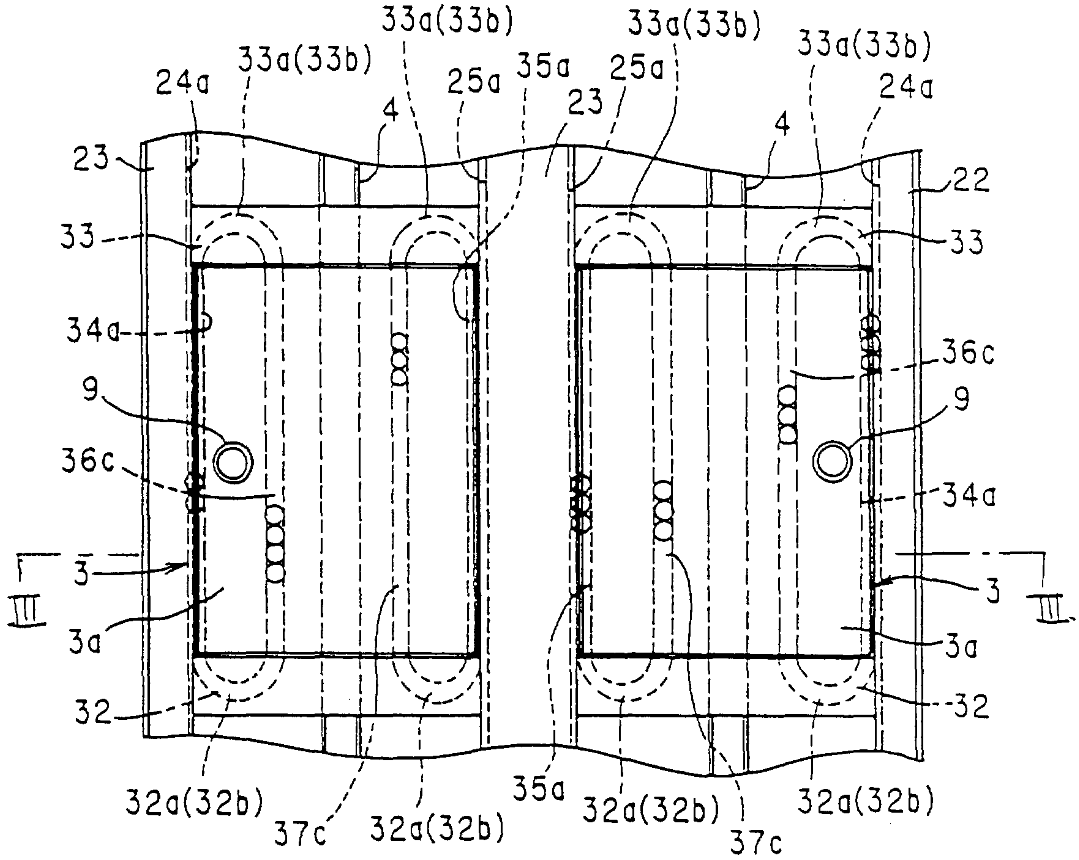


FIG. 2

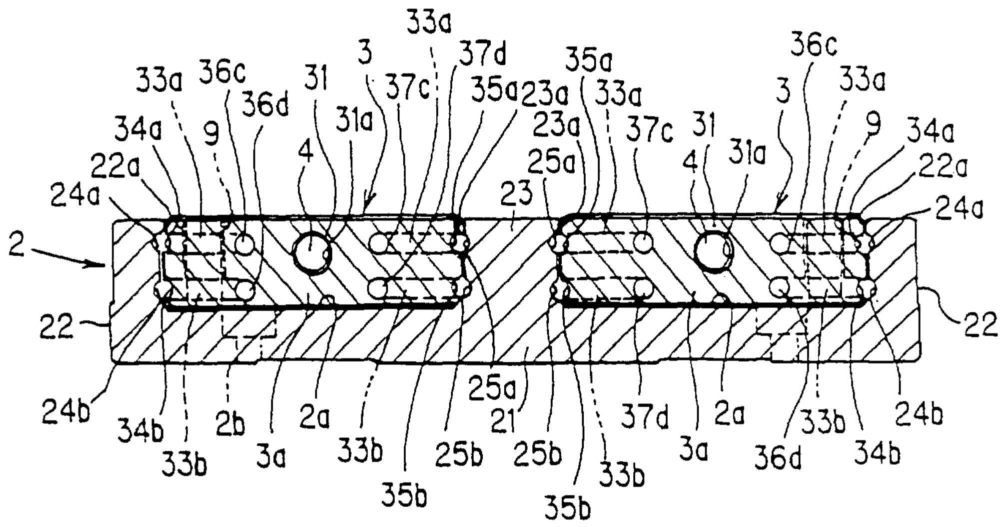


FIG. 3

Nummer: DE 101 15 943 A1
Int. Cl.[7]: F 16 H 25/22
Offenlegungstag: 25. Oktober 2001

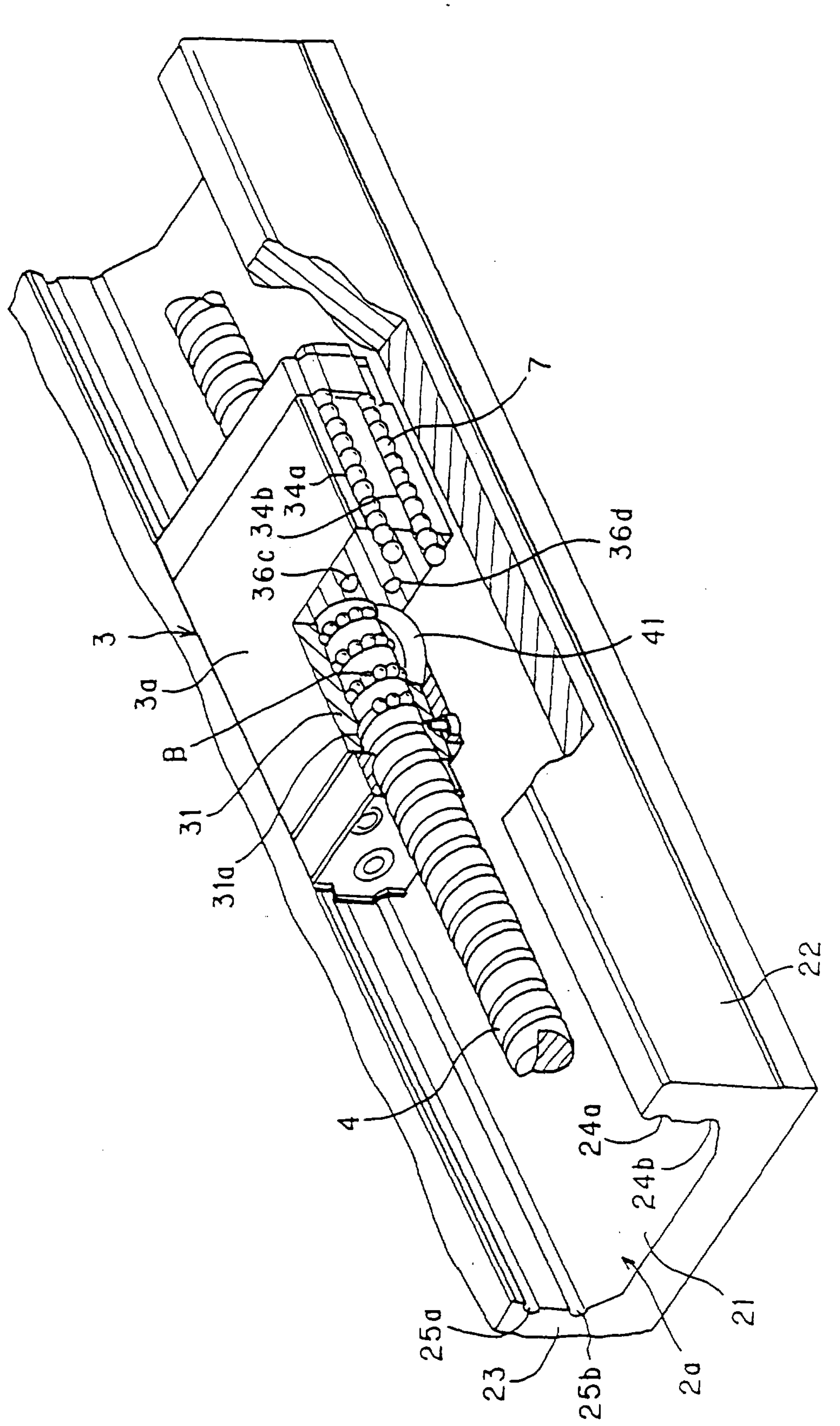


FIG. 4

Nummer: DE 101 15 943 A1
Int. Cl.[7]: F 16 H 25/22
Offenlegungstag: 25. Oktober 2001

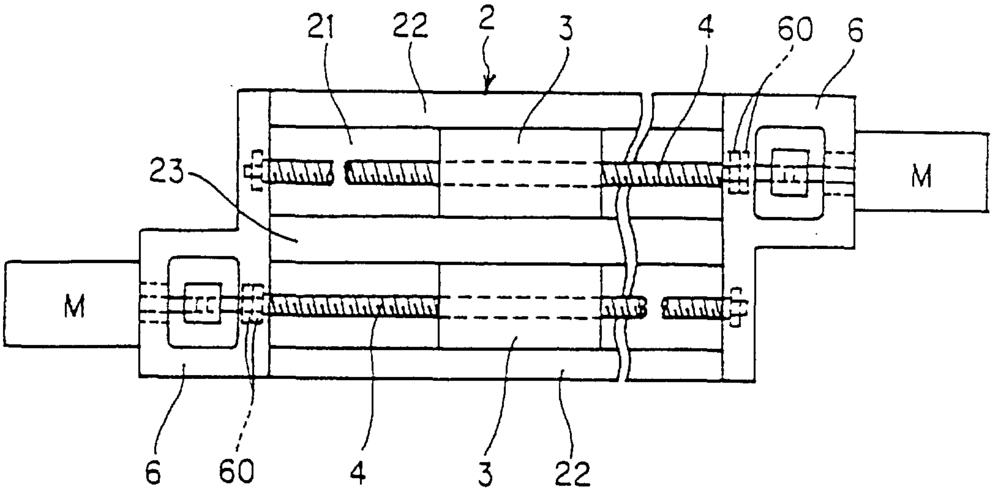


FIG. 5

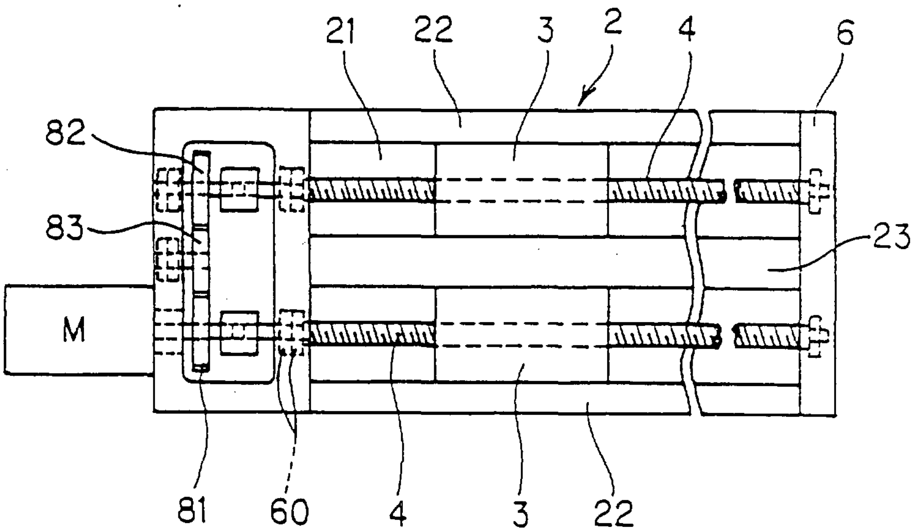


FIG. 6

Nummer: **DE 101 15 943 A1**
Int. Cl.[7]: **F 16 H 25/22**
Offenlegungstag: 25. Oktober 2001

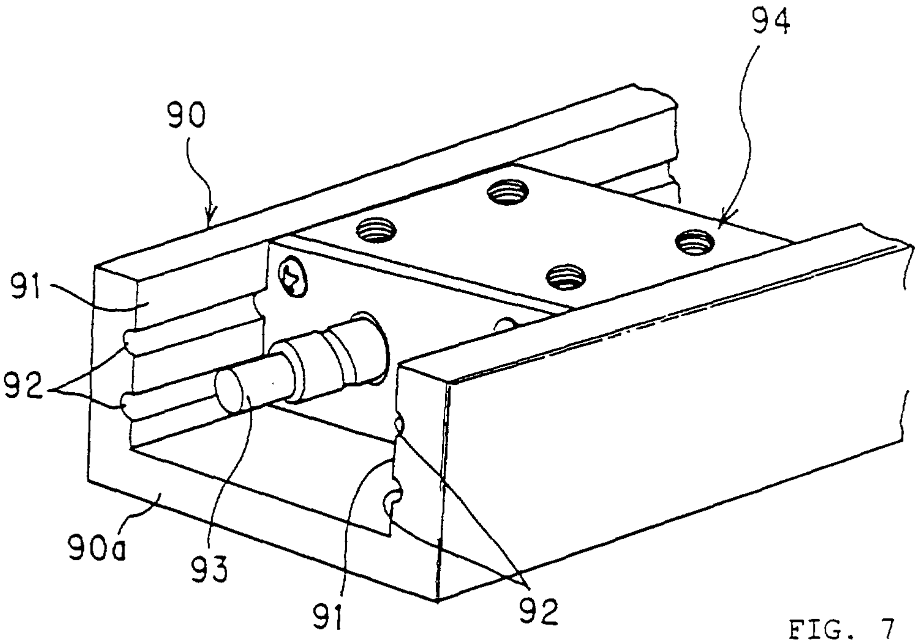


FIG. 7

Stand der Technik

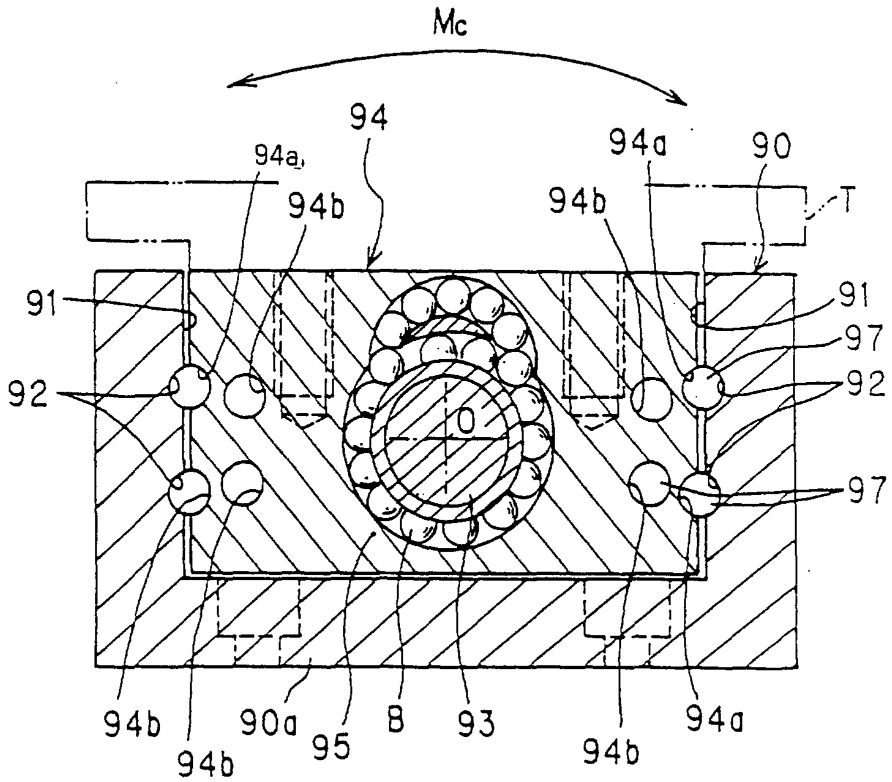


FIG. 8

Stand der Technik

(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

(12) Offenlegungsschrift

(10) DE 101 13 510 A 1

(51) Int. Cl.[7]: **F 16 H 25/22**

(21) Aktenzeichen: 101 13 510.6
(22) Anmeldetag: 20. 3. 2001
(43) Offenlegungstag: 29. 11. 2001

DE 101 13 510 A 1

(30) Unionspriorität:
083253/00 21. 03. 2000 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

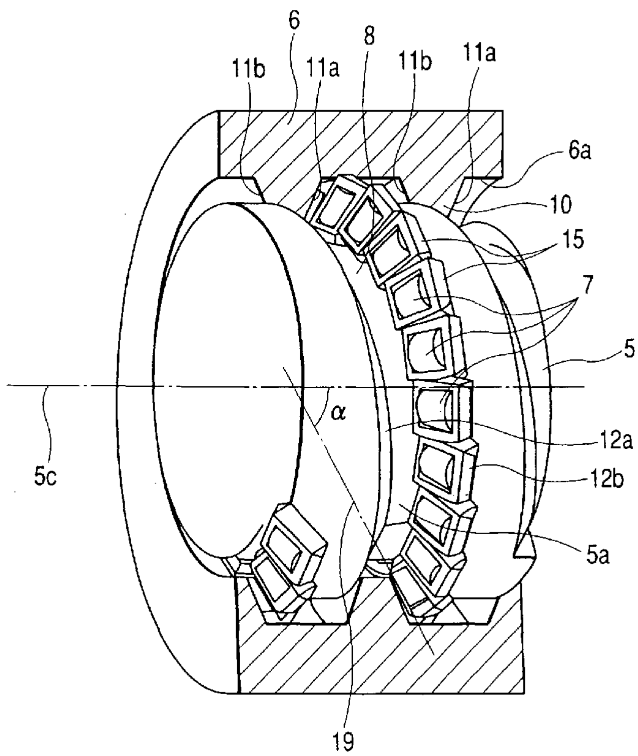
(74) Vertreter:
HOFFMANN · EITLE, 81925 München

(72) Erfinder:
Murata, Tomozumi, Tokio/Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Walzenkäfig, direkt wirkende Führungseinrichtung und Walzenschraube, die den Walzenkäfig verwendet

(57) Bei einer Walzenkäfiganordndung wird ein Walzenkäfig (15) verdünnt, dass eine individuelle einer Vielzahl von Walzen (7) aufgenommen wird, die in einem Walzenumlaufweg umlaufen, der eine lineare und eine gekrümmte Bahn umfasst, und um gegenüberliegende Seitenoberflächen der Walze (7) und vordere und rückwärtige Oberflächen davon in der Walzenbewegungsrichtung zu halten. Eine Kombination von einem linearen und gekrümmten Führungsbereich (16a und 16b), die sich im Neigungswinkel unterscheiden, und eine Kombination eines linearen und gekrümmten Führungsbereichs (17a und 17b), die sich im Neigungswinkel unterscheiden, sind jeweils an gegenüberliegenden Endoberflächen des Walzenkäfigs (15) in einer Käfigbewegungsrichtung geformt. In einer linearen Bahn kommen die linearen Führungsbereiche (16a und 17a) jeweils in Kontakt mit benachbarten Walzenkäfigen (15). In einer gekrümmten Bahn kommen jeweils die gekrümmten Führungsbereiche (16b und 17b) in Kontakt mit benachbarten Walzenkäfigen (15).



DE 101 13 510 A 1

Beschreibung

HINTERGRUND DER ERFINDUNG

1. Gebiet der Erfindung

[0001] Die vorliegenden Erfindung bezieht sich auf einen Walzenkäfig, der in einer direkt wirkenden Führungseinrichtung, einer Walzenschraube oder ähnlichem verwendet wird, und bei dem eine Walze, die in einem umlaufenden Weg abwälzt, so gehalten wird, dass sie drehbar/verschiebbar ist.

2. Beschreibung des Stands der Technik

[0002] Eine Walzenschraube, die Walzen zwischen einer Schraubenwelle und einem Mutterelement zwischengeschaltet hat, ist bekannt. Wenn die Schraubenwelle relativ zu dem Mutterelement gedreht wird, macht das Mutterelement eine Hin- und Herbewegung in einer Richtung der Achse der Schraubenwelle. Die Walzen machen eine Wälzbewegung, so dass sie um den äußeren Umfang einer Schraubennut zwischen der Schraubenwelle und dem Mutterelement laufen. Somit laufen die Walzen in einem Walzenumlaufweg um. Eine helixförmige Walzenabwälznut ist in der Schraubenwelle geformt. Der Walzenumlaufweg, der eine helixförmige Lastabwälznut entsprechend der Walzen Abwälznut enthält, ist in dem Mutterelement geformt. In der Walzenschraube kann die Vielzahl von Walzen in dem Walzenumlaufweg so angeordnet sein, dass sie parallel zueinander sind, damit die Achsen von benachbarten Walzen näherungsweise parallel zueinander gehalten werden, oder die Vielzahl von Walzen kann in dem Walzenumlaufweg so angeordnet sein, dass die Walzen einander kreuzen, dass sich die Achsen von benachbarten Walzen schneiden.

[0003] Im allgemeinen machen im Fall einer Walzenschraube der Voll-Walzenart, bei der nur Walzen in dem Walzenumlaufweg angeordnet sind, die jeweiligen Walzen keine konsistente Bewegung, so dass jede der Walzen in einer Ebene nach unten fällt, die die Achse der Walze enthält und die Richtung der Bewegung der Walze um ein Festklemmen zu bewirken. Somit können sich die Walzen nicht bewegen, während sie in dem Walzenumlaufweg angeordnet sind. Obwohl es sich nicht auf eine Walzenschraube bezieht, ist ein gürtelartiger Kugelkäfig zum drehbar/verschiebbar Halten einer Vielzahl von Kugeln einer Kugelschraube bekannt, um einen geordneten Umlauf der Kugeln zu ermöglichen (beispielsweise aus der JP-A-11-223258). Der Kugelkäfig hält die Kugeln in der Form einer linearen Kette, so dass benachbarte Kugeln der Vorderseite und Rückseite sich glatt bewegen können.

[0004] Andererseits ist ein Käfig zum Halten von korrespondierenden Walzen, die in einem Umlaufweg einer direkt wirkenden Führungseinrichtung angeordnet und aufgenommen sind, bekannt (siehe JP-A-60-205013). **Fig.** 17 zeigt solche Käfige, die in dem Walzenumlaufweg der direkt wirkenden Führungseinrichtung umlaufen. Eine Vielzahl von Walzen **1** ist kreuzangeordnet in dem Walzenführungsweg **2**, so dass die Achsen von benachbarten Walzen **1** einander schneiden. Die Richtung der Walzen **1** wird zweidimensional zwischen einem linearen Lastdurchgang **2**a und einem U-förmigen Richtungsänderungsdurchgang **2**b verändert. **Fig.** 18 ist eine Vorderansicht eins Käfigs **3** mit einer Walze **1**, gesehen in der Bewegungsrichtung davon. **Fig.** 19 ist eine Querschnittsansicht entlang der Linie A-A aus **Fig.** 18. Aufgrund der kreuzenden Anordnung der Walzen **1** ist der Walzenumlaufweg **2** im wesentlichen wie ein Rechteck im Querschnitt geformt. Die Käfige **3** halten die Walzen **1** in Behälterlöchern **3**a der Käfige **3** drehbar/verschiebbar und individuell und entsprechend, wobei die äußeren Umfänge **1**a der Walzen **1** teilweise leicht freigelegt sind. Die Dicke des Käfigs **3** (die radiale Dicke der Walzen) ist näherungsweise gleich derjenigen der Walze **1** gesetzt. Wie es in den Zeichnungen gezeigt ist, bildet die Form des Käfigs **3**, die von der Vorderseite in der Richtung der Bewegung zu sehen ist, ein Rechteck, das näherungsweise gleich der Querschnittsform des Walzenumlaufwegs **2** ist, so dass die Walze **1** durch den Käfig **3** geführt werden kann. Wie es in **Fig.** 17 gezeigt ist, sind zwei Endoberflächen **3**a und **3**b, die einen Winkel bilden, der nicht kleiner als 90° ist, an zwei Enden der benachbarten Käfige **3** in deren Bewegungsrichtung geformt. Wenn der Käfig **3** sich auf dem linearen Lastdurchgang **2**a befindet, ist eine Endoberfläche **3**a so positioniert, dass sie näherungsweise senkrecht zu dem Lastdurchgang **2**a ist. Wenn sich der Käfig **3** auf dem U-förmigen Richtungsänderungsdurchgang **2**b befindet, ist die andere Endoberfläche **3**b in die Richtung des Radius des Richtungsänderungsdurchgangs **2**b gerichtet. Somit laufen die Käfige **3** mit den Walzen **1** in dem Walzenumlaufweg **2** um, wobei die Endoberflächen **3**a und **3**b von benachbarten Käfigen **3** einander drücken.

[0005] Bei dem Kugelkäfig des Stands der Technik, der Kugeln in der Gestalt einer geraden Kette hält, zeichnet jedoch der Umlaufweg der Kugelschraube eine Spirale. Somit wird der Kugelkäfig so spiralförmig verwunden, dass Last auf den Kugelkäfig aufgebracht wird. Es ist eine Gefahr vorhanden, dass der Kugelkäfig durch diese Last beschädigt wird.

[0006] Auf der anderen Seite sind die Käfige **3**, durch die die Walzen **1**, die in dem Walzenführungsweg **2** der direkt wirkenden Führungseinrichtung angeordnet und aufgenommen sind, individuell gehalten werden, an den Fall angepasst, in dem der lineare Lastdurchgang und der U-förmige Richtungsänderungsdurchgang auf eine Ebene positioniert sind, so dass die Richtung der Walzen **1** zweidimensional geändert wird. Beispielsweise ist in einem Umlaufweg einer Walzenschraube jedoch keine zweidimensionale Richtungsänderung, sondern eine dreidimensionale Richtungsänderung vorhanden und entsprechend kann eine Verwindungsbewegung um die Bewegungsrichtung verlangt werden. Bei den vorher erwähnten Käfigen **3** wird den umlaufenden Käfigen **3** nicht ermöglicht, dass sie sich leicht um die Achsen der Walzen **1** jeweils drehen, so dass die Käfige **3** kaum solch eine komplexe Bewegung ausführen können. Dies ist, da die Gestalt jedes Käfigs **3** geformt ist, dass sie näherungsweise gleich der Querschnittsgestalt des Walzenumlaufwegs **2** ist, und da benachbarte Käfige **3** in Oberflächenkontakt miteinander an großflächigen, flachen Endoberflächen **3**a und **3**b sind. Weiterhin kann ein Schmiermittel kaum zwischen den Käfig **3** und eine korrespondierende Walze **1** eindringen, da der Umfang der Walze **1**, außer einem Teil des äußeren Umfangs **1**a, mit dem Käfig **3** bedeckt ist. Somit kann die Walze **1** nicht ausreichend geschmiert werden. Weiterhin ist näherungsweise der gesamte Querschnitt des Walzenumlaufwegs **2** mit dem Käfig **3** bedeckt. Es besteht ein Problem dahingehend, dass ein Stützelement zum Stützen des Käfigs **3** um den Käfig **3** vom Herunterfallen von dem Gleitelement zu hindern, wenn das Gleitelement aus der Laufschiene entfernt wird, kaum in dem Umlaufweg vorgesehen wird.

ZUSAMMENFASSUNG DER ERFINDUNG

[0007] Es ist eine Aufgabe der vorliegenden Erfindung, das oben stehende Ziel zu erreichen, und daher einen Walzenkäfig vorzusehen, der glatt umlaufen kann, selbst unter einem komplexen kinetischen Zustand, wie einem dreidimensionalen Richtungsänderungsdurchgang, und bei dem Schmieröl ausreichend den Walzen zugeführt werden kann, und eine direkt wirkende Führungseinrichtung und eine Walzenschraube vorzusehen, die solche Walzenkäfige verwenden.

[0008] Die vorliegende Erfindung wird unten stehend beschrieben. Obwohl die Referenzziffern in den beigefügten Zeichnungen in Klammern gesetzt sind, um das Verständnis der vorliegenden Erfindung einfach zu machen, ist die vorliegende Erfindung nicht auf die Ausführungsformen beschränkt, die auf den beigefügten Zeichnungen basieren.

[0009] Um das Problem zu lösen, sieht der Erfinder der vorliegenden Erfindung ein System vor, bei dem Walzen, die in einem Umlaufweg umlaufen, nicht in der Gestalt einer geraden Kette gehalten werden, sondern in Walzenkäfigen individuell gehalten werden, so dass die Walzen in einem Umlaufweg umlaufen, wobei der rückseitige Walzenkäfig den vorderseitigen Walzenkäfig drückt. Ferner, da lineare Bereiche und gekrümmte Bereiche hauptsächlich in dem Umlaufweg vorhanden sind, berücksichtigt die Erfinder die Gestalt von jedem Ende des Walzenkäfigs in einer Bewegungsrichtung davon, so dass eine Druckkraft glatt in sowohl den linearen Bereichen als auch in den gekrümmten Bereichen übertragen wird. Weiterhin sieht der Erfinder ein System vor, bei dem Walzenkäfige umlaufen können, wobei ihnen erlaubt wird, sich leicht um die Achsen der Walzen jeweils zu drehen, wenn die Walzenkäfige umlaufen, wobei sie einander pressen. Entsprechend können die Walzenkäfige auf einen dreidimensionalen, komplexen Umlaufweg unter der Annahme angepasst werden, dass die Walzen in dem Umlaufweg angeordnet sind und die Achsen von benachbarten Walzen im wesentlichen parallel zueinander gehalten werden.

[0010] Insbesondere ist gemäß einem ersten Aspekt der vorliegende Erfindung eine Walzenkäfiganordnung vorgesehen, die Walzenkäfige **15** zum individuellen und korrespondierenden Aufnehmen einer Vielzahl von Walzen **7** hat, die in einem Walzenumlaufweg umlaufen, der lineare und gekrümmte Bahnen umfasst, wobei: jeder der Walzenkäfige **15** dünn gestaltet ist, um gegenüberliegende Seitenoberflächen der Walze **7** und vordere und rückwärtige Oberflächen der Walze **7** in einer Bewegungsrichtung der Walze **7** zu halten; ein linearer Führungsbereich **16**a, **17**a und ein gekrümmter Führungsbereich **16**b, **17**b, die sich in einem Neigungswinkel voneinander unterscheiden, in gegenüberliegenden Endoberflächen des Walzenkäfigs **15** in einer Bewegungsrichtung des Walzenkäfigs **15** geformt sind; und der lineare Führungsbereich **16**a, **17**a des Walzenkäfigs **15** in Berührung mit einem benachbarten Walzenkäfig **15** in der linearen Bahn kommt und der gekrümmte Führungsbereich **16**b, **17**b des Walzenkäfigs **15** in Kontakt mit einem benachbarten Walzenkäfig **15** in der gekrümmten Bahn kommt. Durch das Vorsehen des Walzenkäfiganordnung wird daher das oben erwähnte Problem gelöst. Die Dicke des Walzenkäfigs **15** wird ausgewählt, dass sie nicht größer als 90%, vorzugsweise nicht größer als 60%, des Walzendurchmessers ist.

[0011] Gemäß dieser Erfindung können in sowohl linearen Bahnen als auch gekrümmten Bahnen, die eine Umlaufbahn bilden, benachbarte Walzenkäfige einander drücken, ohne die Position einer Walze zu beeinträchtigen, die sich vorderseitig in der Richtung der Bewegung der Walze befindet. Somit können Walzen ausgerichtet werden, dass ein glatter Umlauf erzielt werden kann. Weiterhin, da der Walzenkäfig dünn gestaltet ist, werden die folgenden Wirkungen erzielt.

(1) Benachbarte Walzenkäfige können einander drükken, wobei ihnen erlaubt wird, dass sie sich leicht um die Achsen von entsprechenden Walzen jeweils drehen. Als eine Folge kann der Walzenkäfig als ein Walzenkäfig erzielt werden, der für einen komplexen Umlaufweg, wie einen dreidimensionalen Richtungsänderungsdurchgang oder einen helixförmigen Lastabwälzdurchgang, der wie eine Schraube gestaltet ist, geeignet ist.

(2) Ein großer Raum kann zum Aufnehmen von Schmieröl in dem Umlaufweg sichergestellt werden. Somit können die Walzen ausreichend geschmiert werden.

(3) Ein Element zum Verhindern des Herunterfallens zum Stützen des Walzenkäfigs kann in dem Umlaufweg vorgesehen werden, so dass der Walzenkäfig nicht aus dem Mutterelement fallen kann, oder ähnlichem.

[0012] Gemäß einem zweiten Aspekt der Erfindung ist eine Walzenanordnung vorgesehen, die Walzenkäfige **31** zum individuellen und entsprechenden Zurückhalten einer Vielzahl von Walzen **7** hat, die in einem Walzenumlaufweg, der lineare und gekrümmte Bahnen beinhaltet, umlaufen, wobei: jeder der Walzenkäfige **31** dünn gestaltet ist, um die gegenüberliegenden Seitenoberflächen der Walze **7** zu halten, und entweder die vordere oder die rückwärtige Oberfläche der Walze **7** in einer Bewegungsrichtung der Walze **7**; ein linearer Führungsbereich **32**a und ein gekrümmter Führungsbereich **32**b, die sich in ihrem Neigungswinkel unterscheiden, in einer Endoberfläche des Walzenkäfigs **31** in einer Bewegungsrichtung des Walzenkäfigs **31** geformt sind; und der lineare Führungsbereich **32**a des Walzenkäfigs **31** in Kontakt mit einer benachbarten Walze **7** in der linearen Bahn kommt und der gekrümmte Führungsbereich **32**b des Walzenkäfigs **31** in Kontakt einer benachbarten Walze **7** in der gekrümmten Bahn kommt. Durch das Vorsehen der Walzenkäfiganordnung wird das oben erwähnte Problem daher gelöst.

[0013] Gemäß dieser Erfindung hält zusätzlich zu dem gleichen Betrieb und der gleichen Wirkung wie derjenigen der vorher erwähnten Erfindung der Walzenkäfig entweder die vordere oder die rückwärtige Oberfläche einer entsprechenden Walze in der Bewegungsrichtung der Walze. Somit wird der Raum, der durch einen Walzenkäfig in dem Umlaufweg eingenommen wird, reduziert, so dass die Anzahl der Walzen erhöht werden kann. Entsprechend kann die Lastkapazität einer direkt wirkenden Führungseinrichtung oder Walzenschraube, die solche Walzenkäfige verwendet, erhöht werden.

[0014] Gemäß einem dritten Aspekt der Erfindung wird bei dem ersten Aspekt der Erfindung jeder der linearen Führungsbereiche **16**a, **17**a und der gekrümmten Führungsbereiche **16**b, **17**b des Walzenkäfigs **15** geformt, dass er eine gekrümmte Oberfläche ist, die wie ein kreisförmiger Bogen im Querschnitt geformt ist, so dass sie in einen linearen Kontakt mit dem benachbarten Walzenkäfig **15** kommt.

[0015] Gemäß dieser Erfindung können benachbarte Walzenkäfige einander drücken, während ihnen mit Sicherheit ermöglicht wird, dass sie sich leicht um die Achsen der entsprechenden Walzen jeweils drehen.

[0016] Gemäß einem vierten Aspekt der Erfindung ist bei dem zweiten Aspekt der Erfindung jeder der linearen Führungsbereiche **32**a und gekrümmten Führungsbereiche **32**b des Walzenkäfigs **15** als eine gekrümmte Oberfläche in Übereinstimmung mit einem äußeren Umfang der Walze **7** geformt.

[0017] Gemäß dieser Erfindung können eine Walzen und ein Walzenkäfig, die einander benachbart sind, einander drücken, wobei dem Walzenkäfig mit Sicherheit ermöglicht wird, dass er sich leicht um die Achse einer entsprechenden

Walze dreht. Ferner, da der Walzenkäfig in Oberflächenkontakt mit einer Walze kommt, die sich an der Vorderseite oder Rückseite in der Bewegungsrichtung des Walzenkäfigs befindet, kann ein Berührungsoberflächendruck reduziert werden.

[0018] Gemäß einem fünften Aspekt der Erfindung ist bei der Walzenkäfiganordnung, wie sie dem ersten oder dritten Aspekt entspricht, ein Gelenkvorsprung **26** an einem Schnittpunkt zwischen dem linearen Führungsbereich **16**a und dem gekrümmten Führungsbereich **16**b in einer Endoberfläche des Walzenkäfigs **25** vorgesehen; und eine Gelenkaussparung **27** ist an einem Schnittpunkt zwischen dem linearen Führungsbereich **17**a und dem gekrümmten Führungsbereich **17**b in der anderen Endoberfläche des Walzenkäfigs **25** vorgesehen, so dass die Gelenkaussparung **27** mit dem Gelenkvorsprung **26** eines benachbarten Walzenkäfigs in Eingriff kommt.

[0019] Gemäß dieser Erfindung wird dem Walzenkäfig nur ermöglicht, dass er um ein Gelenk schwingt, das durch eine Kombination des Gelenkvorsprungs und der Gelenkaussparung gebildet wird, in einer Ebene, die die Achse einer entsprechenden Walze und die Bewegungsrichtung der Walze enthält. Somit kann verhindert werden, dass die Walze herunterfällt, selbst an einer Grenze, in der ein Übergang von einer linearen Bahn zu einer gekrümmten Bahn auftritt. Somit kann ein glatter Umlauf der Walze sichergestellt werden.

[0020] Gemäß einem sechsten Aspekt der Erfindung sind bei einem der ersten bis fünften Aspekte Vorsprünge **20**, die ein Herunterfallen verhindern, auf entweder dem Walzenkäfig **15** oder den gegenüberliegenden Seitenoberflächen der Walze **7** geformt; und Aussparungen **21** zum Verhindern des Herunterfallens sind in dem anderen von dem Walzenkäfig und den gegenüberliegenden Seitenoberflächen der Walze geformt, so dass die Vorsprünge zum Verhindern des Herunterfallens in die Aussparungen zum Verhindern des Herunterfallens eingepasst werden.

[0021] Gemäß dieser Erfindung kann verhindert werden, dass die Walze aus dem Walzenkäfig fällt. Beispielsweise kann selbst in dem Fall, in dem ein Gleitelement, wie ein Mutterelement, aus der Bahnschiene entfernt wird, der Walzenkäfig verhindern, dass die Walze aus dem Gleitelement herunterfällt, so dass verhindert werden kann, dass die Walze von dem Gleitelement fällt.

[0022] Gemäß einem siebten Aspekt der Erfindung ist bei einem der ersten bis sechsten Aspekte eine Dicke des Walzenkäfigs **15** gewählt, dass sie nicht kleiner als 50% eines Durchmessers der Walze ist. Wenn eine kegelförmige Walze als jede der Walzen verwendet wird, bedeutet der Ausdruck "Walzendurchmesser", der hier verwendet wird, den kleinsten Walzendurchmesser.

[0023] Wenn die Dicke von jedem der Walzenkäfige kleiner als 50% des Walzendurchmessers ist, dringt das vordere Ende des nachfolgenden Walzenkäfigs in dem Umlaufweg in die Lücke zwischen dem vorderseitigen Walzenkäfig und der Walzenabwälznut ein, so dass benachbarte Walzenkäfige einander überlappen. Als Folge ist eine Gefahr vorhanden, dass der Umlauf der Walzen stoppen könnte. Wenn die Dicke von jedem der Walzenkäfige nicht kleiner als 50% des Walzendurchmessers ist, können solche benachbarten Walzenkäfige daran gehindert werden, einander zu überlappen.

[0024] Ferner ist gemäß der Erfindung auch eine direkt wirkende Führungseinrichtung vorgesehen, die umfasst: eine Bahnwelle **41**, **51**, die eine Walzenabwälzoberfläche **41**a, **51**a enthält; ein Gleitelement **42**, **52**, das einen Walzenumlaufweg umfasst, der eine Lastabwälzoberfläche **42**a, **52**a entsprechend der Walzenabwälzoberfläche **41**a, **51**a umfasst, wobei das Gleitelement **42**, **52** an der Bahnwelle **41**, **51** angepasst ist, so dass es frei bewegbar relativ zu der Bahnwelle **41**, **51** ist; eine Vielzahl von Walzenpaaren **40**, **53**, die in dem Walzenumlaufweg angeordnet und darin aufgenommen sind, so dass sie in Übereinstimmung mit der Bewegung des Gleitelements **42**, **52** relativ zu der Bahnwelle **41**, **51** umlaufen; und eine Vielzahl von Walzenkäfigen **15** zum Halten der Vielzahl von Walzen **43**, **53** individuell und entsprechend, so dass die Vielzahl von Walzen **43**, **53** drehbar/verschiebbar ist, wobei: die Vielzahl von Walzen **43**, **53** angeordnet und aufgenommen ist, so dass die Achsen von benachbarten Walzen **43**, **53** näherungsweise parallel zueinander gehalten werden; jeder der Walzenkäfige **15** dünn gestaltet ist, um gegenüberliegende Seitenoberflächen einer entsprechenden der Walzen **7** und vordere und rückwärtige Oberflächen der Walze **7** in einer Bewegungsrichtung der Walze **7** zu halten; ein linearer Führungsbereich **16**a, **17**a und ein gekrümmter Führungsbereich **16**b, **17**b, die sich im Neigungswinkel voneinander unterscheiden, in jeder der gegenüberliegenden Endoberflächen des Walzenkäfigs **15** in einer Bewegungsrichtung des Walzenkäfigs **15** geformt sind; und der lineare Führungsbereich **16**a, **17**a des Walzenkäfigs **15** in Kontakt mit einem benachbarten Walzenkäfig **15** in einer linearen Bahn und der gekrümmte Führungsbereich **16**b, **17**b des Walzenkäfigs **15** in Kontakt mit einem benachbarten Walzenkäfig **15** in einer gekrümmten Bahn kommt.

[0025] Weiterhin ist gemäß der Erfindung auch eine direkt wirkende Führungseinrichtung vorgesehen, die umfasst: eine Bahnwelle **41**, **51**, die eine Walzenabwälzoberfläche **41**a, **51**a enthält ein Gleitelement **42**, **52**, das einen Walzenumlaufweg umfasst, der eine Lastabwälzoberfläche **42**a, **52**a entsprechend der Walzenabwälzoberfläche **41**a, **51**a umfasst, wobei das Gleitelement **42**, **52** in die Bahnwelle **41**, **51** eingepasst ist, so dass es frei bewegbar relativ zu der Bahnwelle **41**, **51** ist; eine Vielzahl von Walzen **43**, **53**, die in dem Walzenumlaufweg angeordnet und aufgenommen sind, so dass sie in Übereinstimmung mit der Bewegung des Gleitelements **42**, **52** relativ zu der Bahnwelle **41**, **51** umlaufen; und eine Vielzahl von Walzenkäfigen **15** zum Halten der Vielzahl von Walzen **43**, **53** individuell und entsprechend, so dass die Vielzahl von Walzen **43**, **53** drehbar/verschiebbar ist, wobei: die Vielzahl von Walzen **43**, **53** angeordnet und aufgenommen ist, so dass die Achsen von benachbarten Walzen **43**, **53** näherungsweise parallel zueinander gehalten werden; jeder der Walzenkäfige **31** dünn gestaltet ist, um gegenüberliegenden Seitenoberflächen einer entsprechenden der Walzen **7** und entweder eine vordere oder eine rückwärtige Oberfläche der Walze **7** in einer Bewegungsrichtung der Walze **7** zu halten; ein linearer Führungsbereich **32**a und ein gekrümmter Führungsbereich **32**b, die sich in ihrem Neigungswinkel unterscheiden, in einer Endoberfläche des Walzenkäfigs **31** in einer Bewegungsrichtung des Walzenkäfigs **31** geformt sind; und der lineare Führungsbereich **32**a des Walzenkäfigs **31** in Kontakt mit einer benachbarten Walze **7** in einer linearen Bahn kommt und der gekrümmten Führungsbereich **32**b des Walzenkäfigs **31** in Kontakt mit einer benachbarten Walze **7** in einer gekrümmten Bahn kommt.

[0026] Weiterhin ist gemäß der Erfindung auch eine Walzenschraube vorgesehen, die umfasst: eine Bahnwelle **5**, die eine helixförmige Walzenabwälzoberfläche **5**a enthält; ein Gleitelement **6**, das einen Walzenumlaufweg **8** umfasst, der eine helixförmige Walzenabwälzoberfläche **6**a enthält, die der Walzenabwälzoberfläche **5**a entspricht, wobei das Gleitelement **6** in die Bahnwelle **5** eingepasst ist, so dass es frei bewegbar relativ zu der Bahnwelle **5** ist; eine Vielzahl von Walzen **7**, die in dem Walzenumlaufweg **8** angeordnet und aufgenommen sind, so dass sie in Übereinstimmung mit der Bewegung des Gleitelements **6** relativ zu der Bahnwelle **5**

umlaufen; und eine Vielzahl von Walzenkäfigen **15** zum Halten der Vielzahl von Walzen **7** individuell und entsprechend, so dass die Vielzahl von Walzen **7** drehbar/verschiebbar ist, wobei: die Vielzahl von Walzen **7** angeordnet und aufgenommen ist, so dass Achsen von benachbarten Walzen **7** näherungsweise parallel zueinander gehalten werden, jeder der Walzenkäfige **15** dünn gestaltet ist, dass er gegenüberliegende Oberflächen einer entsprechenden der Walzen **7** und vordere und rückwärtige Oberflächen der Walzen **7** in einer Bewegungsrichtung der Walze **7** hält; ein linearer Führungsbereich **16**a, **17**a und ein gekrümmter Führungsbereich **16**b, **17**b, die sich in dem Neigungswinkel voneinander unterscheiden, in jeder der gegenüberliegenden Endoberflächen des Walzenkäfigs **15** in einer Bewegungsrichtung des Walzenkäfigs **15** geformt sind; und der lineare Führungsbereich **26**a, **17**a des Walzenkäfigs **15** in Kontakt mit einem benachbarten Walzenkäfig **15** in einer linearen Bahn kommt und der gekrümmte Führungsbereich **16**b, **17**b des Walzenkäfigs **15** in Kontakt mit einem benachbarten Walzenkäfig **15** in einer gekrümmten Bahn kommt.

[0027] Weiterhin ist gemäß der Erfindung auch eine Walzenschraube vorgesehen, die umfasst: eine Bahnwelle **5**, die eine helixförmige Walzenabwälzoberfläche **5**a umfasst; ein Gleitelement **6**, das einen Walzenumlaufweg **8** umfasst, der eine helixförmige Lastabwälzoberfläche **6**a entsprechend der Walzenabwälzoberfläche **5**a umfasst, wobei das Gleitelement **6** in die Bahnwelle **5** eingepasst ist, so dass es frei bewegbar relativ zu der Bahnwelle **5** ist; eine Vielzahl von Walzen **7**, die in dem Walzenumlaufweg **8** angeordnet und aufgenommen sind, so dass sie in Übereinstimmung mit der Bewegung des Gleitelements **6** relativ zu der Bahnwelle **5** umlaufen; und eine Vielzahl von Walzenkäfigen **15** zum Halten der Vielzahl von Walzen **7** individuell und entsprechend, so dass die Vielzahl von Walzen **7** drehbar/verschiebbar ist, wobei: die Vielzahl von Walzen **7** angeordnet und aufgenommen ist, so dass Achsen von benachbarten Walzen **7** näherungsweise parallel zueinander gehalten werden; jeder der Walzenkäfige **31** dünn gestaltet ist, um gegenüberliegende Seitenoberflächen einer entsprechenden der Walzen **7** zu halten, und entweder eine vordere oder eine rückwärtige Oberfläche der Walze **7** in einer Bewegungsrichtung der Walze **7**; ein linearer Führungsbereich **32**a und ein gekrümmter Führungsbereich **32**b, die im Neigungswinkel unterschiedlich sind, in einer Endoberfläche des Walzenkäfigs **31** in einer Bewegungsrichtung des Walzenkäfigs **31** geformt sind; und der lineare Führungsbereich **32**a des Walzenkäfigs **31** in Kontakt mit einer benachbarten Walze **7** in einer linearen Bahn kommt und der gekrümmte Führungsbereich **32**b des Walzenkäfigs **31** in Kontakt mit einer benachbarten Walze in einer gekrümmten Bahn kommt.

KURZE BESCHREIBUNG DER ZEICHNUNGEN

[0028] **Fig.** 1 ist eine perspektivische Ansicht, die eine Walzenschraube zeigt, bei der Walzenkäfige gemäß einer ersten Ausführungsform der vorliegenden Erfindung beinhaltet sind;

[0029] **Fig.** 2 ist eine perspektivische Ansicht, die ein Rückkehrrohr zeigt, das in der Walzenschraube beinhaltet ist;

[0030] **Fig.** 3 ist eine perspektivische Ansicht, die eine Schraubenwelle in der Walzenschraube zeigt;

[0031] **Fig.** 4 ist eine Vorderansicht, die eine Kombination eines Walzenkäfigs und einer Walze in der ersten Ausführungsform der vorliegenden Erfindung zeigt;

[0032] **Fig.** 5 ist eine Seitenansicht, die eine Kombination eines Walzenkäfigs und einer Walze in der ersten Ausführungsform der vorliegenden Erfindung zeigt;

[0033] **Fig.** 6 ist eine Unteransicht, die eine Kombination eines Walzenkäfigs und einer Walze in der ersten Ausführungsform der vorliegenden Erfindung zeigt;

[0034] **Fig.** 7 ist eine Ansicht, die Walzenkäfige und Walzen zeigt, die in einem Walzenschraubenumlaufweg umlaufen;

[0035] **Fig.** 8 ist eine Ansicht, die Walzen und Walzenkäfige zeigt, die in einem helixförmigen Lastabwälzdurchgang umlaufen;

[0036] **Fig.** 9 ist eine Ansicht, die ein Beispiel zeigt, in dem benachbarte Walzenkäfige einander überlappen;

[0037] **Fig.** 10 ist eine Ansicht, die Walzenkäfige zeigt, die in einem Umlaufweg angeordnet sind, gemäß einer zweiten Ausführungsform der Erfindung;

[0038] **Fig.** 11 ist eine Vorderansicht, die eine Kombination eines Walzenkäfigs und einer Walze in einer dritten Ausführungsform der vorliegenden Erfindung zeigt;

[0039] **Fig.** 12 ist eine Seitenansicht, die eine Kombination eines Walzenkäfigs und einer Walze in der dritten Ausführungsform der vorliegenden Erfindung zeigt;

[0040] **Fig.** 13 ist eine Unteransicht, die eine Kombination eines Walzenkäfigs und einer Walze in der dritten Ausführungsform der vorliegenden Erfindung zeigt;

[0041] **Fig.** 14A ist eine Draufsicht, die ein Beispiel zeigt, in dem Walzenkäfige und Walzen in der dritten Ausführungsform der vorliegenden Erfindung in einer Linie ausgerichtet sind;

[0042] **Fig.** 14B ist eine Seitenansicht, die ein Beispiel zeigt, in dem Walzenkäfige und Walzen in der dritten Ausführungsform der vorliegenden Erfindung in einer Linie ausgerichtet sind;

[0043] **Fig.** 14C ist eine Unteransicht, die ein Beispiel zeigt, in dem Walzenkäfige und Walzen in der dritten Ausführungsform der vorliegenden Erfindung in einer Linie ausgerichtet sind;

[0044] **Fig.** 15 ist eine Ansicht, die eine lineare Führung zeigt, in der Walzenkäfige gemäß der ersten Ausführungsform der vorliegenden Erfindung beinhaltet sind (teilweise einschließlich eines Querschnitts in einer Richtung senkrecht zu einer Führungsschiene);

[0045] **Fig.** 16 ist eine Ansicht, die einen Spline zeigt, bei dem Walzenkäfige gemäß der ersten Ausführungsform der vorliegenden Erfindung beinhaltet sind;

[0046] **Fig.** 17 ist eine Ansicht, die Käfige zeigt, die in einem Walzenumlaufweg einer direkt wirkenden Führungseinrichtung des Stands der Technik umlaufen;

[0047] **Fig.** 18 ist eine Ansicht, die eine Kombination eines Käfigs und einer Walze gemäß dem Stand der Technik zeigt;

und

[0048] **Fig.** 19 ist eine Querschnittsansicht entlang der Linie A-A aus **Fig.** 18.

DETAILLIERTE BESCHREIBUNG DER BEVORZUGTEN AUSFÜHRUNGSFORMEN

[0049] Nun wird eine Beschreibung detaillierter von bevorzugten Ausführungsformen der Erfindung unter Bezug auf die beigefügten Zeichnungen gegeben.

[0050] **Fig.** 1 zeigt eine Walzenschraube, bei der Walzenkäfige gemäß einer ersten Ausführungsform der vorliegenden Erfindung beinhaltet sind. Die Walzenschraube umfasst eine Schraubenwelle **5** (Bahnwelle), ein Mutterelement **6** (Gleitelement), und eine Vielzahl von Walzen **7**. Die Schraubenwelle **5** hat eine helixförmige Walzenabwälznut **5** in ihrer äußeren Umfangsoberfläche, so dass die helixförmige Walzenabwälznut **5**a als eine Walzenabwälzoberfläche dient. Das Mutterelement **6** hat einen Walzenumlaufweg in seiner inneren Umfangsoberfläche geformt. Der Walzenumlaufweg umfasst eine helixförmige Lastabwälznut **6**a, so dass die helixförmige Lastabwälznut **6**a als eine Lastabwälzoberfläche entsprechend der Walzenabwälznut **5**a dient. Das Mutterelement **6** ist an die Schraubenwelle **5** aufgepasst, so dass sie relativ bewegbar sind. Die Vielzahl von Walzen **7** ist in dem Walzenumlaufweg angeordnet und aufgenommen und läuft in Übereinstimmung mit der Relativbewegung des Mutterelements **6** zur Schraubenwelle **5** um. Die Vielzahl von Walzen **7** ist in dem Walzenumlaufweg so angeordnet und aufgenommen, dass Achsen von benachbarten Walzen **7** im wesentlichen parallel zueinander gehalten werden. In dem Walzenumlaufweg wird ein Lastabwälzdurchgang **8** zwischen der Walzenabwälznut **5**a, der Schraubenwelle **5** und der Lastabwälznut **6**a des Mutterelements **6** geformt. Das Mutterelement **6** hat ein Rückkehrrohr. Das Rückkehrrohr bildet einen Rückkehrdurchgang ohne Last, durch den ein Ende des Lastabwälzdurchgangs **8** mit dem anderen Ende des Lastabwälzdurchgangs **8** in Verbindung steht.

[0051] **Fig.** 2 zeigt das Rückkehrrohr **9**. Das Rückkehrrohr **9** hat einen Körperbereich **9**b und gegenüberliegende Endbereiche **9**a, die in bezug auf den Körperbereich **9**b gebogen sind. Die gegenüberliegenden Endbereiche **9**a sind in den Lastabwälzdurchgang eingepasst, so dass ein Abstand von einigen Schraubensteigungen zwischen den gegenüberliegenden Endbereichen **9**a verbleibt. Dabei ist das Rückkehrrohr **9** an dem Mutterelement **6** durch Rohrdrücken angebracht.

[0052] **Fig.** 3 zeigt die Schraubenwelle **5**. Die helixförmige Walzenabwälznut **5**a, die eine vorbestimmte Steigung hat, ist in der äußeren Umfangsoberfläche der Schraubenwelle **5** geformt. Die Walzenabwälznut **5**a ist im Querschnitt wie ein Trapezoid gestaltet. Jede der Walzen **7** wälzt sich auf einer Wandoberfläche **12**a oder **12**b der Walzenabwälznut **5**a ab.

[0053] Wie es in **Fig.** 1 gezeigt ist, ist das Mutterelement **6** im wesentlichen wie ein Zylinder gestaltet. Die helixförmige Lastabwälznut **6**a, die eine Steigung hat, die gleich der Steigung der Schraubenwelle **5** ist, ist in der inneren Umfangsoberfläche des Mutterelements **6** geformt. Die Lastabwälznut **6**a ist ebenfalls wie ein Trapezoid im Querschnitt geformt. Ein Vorsprung **10** zum Bilden der Lastabwälznut **6**a des Mutterelements **6** ist in die Walzenabwälznut **5**a eingepasst, so dass der innere Durchmesser des Mutterelements **6** kleiner ist als der äußere Durchmesser der Schraubenwelle **5**. Jede der Walzen **7** wälzt sich auf einer Wandoberfläche **11**a oder **11**b der Lastabwälznut **6**a ab. Die Lastabwälznut **6**a des Mutterelements **6** kann in der Mitte versetzt sein. Somit ist bis zu der Position des Versatzes ein Raum zum Anordnen der Walzen **7** zwischen der Wandoberfläche **12**b der Walzenabwälznut **5**a und der Wandoberfläche **11**b der Lastabwälznut **6**a geformt, und, nach der Versatzposition, ist ein Raum zum Anordnen der Walzen **7** zwischen der Wandoberfläche **12**a der Walzenabwälznut **5**a und der Wandoberfläche **11**a der Lastabwälznut **6**a geformt. Rückkehrrohrpasslöcher sind in dem Mutterelement **6** geformt, so dass die gegenüberliegenden Seiten des Rückkehrrohrs **9** in die Löcher jeweils eingeführt werden. Die Rückkehrrohrpasslöcher erstrecken sich in die Lastabwälznut **6**a.

[0054] Wie es aus **Fig.** 2 offensichtlich ist, hat das Rückkehrrohr **9** gegenüberliegende Endbereiche **9**a, die um etwa 90° in bezug auf den Körperbereich **9**b gebogen sind. Das heißt, das Rückkehrrohr **9** ist im wesentlichen in der Art eines Doppelgehäuses geformt. Ein Querschnitt des Rückkehrdurchgangs ohne Last des Rückkehrrohrs **9** wird in Übereinstimmung mit der Gestalt jeder Walze **7** bestimmt. Wie es in **Fig.** 2 gezeigt ist, sind die gegenüberliegenden Endbereiche **9**a nicht parallel zueinander, so dass die jeweiligen Richtungen der gegenüberliegenden Endbereiche **9**a einen Torsionswinkel $\theta 1$ bilden (der sich in Übereinstimmung mit dem Steigungswinkel ändert).

[0055] **Fig.** 4 und 6 zeigen Walzenkäfige **15** und Walzen **7**, die in der Walzenschraube beinhaltet sind. **Fig.** 4 ist eine Ansicht (Vorderansicht) in einer Richtung senkrecht zur Richtung der Achse jeder Walze **7** und senkrecht zur Richtung der Bewegung jeder Walze **7**. **Fig.** 5 ist eine Ansicht (Seitenansicht) aus der Richtung der Bewegung jeder Walze **7**. **Fig.** 6 ist eine Ansicht (Unteransicht) aus der Achsenrichtung jede Walze **7**. Walzenkäfige **15** der gleichen Anzahl wie derjenigen der Walzen **7** sind vorgesehen, um die Walzen **7** individuell aufzunehmen. Jeder der Walzenkäfige **15** ist dünn gestaltet, dass er eine vordere und rückwärtige Oberfläche einer entsprechenden Walze **7** in der Bewegungsrichtung der Walze **7** hält. Die frontale Gestalt des Walzenkäfigs **15** (gesehen aus der Richtung senkrecht zur Achse der Walze und senkrecht zur Bewegungsrichtung der Walze) ist wie ein Rahmen geformt. Die Dicke W jeder Seitenoberfläche des Walzenkäfigs **15** ist gesetzt, dass sie in einem Bereich von 50% bis 90%, vorzugsweise in einem Bereich von 50% bis 60% des Durchmessers der Walze ist. Dabei wird, wenn eine kegelförmige Walze als Walze **7** verwendet wird, der minimale Durchmesser der Walze eingesetzt.

[0056] Ein linearer Führungsbereich **16**a und ein gekrümmter Führungsbereich **16**b, die sich im Neigungswinkel voneinander unterscheiden, sind in einer Endoberfläche **16** eines Walzenkäfigs **15** in der Bewegungsrichtung des Walzenkäfigs **15** geformt. Ein linearer Führungsbereich **17**a und ein gekrümmter Führungsbereich **17**b, die sich im Neigungswinkel voneinander unterscheiden, sind in der anderen Endoberfläche **17** des Walzenkäfigs **15** in der Bewegungsrichtung des Walzenkäfigs **15** geformt. Die linearen Führungsbereiche **16**a und **17**a sind so geformt, dass sie im wesentlichen parallel zur Achse jeder Walze **7** sind. Die gekrümmten Führungsbereiche **16**b und **17**b sind so geformt, dass die gekrümmten Führungsbereiche **16**b und **17**b in radialen Richtungen jeweils gerichtet sind, wenn Walzenkäfige in einer gekrümmten Bahn angeordnet sind. Das heißt, in einer gekrümmten Bahn kommen die gekrümmten Führungsbereiche **16**b und **17**b des Walzenkäfigs **15** in Kontakt mit benachbarten Walzenkäfigen **15**, und in einer linearen Bahn kommen die linearen Führungsbereiche **16**a und **17**a des Walzenkäfigs **15** in Kontakt mit benachbarten Walzenkäfigen **15**. Die linearen Führungsbereiche **16**a und **17**a und die gekrümmten Führungsbereiche **16**b und **17**b des Walzenkäfigs **15** sind geformt, dass sie abschnittsweise kreisförmige, bogenförmige, gekrümmte Oberflächen sind, so dass sie in linearen Kontakt mit benachbarten Walzenkäfigen **15** kommen (siehe **Fig.** 6). Wie es in **Fig.** 5 gezeigt ist, sind vier Ecken von Seitenoberflächen des Walzenkäfigs **15** abgeschnitten, dass sie abgeschrägte Bereiche **18** sind. Somit kann verhindert werden, dass der Walzenkäfig **15** mit der Schraubenwelle **5** in Wechselwirkung tritt, selbst in dem Fall, in dem die Achse **19** der Walze **7** nicht senkrecht zur Mittellinie **5**c der Schraubenwelle **5** angeordnet ist, sondern wenn sie geneigt unter einem Winkel α ist, wie es in **Fig.** 1 gezeigt ist. Wie es in **Fig.** 4 gezeigt ist, ist ein Paar von Vorsprüngen zum Verhindern des Herunterfallens **20**, **20** auf oberen und unteren Bereichen des Walzenkäfigs **15** auf der Seite der Walze **7** geformt. Weiterhin ist ein Paar von Aussparungen **21**, **21** auf der Seitenoberfläche der Walze **7** geformt, so dass die Aussparungen **21** zu den Vorsprüngen **20**, **20** passen. Somit hält der Walzenkäfig **15** die Walze **7**, so dass sich die Walze **7** um ihre Achse **19** drehen kann. Dabei können die Vorsprünge **20** zum Verhindern des Herunterfallens auf der Seite der Walze **7** vorgesehen werden, wobei die

Aussparungen **21** zum Verhindern des Herunterfallens auf der Seite des Walzenkäfigs **15** vorgesehen werden können. Der Walzenkäfig **15** ist aus einem Kunstharz oder ähnlichem als einem Rohmaterial durch Spritzguss oder ähnliches gefertigt.

[0057] Eine Kegelwalze kann als Walze **7** verwendet werden. Der Scheitel Q des Konus der Kegelwalze befindet sich auf der Mittellinie **5**c der Schraubenwelle **5**. Somit wälzt die Kegelwalze ohne Rutschen zwischen der Lastabwälznut **6**a und der Walzenabwälznut **5**a ab. Dabei können die Querschnittsform der Walzenabwälznut **5**a, die Querschnittsform der Lastabwälznut **6**a und die Seitengestalt der Walze frei gewählt werden in Übereinstimmung mit der Last, Genauigkeit usw., die von der Walzenschraube verlangt wird.

[0058] Wie es in **Fig.** 1 gezeigt ist, werden, wenn die Schraubenwelle **5** gedreht wird, Walzen **7** und Walzenkäfige **15**, die in dem Lastabwälzdurchgang **8** in der Richtung des Umfangs der Schraubenwelle **5** abwälzen, wobei sie einer Last unterliegen, durch das Rückkehrrohr **9** aufgenommen. Die aufgenommenen Walzen **7** und Walzenkäfige **15** gelangen durch das Rückkehrrohr **9**. Dann werden die Walzen **7** und Walzenkäfige **15** zum Lastabwälzdurchgang **8** zurückgeführt, nach dem Abstand einiger Schraubensteigungen. Wenn die Richtung der Drehung der Schraubenwelle **5** umgedreht wird, laufen die jeweiligen Walzen **7** in umgekehrter Richtung um. Dabei kann das Mutterelement **6** in dem Zustand gedreht werden, dass die Schraubenwelle **5** als stationäre Seite vorgesehen wird. Auch in diesem Fall können die Walzen **7** auf der vorher erwähnten Weise umlaufen.

[0059] **Fig.** 7 zeigt Walzen **7** und Walzenkäfige **15**, die in dem Rückkehrrohr **9** und dem Lastabwälzdurchgang **8** umlaufen. Wie es in **Fig.** 7 gezeigt ist, drückt in einer linearen Bahn (in einem Rückkehrrohr **9**), die einen Umlaufweg bildet, ein linearen Führungsbereich **16**a eines Walzenkäfigs **15**, der sich an der rückwärtigen Seite in der Bewegungsrichtung **1** der Walze **7** befindet, einen linearen Führungsbereich **17**a eines anderen Walzenkäfigs **15**, der sich an der Vorderseite befindet. In einer gekrümmten Bahn (in einem Lastabwälzdurchgang **8**) drückt der gekrümmte Führungsbereich **16**b des rückseitigen Walzenkäfigs **15** den gekrümmten Führungsbereich **17**b des vorderseitigen Walzenkäfigs **15**. Sowohl in der linearen Bahn als auch in der gekrümmten Bahn kann der rückseitige Walzenkäfig **15** den vorderseitigen Walzenkäfig **15** drücken, ohne die Position der Walze **7** zu beeinträchtigen, die sich in der rückwärtigen Seite in der Bewegungsrichtung der Walzen befindet. Wenn eine Kegelwalze als jede der Walzen **7** verwendet wird, insbesondere in einer linearen Bahn, neigt die Walze **7** dazu, in einer Ebene zu fallen, die die Achse und die Bewegungsrichtung der Walze enthält. In der linearen Bahn kommen lineare Führungsbereiche **16**a und **17**a von benachbarten Walzenkäfigen **15** in engen Kontakt miteinander, wohingegen in der gekrümmten Bahn gekrümmten Führungsbereiche **16**b und **17**b der benachbarten Walzenkäfige **15** in engen Kontakt miteinander kommen. Als Folge sind die Walzen **7** so ausgerichtet, dass ein glatter Umlauf erzielt werden kann. In den meisten Fällen hat der Rückkehrdurchgang **9** in einer Nichtlastregion eine lineare Bahn, eine kreisförmige Bogenbahn, eine lineare Bahn und eine kreisförmige Bogenbahn. Wenn die Krümmung eines kreisförmigen Bogens **24** des Rückkehrrohrs **9** zusammenfallend mit der Krümmung des Lastabwälzdurchgangs **8** gestaltet ist, können Walzen **7** ausgerichtet werden, dass ein glatter Umlauf erzielt werden kann. Dies ist, da gekrümmte Führungsbereiche **16**b und **17**b von benachbarten Walzenkäfigen **15** in engen Kontakt miteinander selbst in dem kreisförmigen Bogenbereich des Rückkehrrohrs **9** kommen. Wenn die Krümmung des kreisförmigen Bogens **24** des Rückkehrwegs **9** nicht mit der Krümmung des Lastabwälzdurchgangs **8** zusammenfällt, können die gekrümmten Führungsbereiche **16**b und **17**b weiter in zwei Bereiche getrennt werden, die in ihrem Neigungswinkel unterschiedlich sind. Das heißt, Führungsbereiche können in drei Bereiche getrennt werden, beispielsweise einen linearen Führungsbereich, einen gekrümmten Führungsbereich für den Lastabwälzdurchgang und einen gekrümmten Führungsbereich für das Rückkehrrohr.

[0060] Wie es oben beschrieben ist, ist der Lastabwälzdurchgang **8** der Walzenschraube helixförmig geformt. Wie es oben unter Bezug auf **Fig.** 2 beschrieben ist, hat das Rückkehrrohr zum Ändern der Richtung der aufgenommenen Walze **7** eine Torsion (Torsionswinkel $\theta 1$) um die Bewegungsrichtung der Walze. Das heißt, bei der Walzenschraube ändern die Walzen **7** und Walzenkäfige **15** ihre Richtungen dreidimensional und machen eine komplexe Bewegung. Die vorher beschriebenen Walzenkäfige **15** sind für solch eine komplexe Bewegung angepasst. Wie es in **Fig.** 5 gezeigt ist, ist die Dicke W jeder Seite jedes Walzenkäfigs **15** klein gehalten. Weiterhin sind die linearen Führungsbereiche **16**a und **17**a (die in engem Kontakt sein sollen) und die gekrümmten Führungsbereiche **16**b und **17**b (die in engem Kontakt sein sollen) von benachbarten Walzenkäfigen **15** wie kreisförmige Bögen im Querschnitt geformt, so dass sie miteinander in linearen Kontakt kommen. Somit drücken solche benachbarten Walzenkäfige **15** einander, wobei ihnen ermöglicht wird, sich leicht um die Achsen der entsprechenden Walzen **7** jeweils zu drehen. Als Folge ändern die Walzenkäfige **15** frei ihre Richtung dreidimensional mit entsprechenden Walzen **7**, jeweils, so dass eine komplexe Bewegung, die von der Walzenschraube in dieser Ausführungsform verlangt wird, gemacht werden kann. Insbesondere, wenn die Achse **19** jeder Walze **7** nicht senkrecht zur Mittellinie **5**c der Schraubenwelle **5**, sondern geneigt unter einem bestimmten Winkel ist, wie es in **Fig.** 1 gezeigt ist, läuft die Walze **7** in einer schirmartigen, gekrümmten Bahn um. Daher müssen benachbarte Walzenkäfige **15** in engen Kontakt miteinander kommen, wobei ein Kreuzungswinkel β zwischen den benachbarten Walzenkäfigen **15** konstant gehalten wird, wie es in **Fig.** 8 gezeigt ist. Gemäß der vorliegenden Erfindung drücken benachbarte Walzenkäfige **15** einander, wobei ihnen ermöglicht wird, sich leicht um die Achsen von entsprechenden Walzen **7** jeweils zu drehen. Entsprechend können Walzenkäfige **15**, die ausreichend an eine solche Umlaufform angepasst sind, erhalten werden.

[0061] Da jeder der Walzenkäfige **15** dünn gemacht ist, kann ein großer Raum zum Aufnehmen von Schmieröl in dem Umlaufweg sichergestellt werden. Somit können die Walzen **7** ausreichend geschmiert werden. Weiterhin, da jeder der Walzenkäfige **15** dünn gestaltet ist, kann eine große Lücke zwischen den Walzenkäfigen **15** und der Lastabwälznut **6**a eingenommen werden. Somit kann ein Stützelement zum Stützen der Walzenkäfige **15** in dem Umlaufweg vorgesehen werden, um zu verhindern, dass die Walzenkäfige **15** aus dem Mutterelement **6** oder ähnlichem fallen.

[0062] **Fig.** 9 zeigt den Fall, in dem die Dicke jedes Walzenkäfigs **15** ausgewählt ist, dass sie kleiner als 50% des Walzendurchmessers ist. Wenn die Dicke des Walzenkäfigs **15** kleiner als 50% des Walzendurchmessers gemacht wird, dringt das vordere Ende des nachfolgenden Walzenkäfigs **15** in die Lücke zwischen dem vorderseitigen Walzenkäfig **15** und der Walzenabwälznut **5**a ein, so dass benachbarte Walzenkäfige **15** einander überlappen können. Als Folge ist eine Gefahr vorhanden, dass der Umlauf der Walzen **7** stoppen kann. Wenn die Dicke des Walzenkäfigs **15** ausgewählt wird, dass sie nicht kleiner als 50% des Walzendurchmessers ist, können benachbarte Walzenkäfige **15** daran gehindert werden, einander zu überlappen, wie es oben beschrieben ist.

[0063] **Fig.** 10 zeigt eine zweite Ausführungsform der vorliegenden Erfindung, die Walzen und Walzenkäfige betrifft, die in der Walzenschraube beinhaltet sind. Jeder der Walzenkäfige **25** hat im wesentlichen die gleiche Konfiguration wie diejenige der Walzenkäfige **15** gemäß der ersten Ausführungsform. Der Walzenkäfig **25** hat weiter einen Gelenkvorsprung **26** und eine Gelenkaussparung **27**, die zu dem Gelenkvorsprung **26** des benachbarten Walzenkäfigs **25** passt. Der Gelenkvorsprung **26** ist an einem Schnittpunkt zwischen dem linearen Führungsbereich **16**a und dem gekrümmten Führungsbereich **16**b auf einer Endoberfläche des Walzenkäfigs **25** in der Bewegungsrichtung der Walze **7** vorgesehen. Die Gelenkaussparung **27** ist an einem Schnittpunkt zwischen dem linearen Führungsbereich **17**a und dem gekrümmten Führungsbereich **17**b auf der anderen Endoberfläche des Walzenkäfigs **25** vorgesehen. Da der Gelenkvorsprung **26** und die Gelenkaussparung **27** auf der vorher erwähnten Weise vorgesehen sind, kann der Walzenkäfig **25** nur um ein Gelenk schwingen, das durch eine Kombination des Gelenkvorsprungs **26** und der Gelenkaussparung **27** gebildet wird, in einer Ebene, die die Achse einer entsprechenden Walze **7** und die Bewegungsrichtung **1** der Bewegung der Walze **7** enthält. Somit kann verhindert werden, dass die Walze **7** herunterfällt, selbst an der Grenze, an der die Walze sich von der linearen Bahn zur gekrümmten Bahn bewegt. Somit kann ein glatter Umlauf der Walze **7** sichergestellt werden.

[0064] **Fig.** 11 bis 13 und **Fig.** 14A bis 14C Zeigen eine dritte Ausführungsform der vorliegenden Erfindung, die Walzenkäfige betrifft, die in der Walzenschraube beinhaltet sind. **Fig.** 11 ist eine Ansicht (Vorderansicht) aus einer Richtung senkrecht zur Achse jeder Walze **7** und senkrecht zur Richtung (**1**) der Bewegung der Walze **7**. **Fig.** 12 ist eine Ansicht (Seitenabschnitt) von der rückwärtigen Seite in der Bewegungsrichtung der Walze **7**. **Fig.** 13 ist eine Ansicht (Unteransicht) aus der Richtung der Achse der Walze **7**. **Fig.** 14A bis 14C sind Ansichten, die den Fall zeigen, in dem Walzenkäfige mit Walzen **7** in einer Linie ausgerichtet sind. In dieser Ausführungsform ist jeder der Walzenkäfige **31** dünn gestaltet, um nur die gegenüberliegenden Seitenoberflächen einer entsprechenden Walze **7** und die Vorderoberfläche der gleichen Walze **7** in der Bewegungsrichtung der Walze **7** zu halten. Jeder der Walzenkäfige **31** ist in der Vorderansicht U-förmig gestaltet. Die Dicke W jeder Seite des Walzenkäfigs **31** ist gewählt, dass sie in einem Bereich von 50% bis 90%, vorzugsweise in einem Bereich von 50% bis 60%, des Walzendurchmessers ist.

[0065] Ein linearer Führungsbereich **32**a und ein gekrümmter Führungsbereich **32**b die sich im Neigungswinkel voneinander unterscheiden, sind in einer Endoberfläche des Walzenkäfigs **31** in dessen Bewegungsrichtung geformt. Der lineare Führungsbereich **32**a ist unter einem vorbestimmten Winkel in bezug auf die Achse der Walze **7** geneigt, so dass die Achsen von benachbarten Walzen **7** parallel zueinander gehalten werden. Der gekrümmte Führungsbereich **32**b ist so geneigt, dass die Walzenkäfige **31** in radialen Richtungen gerichtet sind, wenn die Walzenkäfige **31** in einer gekrümmten Bahn angeordnet sind. Das heißt, in einer gekrümmten Bahn kommt der gekrümmte Führungsbereich **32** in Kontakt mit einer benachbarten Walze **7**, und in einer linearen Bahn kommt der lineare Führungsbereich **32**a in Kontakt mit der benachbarten Walze **7**. Der lineare Führungsbereich **32**a und der gekrümmte Führungsbereich **32**b sind als eine gekrümmte Oberfläche entsprechend dem äußeren Umfang der Walze **7** geformt.

[0066] Entsprechend diesem Walzenkäfig **31** können der Walzenkäfig **31** und eine zum Walzenkäfig **31** benachbarte Walze **7** einander drücken, wobei dem Walzenkäfig **31** ermöglicht wird, sich leicht um die Achse einer entsprechenden Walze **7** auf die gleiche Weise zu drehen, wie bei dem Walzenkäfig **15** in der ersten Ausführungsform. Somit kann der Walzenkäfig **31** den gleichen Betrieb und die gleichen Wirkungen wie diejenigen des Walzenkäfigs **15**, die in der ersten Ausführungsform erzielt sind, erfüllen. Weiterhin, da der Walzenkäfig **31** in Oberflächenkontakt mit einer Walze **7** kommt, die sich an der Vorderseite oder Rückseite in der Bewegungsrichtung der Walze befindet, kann ein Kontaktoberflächendruck ebenfalls reduziert werden.

[0067] Im Beispiel dieser Walzenschraube werden Walzen **7**, die in der Walzenabwälznut **5**a der Schraubenwelle **5** sich abwälzen, durch das Rückkehrrohr **9** aufgenommen und um einige Steigungen zurückgebracht. Alternativ kann ein Ablenkungselement zum Einfangen von Walzen **7** in dem Mutterelement **6** vorgesehen werden. Das heißt, eine der Walzen **7**, die auf der Walzenabwälznut **5**a der Schraubenwelle **5** läuft, kann aus der Walzenabwälznut **5**a durch das Ablenkelement genommen werden, so dass die Walze **7** über den äußeren Durchmesserbereich der Schraubenwelle **5** springt und vor einer Steigung zur Walzenabwälznut **5**a zurückkehrt. Obwohl es nicht gezeigt ist, kann eine Walzenschraube des sogenannten Seitenabdecktyps verwendet werden. Das heißt, das Mutterelement **6** wird durch einen Mutterkörper gebildet, der eine Lastabwälznut darin geformt hat, und Seitenabdeckungen, die an gegenüberliegenden Enden des Mutterkörpers angebracht sind. Eine Walzenrückkehrdurchgang ist in dem Mutterkörper geformt. Ein Verbindungsdurchgang, durch den die Lastabwälznut und der Rückkehrdurchgang miteinander in Verbindung stehen, ist in jeder der Seitenabdeckungen geformt.

[0068] Die Walzenaufnahme gemäß der vorliegenden Erfindung ist nicht nur auf die Walzenschraube beschränkt, sondern kann auf eine direkt wirkende Führungseinrichtung, wie eine Linearführung oder einen Spline angewendet werden. Insbesondere kann der Walzenkäfig gemäß der vorliegenden Erfindung angepasst an eine direkt wirkende Führungseinrichtung werden, außer in dem Fall, in dem jede Walze zweidimensional in einer Ebene senkrecht zur Achse der Walze umläuft. Das heißt, der Walzenkäfig gemäß der vorliegenden Erfindung kann auf eine direkt wirkende Führungseinrichtung angepasst werden, die einen Umlaufweg hat, der so komplex ist, dass der Weg gebogen ist, wobei die Walze verwunden wird.

[0069] **Fig.** 15 zeigt eine lineare Führung, in der Walzenkäfige **15** gemäß der ersten Ausführungsform der vorliegenden Erfindung beinhaltet sind. Die lineare Führung ist eine gut bekannte Einrichtung zum Führen eines bewegbaren Körpers, wie einem Tisch auf einem stationären Bereich, wie einem Bett oder einem Sattel. Die lineare Führung hat eine Führungsschiene **41** (Bahnwelle), einen sich bewegenden Block (Gleitelement) **42** und eine Vielzahl von Walzen **43**. Die Führungsschiene **41** ist auf dem stationären Bereich angebracht und hat eine Walzenabwälznut **41**a, die entlang der Richtung von dessen Länge geformt ist, so dass die Walzenabwälznut **41** als eine Walzenabwälzoberfläche dient. Der sich bewegende Block **42** ist an der Führungsschiene **41** angebracht, so dass sie relativ bewegbar sind. Ein Walzenumlaufweg, der eine Lastabwälznut **42**a entsprechend der Walzenabwälznut **41**a der Führungsschiene **41** enthält, ist in dem sich bewegenden Block **42** geformt, so dass die Lastabwälznut **42**a als eine Lastabwälzoberfläche dient. Die Vielzahl von Walzen **43** ist in dem Walzenumlaufweg angeordnet und aufgenommen und läuft in dem Walzenumlaufweg in Übereinstimmung mit der Relativbewegung des sich bewegenden Blocks **42** zur Führungsschiene **41** um. Die Vielzahl von Walzen **43** ist in den Walzenkäfigen **15** individuell und entsprechend gehalten. Die Walzen **43** sind angeordnet und aufgenommen in dem Walzenumlaufweg, so dass die Achsen der Walzen **43** im wesentlichen parallel zueinander gehalten werden. Durch den endlosen Umlauf der Walzen **43** macht der sich bewegende Block **42**, der die Walzen stützt, eine lineare Bewegung entlang der Führungsschiene **41**.

[0070] Die Führungsschiene **41** ist schlank länglich, dass sie ein Rechteck im Querschnitt bildet. Eine Walzenabwälznut **41**a, die als eine Bahn dient, wenn eine Walze **43** sich abwälzt, ist in sowohl der linken als auch der rechten Seitenoberfläche der Führungsschiene **41** geformt, so dass sie sich über die gesamte Länge der Führungsschiene erstreckt. Obwohl **Fig.** 15 den Fall zeigt, in dem die Führungsschiene linear ist, kann die Erfindung auch auf den Fall angewendet werden, in dem die Schiene gekrümmt ist. Obwohl **Fig.** 15 den Fall zeigt, in dem zwei Walzenabwälznuten **41**a links und rechts vorgesehen sind, kann die Erfindung auch auf den Fall angewendet werden, in dem die Anzahl von Walzenabwälznuten variierend in Übereinstimmung mit dem Zweck der Verwendung der linearen Führung oder ähnlichem verändert wird.

[0071] Der sich bewegende Block **42** wird grob durch eine Kombination eines sich bewegenden Körpers **44** und ein Paar von Seitenabdeckungen (nicht gezeigt) geformt, die an gegenüberliegenden Enden des sich bewegenden Körpers **44** angebracht sind. Zwei Lastabwälznuten **42**a entsprechend den Walzenabwälznuten **41**a sind in dem sich bewegenden Körper **44** vorgesehen. Die Kombination der Lastabwälznuten **42**a und der Walzenabwälznuten **41**a bildet zwei Lastabwälzdurchgänge C zwischen der Führungsschiene **41** und dem sich bewegenden Block **42**.

[0072] Zwei Rückkehrdurchgänge D, die sich parallel zu den Lastabwälzdurchgängen C jeweils erstrecken, und Richtungsänderungsdurchgänge B zum Verbinden der Lastabwälzdurchgänge C mit den Rückkehrdurchgängen D sind jeweils weiter in dem sich bewegenden Körper **44** vorgesehen. Die Kombination der Lastabwälzdurchgänge C, der Rückkehrdurchgänge D und dem Paar von Richtungsänderungsdurchgängen zum Verbinden der Lastabwälzdurchgänge C mit den Rückkehrdurchgängen D jeweils bildet einen Walzenumlaufweg. Jeder der Richtungsänderungsdurchgänge B hat eine dreidimensionale komplexe Bahn.

[0073] Wenn sich der sich bewegende Block **42** entlang der Führungsschiene **41** bewegt, wälzt die Walze **43** in dem Lastabwälzdurchgang C von einem Ende zum anderen Ende ab, wobei die Walze **43** eine Last von dem sich bewegenden Black **42** erfährt. Dann wird jede der Walzen **43** durch einen Richtungsänderungsdurchgang B eingefangen und zu dem Rückkehrdurchgang D gebracht. Die Walze **43** wird weiter zu einem Ende des Lastabwälzdurchgangs C durch den gegenüberliegenden Richtungsänderungsdurchgang B zurückgebracht. Bei dieser Gelegenheit drückt in den Lastabwälzdurchgängen C und Rückkehrdurchgängen D, die eine lineare Bahn bilden, der lineare Führungsbereich des rückwärtigen Walzenkäfigs **15** den linearen Führungsbereich des vorderseitigen Walzenkäfigs **15**. In dem Richtungsänderungsdurchgang B, der eine gekrümmte Bahn bildet, drückt der gekrümmte Führungsbereich des rückseitigen Walzenkäfigs **15** den gekrümmten Führungsbereich des vorderseitigen Walzenkäfigs **15**. Sowohl in der linearen Bahn als auch in der gekrümmten Bahn kann der rückseitige Walzenkäfig **15** den vorderseitigen Walzenkäfig **15** drücken, ohne die Position der Walze **7** zu beeinträchtigen, die sich in der Vorderseite in der Bewegungsrichtung der Walzen befindet.

[0074] Wie es oben beschrieben ist, ist jede Seitenoberfläche des Walzenkäfigs **15** dünn gestaltet, und der lineare Führungsbereich und der gekrümmte Führungsbereich zum Bringen von benachbarten Walzenkäfigen in engen Kontakt miteinander sind wie kreisförmige Bögen im Querschnitt geformt, so dass sie in linearen Kontakt mit benachbarten Walzenkäfigen kommen. Somit drücken benachbarte Walzenkäfige einander, während ihnen ermöglicht wird, sich leicht um die Achsen der entsprechenden Walzen jeweils zu drehen. Auf solch eine Weise können die Walzenkäfige **15** mit den Walzen **43** ihre Richtung frei dreidimensional ändern. Somit können die Walzenkäfige **15** solch eine komplexe Bewegung machen, wie diejenige, die von den Richtungsänderungsdurchgängen B der linearen Führung in dieser Ausführungsform verlangt wird.

[0075] Obwohl diese Ausführungsform den Fall gezeigt hat, in dem die Relativbewegung des sich bewegenden Blocks **42** zur Führungsschiene **41** linear gestaltet ist, kann die vorliegende Erfindung vorzugsweise auch auf eine Führungseinrichtung angewendet werden, die so konfiguriert ist, dass die Relativbewegung gekrümmt ist.

[0076] **Fig.** 16 zeigt einen Spline, in dem Walzenkäfige gemäß der ersten Ausführungsform der vorliegenden Erfindung beinhaltet sind. Der Spline hat eine Splinewelle **51** und einen äußeren Zylinder **52**. Die Splinewelle **51** dient als ein Bahnelement, wohingegen der äußere Zylinder **52** als ein Gleitelement dient. Der äußere Zylinder **52** ist auf der Splinewelle **51** montiert, so dass er durch eine Vielzahl von Walzen **53** bewegbar ist. Die Vielzahl von Walzen **53** ist in Walzenkäfigen **15** individuell gehalten, die in der ersten Ausführungsform erzielt werden. Weiterhin werden die Achsen von benachbarten Walzen im wesentlichen parallel zueinander gehalten.

[0077] Die Splinewelle **51** ist wie eine Säule eines tatsächlichen Kreises geformt. Eine Vielzahl von Walzenabwälznuten **51**a, die als Walzenbahnen wirken und als Walzenabwälzoberflächen dienen, die sich in der radialen Richtung der Splinewelle **51** erstrecken, sind in einer Oberfläche der Splinewelle **51** geformt. Beispielsweise sind sechs Walzenabwälznuten **51**a geformt.

[0078] Der äußere Zylinder **52**, der auf die Splinewelle **51** montiert ist, hat Lastabwälznuten **52**a, die den Walzenabwälznuten **51**a entsprechen. Die Lastabwälznuten **52**a dienen als Lastabwälzoberflächen. Eine Vielzahl von Walzen **53** ist in dem Walzenumlaufweg so angeordnet, dass die Walzen **53** zusätzlich zur linearen Bewegung des äußeren Zylinders **52** relativ zu der Splinewelle **51** umlaufen. Ein Lastabwälzdurchgang C ist zwischen jeder Lastabwälznut **52**a, die in dem äußeren Zylinder **52** geformt ist, und einer entsprechenden Walzenabwälznut **51**a, die in der Splinewelle **51** geformt ist, geformt. Ein Nichtlastrückkehrdurchgang D ist benachbart zu jedem Lastabwälzdurchgang C geformt. In dem Nichtlastrückkehrdurchgang D wälzen Walzen **53**, die von der Last freigegeben sind, ab. Ein Richtungsänderungsdurchgang B zum Verbinden jedes Lastabwälzdurchgangs C mit einem entsprechenden Nichtlastrückkehrdurchgang D ist weiter in dem äußeren Zylinder **52** geformt. Der Richtungsänderungsdurchgang B hat eine dreidimensionale, komplexe Bahn, wie diejenige der linearen Führung.

[0079] Wenn der äußere Zylinder **52** relativ zu der Splinewelle **51** bewegt wird, wälzt die Walze **53** in dem Nichtlastabwälzdurchgang C ab, wobei sie Last erfährt. Somit ändert die Walze **53** ihre Richtung in dem Richtungsänderungsdurchgang B und bewegt sich zu dem Nichtlastrückkehrdurchgang D. In dem Nichtlastrückkehrdurchgang D bewegt sich die Walze **53** in der umgekehrten Richtung gegen den Lastabwälzdurchgang C. Die Walzen **53**, die sich in dem Nichtlastrückkehrdurchgang D bewegen, ändern ihre Richtung wiederum in dem anderen Richtungsänderungsdurchgang B und kehren zu dem Nichtlastrückkehrdurchgang C wiederum zurück. Dabei drückt in den Lastabwälzdurchgängen C und Nichtlastrückkehrdurchgängen D, die lineare Bahnen bilden, der lineare Führungsbereich des rückseitigen Walzenkäfigs **15** den linearen Führungsbereich des vorderseitigen Walzenkäfigs **15**. In dem Richtungsänderungsdurchgang B, der eine gekrümmte Bahn bildet, drückt der gekrümmte Führungsbereich des rückseitigen Walzenkäfigs **15** den gekrümmten Führungsbereich des vorderseitigen Walzenkäfigs **15**. Sowohl in der linearen Bahn als auch in der gekrümmten Bahn kann der rückseitige Walzenkäfig **15** den vorderseitigen Walzenkäfig **15** drücken, ohne die Position der Walze **53** zu beeinträchtigen, die sich vorne in der Bewegungsrichtung der Walze befindet.

[0080] Weiterhin ist jede Seitenoberfläche des Walzenkäfigs **15** dünn gestaltet, und der lineare Führungsbereich und gekrümmte Führungsbereich zum Bringen benachbarter Walzenkäfige **15** in engen Kontakt miteinander sind wie kreisförmige Bögen im Querschnitt geformt, so dass sie in linearen Kontakt mit benachbarten Walzenkäfigen kommen. Somit drücken benachbarte Walzenkäfige **15** einander, wobei sie sich leicht um die Achsen von entsprechenden Walzen jeweils drehen können. Auf solch eine Weise können die Walzenkäfige **15** mit den Walzen **53** ihre Richtung frei dreidimensional ändern. Somit können die Walzenkäfige **15** eine solche komplexe Bewegung machen, wie sie von den Richtungsänderungsdurchgängen B der Splines in dieser Ausführungsform verlangt wird.

[0081] Wie es oben beschrieben ist, wird gemäß der vorliegenden Erfindung ein Walzenkäfig dünn gestaltet, um gegenüberliegende Seitenoberflächen einer entsprechenden Walze und vordere und rückwärtige Oberflächen der Walze in der Bewegungsrichtung der Walze zu halten. Ein linearer Führungsbereich und ein gekrümmter Führungsbereich, die sich im Neigungswinkel voneinander unterscheiden, sind in jeder Endoberfläche des Walzenkäfigs in der Bewegungsrichtung des Walzenkäfigs geformt. Somit kommt in der gekrümmten Bahn der gekrümmte Führungsbereich in Kontakt mit einem benachbarten Walzenkäfig. In der linearen Bahn kommt der lineare Führungsbereich in Kontakt mit einem benachbarten Walzenkäfig. Somit kann in sowohl der linearen Bahn als auch der gekrümmten Bahn, die eine Umlaufbahn bilden, der rückwärtige Walzenkäfig den vorderseitigen Walzenkäfig drücken, ohne die Position der Walze zu beeinträchtigen, die sich vorne in der Bewegungsrichtung der Walzen befindet. Somit können die Walzen ausgerichtet werden, dass ein glatter Umlauf erzielt werden kann. Ferner, da der Walzenkäfig dünn gestaltet ist, werden die folgenden Wirkungen erzielt.

(1) Benachbarte Walzenkäfige können einander drükken, wobei ihnen ermöglicht wird, sich leicht um die Achsen von entsprechenden Walzen jeweils zu drehen. Als eine Folge kann der Walzenkäfig als ein Walzenkäfig erzielt werden, der für einen komplexen Umlaufweg, wie einen dreidimensionalen Richtungsänderungsdurchgang oder einen helixförmigen Lastabwälzdurchgang, der wie eine Schraube geformt ist, geeignet ist.

(2) Ein großer Raum kann sichergestellt werden, um Schmieröl in dem Umlaufweg zu bevorraten. Somit können die Walzen ausreichend geschmiert werden.

(3) Ein Element zum Verhindern des Herunterfallens zum Stützen des Walzenkäfigs kann in dem Umlaufweg vorgesehen werden, so dass der Walzenkäfig am Herunterfallen aus dem Mutterelement oder ähnlichem gehindert wird.

Patentansprüche

1. Walzenkäfiganordnung, umfassend:
eine Vielzahl von Walzenkäfigen zum individuellen, entsprechenden Aufnehmen einer Vielzahl von Walzen, die in einem Walzenumlaufweg, der eine lineare und eine gekrümmte Bahn beinhaltet, umlaufen;
wobei jeder der Walzenkäfige dünn gestaltet ist, dass er gegenüberliegende Seitenoberflächen der Walze und vordere und rückwärtige Oberflächen der Walze in einer Bewegungsrichtung der Walze hält;
wobei ein linearer Führungsbereich und ein gekrümmter Führungsbereich, die sich voneinander im Neigungswinkel unterscheiden, an gegenüberliegenden Endoberflächen des Walzenkäfigs in einer Bewegungsrichtung des Walzenkäfigs geformt sind; und
wobei der lineare Führungsbereich des Walzenkäfigs in Kontakt mit einem benachbarten Walzenkäfig in der linearen Bahn und der gekrümmte Führungsbereich des Walzenkäfigs in Kontakt mit dem benachbarten Walzenkäfig in der gekrümmten Bahn kommt.

2. Walzenkäfiganordnung, umfassend:
eine Vielzahl von Walzenkäfigen zum individuellen, entsprechenden Aufnehmen einer Vielzahl von Walzen, die in einem Walzenumlaufweg umlaufen, der eine lineare und eine gekrümmte Bahn umfasst;
wobei jeder der Walzenkäfige dünn gestaltet ist, dass er gegenüberliegende Seitenoberflächen der Walze und entweder die vordere oder rückwärtige Oberfläche der Walze in einer Bewegungsrichtung der Walze hält;
wobei ein linearer Führungsbereich und ein gekrümmter Führungsbereich, die sich im Neigungswinkel voneinander unterscheiden, in einer Endoberfläche des Walzenkäfigs in einer Bewegungsrichtung des Walzenkäfigs geformt sind; und
wobei der lineare Führungsbereich des Walzenkäfigs in Kontakt mit einer benachbarten Walze in der linearen Bahn und der gekrümmte Führungsbereich des Walzenkäfigs in Kontakt mit der benachbarten Walze in der gekrümmten Bahn kommt.

3. Walzenkäfiganordnung nach Anspruch 1, wobei jeder von dem linearen Führungsbereich und dem gekrümmten Führungsbereich des Walzenkäfigs geformt ist, dass er eine gekrümmte Oberfläche ist, die wie ein kreisförmiger Bogen im Querschnitt geformt ist, so dass sie in linearen Kontakt mit dem benachbarten Walzenkäfig kommt.

4. Walzenkäfiganordnung nach Anspruch 2, wobei jeder von dem linearen Führungsbereich und dem gekrümmten Führungsbereich des Walzenkäfigs geformt ist, dass er eine gekrümmte Oberfläche ist in Übereinstimmung mit einem äußeren Umfang der Walze.

5. Walzenkäfiganordnung nach Anspruch 1 oder 3, wobei ein Gelenkvorsprung an einem Schnittpunkt zwischen dem linearen Führungsbereich und dem gekrümmten Führungsbereich in einer Endoberfläche des Walzenkäfigs in der Bewegungsrichtung des Walzenkäfigs vorgesehen ist; und
wobei eine Gelenkaussparung an einem Schnittpunkt zwischen dem linearen Führungsbereich und dem gekrümmten Führungsbereich in der anderen Endoberfläche des Walzenkäfigs in der Bewegungsrichtung des Walzenkäfigs vorgesehen ist, so dass die Gelenkaussparung mit dem Gelenkvorsprung eines benachbarten Walzenkäfigs in Eingriff kommt.

6. Walzenkäfiganordnung nach Anspruch 1, wobei Vorsprünge zum Verhindern des Herunterfallens an entweder dem Walzenkäfig oder gegenüberliegenden

Seitenoberflächen der Walze geformt sind; und wobei Aussparungen zum Verhindern des Herunterfallens in dem anderen von dem Walzenkäfig und den gegenüberliegenden Seitenoberflächen der Walze geformt sind, so dass die Vorsprünge zum Verhindern des Herunterfallens in die Aussparungen zum Verhindern des Herunterfallens eingepasst sind.

7. Walzenkäfiganordnung nach Anspruch 1, wobei eine Dicke des Walzenkäfigs gewählt ist, dass sie nicht kleiner als 50% eines Durchmessers der Walze ist.

8. Direkt wirkende Führungseinrichtung, umfassend:
eine Bahnwelle, umfassend eine Walzenabwälzoberfläche;
ein Gleitelement, das einen Walzenumlaufweg umfasst, der eine Lastabwälzoberfläche entsprechend der Walzenabwälzoberfläche enthält, wobei das Gleitelement mit der Bahnwelle in Passung gebracht ist, so dass es frei bewegbar relativ zu der Bahnwelle ist;
eine Vielzahl von Walzen, die in dem Walzenumlaufweg angeordnet und aufgenommen sind, so dass sie in Übereinstimmung mit der Bewegung des Gleitelements relativ zu der Bahnwelle umlaufen; und
eine Vielzahl von Walzenkäfigen zum Halten der Vielzahl von Walzen individuell und entsprechend, so dass die Vielzahl von Walzen drehbar/verschiebbar ist;
wobei die Vielzahl von Walzen angeordnet und aufgenommen ist, so dass die Achsen von benachbarten Walzen näherungsweise parallel zueinander gehalten werden;
wobei jeder der Walzenkäfige dünn gestaltet ist, dass er gegenüberliegende Seitenoberflächen von benachbarten Walzen und vordere und rückwärtige Oberflächen der Walze in einer Richtung der Bewegung der Walze hält;
wobei ein linearer Führungsbereich und ein gekrümmter Führungsbereich, die im Neigungswinkel voneinander sich unterscheiden, in jeder von gegenüberliegenden Endoberflächen des Walzenkäfigs in einer Bewegungsrichtung des Walzenkäfigs geformt sind; und
wobei der lineare Führungsbereich des Walzenkäfigs in Kontakt mit einem benachbarten Walzenkäfig in einer linearen Bahn und der gekrümmte Führungsbereich des Walzenkäfigs in Kontakt mit dem benachbarten Walzenkäfig in einer gekrümmten Bahn kommt.

9. Direkt wirkende Führungseinrichtung, umfassend:
eine Bahnwelle, die eine Walzenabwälzoberfläche enthält;
ein Gleitelement, das einen Walzenumlaufweg umfasst, der eine Lastabwälzoberfläche entsprechend der Walzenabwälzoberfläche enthält, wobei das Gleitelement an die Bahnwelle angepasst ist, so dass es frei bewegbar relativ zu der Bahnwelle ist;
eine Vielzahl von Walzen, die in dem Walzenumlaufweg angeordnet und aufgenommen sind, so das sie in Übereinstimmung mit der Bewegung des Gleitelements relativ zu der Bahnwelle umlaufen; und
eine Vielzahl von Walzenkäfigen zum Halten der Vielzahl von Walzen individuell und entsprechend, so dass die Vielzahl von Walzen drehbar/verschiebbar ist;
wobei die Vielzahl von Walzen angeordnet und aufgenommen ist, so dass die Achsen von benachbarten Walzen näherungsweise parallel zueinander gehalten werden;
wobei jeder der Walzenkäfige dünn gestaltet ist, dass er gegenüberliegende Seitenoberflächen von entsprechenden der Walzen und entweder die vordere oder die rückwärtige Oberfläche der Walze in einer Bewegungsrichtung der Walze hält;
wobei ein linearer Führungsbereich und ein gekrümmter Führungsbereich, die sich im Neigungswinkel voneinander unterscheiden, in einer Endoberfläche des Walzenkäfigs in einer Bewegungsrichtung des Walzenkäfigs geformt sind; und
wobei der lineare Führungsbereich des Walzenkäfigs in Kontakt mit einer benachbarten Walze in einer linearen Bahn und der gekrümmte Führungsbereich des Walzenkäfigs in Kontakt mit der benachbarten Walze in einer gekrümmten Bahn kommt.

10. Walzenschraube, umfassend:
eine Bahnwelle, die eine helixförmige Walzenabwälzoberfläche enthält;
ein Gleitelement, das einen Walzenumlaufweg umfasst, der eine helixförmige Lastabwälzoberfläche enthält, die der Walzenabwälzoberfläche entspricht, wobei das Gleitelement an die Bahnwelle angepasst ist, so dass es frei bewegbar relativ zu der Bahnwelle ist;
eine Vielzahl von Walzen, die in dem Walzenumlaufweg angeordnet und aufgenommen sind, so dass sie in Übereinstimmung mit der Bewegung des Gleitelements relativ zu der Bahnwelle umlaufen; und
eine Vielzahl von Walzenkäfigen zum Halten der Vielzahl von Walzen individuell und entsprechend, so dass die Vielzahl von Walzen drehbar/verschiebbar ist;
wobei die Vielzahl von Walzen angeordnet und aufgenommen ist, so dass die Achsen von benachbarten Walzen näherungsweise parallel zueinander gehalten werden;
wobei jeder der Walzenkäfige dünn gestaltet ist, dass er gegenüberliegende Seitenoberflächen einer entsprechenden der Walzen und vordere und rückwärtige Oberflächen der Walze in einer Bewegungsrichtung der Walze hält;
wobei ein linearer Führungsbereich und ein gekrümmter Führungsbereich, die im Neigungswinkel voneinander unterschiedlich sind, in jeder der gegenüberliegenden Endoberflächen des Walzenkäfigs in einer Bewegungsrichtung des Walzenkäfigs geformt sind; und
wobei der lineare Führungsbereich des Walzenkäfigs in Kontakt mit einem benachbarten Walzenkäfig in einer linearen Bahn und der gekrümmte Führungsbereich des Walzenkäfigs in Kontakt mit dem benachbarten Walzenkäfig in einer gekrümmten Bahn kommt.

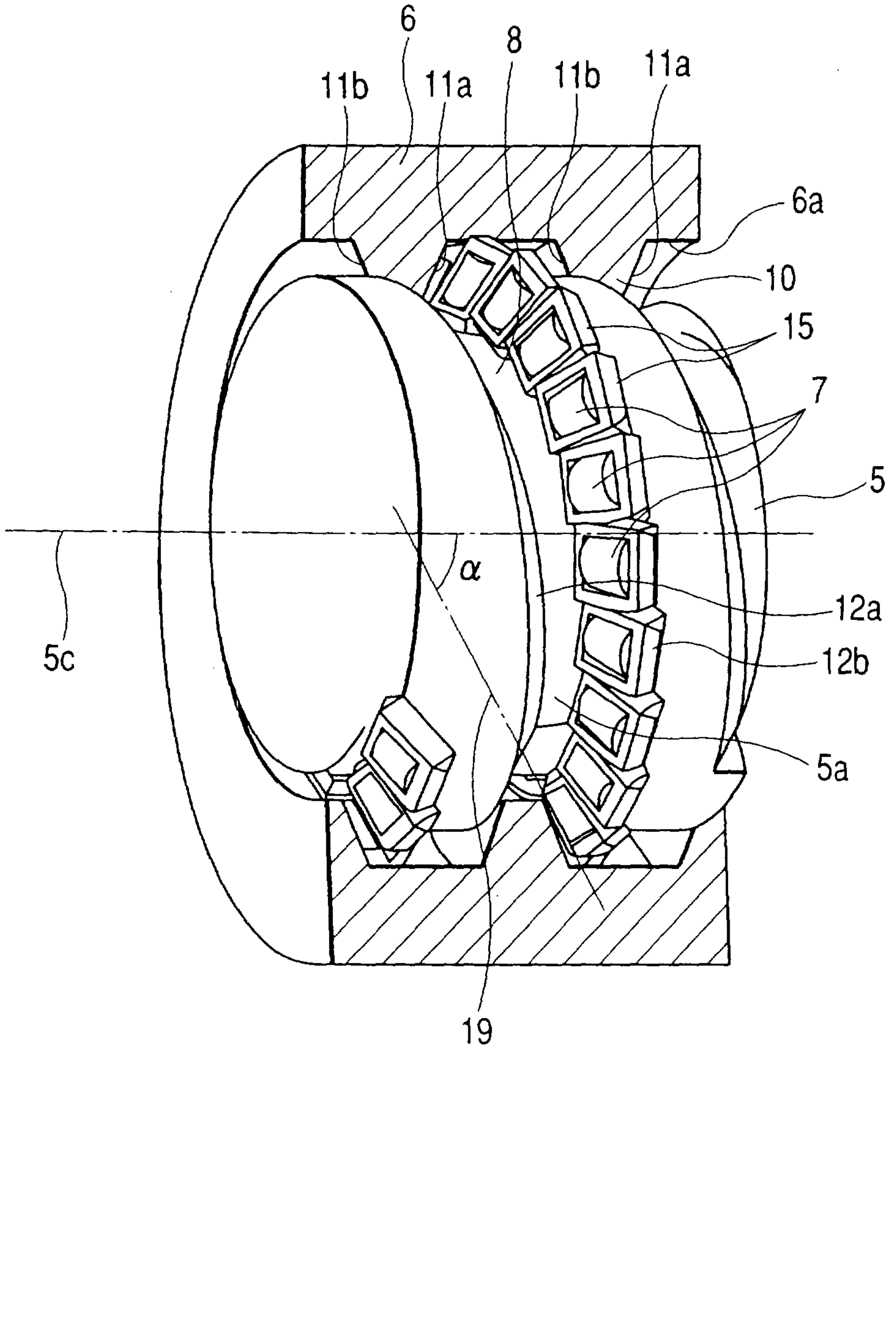
11. Walzenschraube, umfassend:
eine Bahnwelle, die eine helixförmige Walzenabwälzoberfläche enthält;
ein Gleitelement, das einen Walzenumlaufweg umfasst, der eine helixförmige Lastabwälzoberfläche enthält, die der Walzenabwälzoberfläche entspricht, wobei das Gleitelement an die Bahnwelle angepasst ist, so dass es frei bewegbar relativ zu der Bahnwelle ist;
eine Vielzahl von Walzen, die angeordnet und aufgenommen in dem Walzenumlaufweg sind, so dass sie in Übereinstimmung mit der Bewegung des Gleitelements relativ zu der Bahnwelle umlaufen; und
eine Vielzahl von Walzenkäfigen zum Halten der Vielzahl von Walzen individuell und entsprechend, so dass die Vielzahl von Walzen drehbar/verschiebbar ist;
wobei die Vielzahl von Walzen angeordnet und aufgenommen ist, so dass die Achsen von benachbarten Walzen näherungsweise parallel zueinander gehalten werden;
wobei jeder der Walzenkäfige dünn gestaltet ist, um gegenüberliegende Seitenoberflächen von einer entsprechenden der Walzen und entweder die vordere oder die rückwärtige Oberfläche der Walze in einer Bewegungsrichtung der Walze zu halten;

wobei ein linearer Führungsbereich und ein gekrümmter Führungsbereich, die sich im Neigungswinkel voneinander unterscheiden, in einer Endoberfläche des Walzenkäfigs in einer Richtung der Bewegung des Walzenkäfigs geformt sind; und
wobei der lineare Führungsbereich des Walzenkäfigs in Kontakt mit einer benachbarten Walze in einer linearen Bahn und der gekrümmte Führungsbereich des Walzenkäfigs in Kontakt mit der benachbarten Walze in einer gekrümmten Bahn kommt.

Hierzu 10 Seite(n) Zeichnungen

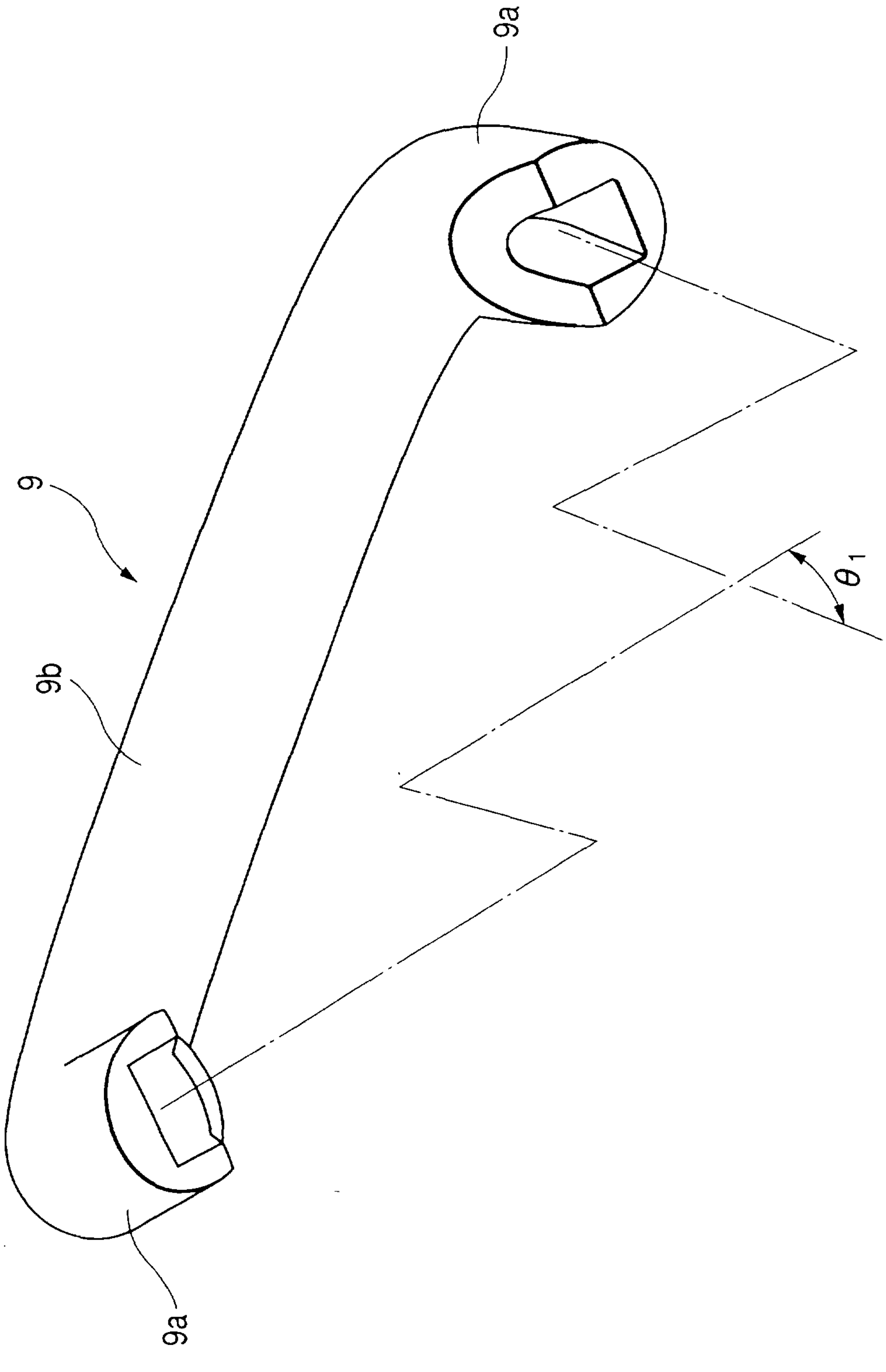
Nummer: DE 101 13 510 A1
Int. Cl.⁷: F 16 H 25/22
Offenlegungstag: 29. November 2001

FIG. 1



Nummer: DE 101 13 510 A1
Int. Cl.[7]: F 16 H 25/22
Offenlegungstag: 29. November 2001

FIG. 2



Nummer: **DE 101 13 510 A1**
Int. Cl.[7]: **F 16 H 25/22**
Offenlegungstag: 29. November 2001

FIG. 3

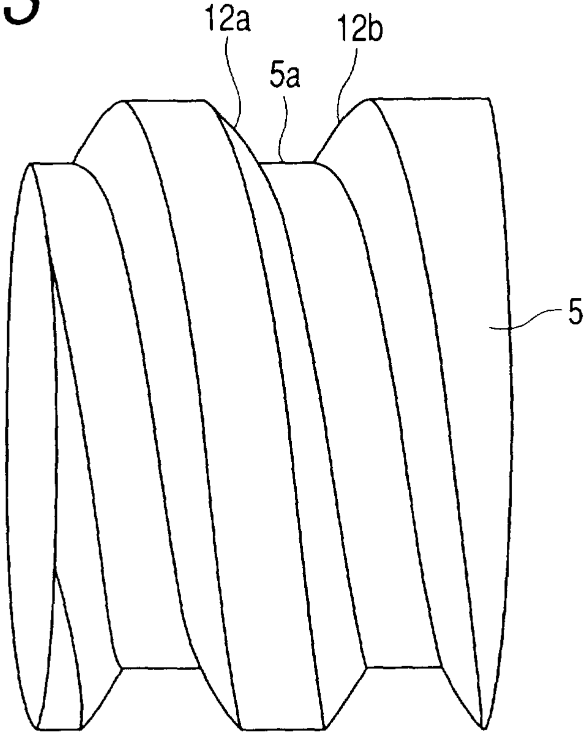
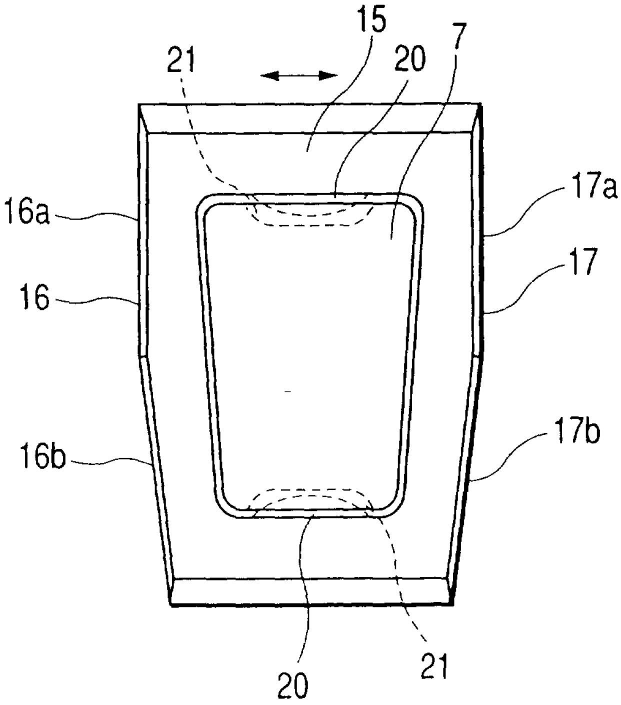


FIG. 4



Nummer: DE 101 13 510 A1
Int. Cl.[7]: F 16 H 25/22
Offenlegungstag: 29. November 2001

FIG. 5

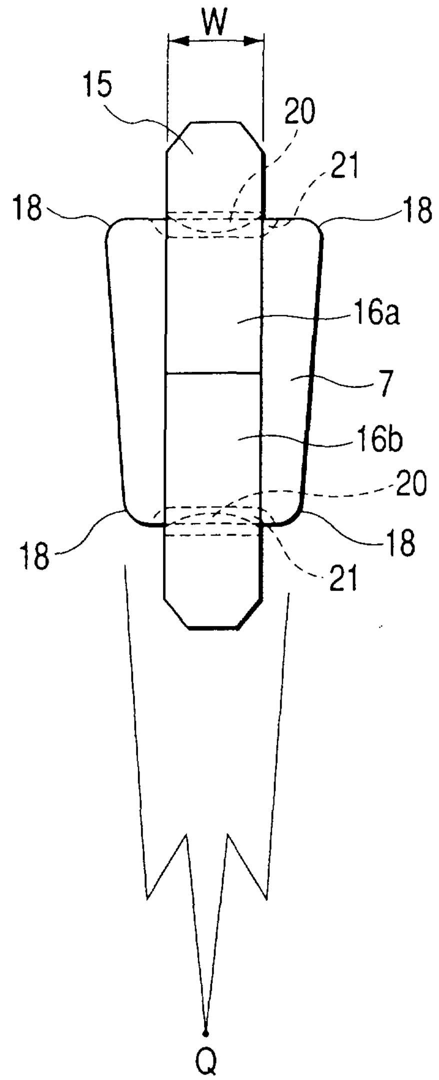
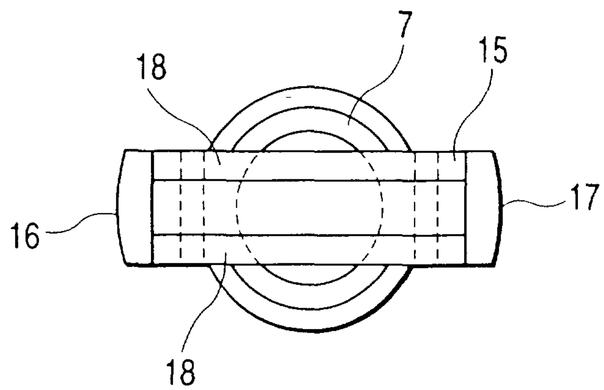
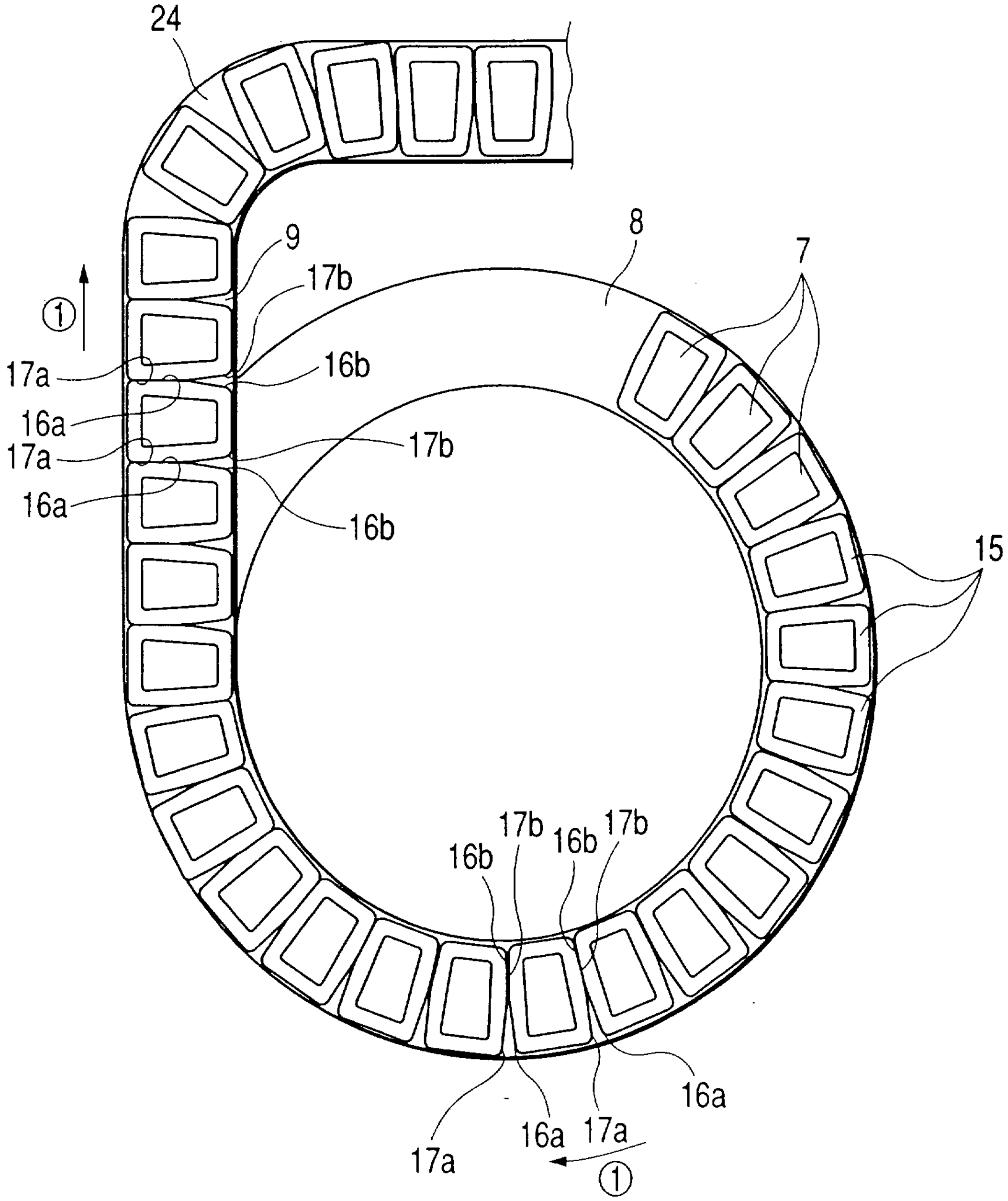


FIG. 6



Nummer: DE 101 13 510 A1
Int. Cl.[7]: F 16 H 25/22
Offenlegungstag: 29. November 2001

FIG. 7



Nummer: **DE 101 13 510 A1**
Int. Cl.[7]: **F 16 H 25/22**
Offenlegungstag: 29. November 2001

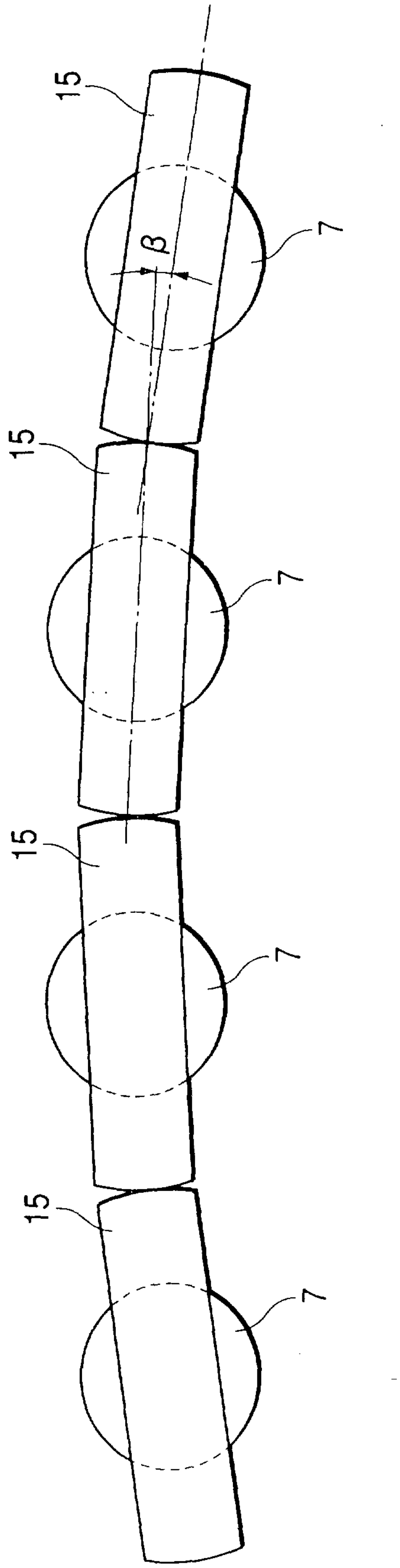


FIG. 8

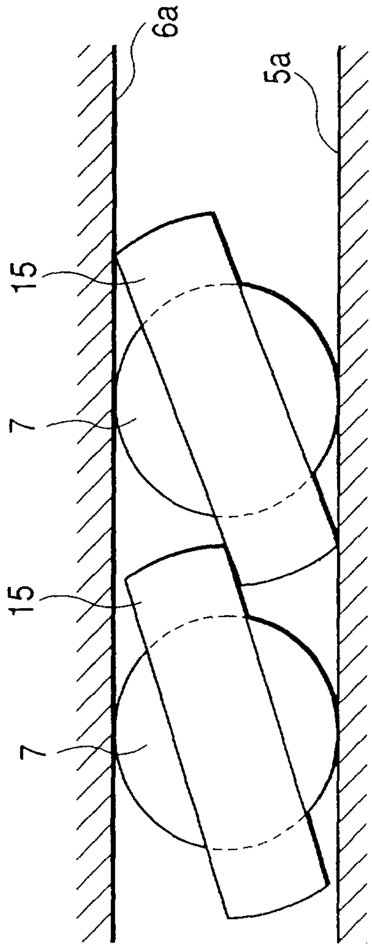


FIG. 9

Nummer: DE 101 13 510 A1
Int. Cl.[7]: F 16 H 25/22
Offenlegungstag: 29. November 2001

FIG. 10

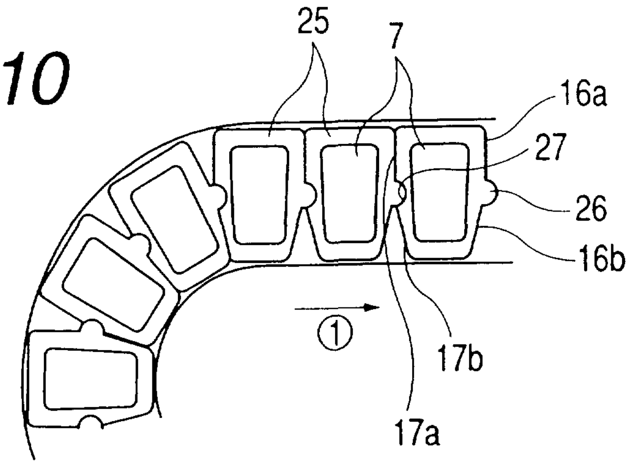


FIG. 11

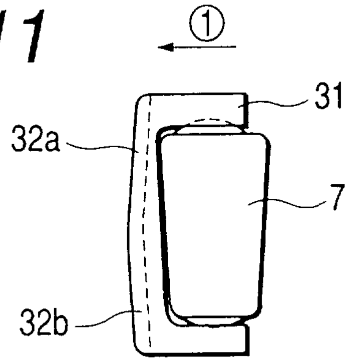


FIG. 12

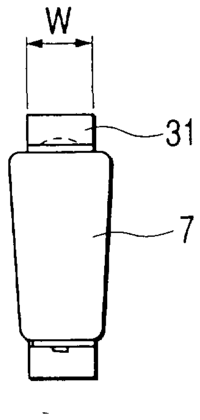


FIG. 13

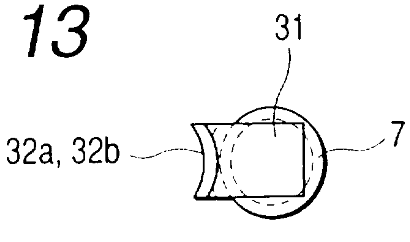


FIG. 14A

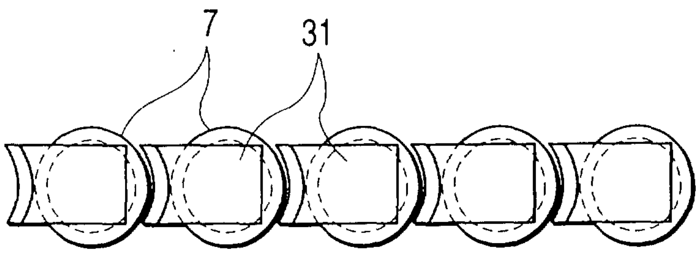


FIG. 14B

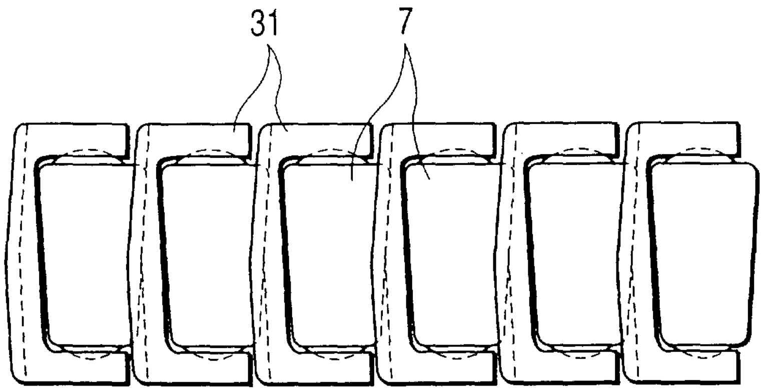
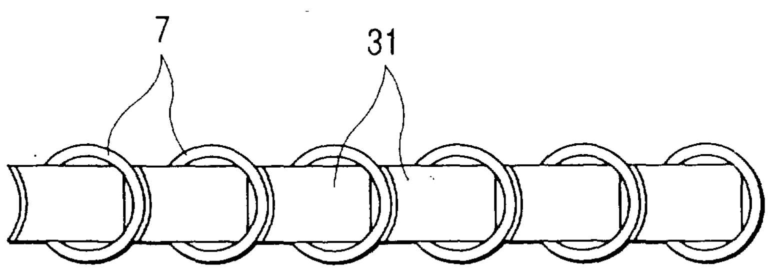


FIG. 14C



Nummer: DE 101 13 510 A1
Int. Cl.⁷: F 16 H 25/22
Offenlegungstag: 29. November 2001

FIG. 15

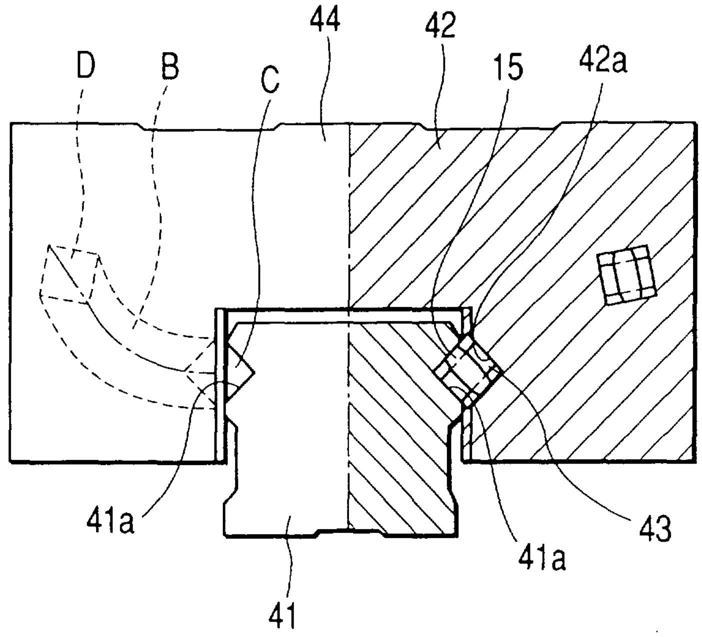
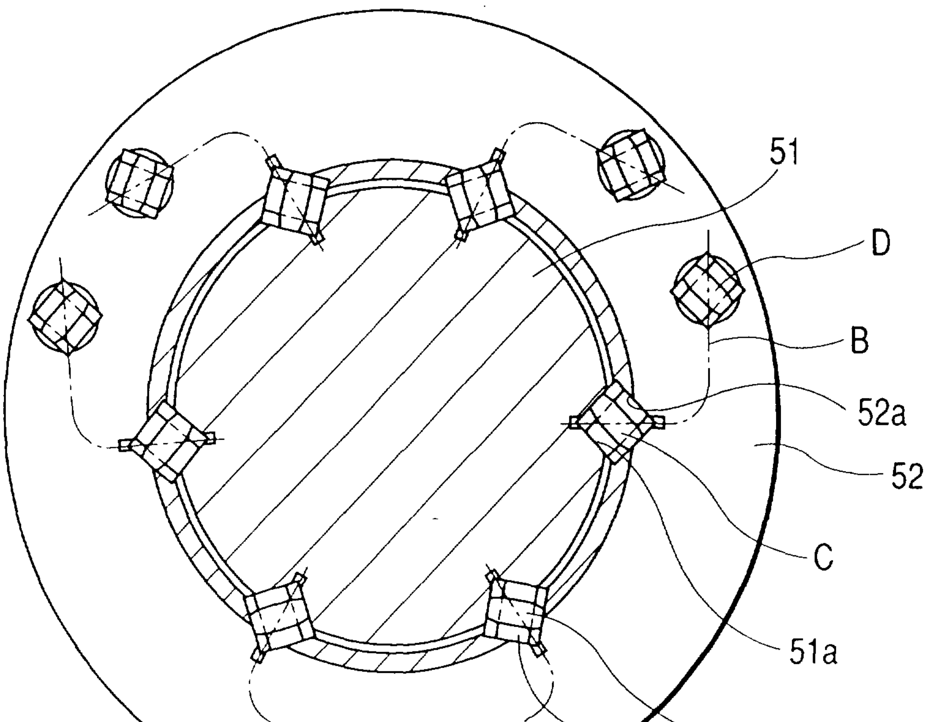


FIG. 16



Nummer: DE 101 13 510 A1
Int. Cl.7: F 16 H 25/22
Offenlegungstag: 29. November 2001

FIG. 17

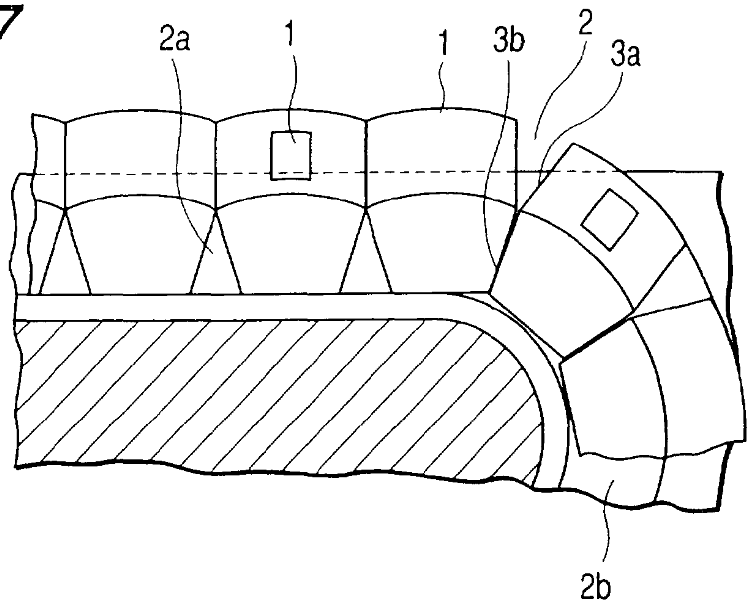


FIG. 18

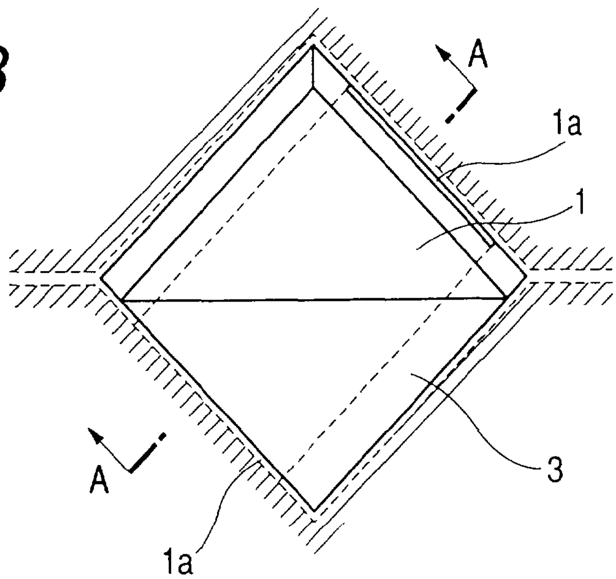
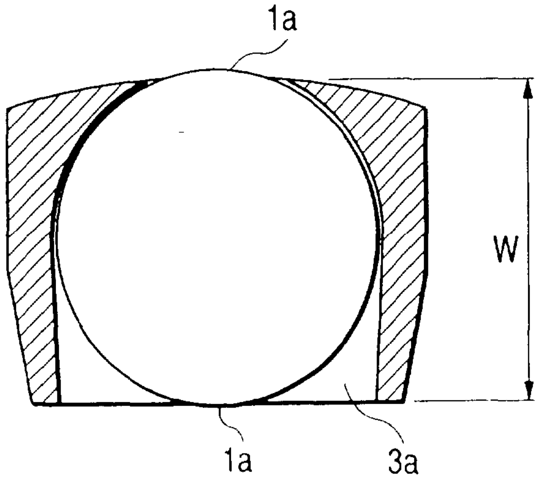


FIG. 19



(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 101 02 179 A 1**

(51) Int. Cl.[7]: **F 16 C 29/06**

(21) Aktenzeichen: 101 02 179.8

(22) Anmeldetag: 18. 1. 2001

(43) Offenlegungstag: 9. 8. 2001

(30) Unionspriorität:

2000-13891 18. 01. 2000 JP

(71) Anmelder:

THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:

Viering, Jentschura & Partner, 80538 München

(72) Erfinder:

Shimizu, Shigeo, Kawasaki, JP; Takahashi, Tooru, Shinagawa, JP

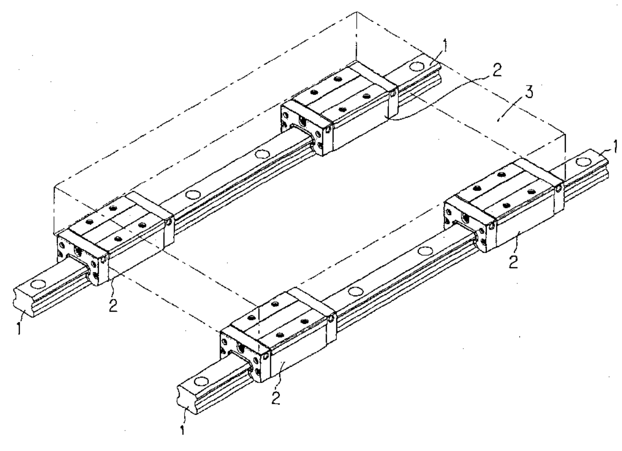
Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Verfahren zur Bestimmung der Länge einer Laufwegoberfläche und des Wälzkörperdurchmessers einer Wälzkörperführungsvorrichtung, sowie eine Wälzkörperführungsvorrichtung und ein Wälzkörperführungsvorrichtungssystem unter Anwendung des Bestimmungsverfahrens

(57) Eine Länge einer Laufwegoberfläche eines bewegbaren Elements und ein Durchmesser eines Wälzkörpers einer Wälzkörperführungsvorrichtung sind derart bestimmt, dass in einer Länge von 2κDa des bewegbaren Elements, in der die relativen Positionen des bewegbaren Elements und der entsprechenden Rollenelemente variieren, ein Verhältnis (I : I-1), bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 100% bis 0% (100% : 0%) festgelegt ist, wobei I = int(2Ux/κDa + 0,5), mit

2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und

κDa = der Wälzkörperdurchmesser oder die Aufnahmehöhe.



DE 101 02 179 A 1

Beschreibung

Hintergrund der Erfindung

Die vorliegende Erfindung betrifft eine Wälzkörperführungsvorrichtung und insbesondere ein Verfahren zur Bestimmung einer Länge einer Laufwegoberfläche und eines Durchmessers eines Wälzkörpers einer Wälzkörperführungsvorrichtung, eine Wälzkörperführungsvorrichtung und ein Wälzkörperführungssystem, in dem obiges Bestimmungsverfahren Anwendung findet.

Als eine Wälzkörperführungsvorrichtung zum Führen einer linearen oder gekrümmten Bewegung sind lineare Führungsvorrichtungen, Kugellaufbuchsen, Kugelspindelmaschinen und dergleichen bekannt. In derartigen Wälzkörperführungsvorrichtungen weist die lineare Kugelführung eine Spurschiene und einen bewegbaren Block als bewegliches Element auf, das derart angeordnet ist, dass es mit Bezug auf die Spurschiene über eine Anzahl von Kugeln als Wälzkörper bewegbar ist. Ein lineares Kugelführungssystem als ein Wälzkörperführungssystem ist ein System, bei dem die lineare Führungsvorrichtung mit einem Maschinenwerkzeugtisch oder dergleichen zusammengesetzt ist und beispielsweise zwei bewegbare Blöcke jeweils mit zwei Spurschienen zum Tragen des Tisches, also insgesamt vier bewegbaren Blökken vorgesehen sind.

In diesem System wird auf den Tisch eine radiale Last, eine horizontale Last und entsprechende Kraftmomente einer Abrolllast, einer Wende-Rolllast, sowie einer Längsmomentenlast als externe Kräfte aufgebracht. Der Tisch verändert seine Lage aufgrund dieser externen Kräfte, wobei die Stellung des Tisches fünf variable Komponenten einer vertikalen (senkrechten) Versetzung, einer horizontalen (transversalen) Versetzung, eines Abrollwinkels, eines Verdrehwinkels und eines Kippwinkels beinhaltet.

Der bewegbare Block hat eine Laufwegoberfläche, wobei eine Anzahl von Kugeln zwischen dieser Laufwegoberfläche und einer Spurschiene als Spurschaft angeordnet sind. In der linearen Wälzkörperführungsvorrichtung laufen die Kugeln gemäß der Bewegung des bewegbaren Elements, womit eine relative Position der Kugeln und des bewegbaren Blocks variabel ist. Diese Änderung der relativen Position der Kugeln und des bewegbaren Blocks verursacht eine Änderung der Lastverteilung in dem linearen Führungssystem, womit die Stellung des Tisches verändert wird. Der Betrag dieser Änderung der Stellung des Tisches stellt die Genauigkeit des linearen Kugelführungssystems dar, wobei demgemäß die Präzision des linearen Kugelführungssystems verbessert werden kann, wenn der Betrag der änderbaren Tischstellung verringert wird.

Zusammenfassung der Erfindung

Im Hinblick auf die zum Stand der Technik oben erwähnten Umstände ist es eine Aufgabe der vorliegenden Erfindung, ein Verfahren zur Bestimmung einer Länge einer Laufwegoberfläche eines bewegbaren Elements und eines Durchmessers eines Wälzkörpers einer Wälzkörperführungsvorrichtung, sowie eine Wälzkörperführungsvorrichtung und ein Wälzkörperführungssystem vorzusehen, bei dem ein derartiges Bestimmungsverfahren Anwendung findet, durch das die Variabilität der fünf Komponenten einer Stellung eines bewegbaren Elements reduziert oder gemindert werden kann, die hinsichtlich einer variablen Lastverteilung gemäß der Änderung der relativen Position eines Elements und einer Anzahl von Wälzkörpern die Genauigkeit eines Kugelspindelsystems darstellt.

In der Wälzkörperführungsvorrichtung sind die relativen Positionen der entsprechenden Wälzkörper und des bewegbaren Elements gemäß der Auslenkung variabel, wobei ein Zyklus vollzogen ist, wenn die Auslenkung den Wert 2 κDa erreicht (Wälzkörperhöhe oder Aufnahmehöhe), wonach dieser Zyklus wiederholt wird. Da sich die relativen Positionen der Wälzkörper in dem Intervall der 2 κDa Länge verändern, verändert sich die Lastverteilung in der Kugelspindel und daher die Stellung des Tischs des Wälzkörperführungssystems gemäß der Änderung dieser Lastverteilung.

Die Erfinder der vorliegenden Anmeldung analysierten die Genauigkeit eines linearen Wälzkörperführungssystems durch Unterteilen der 2 κDa Länge des bewegbaren Elements und durch Lösen der Gleichgewichtsgleichungen betreffend die externen Belastungen und die Belastungen des Wälzkörpers an entsprechenden Positionen, um dadurch fünf variable Komponenten der Stellung des Tisches zu erhalten. In dieser Analyse zeigte sich, dass es durch die Deformation eines Flanschabschnittes des bewegbaren Elementes möglich ist, die Genauigkeit effektiver zu analysieren.

Gemäß dem Ergebnis dieser Analyse hat man herausgefunden, dass sich mit einem Verringern des Durchmessers des Wälzkörpers die radiale Versetzung, die Kipp- und die maximale Lastverteilung verringern, wobei jedoch die radiale Versetzung und die die Genauigkeit des Wälzkörperführungssystems darstellende Kippwinkelvariation nicht direkt proportional zum Durchmesser des Wälzkörpers ist. D. h., dass herausgefunden worden ist, dass es einen anderen Faktor als den Durchmesser des Wälzkörpers geben muss, der einen Einfluss auf die Genauigkeit ausübt. Hinsichtlich dieses Faktors gaben die Erfinder ihr Augenmerk auf ein Verhältnis der Variation der Anzahl der belasteten Wälzkörper, die die Last in der 2 κDa Länge verteilen, und sie fanden heraus, dass die Variationen der radialen Versetzung und des Kippwinkels extrem gering gemacht werden können, indem dieses Verhältnis auf einen bestimmten Wert gesetzt wird, womit dadurch die Genauigkeit des linearen Führungssystems beträchtlich erhöht ist.

Unter Betrachtung der obigen Ausführungen können die Aufgaben der vorliegenden Erfindung gelöst werden, indem in einem Aspekt ein Verfahren zur Bestimmung der Länge einer Laufwegoberfläche eines bewegbaren Elements und eines Durchmessers eines Wälzkörpers einer Wälzkörperführungsvorrichtung vorgesehen ist, welche ein bewegbares Element und Wälzkörper aufweist, wobei in einer Länge von 2 κDa des bewegbaren Elements, innerhalb der relative Positionen des bewegbaren Elements und der entsprechenden Wälzkörper variieren, ein Verhältnis (I : I-1), bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 100% bis 0% (100% : 0%) festgelegt ist, wobei $I = \mathrm{int}(2Ux/\kappa Da + 0{,}5)$, mit 2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und κDa = der Wälzkörperdurchmesser oder die Aufnahmehöhe.

Gemäß diesem Aspekt der Erfindung ist die Veränderung der Anzahl der wirksamen Wälzkörper hinsichtlich der Auslenkungslänge reduziert, wobei die Genauigkeit des Wälzkörperführungssystem und insbesondere die Abwälzpräzision beträchtlich verbessert werden kann. Überdies ist bei einer Reduzierung der Veränderung der Anzahl der wirksamen Wälzkörper auch der Einfluss auf die Abwälzgenauigkeit durch eine Veränderung des Durchmessers des Wälzkörpers verringert, wobei beispielsweise der Durchmesser des Wälzkörpers unter Aufrechterhaltung der Abwälzgenauigkeit groß gewählt werden kann und überdies die grundlegende dynamische Belastungsrate ebenso groß gewählt werden kann.

Obige Aufgabe kann ebenso in einem anderen Aspekt gelöst werden, in dem ein Verfahren zur Bestimmung einer Länge einer Laufwegoberfläche eines bewegbaren Elements und eines Durchmessers eines Wälzkörpers einer Wälzkörperführungsvorrichtung bestimmt wird, die ein bewegbares Element und Wälzkörper aufweist, wobei in einer Wälzlänge von 2 κDa des bewegbaren Elements, innerhalb der relative Positionen des bewegbaren Elements und der entsprechenden Wälzkörper variieren, ein Verhältnis (I : I-1), bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 50% bis 50% (50% : 50%) festgelegt ist, wobei I = int(2Ux/kDa + 0,5), mit 2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und κDa = Wälzkörperdurchmesser oder Aufnahmehöhe.

Gemäß diesem Aspekt kann die Genauigkeit des linearen Wälzkörperführungssystems, die Neigungswinkelgenauigkeit und die Radialgenauigkeit bedeutend verbessert werden.

In einem weiteren Aspekt kann die obige Aufgabe auch durch Vorsehen einer Wälzkörperführungsvorrichtung gelöst werden, die ein bewegbares Element und Wälzkörper aufweist, wobei die Länge einer Laufwegoberfläche des bewegbaren Elements und der Durchmesser des Wälzkörpers derart bestimmt sind, dass in einer Länge von 2 κDa des bewegbaren Elements, in der die relativen Positionen des bewegbaren Elements und der entsprechenden Wälzkörper variieren, ein Verhältnis (I : I-1), bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 100% bis 0% (100% : 0%) festgelegt ist, wobei I = int(2Ux/κDa + 0,5), mit 2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und κDa = der Wälzkörperdurchmesser oder die Aufnahmehöhe.

In einem noch weiteren Aspekt kann die obige Aufgabe gelöst werden, indem eine Wälzkörperführungsvorrichtung vorgesehen ist, die ein bewegbares Element und Wälzkörper aufweist, wobei die Länge der Laufwegoberfläche des bewegbaren Elements und der Durchmesser des Wälzkörpers derart bestimmt sind, dass in einer Länge von 2 κDa des bewegbaren Elements, in der die relativen Positionen des bewegbaren Elements und der entsprechenden Rollenelemente variieren, ein Verhältnis (I : I-1), bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 50% bis 50% (50% : 50%) festgelegt ist, wobei I = int(2Ux/κDa + 0,5), mit 2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und κDa = der Wälzkörperdurchmesser oder die Aufnahmehöhe.

In einem noch weiteren Aspekt kann die obige Aufgabe gelöst werden, indem ein Wälzkörperführungssystem vorgesehen ist, das eine Spurschiene, mindestens ein auf der Spurschiene bewegbar befestigt bewegbares Element und Wälzkörper aufweist, die zwischen der Spurschiene und dem bewegbaren Element angeordnet sind, wobei die Länge einer Laufwegoberfläche des bewegbaren Elements und der Durchmesser des Wälzkörpers derart bestimmt sind, dass in einer Länge von 2 κDa des bewegbaren Elements, in der die relativen Positionen des bewegbaren Elements und der entsprechenden Wälzkörper variieren, ein Verhältnis (I : I-1), bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 100% bis 0% (100% : 0%) festgelegt ist, wobei I = int(2Ux/κDa + 0,5), mit 2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und κDa = der Wälzkörperdurchmesser oder die Aufnahmehöhe.

In einem noch weiteren Aspekt kann obige Aufgabe gelöst werden, indem ein Wälzkörperführungssystem vorgesehen ist, das eine Spurschiene, mindestens ein auf der Spurschiene bewegbar befestigtes bewegbares Element und Wälzkörper aufweist, die zwischen der Spurschiene und den bewegbaren Elementen angeordnet sind, wobei die Länge einer Laufwegoberfläche des bewegbaren Elements und der Durchmesser des Wälzkörpers derart bestimmt sind, dass in einer Länge von 2 κDa des bewegbaren Elements, in der die relativen Positionen des bewegbaren Elements und der entsprechenden Rollenelemente variieren, ein Verhältnis (I : I-1), bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 50% bis 50% (50% : 50%) festgelegt ist, wobei I = int(2Ux/κDa + 0,5), mit 2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und κDa = der Wälzkörperdurchmesser oder die Aufnahmehöhe.

Die Erfinder gaben ihr Augenmerk überdies auf einen weiteren Faktor hinsichtlich der relativen Positionen der Wälzkörper in den bewegbaren Elementen, die an vorderen und hinteren Positionen in derselben Spurschiene des linearen Führungssystems angeordnet sind, und sie fanden heraus, dass die Variation des Neigungswinkels durch Einstellen der lichten Weite der bewegbaren Elemente beträchtlich reduziert werden kann, um so die relativen Positionen der Wälzkörper zueinander übereinstimmend vorzusehen.

D. h., dass obige Aufgabe gemäß der vorliegenden Erfindung hinsichtlich eines noch weiteren Aspektes gelöst werden kann, indem ein Wälzkörperführungssystem vorgesehen ist, das eine Schienenvorrichtung, eine Mehrzahl von bewegbaren Elementen, die auf der Schienenvorrichtung befestigt sind, und eine zwischen der Schienenvorrichtung und den bewegbaren Elementen angeordnete Wälzkörper aufweist, wobei die lichten Weiten der bewegbaren Elementen derart eingestellt sind, dass relative Positionen der Wälzkörper in den entsprechenden bewegbaren Elementen entsprechend übereinstimmen. Diese Einstellung wird dadurch realisiert, dass die lichte Weite des bewegbaren Elements ein ganzzahliges Vielfaches des Rollendurchmessers κDa ist.

Bei einem Aufbau, bei dem das Wälzkörperführungssystem mit einer Mehrzahl von Spurschienen versehen ist, kann die lichte Weite des bewegbaren Elements derart eingestellt sein, dass die relativen Positionen der Wälzkörper in den auf die entsprechenden Spurschienen befestigten bewegbaren Elementen einander entsprechen.

Überdies kann die vorliegende Erfindung die Kombination aus obigen zwei Faktoren (Aspekten) vorsehen, d. h., dass ein Wälzkörperführungssystem vorgesehen ist, bei dem eine Mehrzahl von bewegbaren Elementen auf der Schienenvorrichtung befestigt ist, wobei die Länge einer Laufwegoberfläche des bewegbaren Elements und der Durchmesser des Wälzkörpers derart bestimmt sind, dass in einer Länge von κDa des bewegbaren Elements, in der relative Positionen des bewegbaren Elements und der entsprechenden Wälzkörper variieren, ein Verhältnis (I : I-1), bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 100% bis 0% (100% : 0%) festgelegt ist, wobei I = int(2Ux/κDa + 0,5), mit 2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und κDa = der Wälzkörperdurchmesser oder die Aufnahmehöhe.

Gemäß diesem Aspekt können die zwei obigen Wirkungen oder Funktionen wirksam kombiniert und die Genauigkeit des Wälzkörperführungssystems weiter erhöht werden.

Die Erfindung kann überdies die Kombination der zwei obigen Faktoren (Aspekte) vorsehen, d. h., dass ein Wälzkörperführungssystem vorgesehen ist, bei dem eine Mehrzahl von den bewegbaren Elementen auf der Schienenvorrichtung befestigt ist, wobei die Länge einer Laufwegoberfläche des bewegbaren Elements und der Durchmesser des Wälzkörpers derart bestimmt sind, dass in einer Länge von 2 κDa des bewegbaren Elements, in der die relativen Positionen des bewegbaren Elements und der entsprechenden Rollenelemente variieren, ein Verhältnis (I : I-1), bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 50% bis 50% (50% : 50%) festgelegt ist, wobei I = int(2Ux/κDa + 0,5), mit 2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und κDa = der Wälzkörperdurchmesser oder die Aufnahmehöhe.

Gemäß diesem Aspekt können die zwei obigen Wirkungen oder Funktionen ebenso wirksam kombiniert und die Genauigkeit des Wälzkörperführungssystems überdies erhöht werden.

Die weiteren charakteristischen Merkmale der vorliegenden Erfindung werden aus der mit auf Bezug auf die beigefügten Zeichnungen gemachten Beschreibung deutlicher.

Kurze Beschreibung der Zeichnungen

In den beigefügten Zeichnungen zeigt

Fig. 1 eine perspektivische Ansicht, die ein lineares Kugelführungssystem als ein Wälzkörperführungssystem gemäß der vorliegenden Erfindung zeigt;

Fig. 2 eine perspektivische Ansicht des linearen Kugelführungssystems aus **Fig.** 1;

Fig. 3 Ansichten, in denen Analysebedingungen veranschaulicht sind, von denen **Fig.** 3A eine Draufsicht auf die lineare Kugelführung von **Fig.** 2 zeigt und **Fig.** 3B deren Seitenansicht ist;

Fig. 4 eine Darstellung eines Längsschnittes eines bewegbaren Blocks;

Fig. 5 eine Ansicht, in der eine Beziehung zwischen einer Auslenkungslänge und einer Kugelposition dargestellt ist;

Fig. 6 Ansichten, in denen die Zustände der Anzahl der wirksamen Kugeln dargestellt ist, wobei in **Fig.** 6A die hypothetische Anzahl der wirksamen Kugeln und in **Fig.** 6B die tatsächliche Anzahl der wirksamen Kugeln dargestellt ist;

Fig. 7 eine Ansicht, die ein Positionsverhältnis zwischen der Spurschiene, deren bewegbaren Block und den Kugeln zeigt;

Fig. 8 eine Ansicht zur Lastverteilung;

Fig. 9 eine Ansicht zur Erklärung einer Anwendung einer Trägertheorie eines Blockflanschabschnittes;

Fig. 10 ein Newton-Raphson-Verfahren;

Fig. 11 Grafiken, die den Einfluss der Auslenkungslänge darstellen, wobei **Fig.** 11A ein die Versetzung in der vertikalen Richtung darstellender Graph ist, **Fig.** 11B ein einen Neigungswinkel darstellender Graph und **Fig.** 11C ein die Lastverteilung darstellender Graph ist;

Fig. 12 Graphen, die die Variation in Abhängigkeit des Kugeldurchmessers darstellen, wobei **Fig.** 12A ein eine Fluktuation in der vertikalen Richtung darstellender Graph, **Fig.** 12B ein eine Fluktuation des Neigungswinkels darstellender Graph und **Fig.** 12C ein eine Fluktuation der Lastverteilung darstellender Graph ist;

Fig. 13 Graphen, die eine Variation in Abhängigkeit des Kugeldurchmessers in einem Fall darstellen, in dem die Phasen zueinander übereinstimmend gewählt sind, wobei 13A ein eine Fluktuation der vertikalen Richtung darstellender Graph, **Fig.** 13B ein eine Fluktuation des Neigungswinkels darstellender Graph und **Fig.** 13C ein eine Fluktuation der Lastverteilung darstellender Graph ist;

Fig. 14 Graphen, die eine Variation in Abhängigkeit des Kugeldurchmessers in einem Fall darstellen, in dem die Phasen zueinander übereinstimmend gewählt sind, und die Länge einer Laufwegoberfläche wahlweise als ein Vielfaches des Kugeldurchmessers gewählt ist, wobei **Fig.** 14A ein eine Fluktuation der vertikalen Richtung darstellender Graph, **Fig.** 14B ein eine Fluktuation des Neigungswinkels darstellender Graph und **Fig.** 14C ein eine Fluktuation der Lastverteilung darstellender Graph ist;

Fig. 15 Graphen, die eine Variation in Abhängigkeit des Kugeldurchmessers unter jeder der Bedingungen darstellen, wobei **Fig.** 15A ein eine Fluktuation der vertikalen Richtung darstellender Graph, **Fig.** 15B ein eine Fluktuation des Neigungswinkels darstellender Graph und **Fig.** 15C ein eine Fluktuation der Lastverteilung darstellender Graph ist;

Fig. 16 einen Graph, der den dynamischen Basisbelastungs-Nennwert in Abhängigkeit des Kugeldurchmessers zeigt;

Fig. 17 Graphen, die eine Variation in Abhängigkeit des Kugeldurchmessers in einem Fall darstellen, in dem die Phasen der bewegbaren Blöcke zueinander übereinstimmend gewählt sind und die Länge einer Laufwegoberfläche wahlweise ein Vielfaches des Kugeldurchmessers beträgt, wobei **Fig.** 17A ein eine Fluktuation der vertikalen Richtung aufzeigender Graph,

Fig. 17B ein eine Fluktuation des Neigungswinkels aufzeigender Graph und **Fig.** 17C ein eine Fluktuation der Lastverteilung zeigender Graph ist;

Fig. 18 Graphen, die einen Vergleich der Variationen in Abhängigkeit des Kugeldurchmessers unter jeder der Bedingungen zeigen, wobei **Fig.** 18A ein eine Fluktuation der Vertikalrichtung darstellender Graph, **Fig.** 18B ein eine Fluktuation des Neigungswinkels darstellender Graph und **Fig.** 18C ein eine Fluktuation der Lastverteilung darstellender Graph ist; und

Fig. 19 einen Graph, der einen dynamischen Basisbelastungs-Nennwert in Abhängigkeit des Kugeldurchmessers zeigt.

Beschreibung von bevorzugten Ausführungsformen

Die vorliegende Erfindung wird nun nachfolgend mit Bezug auf die beigefügten Zeichnungen beschrieben.

Fig. 1 zeigt ein lineares Kugelführungssystem als ein Wälzkörperführungssystem, dessen Gegenstand hinsichtlich der vorliegenden Erfindung analysiert wurde, wobei dieses lineare Kugelführungssystem unter Zuständen mit unterschiedlichen schweren Belastungen, Kraftmomenten und dergleichen in einer Maschineneinrichtung, einer Transporteinrichtung, Industrierobotern und dergleichen verwendet wird.

Das in **Fig.** 1 gezeigte lineare Kugelführungssystem weist zwei Spurschienen **1** als parallel zueinander angeordnete Spurschafte und vier bewegbare Blöcke **2** (zwei für jede Spurschiene) als bewegbare Elemente auf, die mit den Spurschienen **1** zusammengesetzt sind und einen Tisch **3** tragen, der linear bewegt wird.

Fig. 2 zeigt eine lineare Kugelführung in Zusammenhang mit dem als Wälzkörperführungsvorrichtung in **Fig.** 1 gezeigten linearen Führungssystems. Diese lineare Kugelführung weist eine auf einem feststehenden Element (Teil) angeordnete Spurschiene **1**, die mit einer Kugellaufnut **1**a als Wälzkörperlauffläche entlang einer Längsrichtung der Schiene ausgebildet ist, einen bewegbaren Block **2**, der mit einem Kugelzirkulationsdurchgang **7** ausgebildet ist, der eine Lastlaufnut **2**a als eine Lastlauffläche entsprechend der Kugellaufnut **1**a der Spurschiene **1** hat und der mit der Spurschiene **1** zusammengesetzt ist, um zu dieser relativ beweglich zu sein, und eine Anzahl von Kugeln **4** als Wälzkörper auf, die in dem Kugelzirkulationsdurchgang **7** aufgenommen sind und darin gemäß der Relativbewegung des bewegbaren Blocks bezüglich der Spurschiene **1** zirkulieren.

Die Spurschiene **1** hat einen länglichen und einen schmalen Aufbau und weist eine im Wesentlichen rechteckige Form im Querschnitt auf. Die Kugellaufnuten **1**a sind an beiden Seitenflächen der Spurschiene **1** als Spuren für die Laufkugeln **4** ausgebildet, um sich so über die gesamte Längsrichtung der Spurschiene zu erstrecken. Obwohl die zwei Reihen der Kugellaufnuten **1**a an jeder Seitenfläche der Spurschiene **1** ausgebildet sind, können überdies die Anzahl und die Anordnung der Nuten **1**a gemäß den Aufgaben und den Anwendungsbedingungen verschiedenartig geändert werden. Die Spurschiene **1** ist mit Schraubenlöchern **5** zum Befestigen der Schiene **1** an einem feststehenden Abschnitt ausgebildet. Anstelle der gezeigten linearen Spurschiene **1** kann eine gekrümmte Schiene verwendet werden.

Der bewegbare Block **2** setzt sich aus einem Blockkörper **12** und einem Paar Endplatten **8** zusammen, die an beiden Längsenden des Blockkörpers **12** angeordnet und an diesem befestigt sind. Die Endplatte **8** ist mit einem Richtungswechseldurchgang ausgebildet und kann daher als richtungswechselndes Durchgangselement bezeichnet werden. Der Blockkörper **12** ist ein Blockelement mit einem ⊐-förmigen Querschnitt, der in einem zusammengesetzten Zustand einen der oberen Fläche der Spurschiene **1** zugewandten horizontalen Abschnitt **6**a und ein Paar Trägerschenkel **6**b hat, die Innenoberflächen aufweisen, die den Seitenflächen der Spurschiene **1** zugewandt sind. Jeder Trägerschenkel **6**b ist an seinen Innenflächen mit zwei Reihen Lastlaufnuten **2**a ausgebildet, die den an der Spurschiene **1** ausgebildeten Kugellaufnuten **1**a zugewandt sind. Überdies ist jeder Trägerschenkel **6**b mit zwei Kugelrückführdurchgängen **9** in der Form eines sich parallel zu den Kugellaufnuten **1**a erstreckenden Tunnels ausgebildet. Der Blockkörper **12** ist auch mit Schraubenlöchern **10** ausgebildet, um den Tisch **3** an der Oberfläche des Blockkörpers **12** mittels Schrauben oder dergleichen zu befestigen.

Gemäß der Bewegung des bewegbaren Blocks **6** entlang der Spurschiene **1** werden die Kugeln **4** entlang des Lastlaufdurchgangs bewegt und mit einer Last abgerollt, die von dem bewegbaren Block **6** aufgebracht wird, wobei die Kugeln **4** an ein Ende des Lastlaufdurchganges rollen und die Kugeln **4** dann nach oben gehoben und an den Rückführdurchgang **9** durch den Richtungswechseldurchgang geführt werden und danach an das eine Ende des Lastlaufdurchganges durch den anderen Richtungswechseldurchgang zurückgeführt werden.

Die Ausführung der Bewegung (des Laufs) des linearen Kugelführungssystems wird hierin unter der Annahme analysiert, dass ein lineares Kugelführungssystem an einem Maschinenwerkzeugtisch oder dergleichen angebracht ist, sowie in Betrachtung einer Deformation eines Flanschabschnittes des bewegbaren Blocks, wobei eine Gleichgewichtsgleichung hinsichtlich eines Lastverteilungszustandes in dem linearen Kugelführungssystems eingeführt wird, um damit die Beziehung zwischen einem Durchmesser des in der linearen Kugelführung aufgenommenen Kugel und einem Laufvorgang im Hinblick auf die Einflüsse der Steifheit und der Lebensdauer der Kugelführung klarzustellen.

Fig. 3 zeigt die Zustände, unter denen die Analysen vorgenommen wurden, wobei ein zu analysierender Gegenstand ein X-Tisch (einachsig) ist, bei dem vier bewegbare Blöcke durch zwei Schienen unterstützt sind. Zu **Fig.** 3 gehört die eine Draufsicht darstellende **Fig.** 3A, sowie die eine Seitenansicht darstellende **Fig.** 3B.

Mit Bezug zu **Fig.** 3:

Setzen der Koordinatenachsen: die X-Achse und Z-Achse liegen auf dem Tisch **3** und die Y-Achse ist in die zur Oberfläche des Tisches **3** senkrechte Achse gelegt.

Aufbringen einer äußeren Kraft: eine auf den Tisch **3** aufgebrachte radiale Last ist mit F_y bezeichnet; eine darauf aufgebrachte horizontale (transversale) Last ist mit F_z bezeichnet; eine um die X-Achse auftretende Abrollkraft ist mit M_c bezeichnet; eine um die Y-Achse auftretende Scherkraft ist mit M_b bezeichnet und eine Kippkraft um die Z-Achse ist mit M_a bezeichnet. Diese äußeren Kräfte wirken als statischer Äquivalenzbetrag auf den Ursprung der Koordinaten unterhalb des Zentralabschnitts des Tisches **3**.

Setzen einer Versetzung: eine radiale Versetzung des Tisches ist mit $\alpha1$ gekennzeichnet; seine horizontale Versetzung ist mit $\alpha4$; ein Abrollwinkel ist mit $\alpha3$ bezeichnet; ein Abrollwinkel ist mit $\alpha5$ bezeichnet; und ein Neigungswinkel ist mit $\alpha2$ bezeichnet.

Setzen der Tischposition: ein Abstand zwischen dem Endabschnitt der Spurschiene **1** zum Zentrum des Tisches ist mit l_{Start} bezeichnet.

Überdies sind die Bezeichnungen k1, k2, k3 und k4 jeweils den bewegbaren Blöcken zugeordnet, wobei die Montagenlängen des bewegbaren Blocks in der X-Richtung mit 2lx, und in der Z-Richtung mit 21z bezeichnet sind. Bezugszeichen von i = 1, i = 2, ... i = I sind den entsprechenden Kugeln **4** der linearen Kugelführung beigefügt, wobei Bezugszeichen von j = 1, j = 2, j = 3 und j = 4 zu den vier Lastlaufdurchgängen hinzugefügt sind, in denen die Kugeln angeordnet sind.

Fig. 4 zeigt einen Längsschnitt eines bestimmten bewegbaren Blocks **2** in einem bestimmten Zustand. Da sich eine hohe Hertzsche Pressung an den zwei Enden der Laufwegoberfläche des bewegbaren Blocks **2** mit entweder keiner Scheitelbombierung oder einer geringen Bombierung entwickelt, wenn die Kugeln den Durchgang passieren und dann an den Ausgang laufen, ist eine Scheitelbombierung vorzusehen, um diese Situation auszugleichen. In dem dargestellten Fall wird an beiden Endabschnitten des bewegbaren Blocks **2** eine kreisförmige R-Scheitelbombierung vorgenommen. Diese Scheitelbombierung wird in einem Abstand von der Endfläche des Führungsblocks zu einer Position $X\varepsilon$ mit einer durch einen Ausdruck $x = R(1 - \cos\theta)$ dargestellten Form ausgeführt. Da überdies der bewegbare Block von der Endfläche der Spurschiene **1** eingesetzt ist, wird die relative Position des bewegbaren Blocks **2** und der Kugel(n) **4** theoretisch durch den Abstand von der Schienenendfläche bestimmt.

Fig. 5 zeigt eine Beziehung zwischen der Wälzlänge des bewegbaren Blocks **2** und der Kugelposition. Wenn sich der bewegbare Block **2** bewegt, rollen die Kugeln **4**, wobei sich die relative Position des bewegbaren Blocks **2** zu den Kugeln **4** verändert. In dem dargestellten Beispiel verändert sich die relative Position des bewegbaren Blocks **2** zu den Kugeln gemäß der Darstellung in **Fig.** 5, wenn die Auslenkung des bewegbaren Blocks **2** von $0 \rightarrow 0{,}5\ \kappa Da \rightarrow 1{,}0\ \kappa Da \rightarrow 1{,}5\ \kappa Da \rightarrow 2{,}0\ \kappa Da$ verändert wird. Vorausgesetzt, dass der Kugeldurchmesser gleich κDa ist, wird bei einer Bewegung des bewegbaren Blocks **2** um 2 κDa ein anfänglicher Zustand eingenommen, der dem relativen Positionszustand des bewegbaren Blocks **2** und den Kugeln **4** in dem Fall der Auslenkung "0" entspricht. Das bedeutet, dass sich die relative Position des bewegbaren Blocks **2** und der Kugeln **4** mit 2 κDa des bewegbaren Blocks **2** in einem Zyklus verändert und dieser Zyklus darauffolgend wiederholt wird.

Dabei ist zu betonen, dass der Term "κ" aus κDa ein Vorfaktor und der Term "Da" den Kugeldurchmesser kennzeichnet. Der Vorfaktor "κ" ist einstimmig für eine Wälzkörperführungsvorrichtung bestimmt, die mit einem Aufnehmer versehen ist, wobei jedoch vorausgesetzt wird, dass der Vorfaktor auf "1" bezüglich des gesamten Kugelführungselements ohne Aufnehmer gesetzt wird und ein unbekannter Vorfaktor aufgrund der Erzeugung von Reibung zwischen den Kugeln in dem Lastlaufbereich wiederum angepasst werden muss. Die Verteilung des Vorfaktors "κ" wird experimentell durch Verwendung eines Kugeldurchlaufsensors oder dergleichen erhalten und auf die folgende Weise bestimmt.

Wälzkörperführungselement mit einem Aufnehmer:
κDa = Aufnehmerhöhe

Wälzkörperführungselement ohne Aufnehmer:
$\kappa Da = (1.000–1.005)\ Da$

Fig. 6 zeigt Zustände der Anzahl wirksamer Kugeln, die Kugeln sind, die die Laufwegoberfläche kontaktieren und eine aufgebrachte Last verteilen. Die Anzahl der wirksamen Kugeln wird erhalten, indem die Länge 2Ux der Schienenoberfläche durch die Kugeldurchmesser κDa dividiert und dann gerundet (Halb-Regelung) wird. **Fig.** 6A zeigt einen von einem Konstrukteur betrachteten Zustand der Anzahl von wirksamen Kugeln, wobei der Einfluss der Scheitelbombierung nicht miteinbezogen ist. Die konstruktive Anzahl wirksamer Kugeln beträgt $I = \mathrm{int}(2Ux/\kappa Da + 0{,}5)$, wobei "int" eine Funktion zum Weglassen der Ziffer hinter der ersten Dezimalstelle, 2Ux eine Länge einer Laufwegfläche eines bewegbaren Blocks und κDa eine Höhe des Wälzkörpers oder des Aufnehmers ist, und in diesem Fall $2Ux/\kappa Da$ abgerundet (Halb-Regelung) ist, da zu $2Ux/\kappa Da$ 0,5 addiert wird. **Fig.** 6B zeigt einen tatsächlichen Zustand, bei dem ausgehend von der Beziehung zwischen der Form der Scheitelbombierung und der elastischen Deformation der belasteten Kugeln die tatsächliche Länge des Kugelkontaktabschnittes 2Ux' ist, welche Länge kürzer als die Laufwegoberflächenlänge des bewegbaren Blocks 2Ux ist. Die tatsächliche Anzahl der wirksamen Kugeln ist ausgedrückt durch $I = \mathrm{int}(2Ux'/\kappa Da + 0{,}5)$, in der 2Ux' eine Länge einer Laufwegoberfläche des bewegbaren Blocks und κDa eine Höhe des Wälzkörpers oder Aufnehmers ist, und sich die Anzahl der wirksamen Kugeln innerhalb der Länge von 2 κDa beispielsweise mit I und I-1, und I' und I'-1 ändert.

Fig. 7 zeigt eine relative Beziehung zwischen der Spurschiene **1**, dem bewegbaren Block und den Kugeln **4**. Eine Bedienperson bestimmt eine Blockspannweite einer Mehrzahl von beweglichen Blöcken **2**, die auf der einzelnen Schiene befestigt sind. Im Allgemeinen sind die relativen Positionen der bewegbaren Blöcke **2** und der Kugeln **4** gemäß den entsprechenden bewegbaren Blöcken **2** unterschiedlich. D. h., dass gemäß **Fig.** 7, bei unterschiedlichen bewegbaren Blökken **2**, der Abstand lx01 zwischen einer Endfläche eines bewegbaren Blocks **2** (bei Draufsicht rechter Block) und der ersten Kugel **4** zu dem Abstand lx02 zwischen einer Endfläche eines anderen bewegbaren Blocks **2** (linker Block bei Draufsicht) unterschiedlich ist. Überdies variiert die Belastung, wobei sich demgemäß unter einer bestimmten Bedingung einer Belastung die Anzahl der wirksamen Kugeln **4** gemäß der Konstruktion von der tatsächlichen Anzahl derer für den entsprechenden bewegbaren Block **2** unterscheiden.

Fig. 8 zeigt die Lastverteilungen in den entsprechenden bewegbaren Blöcken **2**. Das Belastungsgleichgewicht in jedem der bewegbaren Blöcke **2** variiert von einem Moment auf den anderen gemäß der Positionsänderung der Kugeln **4** in jedem der bewegbaren Blöcke **2**. D. h., dass die Zustände der Lastverteilungen in den entsprechenden bewegbaren Blökken **2**, wenn der Tisch **3** in fünf Richtungskomponenten einer in einem bestimmten Moment verursachten Versetzung bewegt wird. Mit Bezug auf **Fig.** 8 bezeichnet ein Symbol Ab ein Krümmungszentrum der Lastrollnut **2**a des bewegbaren Blocks **2** und ein Symbol Ab' bezeichnet eine Position von Ab nach der Bewegung. Die Symbole $\delta yi2k$ und $\delta zi2k$ zeigen Komponenten in Y- und Z-Richtung des Bewegungsbetrages des Krümmungszentrums Ab. **Fig.** 8 zeigt den Zustand bei Betrachtung einer Fehlausrichtung, wobei ein Symbol Ar ein Krümmungszentrum der Kugelrollnut **1**a der Schiene **1** zeigt. Ein Symbol Ar' ist eine Position Ar nach der Bewegung. Die Symbole Δyil und Δzil zeigen Komponenten in Y- und Z-Richtung des Bewegungsbetrages des Krümmungszentrums Ar. Ein Symbol Vy zeigt eine Länge in Y-Richtung einer die Positionen Ab' und Ar' verbindenden Linie, und ein Symbol Vz zeigt eine Länge einer die Positionen Ab' und Ar' verbindenden Linie in Z-Richtung. Des Weiteren zeigt ein Symbol P_{ijk} eine Belastung des Wälzkörpers gemäß der Versetzung, welche Belastung in der Richtung der die Positionen Ab' und Ar' verbindenden Linie wirkt. Ein Winkel β_{ijk} ist ein durch die Richtung der Belastung Pijk mit der Horizontalebene festgelegter Winkel.

Überdies bezeichnet der Buchstabe "i" die Nummer des Wälzkörpers auf der Laufwegfläche, der Buchstabe "j" bezeichnet die Reihennummer des Wälzkörpers und der Buchstabe "k" bezeichnet die Nummer des Führungsblocks.

Fig. 9 zeigt einen deformierten Zustand des Blockflanschabschnittes (Flansch) **11**, wobei eine Trägertheorie auf die Deformation des Blockflansches **11** anwendbar ist. Ein rechteckiges Trägermodell wird durch Schneiden des Blockflanschs **11** hergestellt, so dass dessen Dicke dem Kugeldurchmesser entspricht, wobei der minimale Dicke-Abschnitt eines deformierten Flansches herausgenommen ist. Eine Trägerdeformation wird durch Verwendung der Lastverteilung (N = 1) im Voraus erhalten. Dann wird wiederum der Bewegungsbetrag des Krümmungszentrums Ab' der Nut in Abhängigkeit der Trägerdeformation erhalten, wobei die Lastverteilung an diesem bewegten Krümmungszentrum Ab' der Nut wiederum berechnet wird (N = 2). In diesem Fall, wenn die Differenz der Summe der Lastverteilungen aller Kugeln in den Fällen von N = 1 und N = 2 größer als 0,001 ist, wird wiederum eine Trägerdeformation erhalten und oben erwähnte Verfahren werden wiederholt. Eine Bedingung der Konvergenz dieser Lösung wird durch den folgenden Ausdruck ausgedrückt.

[Ausdruck 1]

Bedingung der Lösungskonvergenz

$$\sum_{k=1}^{4}\sum_{j=1}^{4}\sum_{i=1}^{I} P_{ijk}(N) - \sum_{k=1}^{4}\sum_{j=1}^{4}\sum_{i=1}^{I} P_{ijk}(N-1) < 10^{-3}$$

Die Bewegung des Tisches **3** hinsichtlich aller Auslenkungen kann durch Wiederholen obiger Berechnungsserien an der Position analysiert werden, an der die Länge unterteilt wird.

Hierunter wird ein Beziehungsausdruck der Lastverteilungstheorie erklärt, wobei hierin der Beziehungsausdruck durch Verwendung der fünf Variationskomponenten erhalten wird. Zunächst wird der folgende Berechnungsausdruck als ein Basisausdruck der obigen fünf Variationskomponenten festgelegt.

[Ausdruck 2]

Versetzung in Y-Richtung

$$\alpha_y = \alpha_1 + \alpha_{2x} + \alpha_{3z}$$

Versetzung in Z-Richtung

$$\alpha_z = \alpha_4 + \alpha_{5x} - \alpha 3_y$$

Die Hertzsche Elastizitätkontakttheorie (Hertzsches Gesetz) wird auf die elastische Deformation der Kugeln angewendet. Die Lastverteilung P_{ijk}, die elastische Versetzung δ_{ijk} und der Kontaktwinkel β_{ijk} werden mit der Hertzkonstante, dargestellt mit Cb, wie folgt ausgedrückt.

[Ausdruck 3]

$$\delta_{ijk} = \sqrt{V_y^{\,2} + V_z^{\,2}} - (2f-1)D_a + \lambda - \lambda_x$$

$$\tan\beta_{ijk} = \frac{V_y}{V_z}$$

Gemäß dieser Ausdrücke werden die folgenden fünf Bedingungsausdrücke zum Kräfteausgleich festgelegt.

[Ausdruck 4]

$$g_1 = \sum_{k=1}^{4}\sum_{j=1}^{4}\sum_{i=1}^{I} P_{ijk}\sin\beta_{ijk} - F_y = 0$$

für den Neigungswinkel:

$$g_2 = \sum_{k=1}^{4}\sum_{j=1}^{4}\sum_{i=1}^{I} P_{ijk}\sin\beta_{ijk}\,x_{ijk} - M_a = 0$$

für den Abrollwinkel:

$$g_3 = \sum_{k=1}^{4}\sum_{j=1}^{4} f_{ik} \sum_{i=1}^{I} P_{ijk}(z_{rijk}\sin\beta_{ijk} - y_{rijk}\cos\beta_{ijk}) - M_c = 0$$

wobei für f_{jk} gilt: $f_{1k} = f_{2k} = 1$, $f_{3k} = f_{4k} = -1$ mit Bezug auf die Spurschiene **1** und $f_{1k} = f_{2k} = -1$, $f_{3k} = f_{4k} = 1$ mit Bezug auf die Spurschiene **2**;
für die horizontale Versetzung:

$$g_4=\sum_{k=1}^{4}\sum_{j=1}^{4}\sum_{i=1}^{I} P_{ijk}\cos\beta_{ijk} - F_z = 0$$

für den Verdrehwinkel:

$$g_5=\sum_{k=1}^{4}\sum_{j=1}^{4}\sum_{i=1}^{I} P_{ijk}\cos\beta_{ijk}\, x_{ijk} - M_b = 0$$

Die fünf Variationskomponenten werden durch Lösen des obigen Gleichungssystems erhalten, wobei die Lösung durch das Newton-Raphson-Verfahren erhalten wird, das in **Fig.** 10 gezeigt ist.

Nachfolgend wird nun das Ergebnis der Analyse beschrieben.

Fig. 11 zeigt ein Analyseergebnis Nr. 1 "Einfluss durch Auslenkungslänge", wobei **Fig.** 11A ein eine Versetzung $\alpha 1$ in der vertikalen Richtung der Länge 4 κDa darstellender Graph, **Fig.** 11B ein den Neigungswinkel $\alpha 2$ darstellender Graph und **Fig.** 11C ein Graph ist, der die maximale Lastverteilung P_{ijkmax} für eine Kugel aufzeigt. Überdies sind als feste Bestandteile eine Form der Scheitelbombierung, eine Schienenspannweite, eine radiale Belastung und ein Vorlastbetrag ($\lambda = 0$) wie folgt festgelegt.

[Ausdruck 5]

$2\,l_z = 250$ mm "R" Bombierungsform
$F_y = 1000$ N $X_\varepsilon = 1.5 \times$ Da mm
$\lambda = 0$

$$\lambda_\varepsilon = \frac{Da}{500}\text{mm}$$

Überdies sind als variable Zustände eine Blocklänge und eine Blockspannweite auf die folgenden Zustände festgesetzt.

[Ausdruck 6]

2Ux = 80,4 mm
2lx = 250 mm

Es wurden fünf Arten von Kugeln mit fünf Arten von Durchmessern verwendet, von denen die Kugeln mit einem jeweiligen Durchmesser von 6,35000 mm als Basis (Bezug) verwendet wurden, und die anderen vier Arten von Kugeln jeweils einen Durchmesser hatten, der größer war als derjenige der Basiskugeln und zwei Durchmesser jeweils kleiner waren als derjenige der Basiskugel, wie das durch den JIS (Japanischen Industriestandart) festgelegt ist (d. h. fünf Arten von Kugeln wurden verwendet). Wie in **Fig.** 11 gezeigt, neigen die radiale Versetzung, der Neigungswinkel und die maximale Lastverteilung mit einer Abnahme des Kugeldurchmessers ebenso dazu abzunehmen. Die Kugeln mit einem Durchmesser von 5,55625 mm zeigten jedoch gute Fluktuationswerte des Neigungswinkels, der Versetzung in der vertikalen Richtung (radiale Versetzung) und der Variation der maximalen Lastverteilung, mehr als diejenigen Kugeln mit einem jeweiligen geringsten Durchmesser von 4,76250 mm. Es wird davon ausgegangen, dass das Ergebnis davon abhängt, ob diese Ausführungen eine direkte Proportionalität zu den Kugeldurchmessern haben oder andere Faktoren beteiligt sind, die dieses Ergebnis bewirken.

Fig. 12 zeigt den Graphen, der ein Analyseergebnis Nr. 2 "Fluktuation in Abhängigkeit des Kugeldurchmessers" darstellt, bei dem die Abszissenachse den Kugeldurchmesser und die Ordinatenachse die Fluktuationen der entsprechenden Werte aufzeigt. Aus diesem Graphen ist ebenso zu ersehen, dass diese Werte nicht direkt proportional zu den Kugeldurchmessern sind und eine unnatürliche Beziehung gegeben ist. Davon ausgehend wird erachtet, dass der Unterschied in den relativen Positionen der Kugeln **4** in den bewegbaren Blöcken **2**, die an der vorderen und hinteren Position in der Längsrichtung der Schiene **1** angeordnet sind, wie sie in dem vorigen Festlegungsverfahren festgelegt wurden, den diesen Einfluss ausmachenden Faktor darstellt.

Fig. 13 zeigt den Graphen, der ein Analyseergebnis Nr. 3 "Fluktuation in Abhängigkeit des Kugeldurchmessers im Falle koindizierender Phasen der bewegbaren Blöcke" darstellt, bei dem die Blockspannweiten so gewählt sind, dass die relative Position der Kugeln **4** in den bewegbaren Blöcken zur Deckung kommt, die an der längsseitigen vorderen und rückwärtigen Position angeordnet sind. Das Zusammenfallen der relativen Positionen der Kugeln **4** in den bewegbaren Blöcken **2** wird erhalten, in dem lx01 = lx02 gesetzt wird, wie das in **Fig.** 7 gezeigt ist. Da der bewegbare Block **2** auf der Spurschiene **1** von deren Endabschnitt angebracht wird, können die relativen Positionen der Kugeln **4** in den bewegbaren Blöcken einander koindizent vorgesehen werden, in dem die Blockspannweite 2lx als ein ganzzahliges Vielfaches von 2 κDa gewählt wird. Die Blockspannweite 2lx wird auf einen Wert nahe des ursprünglich gesetzten Wertes von 250 mm gesetzt. D. h., dass die variable Blockspannweite gemäß der folgenden Bedingungen gesetzt wird.

[Ausdruck 7]

2Ux = 80.4 mm
2lx = nl × 2 κDa mm (nl: integer)
lx01: = lx02
wobei nl ein Wert ist, bei dem sich 2lx 250 mm annähert.

Wie in **Fig.** 13 gezeigt, wird durch Vorsehen einer Koinzidenz der relativen Positionen der Kugeln **4** in dem vorderen (front-) und dem rückwärtigen (hinteren) bewegbaren Block **2** die Fluktuation des Neigungswinkels extrem gering (siehe Skalierung der Ordinatenachse). Die Größenordnung der Fluktuation ist jedoch nicht proportional zu dem Kugeldurchmesser und es scheint, dass noch ein anderer Faktor existiert.

Einer der anderen Faktoren, der in Betrachtung gezogen wird, ist ein Verhältnis der Variation der Anzahl der wirksamen Kugeln in der 2 κDa Länge. Das Verhältnis der Variation der Anzahl der wirksamen Kugeln fällt natürlich unterschiedlich aus, indem die Kugeldurchmesser gemäß der feststehenden Laufwegoberflächenlänge verändert werden. Durch Vereinheitlichung dieses Gegenstandes scheint es, dass demzufolge eine klarere Beziehung hervortritt.

Fig. 14 zeigt den ein Analyseergebnis Nr. 4 "Fluktuation in Abhängigkeit des Kugeldurchmessers" darstellenden Graphen, bei dem wie oben erwähnt, die Blockspannweiten so eingestellt sind, dass die relativen Positionen der Kugeln in dem vorderen und rückwärtigen bewegbaren Block zusammenfallen. Überdies ist die Länge der Laufwegoberfläche und der Kugeldurchmesser bestimmt, so dass ein Verhältnis, bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 50% bis 0% festgelegt ist. Das wird sowohl bei der theoretischen Anzahl von wirksamen Kugeln als auch bei deren tatsächlicher Anzahl bestimmt. D. h., dass die variablen Bedingungen auf die folgenden Werte gesetzt werden.

[Ausdruck 8]

$2Ux = ni \times \kappa Da$ mm (ni: optional)
$2lx = nl \times 2\,\kappa Da$ mm (nl: integer)
$lx01 := lx02$
mit ni ist ein Wert, bei dem sich 2Ux 80,4 mm annähert,
nl ist ein Wert, bei dem sich 2lx 250 mm annähert

ni ist ein Wert, so dass die theoretische Anzahl der wirksamen Kugeln I : I-1 = 50 : 50 wird, und die tatsächliche Anzahl der wirksamen Kugeln I' : I'-1 = 50 : 50 in der Länge von 2 κDa wird.

Wie in **Fig.** 14 gezeigt, zeigen der Kugeldurchmesser und die Fluktuationen der entsprechenden Werte eine im Wesentlichen proportionale Beziehung. Daraus wird geschlossen, dass die Phasen der Kugeln und das Verhältnis der Anzahl von wirksamen Kugeln in dem vorderen und dem hinteren Block derjenige Faktor ist, der die proportionale Beziehung des Kugeldurchmessers stört.

Fig. 15 zeigt den Graphen, der ein Analyseergebnis Nr. 5 "Fluktuation in Abhängigkeit des Kugeldurchmessers" darstellt, in dem die Analyseergebnisse Nr. 3 bis Nr. 5 in demselben Graphen beschrieben sind. Im Standardzustand (Standard), bei dem die Phasen der bewegbaren Blöcke **2** nicht miteinander koindizieren und das Verhältnis der Anzahl wirksamer Kugeln nicht festgelegt ist, ist die Fluktuation nicht proportional zu dem Kugeldurchmesser. Wenn die Phasen der bewegbaren Blöcke ($2lx = nlx \times \kappa Da$) koinzident gemacht sind, wird die Wälzgenauigkeit beträchtlich hoch und nahezu proportional zum Kugeldurchmesser. Wenn das Verhältnis der Variation der Anzahl wirksamer Kugeln zu dem entsprechenden Kugeldurchmesser (I : I-1 = 50 : 50, I' : I'-1 = 50 : 50) konstant gemacht wird, wird erstmals ein einfaches Verhältnis des Kugeldurchmessers vorgesehen.

Fig. 16 zeigt ein Analyseergebnis Nr. 6 "dynamischer Basisbelastungs-Nennwert in Abhängigkeit des Kugeldurchmessers", bei dem ein dynamischer Basisbelastungs-Nennwert in einem System gezeigt ist, das mit 4 Blöcken versehen ist. Der dynamische Basisbelastungs-Nennwert wurde gemäß dem folgenden Ausdruck berechnet.

[Ausdruck 9]

$$S_t = 2U_x$$

$$Q_{cg} = K_c(2U_x)^{-03}(2\kappa Da)^{1/3}$$

$$Q_{cr} = K_c\{\frac{18}{19}(2U_x)\}^{-0.3}(2\kappa Da)^{1/3}$$

$$C_{sys} = (2K)^{0.7}\ I\ \sin\beta(Q_{cg}^{-\frac{10}{3}} + Q_{cr}^{-\frac{10}{3}})^{-0.3}$$

mit:
Q_{cg} = Wälzelementbelastung (N) bezüglich einer gesamten Reihe eines Blocks;
Q_{cr} = Wälzelementbelastung (N) bezüglich einer gesamten Schiene;
C_{sys} = dynamischer Basisbelastungs-Nennwert des gesamten Systems;
K_c = Proportionalitätskonstante (bestimmt durch die Gestalt des Kontaktabschnitts);
I = theoretische Anzahl der wirksamen Kugeln
β = Kontaktwinkel (in deg Grad);
K = Anzahl der Blöcke (4).

Wie das aus **Fig.** 16 zu erkennen ist, wurde herausgefunden, dass die dynamische Belastungsrate einfach proportional zum Kugeldurchmesser ist.

Fig. 17 zeigt den ein Analyseergebnis Nr. 7 "Fluktuation in Abhängigkeit des Kugeldurchmessers" darstellenden Graphen, bei dem wie oben erwähnt, die Blockspannweiten angepasst sind, so dass die relative Position der Kugeln **4** jeweils in den bewegbaren Blöcken in der vorderen und rückwärtigen Längsrichtung zusammenfällt. Überdies ist die Länge der Laufwegoberfläche und der Kugeldurchmesser derart bestimmt, dass das Verhältnis, bei dem I die Anzahl der wirksamen

Kugeln und I-1 der Bereich der Anzahl der wirksamen Kugeln ist, bei einer 2 κDa-Länge, bei der die relative Position der entsprechenden Kugeln und der bewegbaren Blöcke variiert, mit ca. 100% : 0% festgelegt ist. Das wird sowohl hinsichtlich der theoretischen Anzahl wirksamer Kugeln als auch der tatsächlichen Anzahl derer bestimmt. D. h., dass variable Bedingungen auf die folgenden Werte gesetzt sind.

[Ausdruck 10]

$2Ux = ni \times \kappa Da$ mm (ni: optional)
$2lx = nl \times 2\ \kappa Da$ mm (nl: integer)
$lx01 := lx02$

ni ist ein Wert, bei dem in der Länge 2 κDa die theoretische Anzahl der wirksamen Kugeln I : I-1 = 50 : 50, I : I-1 = 100 : 0 wird und die tatsächliche Anzahl der wirksamen Kugeln I' : I'-1 = 50 : 50 und I' : I'-1 wird.

Wenn das Verhältnis wie in **Fig.** 17 gezeigt 100% : 0% ist, wird erachtet, dass die entsprechenden Fluktuationen proportional zum Kugeldurchmesser sind. Überdies kann die Fluktuation in dem Neigungswinkel dann extrem klein gemacht werden, wenn das Verhältnis, verglichen mit dem Verhältnis 50% : 0%, 100% : 0% ist.

Fig. 18 zeigt den ein Analyseergebnis Nr. 8 "Fluktuation in Abhängigkeit des Kugeldurchmessers" darstellenden Graphen, der einen Fall aufzeigt, der den Fall mit einem Verhältnis von I : I-1 = 100% : 0% des Analyseergebnisses Nr. 5 aus **Fig.** 15 überdeckt. Wie in **Fig.** 18 gezeigt, kann zunächst die Neigungsgenauigkeit insbesondere dadurch erhöht werden, dass die Phasen der bewegbaren Blöcke **2** zueinander koinzident (2lx = nlx κDa) gemacht sind. Indem das Verhältnis (I : I-1) der Variation der Anzahl an wirksamen Kugeln 50 : 50 gesetzt wird, kann die Neigungsgenauigkeit erhöht und ebenso die Steifigkeit in der Radialrichtung erhöht werden. Des Weiteren kann die Wälzgenauigkeit überdies erhöht werden, indem das Verhältnis (I : I-1) der Variation der Anzahl der wirksamen Kugeln auf 100 : 0 gesetzt wird.

Fig. 19 zeigt einen ein Analyseergebnis Nr.9 "dynamischer Basisbelastungs-Nennwert in Abhängigkeit des Kugeldurchmessers" darstellenden Graphen, wobei derselbe Berechnungsausdruck wie der für das Analyseergebnis Nr. 6 für den Berechnungsausdruck des dynamischen Basisbelastungs-Nennwerts verwendet wurde.

Die folgende Schlussfolgerung wird aus den obigen Analyseergebnissen Nr. 1 bis Nr. 9 erhalten.

Es wurde herausgefunden, dass die Genauigkeit und die Steifheit des linearen Kugelführungssystems im Fall einer vorbestimmten Blocklänge mit Verringerung des Kugeldurchmessers hoch wurden, in welchem System die Steifigkeit von der Versetzung $\alpha 1$ in der Vertikalrichtung angenommen wird und die Steifigkeit mit der Verringerung der Versetzung $\alpha 1$ erhöht wird. Der auf die Lebensdauer Einfluss ausübende dynamische Basisbelastungs-Nennwert kann mit Erhöhung des Kugeldurchmessers erweitert werden.

Überdies wurde befunden, dass ein Einfluss aufgrund der Differenz der relativen Positionen der Kugeln in den bewegbaren Blöcken in dem vorderen und hinteren bewegbaren Block beträchtlich groß ist.

Noch weiter wurde befunden, dass der Einfluss basierend auf dem Variationsverhältnis der Anzahl wirksamer Kugeln sehr hoch ist, die in der Länge variiert. Wenn die Variation der Anzahl wirksamer Kugeln aufgrund der Länge geringer wird (wenn (I : I-1) sich 100% : 0% annähert) verringert sich der Einfluss des Kugeldurchmessers auf die Auslenkgenauigkeit. Andererseits wird die Variation hoch (wenn (I : I-1) sich 50% : 50% annähert), wobei der Einfluss des Kugeldurchmessers auf die Fluktuation der Steifigkeit und der maximalen Lastverteilung gering wird.

Tatsächlich ist es jedoch schwierig, einfach zu sagen, dass durch Verringerung des Kugeldurchmessers die Funktion verbessert ist, weil die Blockspannweite durch eine Bedienperson festgelegt wird und die Länge der Laufwegfläche im Voraus bestimmt ist. Dann wird eine unmittelbare Anwendung der bestehenden Maschine durch eine minutiöse Einstellung der Blockspannweite durch eine Bedienperson ausgeführt. Wenn eine kleine spezielle Konstruktion für die bestehende Maschine erlaubt ist, kann die Scheitelbombierung durch Bestätigung der tatsächlichen Belastungsbedingung und durch Wählen eines optimalen Variationsverhältnis der Anzahl wirksamer Kugeln angepasst werden.

Die folgende Tabelle 1 zeigt Beispiele der Wälzkörperlänge κDa, der Länge 2Ux der Laufwegfläche (Block), der Blockspannweite 2lx und des dynamischen Basisbelastungs-Nennwertes C, in der "κ" auf κ = 1,003 und die Blocklänge 2Ux in Annäherung auf den oben erwähnten gesetzten Wert von 80,4 mm gesetzt ist. Indem die entsprechenden Zustände auf die in dieser Tabelle 1 gezeigten Werte gesetzt und bestimmt werden, ist es möglich, die Wälzgenauigkeit und die Genauigkeit in der Radialrichtung des linearen Kugelführungssystems zu erhöhen. Überdies ist zu beachten, dass die in dieser Tabelle 1 beschriebenen Werte lediglich Beispiele sind und viele andere Werte gewählt werden können, insoweit die vorigen erwähnten Ausdrücke erfüllt sind.

Tabelle 1

$$\kappa D_a\text{-}2U_x(n_1)\text{-}2l_x(n_l)\text{-}C$$

k = 1.003			2Ux		2Ux		2Ux		2Ux	
Da	2lx	nl	l:l-1=50:50	nl	l:l-1=100:0	nl	l':l'-1=50:50	nl'	l':l'-1=100:0	nl'
3.0	252.756	42	79.7	26.487	81.2	26.986	78.7	26.155	80.2	26 653
3.5	252.756	36	78.95	22.490	80.7	22.988	78.0	22.219	79.7	22.703
4.0	248.744	31	78.2	19.492	80.7	20.115	77.2	19.242	79.3	19.766
4.5	252.756	28	78.9	17.481	81.2	17.990	78.1	17.304	80.4	17.813
5.0	250.750	25	77.7	15.494	80.2	15.992	76.9	15.334	79.4	15.833
5.5	253.759	23	79.9	14.484	82.7	14.991	79.3	14.375	82.0	14.864
6.0	252.756	21	81.2	13.493	84.2	13.991	80.7	13.410	83.7	13.908
6.5	247.741	19	81.4	12.486	84.7	12.992	81.1	12.440	84.3	12.930
7.0	252.756	18	80.7	11.494	84.2	11.993	80.3	11.437	83.8	11.936
7.5	255.765	17	78.9	10.489	82.7	10.994	78.6	10.449	82.3	10.941
8.0	256.768	16	76.1	9.484	80.2	9.995	75.8	9.447	79.8	9.945

k = 1.003		2Ux					2Ux				
Da	Kc	l:l-1=50:50	l	Qcg	Qcr	C	l:l-1=100:0	l	Qcg	Qcr	C
3.0	1.50063E+03	79.7	26	733.9	745.9	47363.2	81.2	27	729.8	741.8	48910.6
3.5	2.07426E+03	78.95	22	1071.0	1088.5	58482.6	80.7	23	1064.0	1081.4	60740.1
4.0	2.74566E+03	78.2	19	1486.4	1510.7	70099.5	80.7	20	1472.5	1496.6	73095.6
4.5	3.51614E+03	78.9	17	1974.5	2006.8	83314.4	81.2	18	1957.6	1989.6	87458.1
5.0	4.38689E+03	77.7	15	2563.3	2605.2	95433.9	80.2	16	2539.1	2580.6	100833.6
5.5	5.35897E+03	79.9	14	3205.4	3257.8	111384.2	82.7	15	3172.4	3224.3	118113.5
6.0	6.43336E+03	81.2	13	3942.1	4006.6	127200.4	84.2	14	3899.5	3963.2	135502.2
6.5	7.61094E+03	81.4	12	4786.3	4864.6	142558.7	84.7	13	4729.6	4806.9	152608.3
7.0	8.89254E+03	80.7	11	5747.0	5841.0	156908.5	84.2	12	5674.3	5767.0	169006.5
7.5	1.02789E+04	78.9	10	6843.7	6955.6	169864.7	82.7	11	6747.8	6858.1	184233.0
8.0	1.17709E+04	76.1	9	8094.7	8227.1	180824.2	80.2	10	7968.3	8098.6	197777.7

k = 1.003		2Ux					2Ux				
Da	Kc	l':l'-1=50:50	l	Qcg	Qcr	C	l':l'-1=100:0	l	Qcg	Qcr	C
3.0	1.50063E+03	78.7	26	736.7	748.8	47543.0	80.2	27	732.6	744.5	49092.7
3.5	2.07426E+03	78.0	22	1074.9	1092.5	58695.4	79.7	23	1068.0	1085.4	60967.7
4.0	2.74566E+03	77.2	19	1492.2	1516.6	70370.7	79.3	20	1480.2	1504.4	73480.4
4.5	3.51614E+03	78.1	17	1980.5	2012.9	83569.5	80.4	18	1963.4	1995.5	87718.3
5.0	4.38689E+03	76.9	15	2571.3	2613.3	95730.6	79.4	16	2546.7	2588.3	101137.3
5.5	5.35897E+03	79.3	14	3212.7	3265.2	111636.4	82.0	15	3180.5	3232.6	118415.0
6.0	6.43336E+03	80.7	13	3949.4	4014.0	127436.3	83.7	14	3906.4	3970.3	135744.5
6.5	7.61094E+03	81.1	12	4791.6	4869.9	142716.7	84.3	13	4736.3	4813.7	152825.1
7.0	8.89254E+03	80.3	11	5755.6	5849.7	157142.6	83.8	12	5682.4	5775.3	169248.1
7.5	1.02789E+04	78.6	10	6851.5	6963.5	170059.0	82.3	11	6757.6	6868.1	184501.1
8.0	1.17709E+04	75.8	9	8104.3	8236.8	181038.6	79.8	10	7980.2	8110.7	198074.5

Überdies ist zu beachten, dass in den obigen Beschreibungen die vorliegende Erfindung nicht auf eine lineare Kugelführungsvorrichtung beschränkt ist, obwohl das lineare Kugelführungssystem als Gegenstand einer Analyse erklärt wurde, und sie kann bei einer Wälzkörperführungsvorrichtung angewendet werden, bei der Rollen als Wälzkörper verwendet werden. Andere Wälzkörperführungsvorrichtungen, die eine Kugelbüchse, eine Kugelspindel oder dergleichen verwenden, können ebenso verwendet werden. Noch weiter kann die vorliegende Erfindung auf eine Vorrichtung mit einer kurzen Aufnehmerstruktur angewendet werden, in der Wälzkörper nicht zirkulieren. Kurvenlineare Schienenelemente können anstelle der linearen Schienenelemente verwendet werden.

Patentansprüche

1. Verfahren zur Bestimmung der Länge einer Laufwegoberfläche eines bewegbaren Elements und eines Durchmessers eines Wälzkörpers einer Wälzkörperführungsvorrichtung, die ein bewegbares Element und Wälzkörper aufweist, wobei in einer Länge von 2 κDa des bewegbaren Elementes, in der relative Positionen des bewegbaren Elements und der entsprechenden Wälzkörper variieren, ein Verhältnis (I : I-1), in dem I die Anzahl wirksamer Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, im Bereich von ca. 100% bis 0% (100% : 0%) festgelegt ist, wobei I = int(2Ux/κDa + 0,5) ist, mit
2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und
κDa = die Rollenkörper- oder Aufnehmerhöhe.
2. Verfahren zur Bestimmung einer Länge einer Laufwegoberfläche eines bewegbaren Elements und eines Durchmessers eines Wälzkörpers einer Wälzkörperführungsvorrichtung, die ein bewegbares Element und Wälzkörper aufweist, wobei wobei in einer Länge von 2κDa des bewegbaren Elementes, in der relative Positionen des bewegbaren Elements und der entsprechenden Wälzkörper variieren, ein Verhältnis (I : I-1), in dem I die Anzahl wirksamer Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, im Bereich von ca. 50% bis 50% (50% : 50%) festgelegt ist, wobei I = int(2Ux/κDa + 0,5) ist, mit

2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und
κDa = die Rollenkörper- oder Aufnehmerhöhe.

3. Wälzkörperführungsvorrichtung, die ein bewegbares Element und Wälzkörper aufweist, wobei eine Länge einer Laufwegoberfläche des bewegbaren Elements und ein Durchmesser des Wälzkörpers derart bestimmt sind, dass in einer Länge von 2 κDa des bewegbaren Elements, in der die relativen Positionen des bewegbaren Elements und der entsprechenden Rollenelemente variieren, ein Verhältnis (I : I-1), bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 100% bis 0% (100% : 0%) festgelegt ist, wobei I = int(2Ux/κDa + 0,5), mit
2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und
κDa = der Wälzkörperdurchmesser oder die Aufnahmehöhe.

4. Wälzkörperführungsvorrichtung, die ein bewegbares Element und Wälzkörper aufweist, wobei eine Länge einer Laufwegoberfläche des bewegbaren Elements und ein Durchmesser des Wälzkörpers derart bestimmt sind, dass in einer Länge von 2 κDa des bewegbaren Elements, in der die relativen Positionen des bewegbaren Elements und der entsprechenden Rollenelemente variieren, ein Verhältnis (I : I-1), bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 50% bis 50% (50% : 50%) festgelegt ist, wobei I = int(2Ux/κDa + 0,5), mit
2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und
κDa = der Wälzkörperdurchmesser oder die Aufnahmehöhe.

5. Wälzkörperführungssystem, das eine Spurschiene, mindestens ein auf der Spurschiene bewegbar befestigtes bewegbares Element und Wälzkörper aufweist, die zwischen der Spurschiene und dem bewegbaren Element angeordnet sind, wobei eine Länge einer Laufwegoberfläche des bewegbaren Elements und ein Durchmesser des Wälzkörpers derart bestimmt sind, dass in einer Länge von 2KDa des bewegbaren Elements, in der die relativen Positionen des bewegbaren Elements und der entsprechenden Rollenelemente variieren, ein Verhältnis (I : I-1), bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 100% bis 0% (100% : 0%) festgelegt ist, wobei I = int (2Ux/κDa + 0,5), mit
2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und
κDa = der Wälzkörperdurchmesser oder die Aufnahmehöhe.

6. Wälzkörperführungssystem, das eine Spurschiene, mindestens ein auf der Spurschiene bewegbar befestigtes bewegbares Element und Wälzkörper aufweist, die zwischen der Spurschiene und dem bewegbaren Element angeordnet sind, wobei eine Länge einer Laufwegoberfläche des bewegbaren Elements und ein Durchmesser des Wälzkörpers derart bestimmt sind, dass in einer Länge von 2 κDa des bewegbaren Elements, in der die relativen Positionen des bewegbaren Elements und der entsprechenden Rollenelemente variieren, ein Verhältnis (I : I-1), bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 50% bis 50% (50% : 50%) festgelegt ist, wobei I = int(2Ux/κDa + 0,5), mit
2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und
κDa = der Wälzkörperdurchmesser oder die Aufnahmehöhe.

7. Wälzkörperführungssystem, aufweisend eine Spurvorrichtung, eine Mehrzahl von auf der Spurvorrichtung befestigter bewegbarer Elemente und eine Anzahl von Wälzkörpern, die zwischen der Spurvorrichtung und den bewegbaren Elementen angeordnet sind, wobei die lichte Weite der bewegbaren Elemente derart gewählt ist, dass relative Positionen der Wälzkörper in den entsprechenden bewegbaren Elementen miteinander übereinstimmen.

8. Ein Wälzkörperführungssystem gemäß Anspruch 7, wobei die Spurvorrichtung eine Mehrzahl von Spurschaften aufweist, eine Mehrzahl von bewegbaren Elementen auf den entsprechenden Spurschaften befestigt sind, und die lichten Weiten der bewegbaren Elemente derart gewählt sind, dass relative Positionen der Wälzkörper in den bewegbaren Elementen, die auf den entsprechenden Spurschaften befestigt sind, miteinander übereinstimmen.

9. Ein Wälzkörperführungssystem gemäß Anspruch 7, wobei eine Länge einer Laufwegoberfläche des bewegbaren Elements und ein Durchmesser des Wälzkörpers derart bestimmt sind, dass in einer Länge von 2 κDa des bewegbaren Elements, in der die relativen Positionen des bewegbaren Elements und der entsprechenden Rollenelemente variieren, ein Verhältnis (I : I-1), bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 100% bis 0% (100% : 0%) festgelegt ist, wobei I = int(2Ux/κDa + 0, 5), mit
2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und
κDa = der Wälzkörperdurchmesser oder die Aufnahmehöhe.

10. Ein Wälzkörperführungssystem gemäß Anspruch 7, wobei eine Länge einer Laufwegoberfläche des bewegbaren Elements und ein Durchmesser des Wälzkörpers derart bestimmt sind, dass in einer Länge von 2 κDa des bewegbaren Elements, in der die relativen Positionen des bewegbaren Elements und der entsprechenden Rollenelemente variieren, ein Verhältnis (I : I-1), bei dem I gleich der Anzahl der wirksamen Wälzkörper und I-1 ein Bereich der Anzahl der wirksamen Wälzkörper ist, innerhalb eines Bereiches von ca. 50% bis 0% (50% : 0%) festgelegt ist, wobei I = int(2Ux/κDa + 0,5), mit
2Ux = die Länge der Laufwegoberfläche des bewegbaren Elements und
κDa = der Wälzkörperdurchmesser oder die Aufnahmehöhe.

Hierzu 19 Seite(n) Zeichnungen

- Leerseite -

Nummer: **DE 101 02 179 A1**
Int. Cl.^{7}: **F 16 C 29/06**
Offenlegungstag: 9. August 2001

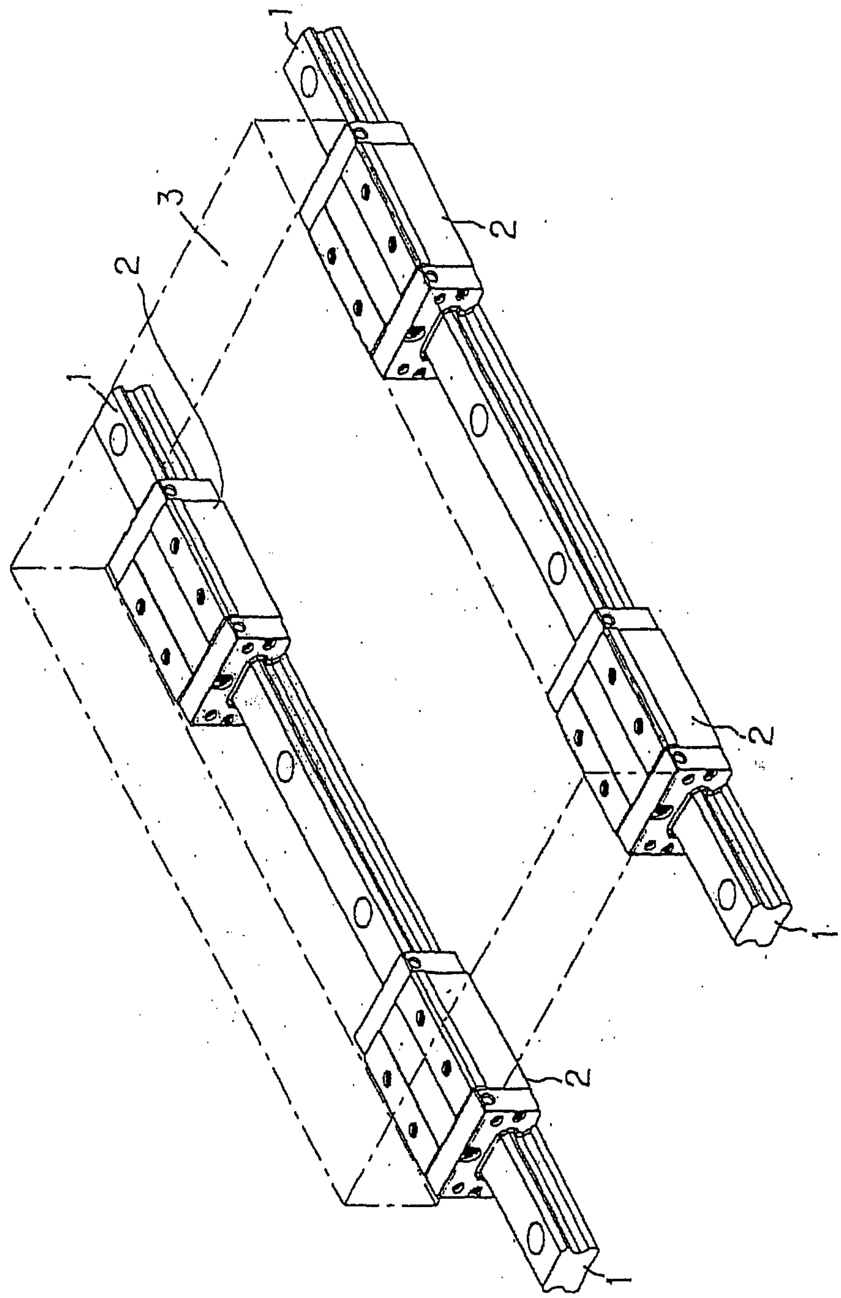


FIG. 1

Nummer: DE 101 02 179 A1
Int. Cl.⁷: F 16 C 29/06
Offenlegungstag: 9. August 2001

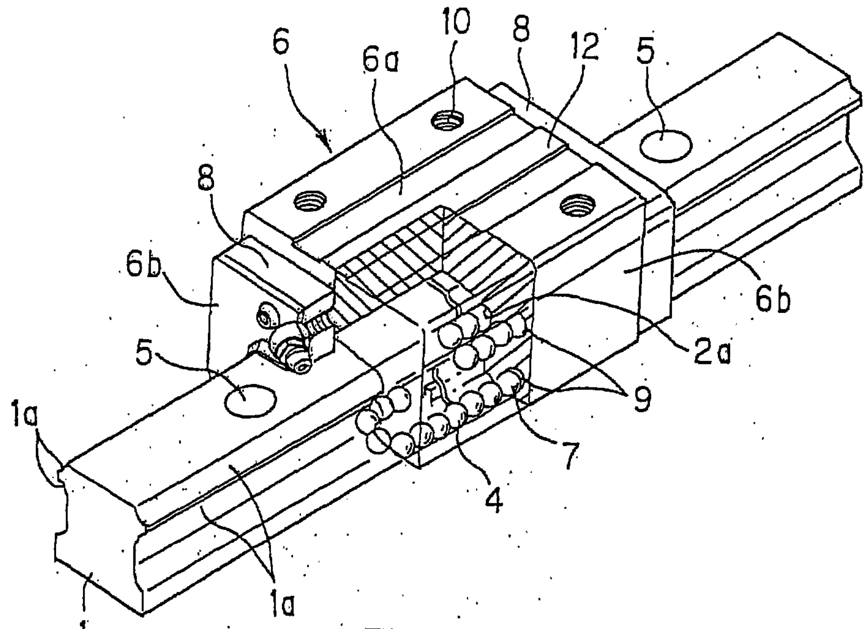


FIG. 2

Nummer: **DE 101 02 179 A1**
Int. Cl.[7]: **F 16 C 29/06**
Offenlegungstag: 9. August 2001

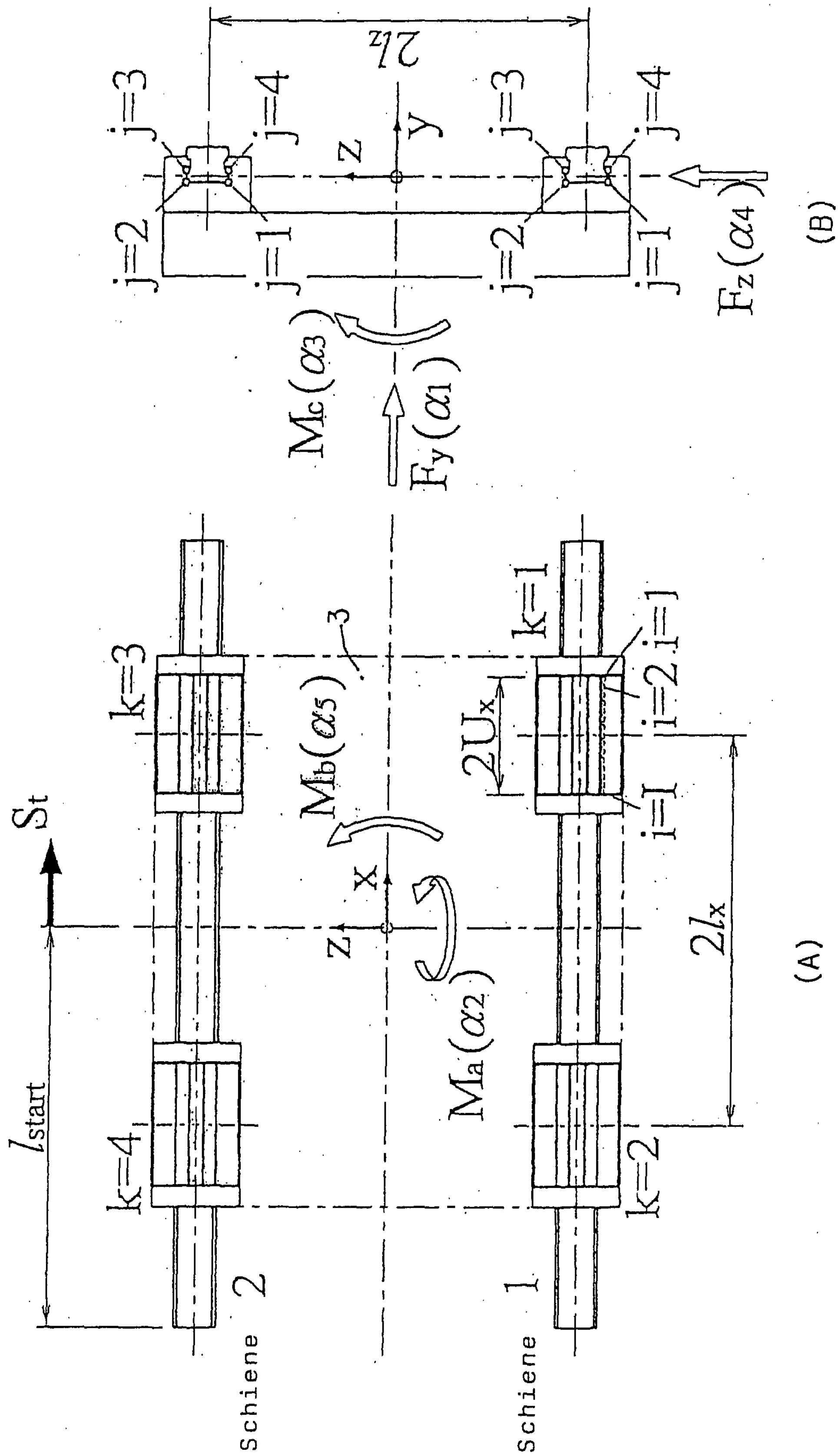


FIG. 3

Nummer: DE 101 02 179 A1
Int. Cl.[7]: F 16 C 29/06
Offenlegungstag: 9. August 2001

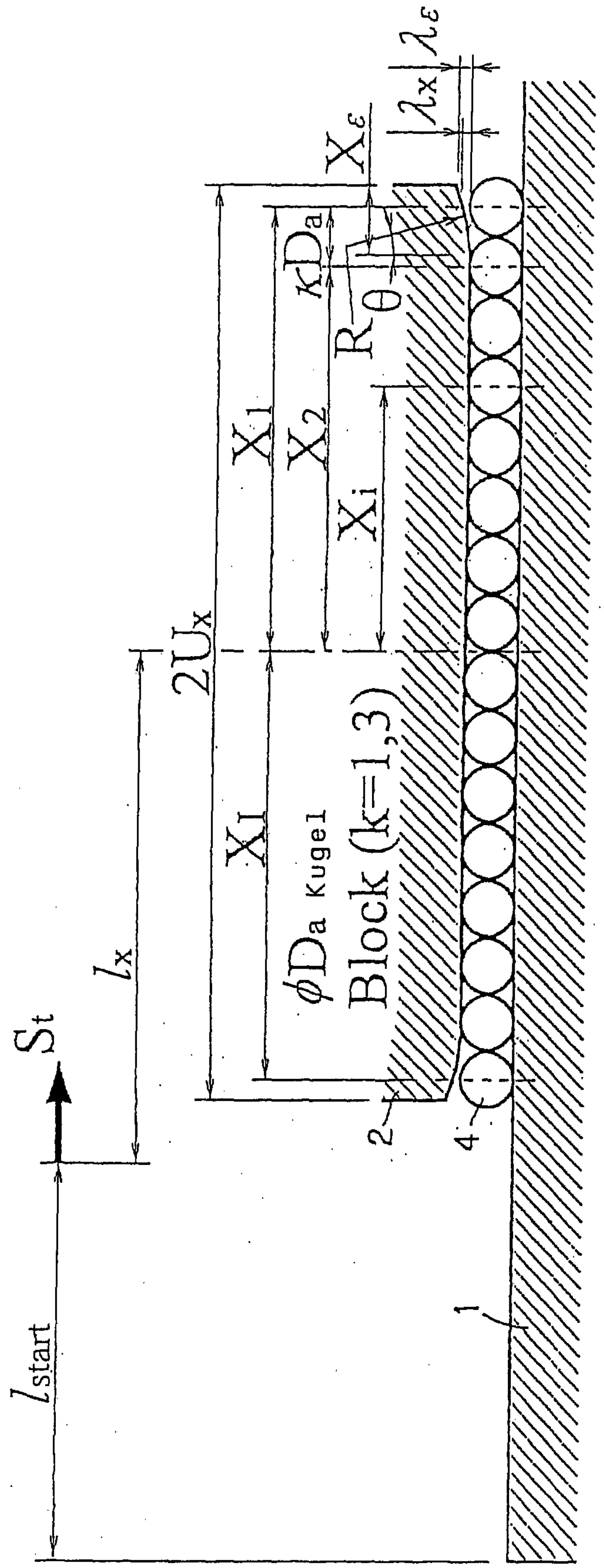


FIG. 4

Nummer: DE 101 02 179 A1
Int. Cl.[7]: F 16 C 29/06
Offenlegungstag: 9. August 2001

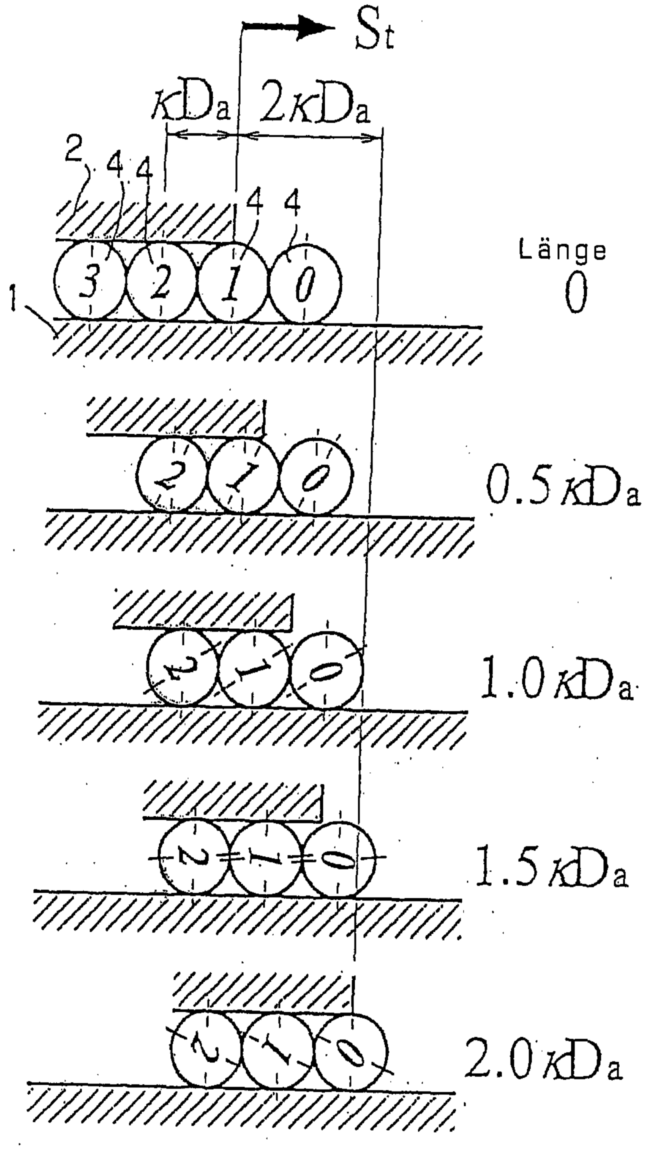


FIG. 5

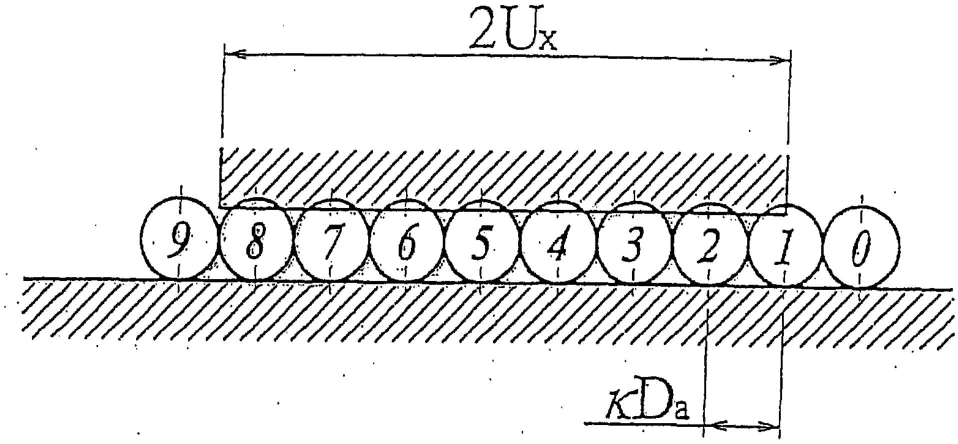


FIG. 6A

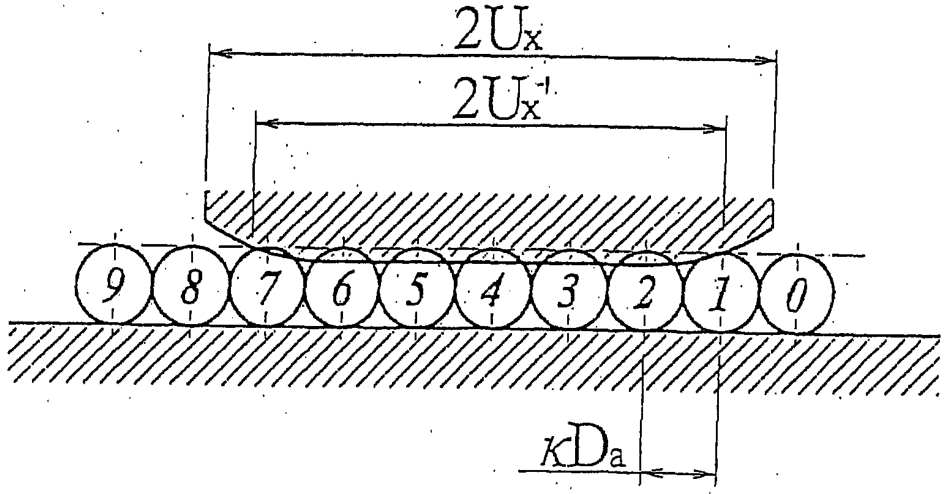


FIG. 6B

Nummer: **DE 101 02 179 A1**
Int. Cl.[7]: **F 16 C 29/06**
Offenlegungstag: 9. August 2001

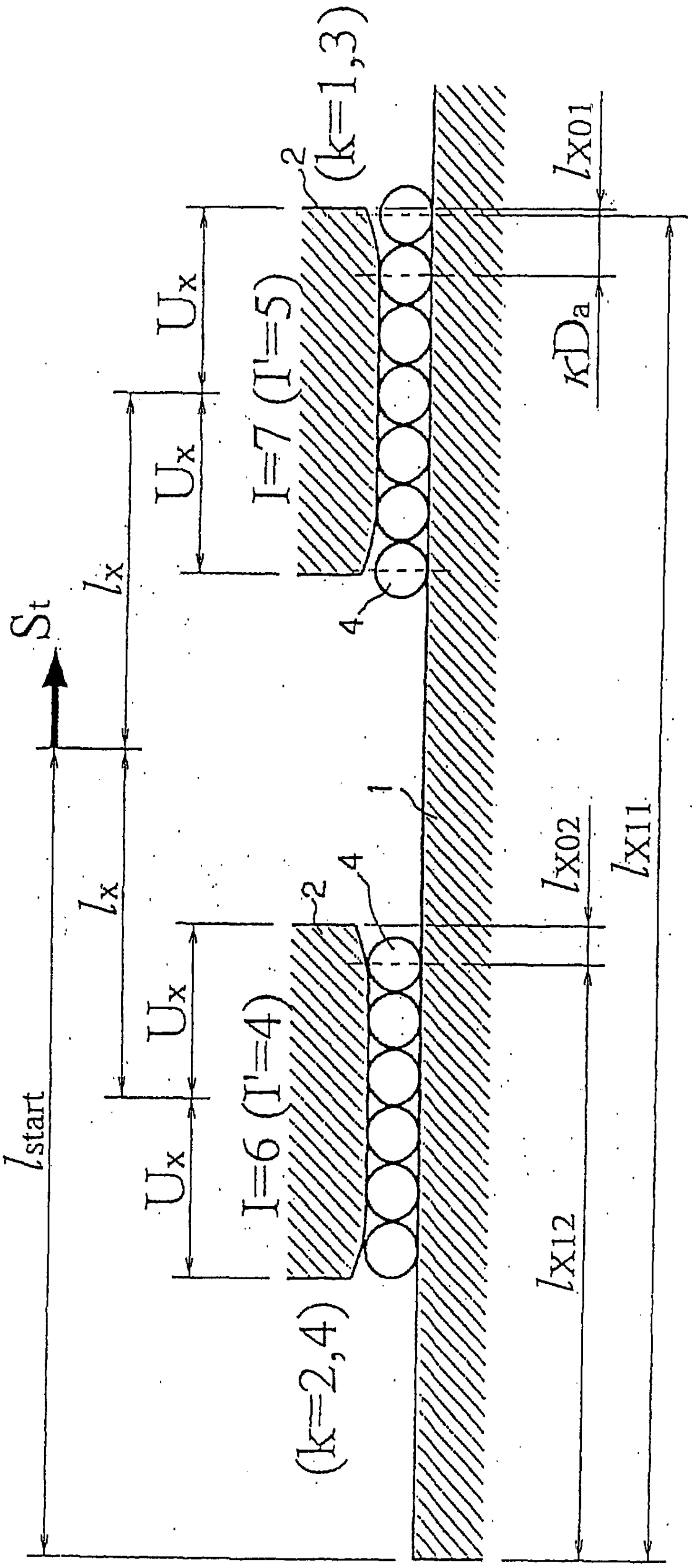


FIG. 7

Nummer: **DE 101 02 179 A1**
Int. Cl.[7]: **F 16 C 29/06**
Offenlegungstag: 9. August 2001

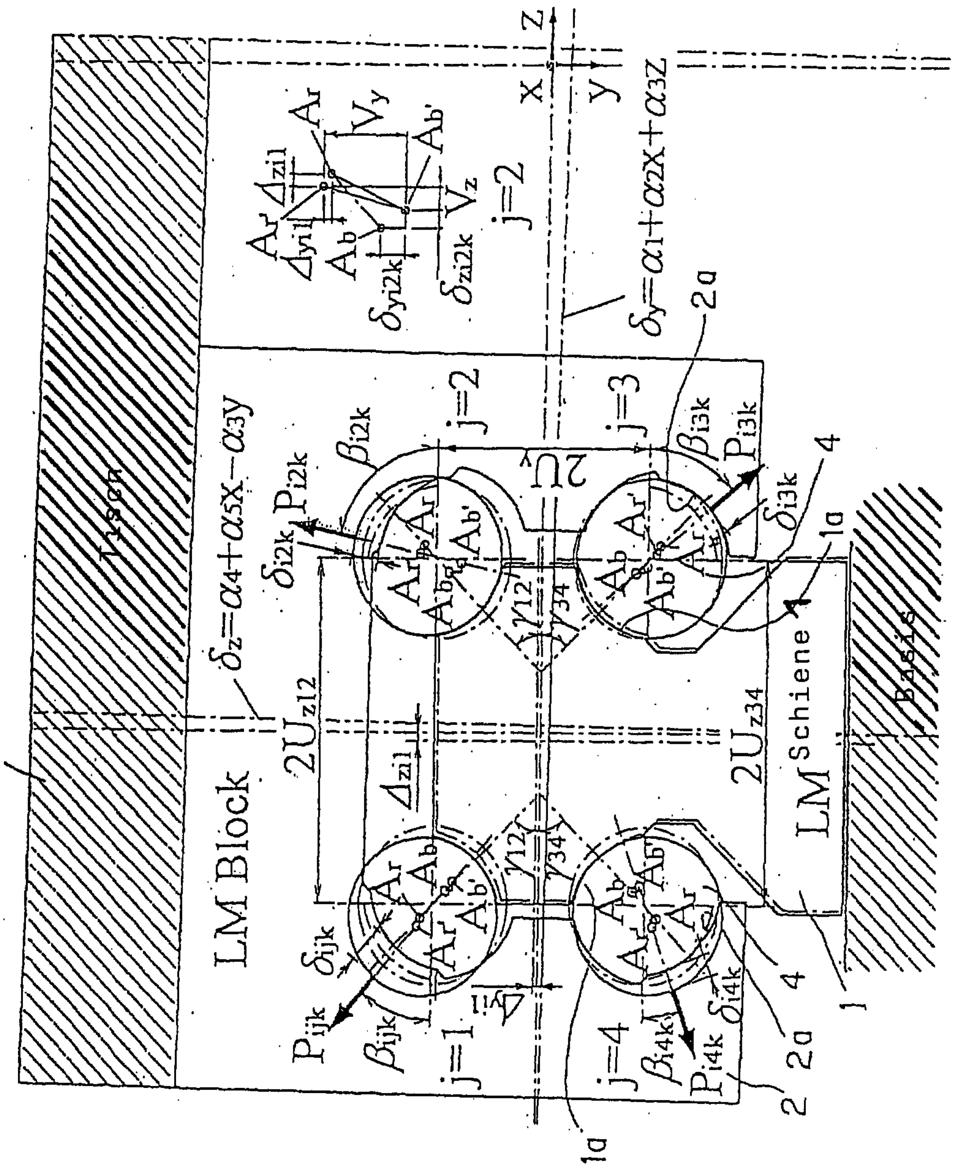


FIG. 8

Nummer: **DE 101 02 179 A1**
Int. Cl.[7]: **F 16 C 29/06**
Offenlegungstag: 9. August 2001

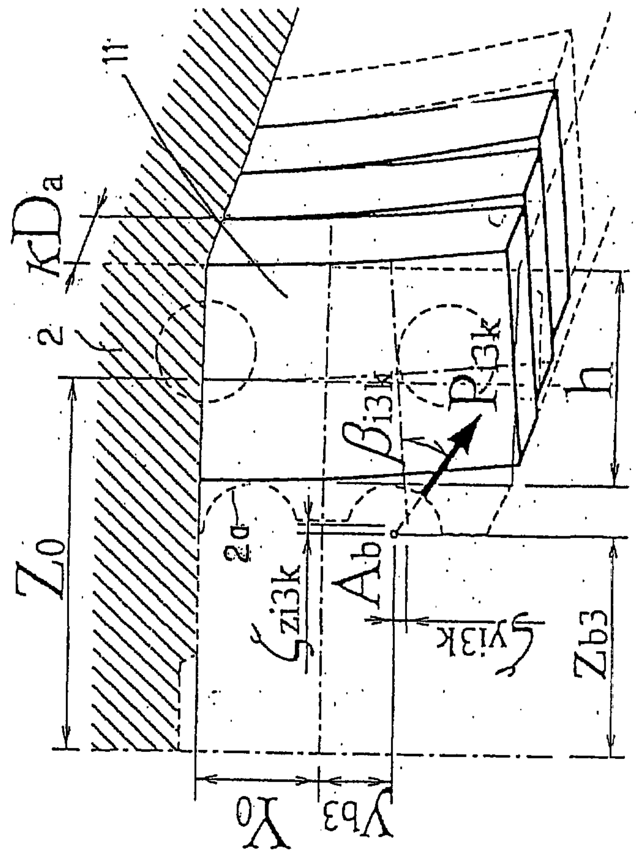


FIG. 9

Nummer: DE 101 02 179 A1
Int. Cl.⁷: F 16 C 29/06
Offenlegungstag: 9. August 2001

$$\begin{pmatrix} \frac{\partial g_1}{\partial \alpha_1} & \frac{\partial g_1}{\partial \alpha_2} & \frac{\partial g_1}{\partial \alpha_3} & \frac{\partial g_1}{\partial \alpha_4} & \frac{\partial g_1}{\partial \alpha_5} \\ \frac{\partial g_2}{\partial \alpha_1} & \frac{\partial g_2}{\partial \alpha_2} & \frac{\partial g_2}{\partial \alpha_3} & \frac{\partial g_2}{\partial \alpha_4} & \frac{\partial g_2}{\partial \alpha_5} \\ \frac{\partial g_3}{\partial \alpha_1} & \frac{\partial g_3}{\partial \alpha_2} & \frac{\partial g_3}{\partial \alpha_3} & \frac{\partial g_3}{\partial \alpha_4} & \frac{\partial g_3}{\partial \alpha_5} \\ \frac{\partial g_4}{\partial \alpha_1} & \frac{\partial g_4}{\partial \alpha_2} & \frac{\partial g_4}{\partial \alpha_3} & \frac{\partial g_4}{\partial \alpha_4} & \frac{\partial g_4}{\partial \alpha_5} \\ \frac{\partial g_5}{\partial \alpha_1} & \frac{\partial g_5}{\partial \alpha_2} & \frac{\partial g_5}{\partial \alpha_3} & \frac{\partial g_5}{\partial \alpha_4} & \frac{\partial g_5}{\partial \alpha_5} \end{pmatrix} \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \end{pmatrix} = - \begin{pmatrix} g_1 \\ g_2 \\ g_3 \\ g_4 \\ g_5 \end{pmatrix} \quad \text{- - - - - - - (1)}$$

$$rms = \frac{1}{5}\sqrt{\sum_{\ell=1}^{5} \varepsilon_\ell^{\,2}}$$

$rms \leq 10^{-10}$ $\quad \alpha_\ell =$ Lösungen $\Rightarrow$ Ende

$rms > 10^{-10}$ $\quad \alpha_\ell = \alpha_\ell + \varepsilon_\ell$ $\Rightarrow$ in Gleichung (1)

FIG. 10

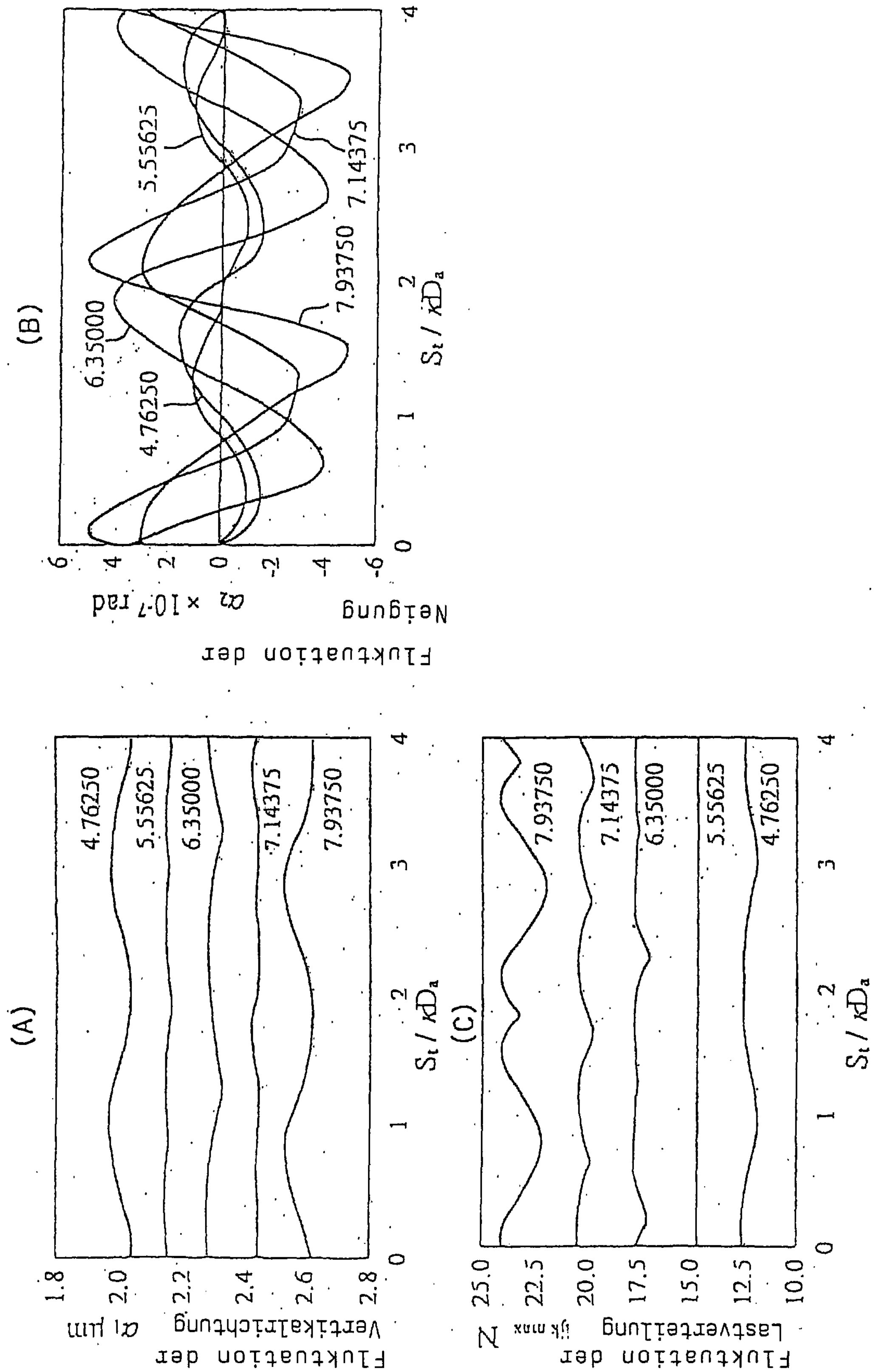

(A)
(B)
(C)
Fluktuation der Vertikalrichtung α_1 μm
Fluktuation der Neigung α_2 ×10⁻⁷ rad
Fluktuation der Lastverteilung $Z_{ijk\,max}$
$S_t / \kappa D_a$
4.76250
5.55625
6.35000
7.14375
7.93750

FIG. 11

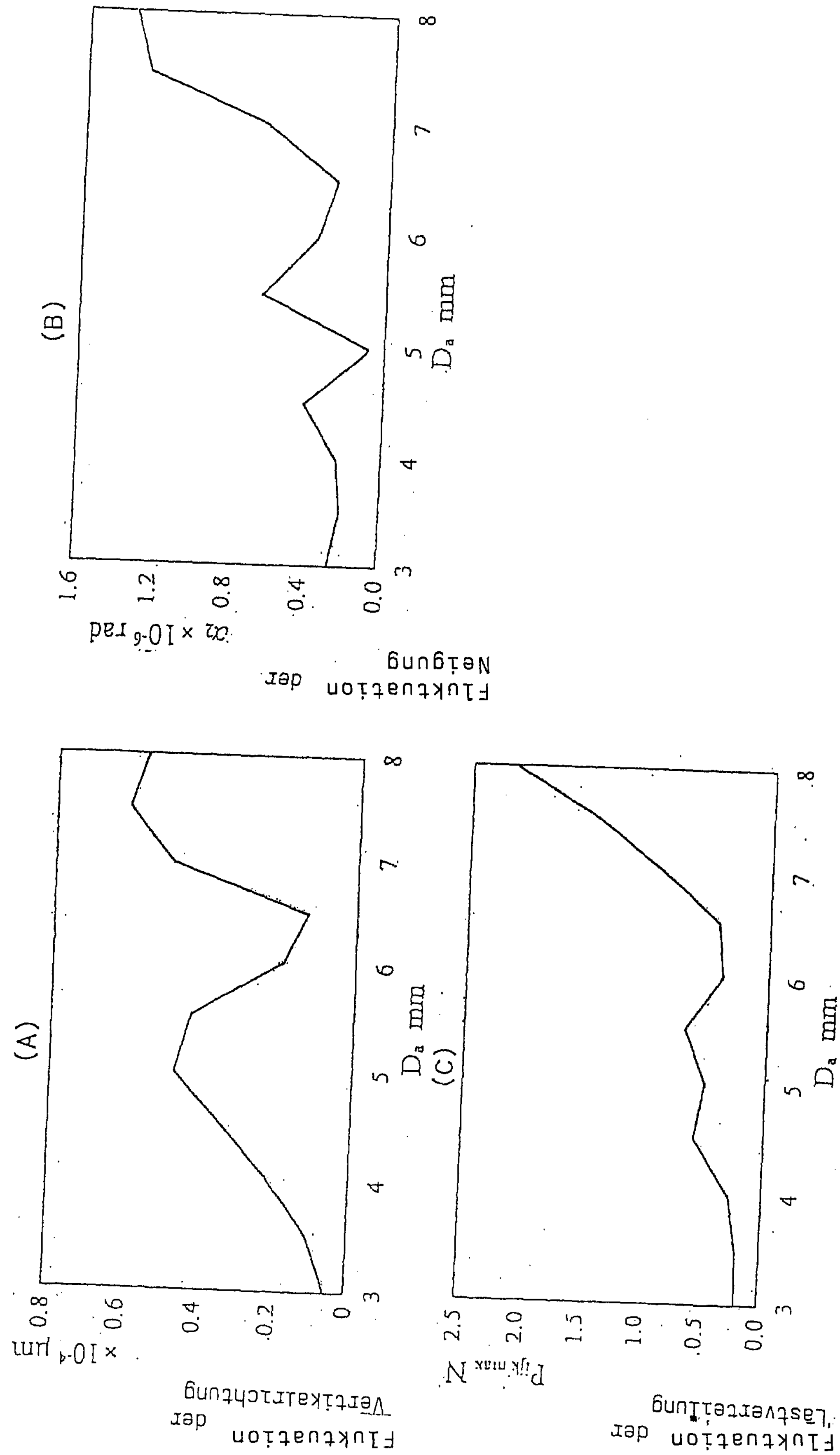

(A)
Fluktuation der Vertikalrichtung
× 10⁻⁴ µm
D_a mm
(B)
Fluktuation der Neigung
$\alpha_2 \times 10^{-6}$ rad
D_a mm
(C)
Fluktuation der Lastverteilung
$P_{ijk\,max}$ N
D_a mm

FIG. 12

Nummer: **DE 101 02 179 A1**
Int. Cl.[7]: **F 16 C 29/06**
Offenlegungstag: 9. August 2001

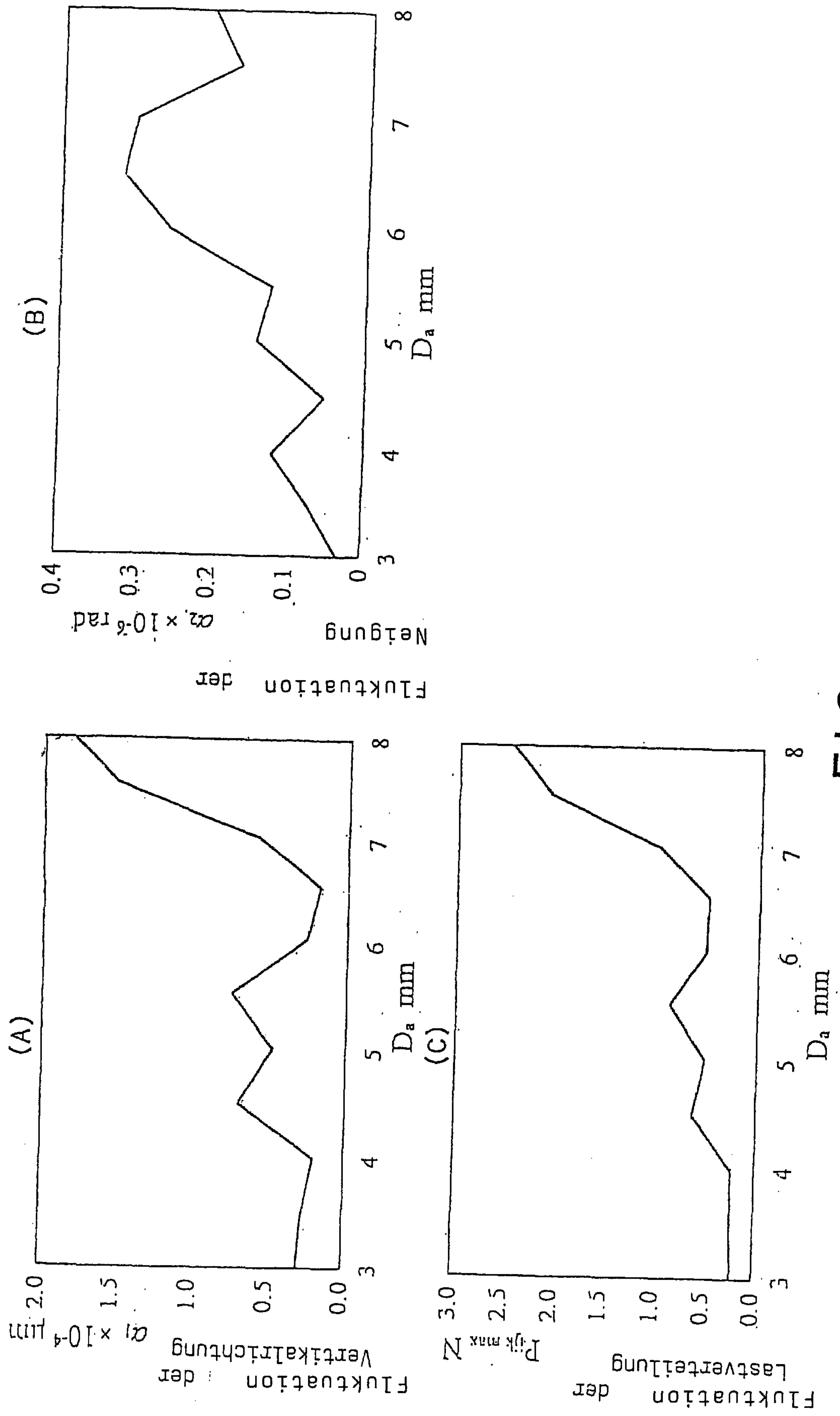


FIG.13

Nummer: DE 101 02 179 A1
Int. Cl.[7]: F 16 C 29/06
Offenlegungstag: 9. August 2001

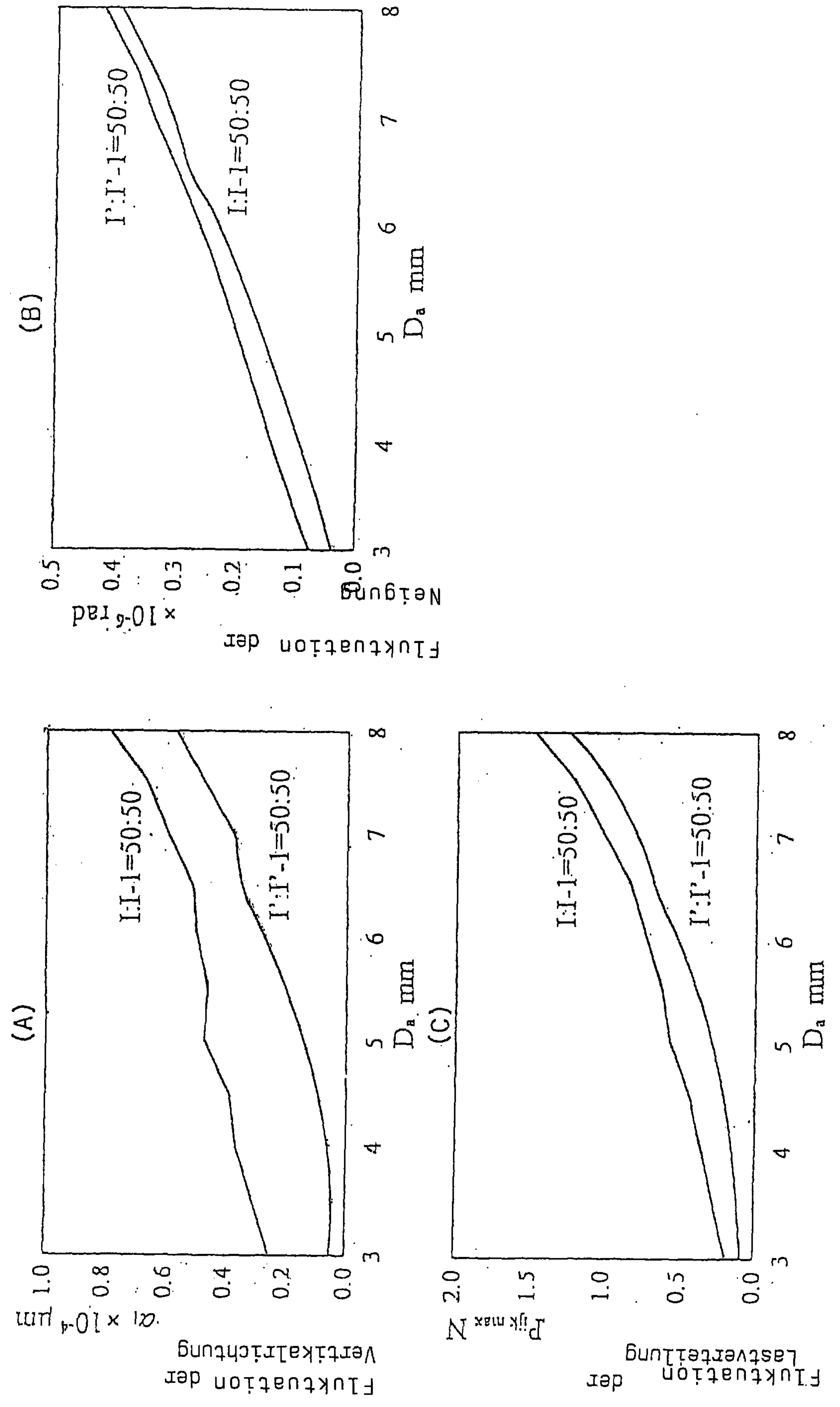


FIG.14

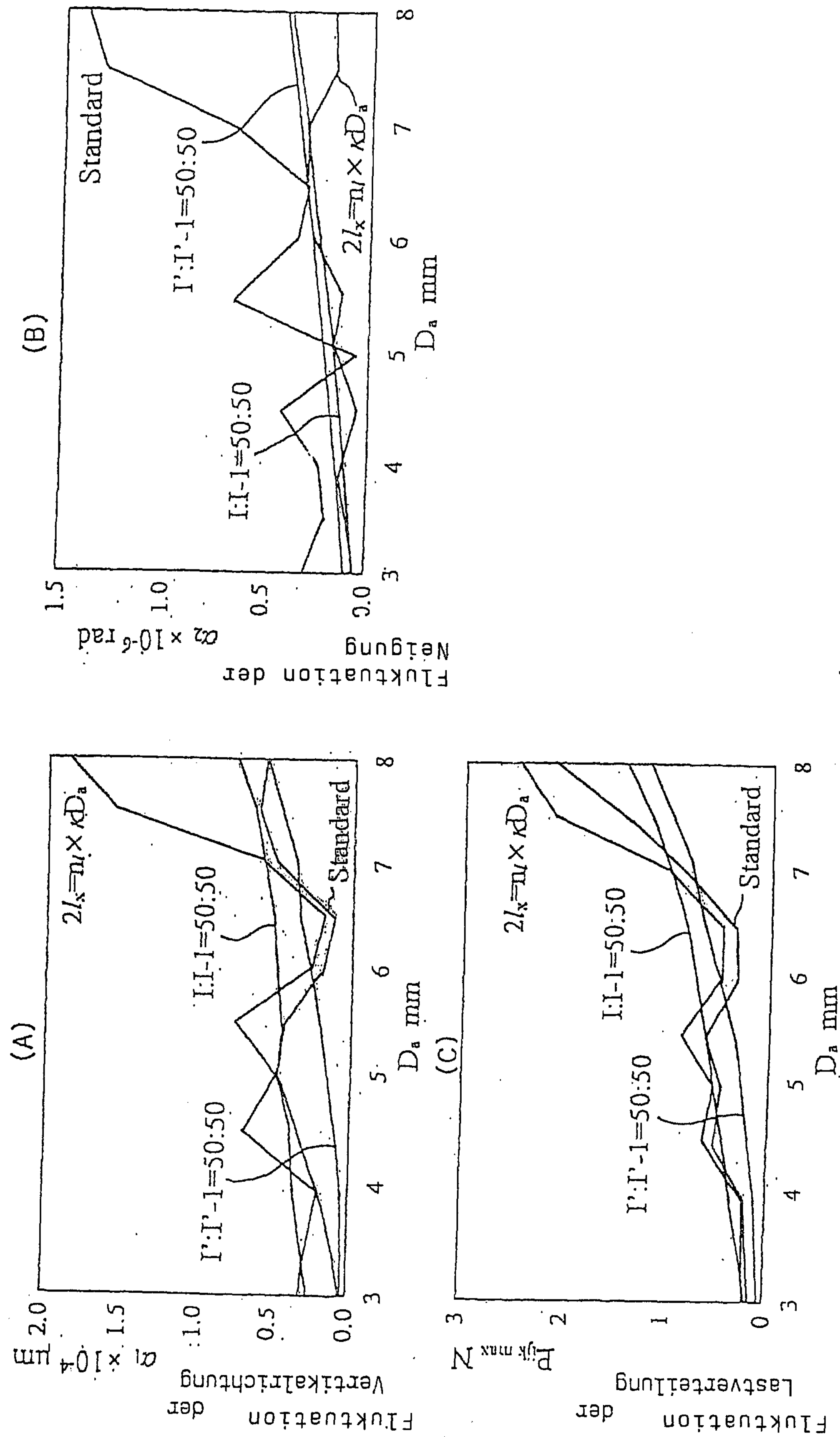

(A)
Fluktuation der Vertikalrichtung
$\alpha_1 \times 10^{-4}$ µm
$2l_x = n_l \times \kappa D_a$
I:I-1=50:50
I':I'-1=50:50
Standard
D_a mm
(B)
Fluktuation der Neigung
$\alpha_2 \times 10^{-6}$ rad
Standard
I':I'-1=50:50
I:I-1=50:50
$2l_x = n_l \times \kappa D_a$
D_a mm
(C)
Fluktuation der Lastverteilung
$P_{ijk\,max}$ N
$2l_x = n_l \times \kappa D_a$
I:I-1=50:50
I':I'-1=50:50
Standard
D_a mm

FIG. 15

Nummer: **DE 101 02 179 A1**
Int. Cl.[7]: **F 16 C 29/06**
Offenlegungstag: 9. August 2001

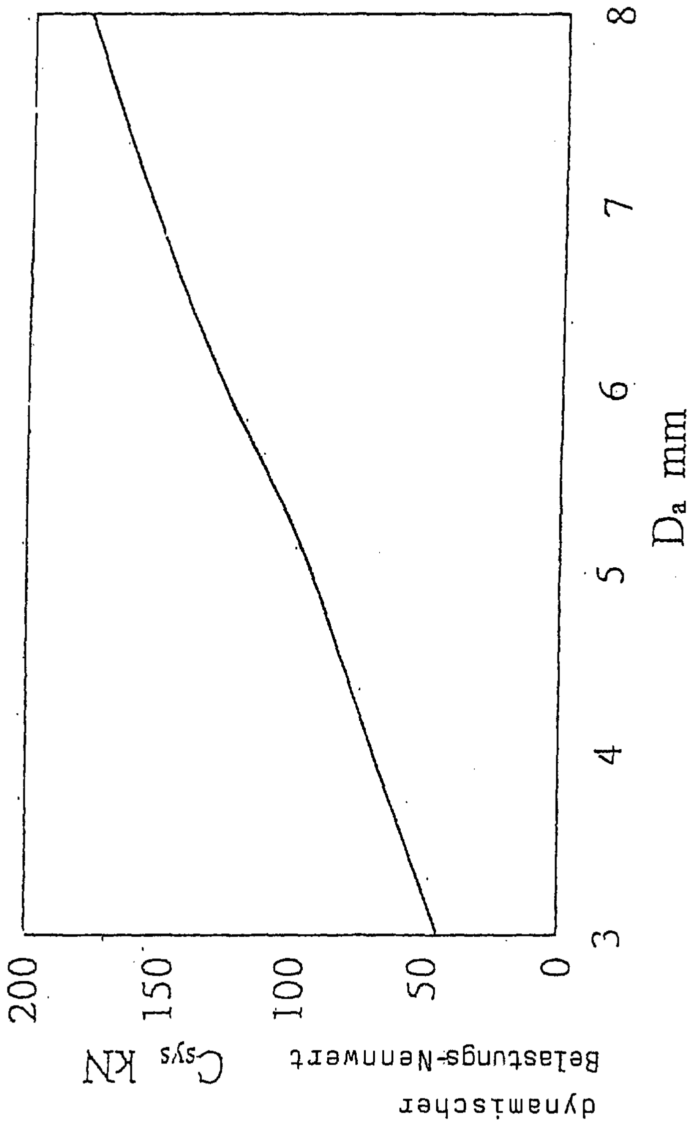


FIG. 16

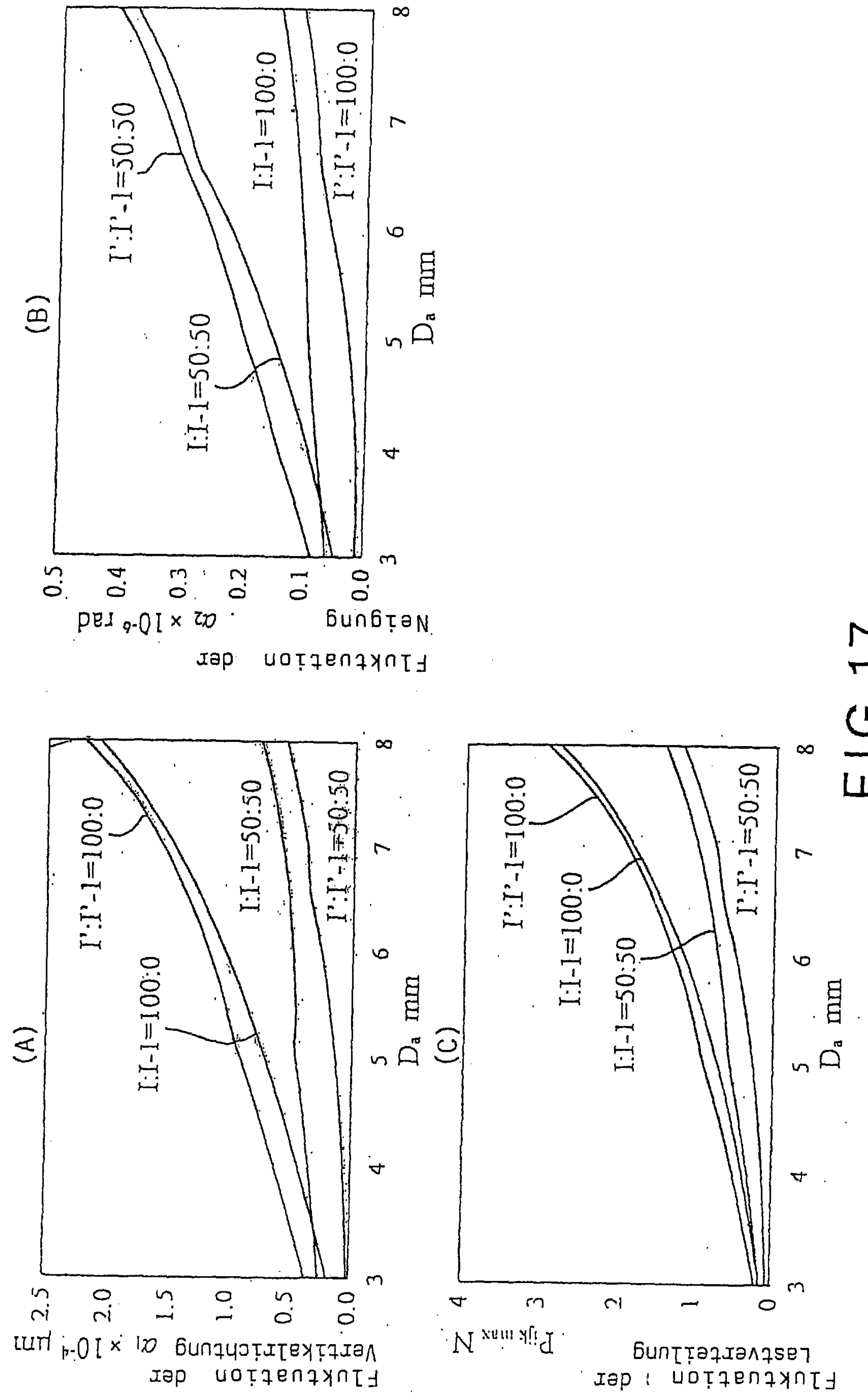

(A)
Fluktuation der Vertikalrichtung α1 × 10-4 μm
Da mm
I':I'-1=100:0
I:I-1=100:0
I:I-1=50:50
I':I'-1=50:50
(B)
Fluktuation der Neigung α2 × 10-6 rad
Da mm
I':I'-1=50:50
I:I-1=50:50
I:I-1=100:0
I':I'-1=100:0
(C)
Fluktuation der Lastverteilung Pijk max N
Da mm
I':I'-1=100:0
I:I-1=100:0
I:I-1=50:50
I':I'-1=50:50

FIG. 17

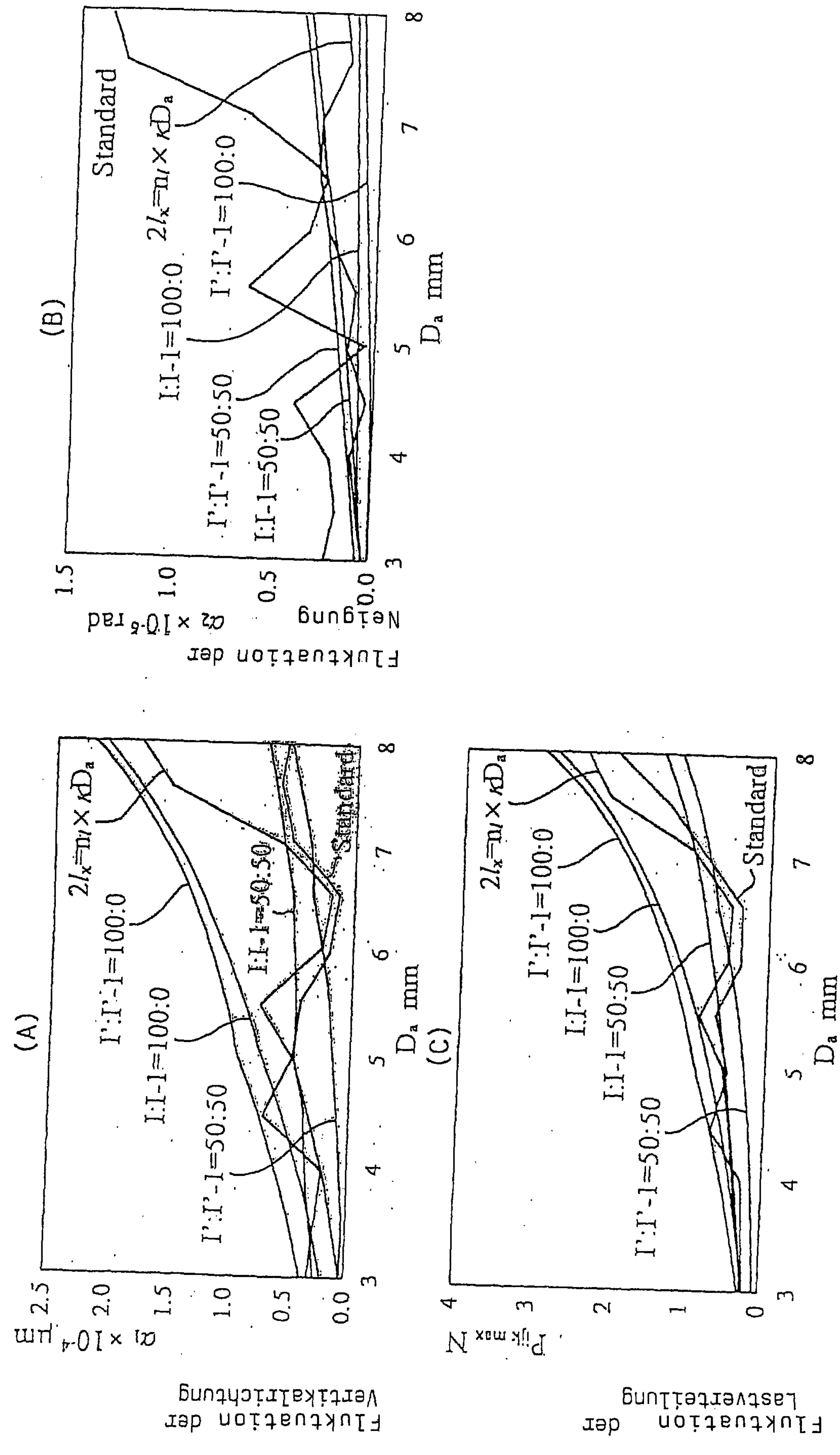

(A)
(B)
(C)
Standard
Fluktuation der Vertikalrichtung
Fluktuation der Neigung
Fluktuation der Lastverteilung
Dₐ mm

FIG.18

Nummer: DE 101 02 179 A1
Int. Cl.[7]: F 16 C 29/06
Offenlegungstag: 9. August 2001

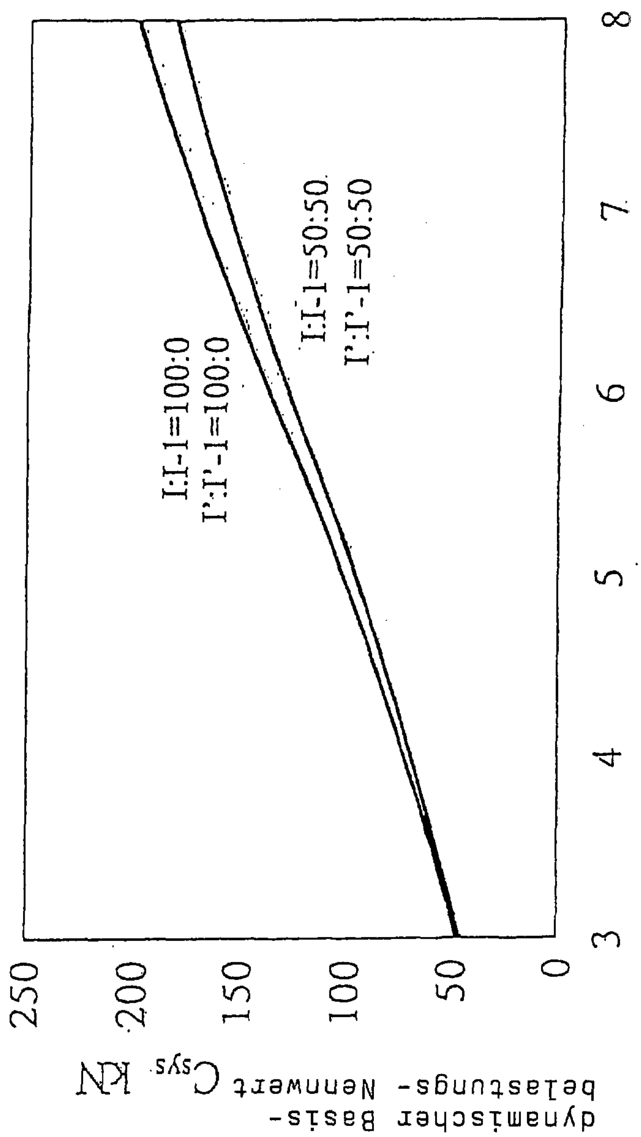


FIG.19

(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 100 58 317 A 1**

(51) Int. Cl.[7]:
F 16 C 11/06
B 25 J 17/00

(21) Aktenzeichen: 100 58 317.2
(22) Anmeldetag: 24. 11. 2000
(43) Offenlegungstag: 31. 5. 2001

(30) Unionspriorität:
11-334055 25. 11. 1999 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

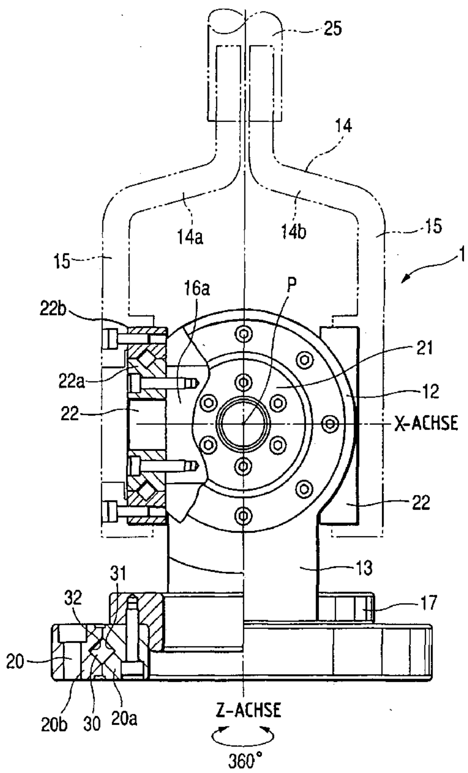
(74) Vertreter:
HOFFMANN · EITLE, 81925 München

(72) Erfinder:
Shirai, Takeki, Tokio/Tokyo, JP; Hirokawa, Tadashi, Tokio/Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Universalgelenk

(57) Ein Universalgelenk (11) ist mit einer Pendellager-Montageplatte (13) geformt, die ein gekrümmtes Joch (12) hat, einer Verbindung (14), die ein gekrümmtes Joch (15) hat, und einem kreuzförmigen Element (16), das kreuzförmige Schaftbereiche (16a und 16b) hat, die mit den jeweiligen Jochen (12 und 15) verbunden sind. Ein Y-Achsen-Pendellager (21) ist zwischen dem Joch (12) und dem Schaftbereich (16b) des kreuzförmigen Elements (16) vorgesehen, und ein X-Achsen-Pendellager (22) ist zwischen dem anderen Joch (15) und dem Schaftbereich (16a) davon vorgesehen. Da das Universalgelenk (11) drei Freiheitsgrade des Schwenkens hat, wird das Universalgelenk (11) stoßfrei und glatt betätigt, wenn die Position und Lage einer Gleitbasis in dem parallelen Verbindungsgliedmechanismus beispielsweise bestimmt sind.



DE 100 58 317 A 1

Beschreibung

HINTERGRUND DER ERFINDUNG

1. Gebiet der Erfindung

Die vorliegende Erfindung bezieht sich auf ein Universalgelenk, beispielsweise zur Verwendung in einem parallelen Verbindungsgliedmechanismus.

2. Beschreibung des Stands der Technik

Bislang ist ein paralleler Verbindungsgliedmechanismus bekannt, bei dem eine Vielzahl von Verbindungen zwischen einer Basis und einer schwankenden Basis besteht, so dass bewirkt wird, dass die schwankende Basis eine räumliche Bewegung ausführt. **Fig.** 15 zeigt einen Fahrsimulator, der solch einen parallelen Verbindungsmechanismus verwendet (siehe JP-A-11-224472, die durch die vorliegende Anmelderin vorgeschlagen worden ist). Stellglieder in der Form von sechs Verbindungen **3**, beispielsweise, sind zwischen der Basis **1** und der schwankenden Basis **2** angebracht, und eine schwankende Bewegung wird auf die schwankende Basis **2** auferlegt, wobei die dreidimensionale Position (räumliche Position) und die Lage der schwankenden Basis **2** geregelt werden, indem selektiv jedes der Stellglieder expandiert und kontraktiert wird. Zu dieser Zeit hat die schwankende Basis **2** sechs Freiheitsgrade, einschließlich drei Freiheitsgraden zur Bestimmung der Position der Stellglieder und drei Freiheitsgraden zum Bestimmen von deren Lage.

Als ein Gelenk **4**, das zwischen dem Ende jeder Verbindung **3** des parallelen Verbindungsgliedmechanismus und der Basis **1** oder der schwankenden Basis **2** gehalten werden muss, ist ein kugelförmiges Lager **5** bekannt, um die kugelförmige Bewegung der Verbindung **3** zu ermöglichen, oder ein Universalgelenk **6**, um zu ermöglichen, dass Kreuzwinkel der Verbindung **3** in bezug auf die Basis **1** oder die schwankende Basis **2** variiert werden können, wie es in **Fig.** 16 gezeigt ist.

Die kugelförmige Lagerung **5** ist eine Lagerung, um einen kugelförmigen Achszapfen **7** zu lagern, der an dem Endbereich der Verbindung **3** vorgesehen ist, und hat einen Freiheitsgrad von drei verschiedenen Drehbewegungen. Daher kann die kugelförmige Lagerung **5** stoßfrei betätigt werden, wenn die Position und Lage der schwankenden Basis **2** bestimmt sind.

Das Universalgelenk **6** hat zwei Freiheitsgrade des Schwenkens mit einem bekannten Mechanismus, der einen Gelenkkörper **9** umfasst, der ein Joch **8** hat, und ein metallisches Querpassstück **10**, wobei die Lagerung zwischen das Joch **8** und den Gelenkkörper **9** eingesetzt ist.

Der parallele Verbindungsgliedmechanismus ist jedoch strukturell durch die Tatsache charakterisiert, dass Lasten auf die Verbindungen axial auf die Gelenke **4** aufgebracht werden, und die Steifigkeit der kugelförmigen Lagerung **5** ist nicht ausreichend, um die axialen Lasten der Verbindungen **3** zu stützen. Obwohl es notwendig ist, dass der Auslenkwinkel α von jeder Verbindung **3** größer gemacht wird, um die Position und Lage der schwankenden Basis **2** in großem Maß zu variieren, wird bewirkt, dass die Verbindung **3** gegen die kugelförmige Lagerung **5** stößt im Fall, wenn die Lagerung eingesetzt wird, und dies macht es unmöglich, einen großen Auslenkwinkel α sicherzustellen.

In bezug auf das Universalgelenk **6**, da es nur zwei Freiheitsgrade des Schwenkens hat, obwohl der Schwenkwinkel α jeder Verbindung **3** vergrößert werden kann, ist es nicht in der Lage, stoßfrei betätigt zu werden, wenn die Position und Lage der schwankenden Basis **2** bestimmt sind, aufgrund einer nicht ausreichenden Freiheit zum Bestimmen der Position und Lage von sechs Freiheitsgraden der schwankenden Basis **2**.

ZUSAMMENFASSUNG DER ERFINDUNG

Eine Aufgabe der vorliegenden Erfindung angesichts der vorstehenden Probleme ist es, ein in hohem Maß steifes Universalgelenk zur Verwendung in einem parallelen Verbindungsgliedmechanismus vorzusehen, das nicht nur in der Lage ist, einen großen Auslenkwinkel für jede Verbindung sicherzustellen, sondern auch die axialen Lasten der Verbindung aufnehmen kann.

Die vorliegende Erfindung wird nun beschrieben. Obwohl Referenzziffern gemäß den beigefügten Zeichnungen angegeben sind, um das Verstehen der vorliegenden Erfindung zu erleichtern, ist die Erfindung nicht auf die Anordnung beschränkt, die in den Zeichnungen dargestellt ist.

Um die oben stehende Aufgabe zu erfüllen, ist gemäss einem ersten Aspekt der vorliegenden Erfindung ein Universalgelenk **11** vorgesehen, das gemäss einem Aspekt der Erfindung umfasst: eine erste drehbare Führungseinrichtung **20**, eine zweite drehbare Führungseinrichtung **21**, die drehbar durch die erste drehbare Führungseinrichtung **20** geführt wird, und eine dritte drehbare Führungseinrichtung **22**, die drehbar durch die zweite drehbare Führungseinrichtung **21** geführt wird, so dass das Universalgelenk drei Freiheitsgrade des Drehens insgesamt hat, wobei das Universalgelenk ein Paar von Gelenkkörpern **13**, **14** umfasst, die jeweils gegabelte Joche **12**, **15** haben, und ein kreuzförmiges Element **16**, das kreuzförmige Schaftbereiche **16**a, **16**b hat, die mit den jeweiligen Jochen **12**, **15** verbunden sind; wobei die zweite drehbare Führungseinrichtung **21** zwischen dem Joch **12** von einem Gelenkkörper **13** und dem Schaftbereich **16**b des kreuzförmigen Elements **16** vorgesehen ist; wobei die dritte drehbare Führungseinrichtung **22** zwischen dem Joch **15** des anderen Gelenkkörpers **14** und dem Schaftbereich **16**a vorgesehen ist, der den Schaftbereich **16**b des kreuzförmigen Elements **16** quert; und wobei die erste drehbare Führungseinrichtung **20** an einem des Paars von Gelenkkörpern **13**, **14** vorgesehen ist.

Gemäss der Erfindung wird, da das Universalgelenk **11** drei schwenkbare Freiheitsgrade hat, das Gelenk stoßfrei und glatt betätigt, so dass die Verbindung jede dreidimensionale Lage einnehmen kann, wenn die Position und Lage einer schwankenden Basis bestimmt sind. Da das Universalgelenk **11** im wesentlichen aus dem Paar von Gelenkkörpern **13**, **14** besteht, die jeweils die Joche **12**, **15** haben, und dem kreuzförmigen Element **16** zum Verbinden der Joche **12**, **15**, kann ein großer Auslenkwinkel des Paars der Gelenkkörper **13**, **14** sichergestellt werden, wodurch der Schwenkwinkel der Verbindung, beispielsweise in einem parallelen Verbindungsgliedmechanismus, vergrößerbar wird. In diesem Fall ist es nur notwendig, dass jede der drehbaren Führungseinrichtungen **20**, **21**, **22** einen Freiheitsgrad hat. Somit können Wälzlager, Gleitlager, Pendellager, gekrümmte Führungseinheiten und ähnliches beispielsweise verwendet werden.

Gemäss einem zweiten Aspekt der Erfindung hat bei dem Universalgelenk **11** des ersten Aspekts der Erfindung zumindest eine der ersten, zweiten und dritten drehbaren Führungseinrichtungen **20**, **21**, **22** einen äußeren Ring **20**b, der mit einer im Querschnitt im wesentlichen V-förmigen Walzentransfernut **32** auf der inneren Umfangsseite der drehbaren Führungseinrichtung geformt ist; einen inneren Ring **20**a, der mit einer im Querschnitt im wesentlichen V-förmigen Walzentransfernut **31** auf seiner äußeren Umfangsseite geformt ist, wobei der innere Ring **20**a in den äußeren Ring **20**b eingepasst ist; und eine Vielzahl von Walzen **33**, die zwischen diesen Walzentransfernuten **31**, **32** angeordnet sind und gehalten werden, so dass die Drehachsen von benachbarten Walzen einander senkrecht schneiden können.

Wenn eine axiale Last auf das Universalgelenk **11** von der Verbindung in dem parallelen Verbindungsgliedmechanismus beispielsweise aufgebracht wird, variiert der Schwenkwinkel der Verbindung, wodurch eine Last in Form einer Mischung aus radialen, Schub- und Drehmomentlasten auf jedes der Pendellager **20**, **21**, **22** des Universalgelenks **11** aufgebracht wird. Gemäss der Erfindung, da jedes der Pendellager **20**, **21**, **22** den äußeren Ring **20**b hat, der mit der im Querschnitt im wesentlichen V-förmigen Walzentransfernut **32** auf der inneren Umfangsseite der drehbaren Führungseinrichtung ausgestattet ist; den inneren Ring **20**a, der mit einer im Querschnitt im wesentlichen V-förmigen Walzentransfernut **31** auf seiner äußeren Umfangsseite geformt ist, wobei der innere Ring **20**a in den äußeren Ring **20**b eingepasst wird; und die Vielzahl von Walzen **33**, die zwischen diesen Walzentransfernuten **31**, **32** angeordnet sind und gehalten werden, so dass die Drehachsen der benachbarten Walzen sich senkrecht schneiden können, wird ein in hohem Maß steifes Universalgelenk **11** erzielbar, das in der Lage ist, die Mischung von radialen, Schub- und Momentenlasten zu stützen, erzielbar. Zudem, da die Walze **33** die Wälzbewegung zwischen den Walzentransfernuten **31**, **32** macht, ist es nicht nötig, ein Spiel zwischen dem inneren und äußeren Ring **20**a, **20**b vorzusehen, wie in dem Fall, in dem bewirkt wird, dass eine Verschiebebewegung gemacht werden soll, und dies bewirkt, dass die verlangte Präzision direkt erreichbar ist. Der Reibwiderstand wird ebenfalls durch die Wälzbewegung reduziert, so dass ein Universalgelenk **11**, das die Abnutzung minimiert und kaum Wärme erzeugt, erzielbar ist.

Gemäss einem dritten Aspekt der Erfindung ist ein Universalgelenk **11** vorgesehen, das umfasst: ein Paar von Gelenkkörpern **13**, **14**, die jeweils gegabelte Joche **12**, **15** haben; ein kreuzförmiges Element **16**, das kreuzförmige Schaftbereiche **16**a, **16**b hat, die mit den jeweiligen Jochen **12**, **15** verbunden sind; und Lager **21**, **22**, die jeweils zwischen dem Joch **12** von einem Gelenkkörper **13** und dem Schaftbereich **16**b des kreuzförmigen Elements **16** und zwischen dem Joch **15** des anderen Gelenkkörpers **13** und dem Schaftbereich **16**a, der den Schaftbereich **16**b des kreuzförmigen Elements **16** schneidet, vorgesehen sind, wobei die Lager äußere Ringe **21**b, **22**b haben, die mit einer im Querschnitt im wesentlichen V-förmigen Walzentransfernut auf der inneren Umfangsseite der drehbaren Führungseinrichtung geformt ist; innere Ringe **21**a, **22**a, die mit einer im Querschnitt im wesentlichen V-förmigen Walzentransfernut auf ihrer äußeren Umfangsseite geformt sind, wobei die inneren Ringe **21**a, **22**a in die äußeren Ringe **21**b, **22**b eingepasst werden; und eine Vielzahl von Walzen, die zwischen diesen Walzentransfernuten angeordnet sind und gehalten werden, so dass die Drehachsen von aneinandergrenzenden Walzen sich senkrecht schneiden können. Somit wurden die vorstehenden Probleme gelöst.

Gemäss der Erfindung, da die Lager **21**, **22** des Universalgelenks **11** in der Lage sind, die radialen, Schub- und Momentenlasten aufzunehmen, wie es oben festgestellt wurde, ist ein Universalgelenk, das in der Lage ist, die axiale Last aufzunehmen, erzielbar.

Gemäss einem vierten Aspekt der Erfindung ist in einem Universalgelenk **11** gemäß dem ersten bis dritten Aspekt der Erfindung der Gelenkkörper **14** in zwei Teile **14**a, **14**b geteilt, und diese Teile, die so geteilt sind, werden unabhängig voneinander in bezug auf den Schaftbereich **16**a des kreuzförmigen Elements **16** verschwenkt.

Gemäss der Erfindung, wenn ein Paar von Verbindungen in parallelen Ebenen in einem parallelen Verbindungsgliedmechanismus schwenkt, der eine sechsschaftige Verbindung beispielsweise hat, können diese Verbindungen mit den jeweiligen geteilten Gelenkkörpern **14**a, **14**b verbunden werden zu der Zeit, zu der das Paar von Verbindungen innerhalb parallelen Ebenen schwenkt, wodurch die Anzahl von Universalgelenken **11**, die für den parallelen Verbindungsgliedmechanismus notwendig ist, verringerbar wird. Obwohl die Teilung als solche bewirkte, dass die Gelenkkörper **14**a, **14**b auskragen, wird die stoßfreie Verschwenkung der Gelenkkörper **14**a, **14**b durch ein schwenkbares Einpassen von innen in die drehbare Führungseinrichtung **22** kompensiert, die in der Lage ist, die Momentenlast aufzunehmen.

Gemäss einem fünften Aspekt der Erfindung ist ein Universalgelenk **41** vorgesehen, das umfasst: eine erste drehbare Führungseinrichtung **44** und eine zweite drehbare Führungseinrichtung **51**, **52**, die drehbar durch die erste drehbare Führungseinrichtung **44** geführt wird, wobei mindestens eine der ersten und zweiten drehbaren Führungseinrichtungen **44**, **51**, **53** gekrümmte Schienen **42** hat, die mit einer vorbestimmten Krümmung geformt sind, und Wälzkörpertransferflächen **42**a, **42**b entlang der längeren Richtung; eine Gleitbasis **53**, die mit einem unendlich umlaufenden Weg geformt ist, der die belasteten Wälzkörpertansferflächen **66**a, **66**b umfasst, die den Wälzkörpertansferflächen **66**a, **66**b entsprechen, und so hergestellt ist, dass er zu einer relativen, gekrümmten Bewegung in bezug auf die gekrümmten Schienen **42** in der Lage ist; und eine Vielzahl von Wälzkörpern **60**, die in der unendlichen, umlaufenden Bahn angeordnet sind und dort gehalten werden, und die dazu gebracht werden, umlaufend sich zu bewegen, wenn die gekrümmten Schienen **42** die relative, gekrümmte Bewegung in bezug auf die Gleitbasis **43** machen.

Gemäss der Erfindung, da die drehbare Führungseinrichtung **44** die gekrümmten Schienen **42** und die Gleitbasis **43** so über die Vielzahl von Wälzkörpern **60** hergestellt hat, dass sie zu der relativen, gekrümmten Bewegung in bezug auf die gekrümmten Schienen **42** in der Lage ist, ist ein in hohem Maß steifes Universalgelenk **41** erzielbar, das in der Lage ist, die Mischung von radialen, Schub- und Momentenlasten aufzunehmen. Weiterhin, da die Walze **60** die Wälzbewegung zwischen den Walzentransferflächen **42**a, **42**b und den belasteten Wälzkörpertansferflächen **66**a, **66**b macht, ist es nicht nötig, ein Spiel zwischen den gekrümmten Schienen **42** und der Gleitbasis **43** vorzusehen, und dies macht die verlangte Präzision direkt erreichbar. Der Reibwiderstand ist ebenfalls durch die Wälzbewegung reduziert, so dass ein Universalgelenk **11**, das die Abnutzung minimiert und kaum Wärme erzeugt, erzielbar ist.

In dem Fall des Universalgelenks **41**, das so angeordnet ist, ist es nicht nur auf das Universalgelenk für die parallelen Verbindungsglieder anwendbar, sondern auch als ein Universalgelenk, das in der Lage ist, eine Rotation zu übertragen, selbst wenn der Winkel, unter dem sich die zwei Achsen schneiden, frei variiert. Die Verwendung der gekrümmten Führungseinheit **44** macht das Universalgelenk **41** erzielbar, das in der Lage ist, die Rotation stabil zu übertragen, selbst wenn axiale Last aufgebracht wird.

Gemäss einem sechsten Aspekt der Erfindung ist ein Universalgelenk **41** vorgesehen, das umfasst: eine erste drehbare Führungseinrichtung **20**, eine zweite drehbare Führungseinrichtung **44**, die drehbar durch die erste drehbare Führungseinheit **20** geführt wird, und eine dritte drehbare Führungseinrichtung **51**, **52**, die drehbar durch die zweite drehbare Führungseinrichtung **44** geführt wird, wobei das Universalgelenk drei schwenkbare Freiheitsgrade insgesamt hat, wobei mindestens eine der ersten, zweiten und dritten drehbaren Führungseinrichtungen **20**, **44**, **51**, **52** gekrümmte

Schienen hat, die mit einer vorbestimmten Krümmung geformt sind, und Wälzkörpertansferflächen **42**a, **42**b entlang der längeren Richtung; eine Gleitbasis **43**, die mit einem unendlich umlaufenden Weg geformt ist, der belastete Wälzkörpertansferflächen **66**a, **66**b umfasst, die den Wälzkörpertansferflächen **42**a, **42**b entsprechen, und so hergestellt ist, dass er in der Lage ist, eine relative, gekrümmte Bewegung in bezug auf die gekrümmten Schienen auszuführen; und eine Vielzahl von Wälzkörpern **60**, die in dem unendlich umlaufenden Weg angeordnet und gehalten sind und dazu gebracht werden, sich auf einer umlaufenden Bahn zu bewegen, wenn die gekrümmten Schienen die relative, gekrümmte Bewegung in bezug auf die Gleitbasis **43** ausführen.

Gemäss der Erfindung, da das Universalgelenk **41** drei Freiheitsgrade des Schwenkens hat, wird das Gelenk stoßfrei und glatt betätigt, so dass die Verbindungen jede dreidimensionale Lage einnehmen können, wenn die Position und Lage der Gleitbasis bestimmt sind. Wie es oben bemerkt wurde, werden zudem die radialen, Schub- und Momentenlasten auf jede der drehbaren Führungseinrichtungen **20**, **44**, **51**, **52** des Universalgelenks **41** aufgebracht. Gemäss der Erfindung, da die drehbare Führungseinrichtung **44** die gekrümmten Schienen **42** und die Gleitbasis **43** so über die Vielzahl von Wälzkörpern **60** hergestellt hat, dass sie in der Lage zu der relativen, gekrümmten Bewegung in bezug auf die gekrümmten Schienen **42** ist, ist die drehbare Führungseinrichtung **44** in der Lage, die radialen, Schub- und Bewegungslasten aufzunehmen, wobei das Universalgelenk **41**, das zur Verwendung in dem parallelen Verbindungsgliedmechanismus passend ist, erzielbar ist. Weiterhin, da die Walze **60** die Wälzbewegung zwischen den Walzentransferflächen **42**a, **42**b und den belasteten Wälzkörpertansferflächen **66**a, **66**b macht, ist es nicht nötig, ein Spiel zwischen den gekrümmten Schienen **42** und der Gleitbasis **43** vorzusehen, und dies macht die verlangte Präzision auf direktem Weg erzielbar. Der Reibungswiderstand ist ebenfalls durch die Wälzbewegung reduziert, so dass ein Universalgelenk **41**, das die Abnutzung minimiert und kaum Wärme erzeugt, erzielbar ist.

Gemäss einem siebten Aspekt der Erfindung ist in dem Universalgelenk gemäss dem fünften Aspekt der Erfindung die erste drehbare Führungseinrichtung **44** mit den gekrümmten Schienen **42** versehen, die mit der vorbestimmten Krümmung gebildet sind, und den Wälzkörpertransferflächen **42**a, **42**b entlang der längeren Richtung; die Gleitbasis **43**, die mit dem unendlichen umlaufenden Weg einschließlich der belasteten Wälzkörpertransferflächen **66**a, **66**b, die den Wälzkörpertransferflächen **42**a, **42**b entsprechen, geformt ist und so hergestellt ist, dass sie in der Lage ist, eine relative, gekrümmte Bewegung in bezug auf die gekrümmten Schienen **42** auszuführen; und die Vielzahl von Wälzkörpern **60**, die in dem unendlich umlaufenden Weg angeordnet sind und gehalten werden und dazu gebracht werden, sich auf einer umlaufenden Bahn zu bewegen, wenn die gekrümmten Schienen die relative, gekrümmte Bewegung in bezug auf die Gleitbasis **43** machen; und die zweite drehbare Führungseinrichtung **51**, **52** ist auf der inneren Umfangsseite mit den gekrümmten Schienen versehen.

Gemäss der Erfindung macht die Anordnung der zweiten drehbaren Führungseinrichtung **51**, **52** innerhalb der gekrümmten Schienen das Universalgelenk **41** verkleinerbar ebenso wie sich erwiesen hat, dass die vorher erwähnte Arbeits/Betriebswirkung erzielbar ist.

Gemäss einem achten Aspekt der Erfindung sind bei dem Universalgelenk gemäss dem ersten bis siebten Aspekt der Erfindung die Drehachsen der drehbaren Führungseinrichtungen **20**, **21**, **22** einander unter rechten Winkeln kreuzend und weiterhin schneiden sich ihre Drehachsen gegenseitig in einem Punkt.

Gemäss der Erfindung können Variationen in der Lage von jeder Verbindung, die mit dem Universalgelenk verbunden ist, behandelt werden.

KURZE BESCHREIBUNG DER ZEICHNUNGEN

Fig. 1 ist eine Vorderansicht (einschließlich einer Teilquerschnittsansicht) eines Universalgelenks in einer ersten Ausführungsform der Erfindung.

Fig. 2 ist eine Seitenansicht (einschließlich einer Teilquerschnittsansicht) des Universalgelenks aus **Fig.** 1.

Fig. 3 ist eine Draufsicht (einschließlich einer Teilquerschnittsansicht) des Universalgelenks aus **Fig.** 1.

Fig. 4 ist eine perspektivische Ansicht eines Pendelgelenks, das in das Universalgelenk einzubauen ist.

Fig. 5 ist eine Seitenansicht (einschließlich einer Teilquerschnittsansicht), die einen Zustand zeigt, in dem die Verbindungen um die Y-Achse geschwenkt sind.

Fig. 6 ist eine Seitenansicht des Universalgelenks aus **Fig.** 5:

Fig. 7 ist eine Draufsicht auf das Universalgelenk aus **Fig.** 5.

Fig. 8 ist eine Seitenansicht (einschließlich einer Teilquerschnittsansicht) eines Universalgelenks in einer zweiten Ausführungsform der Erfindung.

Fig. 9 ist eine Seitenansicht (einschließlich einer Teilquerschnittsansicht) des Universalgelenks aus **Fig.** 8.

Fig. 10 ist eine Ansicht des Universalgelenks aus **Fig.** 8.

Fig. 11 ist eine perspektivische Ansicht (einschließlich einer Teilquerschnittsansicht) einer linearen Führungseinheit.

Fig. 12 ist eine Seitenansicht eines Zustands, in dem die Verbindungen des Universalgelenks um die Y-Achse geschwenkt sind.

Fig. 13 ist eine Seitenansicht des Universalgelenks aus **Fig.** 12.

Fig. 14 ist eine Seitenansicht (einschließlich einer Teilquerschnittsansicht) eines Universalgelenks in einer dritten Ausführungsform der Erfindung.

Fig. 15 ist eine schematische Ansicht eines parallelen Verbindungsgliedmechanismus.

Fig. 16 ist eine Querschnittsansicht einer herkömmlichen kugelförmigen Lagerung.

Fig. 17 ist eine perspektivische Ansicht der herkömmlichen kugelförmigen Lagerung.

DETAILLIERTE BESCHREIBUNG DER BEVORZUGTEN AUSFÜHRUNGSFORMEN

Die vorliegende Erfindung wird nun im einzelnen unter Bezug auf die beigefügten Zeichnungen beschrieben.

Fig. 1 bis 3 zeigen ein Universalgelenk als eine erste Ausführungsform der Erfindung: **Fig.** 1 ist eine weitere Seitenansicht des Universalgelenks; **Fig.** 2 ist eine Seitenansicht davon; und **Fig.** 3 ist eine Draufsicht davon. Das Universalgelenk wird für einen parallelen Verbindungsgliedmechanismus mit einer Vielzahl von Verbindungen zwischen einer Basis und einer schwankenden Basis verwendet, wobei das Universalgelenk zwischen beiden Enden jeder Verbindung und der schwankenden Basis gehalten wird.

Wie es in **Fig.** 1 und 2 gezeigt ist, umfasst ein Universalgelenk **11** Z-Achsen-Pendellager **20** als eine erste drehbare Führungseinrichtung; Y-Achsen-Pendellager **21** als eine zweite drehbare Führungseinrichtung, die schwenkbar durch die Z-Achsen-Pendellager **20** geführt wird, und X-Achsen-Pendellager **22** als eine dritte schwenkbare Führungseinrichtung, die schwenkbar durch die Y-Achsen-Pendellager **21** geführt wird. Weiterhin ist das Universalgelenk **11** mit einer Pendellagermontageplatte **13** als ein Gelenkkörper geformt, die ein gegabeltes Joch **12** hat, einer Verbindung als dem anderen Gelenkkörper, der ein gegabeltes Joch **15** hat, und einem kreuzförmigen Element **16** (siehe **Fig.** 3), das kreuzförmige Schaftbereiche **16**a und **16**b hat, die mit den Jochen **12** und **15** zu verbinden sind. Das Z-Achsen-Pendellager **20** ist an dem unteren Ende der Pendellagermontageplatte **13** aufgepasst; das Y-Achsen-Pendellager **21** ist zwischen dem Joch **12** und dem koaxialen Schaftbereich **16**b des kreuzförmigen Elements **16** vorgesehen; und das X-Achsen-Pendellager **22** ist zwischen dem Joch **15** und dem koaxialen Schaftbereich **16**a des kreuzförmigen Elements **16** vorgesehen. Die Drehachsen der Pendellager kreuzen sich unter rechten Winkeln gegenseitig und zudem sind die X-, Y- und Z-Achsen so gerichtet, dass sie einander im Punkt P schneiden. Somit hat das Universalgelenk **11** drei Freiheitsgrade des Schwenkens insgesamt.

Wie es in **Fig.** 2 gezeigt ist, hat die Pendellagermontageplatte **13** das gegabelte Joch **12** an ihrer Seite des vorderen Endes und einen ringartigen Verbindungsbereich **17** an ihrer Basisseite, mit dem das Joch **12** verbunden ist. Der Verbindungsbereich **17** ist an dem inneren Ring **20**a des Z-Achsen-Pendellagers **20** befestigt. Der äußere Ring **20**b des Z-Achsen-Pendellagers **20** ist an der Basis des parallelen Verbindungsgliedmechanismus beispielsweise befestigt. Die Pendellagermontageplatte **13** ist um 360° um die Z-Achse schwenkbar in bezug auf die Basis angebracht.

Wie es in **Fig.** 3 gezeigt ist, hat das kreuzförmige Element **16** die Schaftbereiche **16**a und **16**b in der Gestalt eines Kreuzes angebracht. Der Schaftbereich **16**a entspricht mit seiner mittleren Achse der X-Achse, wohingegen der Schaftbereich **16**b mit seiner mittleren Achse der Y-Achse, senkrecht zur X-Achse, entspricht. Ein Paar von Y-Achsen-Pendellagern **21** ist zwischen dem Schaftbereich **16**b und dem Joch **12** vorgesehen. Wie es in **Fig.** 2 gezeigt ist, ist der innere Ring **21**a von jedem Y-Achsen-Pendellager **21** an dem Schaftbereich **16**b angebracht, wohingegen dessen äußerer Ring **21**b an dem Joch **12** befestigt ist. Weiterhin ist das kreuzförmige Element **16** schwenkbar auf der Y-Achse in bezug auf das Joch **12** eingerichtet.

Wie es in **Fig.** 1 gezeigt ist, hat eine Verbindung **14** ebenfalls ein gegabeltes Joch **15** an ihrer vorderen Endseite (der unteren Seite in **Fig.** 1) und einen Verbindungsbereich **25** zum Verbinden des Jochs mit seiner Basisbereichsseite (der oberen Seite darin). Ein Paar von X-Achsen-Pendellagern **22** ist zwischen dem kreuzförmigen Element **16** und dem Schaftbereich **16**a vorgesehen. Der innere Ring **22**a des X-Achsen-Pendellagers **22** ist an dem Schaftbereich **16**a befestigt, wohingegen der äußere Ring davon an dem Joch **15** befestigt ist. Weiterhin ist die Verbindung **14** schwenkbar auf der X-Achse in bezug auf das kreuzförmige Element **16** eingerichtet. Weiterhin kann die Verbindung **14** seitlich in zwei Teile geteilt sein. In diesem Fall sind die Verbindungen **14**a und **14**b, die von der Teilung in die zwei Teile resultieren, an den jeweiligen X-Achsen-Pendellagern **22** angepasst und schwenkbar um die X-Achse in bezug auf den Schaftbereich **16**a unabhängig voneinander (siehe **Fig.** 2).

Fig. 4 zeigt das Z-Achsen-Pendellager **20**. Da alle der Pendellager im wesentlichen die gleiche Konstruktion aufweisen, wird das Z-Achsen-Pendellager **20** als ein repräsentatives Beispiel beschrieben. Das Z-Achsen-Pendellager **20** hat den äußeren Ring **20** mit einer im Querschnitt im wesentlichen 90°-V-förmigen Walzentransfernut **32** auf seiner inneren Umfangsseite geformt, den inneren Ring **20**a in den äußeren Ring **20**b mit einer in im Querschnitt im wesentlichen 90°-V-förmigen Walzentransfernut **31** auf dessen äußerer Umfangsseite in den äußeren Ring **20**b eingepasst, und eine Vielzahl von Walzen **33**, die zwischen diesen Walzentransfernuten **31** und **32** angeordnet sind und dort gehalten werden (siehe **Fig.** 1).

Ein im Querschnitt im wesentlichen quadratischer Walzentransferweg ist mit den V-förmigen Walzentransfernuten **31** und **32** geformt, die in den jeweiligen äußeren und inneren Ringen **20**a und **20**b geformt sind. Die Vielzahl von Walzen **33** sind in dem Walzentransferweg angeordnet und werden dort gehalten, so das die Schwenkachsen von benachbarten sich unter rechten Winkeln treffen können. Ein Abstandshalter **34** zum Halten der Walzen **33** in der vorbestimmten Lage wird zwischen den benachbarten Walzenn **33** gehalten. In dem Walzentransferweg kreuzen sich die seitlich benachbarten Walzen **33** des Abstandshalters **34** und ihre Achsen unter rechten Winkeln und sind in nach außen und nach innen gerichtete Walzen **33**a und **33**b aufgeteilt. Die nach außen gerichtete Walze **33**a wird so gehalten, dass ihre Achse C so gehalten wird, dass sie auf das Drehzentrum B, das auf den Drehmittellinien des äußeren und inneren Rings **20**b und **20**a positioniert ist, gerichtet sein kann. Die nach innen gerichtete Walze **33**b wird ebenfalls so gehalten, dass ihre Achse D so ausgerichtet sein kann, dass sie auf das Drehzentrum A, das auf der Drehmittellinie davon positioniert ist, gerichtet ist. Wenn die Walzen **33**a und **33**b transferiert werden, wobei sie Lasten aufnehmen, werden die Achsen der Walzen **33**a, **33**b senkrecht zu dem verbindungsartigen Walzentransferweg gehalten, und jede der Walzen **33**a und **33**b wird transferiert, wobei sie ein gleichmäßiges Verschieben beibehält.

Da jedes Z-Achsen-Pendellager **20** so ist, dass die Drehachsen der benachbarten Walzen, die sich wechselweise unter rechten Winkeln treffen, in den 90° V-förmigen Walzentransfernuten **31** und **32**, wie es oben beschrieben wurde, angeordnet sind, kann es eine Last in jeder Richtung aufnehmen, wie eine radiale Last, eine Schub- und eine Momentenlast.

Fig. 5 bis 7 zeigen einen Zustand, in dem das Universalgelenk gedreht worden ist. **Fig.** 5 ist eine Seitenansicht, wobei das Universalgelenk um 60° um die Y-Achse geschwenkt ist; **Fig.** 6, eine Seitenansicht von **Fig.** 5; und **Fig.** 7 eine Draufsicht auf **Fig.** 5. Wie es in **Fig.** 5 gezeigt ist, wird der Pendellagermontageplatte **13**, die auf dem Z-Achsen-Pendellager montiert ist, gestattet, sich um 360° frei um die Z-Achse zu drehen. Weiterhin, da das Joch **12** der Pendellagermontageplatte **13** und das Joch **15** der Verbindung **14** durch das kreuzförmige Element **16** miteinander verbunden sind, ist es möglich, einen Schwenkwinkel auf der Y-Achse sicherzustellen und um die X-Achse bis zu ±60° zu drehen. Somit hat das Universalgelenk **11** drei Freiheitsgrade des Schwenkens um die X-, Y- und Z-Achse, wobei das Universalgelenk **11** stoßfrei und glatt betätigt wird, wenn die Position und Lage der schwankenden Basis des parallelen Verbindungsgliedmechanismus beispielsweise bestimmt sind. Weiterhin, da das Universalgelenk **11** einen großen Schwenkwinkel auf jeder der X-, Y- und Z-Achsen hat, ist die schwankende Basis fähig, sich in einem breiten Bereich zu bewegen. In dem parallelen Verbindungsgliedmechanismus, genau genommen, hat die schwankende Basis sechs Freiheitsgrade unter der Bedingung, dass das Universalgelenk an beiden Enden der Verbindungen insgesamt fünf Freiheitsgrade hat. Daher werden die Universalgelenke an beiden Enden der Verbindungen benötigt, um mindestens fünf Freiheitsgrade insgesamt zu haben, und in einem Fall, in dem das Universalgelenk auf der Basisseite drei Freiheitsgrade hat, muss das Universalgelenk auf der Seite der schwankenden Basis nur zwei Freiheitsgrade aufweisen.

Wenn eine axiale Last auf das Universalgelenk **11** von der Verbindung **14** aufgebracht wird, variiert der Schwenkwinkel der Verbindung **14**, wodurch eine Last als eine Mischung von radialen, Schub- und Momentenlasten auf jedes der Pendellager **20**, **21** und **22** des Universalgelenks **11** aufgebracht wird. Da jedoch jedes der Pendellager **20**, **21** und **22** wie oben erwähnt geformt ist, kann die Mischung der radialen, Schub- und Momentenlasten auf die Pendellager aufgebracht werden. Weiterhin, da die Walze **33** die Wälzbewegung zwischen den Walzentransfernuten **31** und **32** macht, ist es nicht nötig, ein Spiel zwischen dem inneren und äußeren Ring **20**a und **20**b vorzusehen, wie in dem Fall, in dem die Verschiebebewegung bewirkt wird, und dies macht die verlangte Präzision direkt erreichbar. Der Reibungswiderstand ist ebenfalls durch die Wälzbewegung reduziert, so dass ein Universalgelenk, das die Abnutzung minimiert, und kaum Wärme erzeugt, erreichbar ist.

Wenn ein Paar von Verbindungen in parallelen Ebenen in einem parallelen Verbindungsgliedmechanismus, der z. B. eine sechsschaftige Verbindung hat, schwenkt, kann jede Verbindung mit geteilten Verbindungen **14**a und **14**b verbunden sein, wenn das Paar von Verbindungen innerhalb paralleler Ebenen verschwenkt wird. In diesem Fall können zwei Verbindungen mit einem Universalgelenk **11** verbunden werden, wodurch die Anzahl von Universalgelenken **11**, die für den parallelen Verbindungsgliedmechanismus notwendig sind, verringerbar ist. Obwohl die geteilten Verbindungen **14**a und **14**b vorstehen sollen, wird das stoßfreie Verschwenken der Verbindungen **14**a und **14**b ausgeglichen, indem die Verbindungen an dem Pendellager, das in der Lage ist, die Momentenlast aufzunehmen, schwenkbar aufgepasst werden.

Fig. 8 bis 10 zeigen ein Universalgelenk **41** in einer zweiten Ausführungsform der Erfindung. **Fig.** 8 ist eine Seitenansicht des Universalgelenks **41**; **Fig.** 9 ist eine Seitenansicht aus **Fig.** 8; und **Fig.** 10 ist eine Draufsicht aus **Fig.** 8. Das Universalgelenk **41** hat ebenfalls drei drehbare Führungseinrichtungen, wie im Fall des Universalgelenks **11** in der ersten Ausführungsform der Erfindung, und drei Freiheitsgrade des Schwenkens. Die Drehachsen der jeweiligen drehbaren Führungseinrichtungen kreuzen sich gegenseitig unter rechten Winkeln und weiterhin sind die X-, Y- und Z-Achse so gerichtet, dass sie sich gegenseitig in einem Punkt P schneiden. Somit hat das Universalgelenk **14** insgesamt drei Freiheitsgrade des Schwenkens. Das Universalgelenk **41** unterscheidet sich von dem Universalgelenk **11** in der ersten Ausführungsform der Erfindung dahingehend, dass die zweite drehbare Führungseinrichtung mit gekrümmten Führungseinheiten **44** geformt ist, die gekrümmte Schienen und Gleitbasen **43** zum Durchführen einer gekrümmten Bewegung relativ zu den gekrümmten Schienen **42** hat. Um die Gesamtgröße des Universalgelenks **41** zu verringern, befindet sich die dritte drehbare Führungseinrichtung in den gekrümmten Schienen **41**. Die gekrümmte Führungseinheit **44**, als die zweite gekrümmte Führungseinrichtung, ist drehbar durch das Z-Achsen-Pendellager **20** als die erste drehbare Einrichtung geführt, und ein X-Achsen-Pendellager **46** als die dritte drehbare Führungseinrichtung ist schwenkbar durch die gekrümmte Führungseinheit **44** geführt.

Da das Z-Achsen-Pendellager **20** in der Konstruktion ähnlich dem Z-Achsen-Pendellager **20** der ersten Ausführungsform der Erfindung ist, sind gleiche Referenzziffern für die gleichen Bauteile des Pendellagers vergeben, wobei deren Beschreibung ausgelassen wird.

Ein Verbindungsring **45** ist an dem inneren Ring **20**a des Z-Achsen-Pendellagers **20** befestigt, und eine bogenförmige Montageplatte **48** für die Gleitbasis in einer Seitenansicht ist stehend in dem Verbindungsring **45** vorgesehen. Wie es in **Fig.** 9 gezeigt ist, ist ein Paar von gekrümmten Führungseinheiten **44** in die jeweils gegenüberliegenden inneren Wandoberflächen von den Pendellagermontageplatten eingepasst. Insbesondere ist die Gleitbasis **43** der gekrümmten Führungseinheit **44** an der Gleitbasismontageplatte **48** befestigt. Es sind eine Vielzahl von Gleitbasen vorgesehen, beispielsweise sind zwei Gleitbasen für die jeweiligen gekrümmten Schienen **42** vorgesehen. Ein Paar von gekrümmten Schienen ist durch eine Schienenmontageplatte **41** verbunden, so dass die gekrümmten Schienen **42** und die Schienenmontageplatte **49** die gekrümmte Bewegung auf der Y-Achse durchführen können.

Wie es in **Fig.** 8 gezeigt ist, ist ein Schaftbereich **50**, der sich in der Richtung der X-Achse erstreckt, an der Schienenmontageplatte **49** befestigt. Verbindungen **53**a und **53**b sind an dem Schaftbereich **50** über X-Achsen-Pendellager **51** und **52** angebracht, so dass sie axial Seite an Seite platziert sind. Zwei Schichten von im Querschnitt V-förmigen Walzentransfernuten sind auf dem äußeren Umfang eines im Durchmesser vergrößerten Orts in der Nähe der Mitte des Schaftbereichs **50** geformt, und innere Ringe **51**a und **52**a, die die X-Achsen-Pendellager **51** und **52** bilden, sind integral damit geformt. Äußere Ringe **51**b und **52**b, an denen V-förmige Walzentransfernuten auf der inneren Umfangsseite geformt sind, sind zusammenpassend mit den äußeren Umfängen der inneren Ringe **51**a und **52**a. Die Drehachsen von einer Vielzahl von benachbarten Walzen **54**, die sich wechselweise unter rechten Winkeln treffen, sind angeordnet und werden gehalten zwischen den Walzentransfernuten, wie es oben beschrieben worden ist. Die Verbindungen **53**a und **53**b können unabhängig voneinander, wie die Verbindungen **14**a und **14**b in der ersten Ausführungsform der Erfindung, gedreht werden oder integral gedreht werden.

Fig. 11 zeigt eine Anordnung im einzelnen von der gekrümmten Führungseinheit. In **Fig.** 11 bezeichnet Referenzziffer **42** bogenförmige, gekrümmte Schienen, die mit einer vorbestimmten Krümmung geformt sind; 43 Gleitbasen, die entlang der gekrümmten Schienen bewegbar sind. Es ist zu bemerken, dass obwohl die Gleitbasen in einer linearen Form gezeigt sind, sie tatsächlich gekrümmt sind.

Die gekrümmten Schienen **42** sind rechteckig im Querschnitt und vier der Kugeltransfernuten **42**a und **42**b als Wälzkörpertansferflächen zur Verwendung beim Transferieren von Kugeln **60** als Wälzkörper sind entlang der längeren Richtung geformt. Diese Kugeltransfernuten **42**a und **42**b sind auf beiden Seiten von jeder gekrümmten Schiene **42** geformt und an beiden Kantenbereichen von ihrer Oberfläche. Weiterhin sind die gekrümmten Schienen **42** mit Bolzenpasslöchern **61** in geeigneten Intervallen in der längeren Richtung geformt, und die gekrümmten Schienen **42** sind an der Schienenmontageplatte **49** mit Fixierbolzen (nicht gezeigt) befestigt, die in die Bolzenpasslöcher **61** eingeführt sind.

Die Gleitbasis **43** ist mit einem sich bewegenden Block **63** geformt, der Bohrungslöcher **62** hat, und ein Paar von Deckelkörpern **64** und **64**, die jeweils an beiden Kantenflächen in Längsrichtung des sich bewegenden Blocks befestigt sind, so dass ein unendlich umlaufender Weg für die Kugeln in der Gleitbasis **43** geformt wird, indem die Deckelkörper **64** an dem sich bewegenden Block **63** befestigt werden. Weiterhin ist ein Dichtelement **65**, das in einen verschiebbaren Kontakt mit den gekrümmten Schienen **42** gebracht ist, in die Deckelkörper **64** eingepasst, um zu verhindern, dass Staub und ähnliches, das an den gekrümmten Schienen **42** haftet, in die Gleitbasis **43** eindringt.

Der sich bewegende Block **63** ist mit einem horizontalen Bereich **63**a versehen, der mit einer Montagefläche geformt ist, und einem Paar von Randbereichen **63**b und **63**b, die von dem horizontalen Bereich **63**a hängen und im Querschnitt im wesentlichen sattelförmig sind. Weiterhin sind gekrümmte Lasttransfernuten **66**a und **66**b als Transferflächen von vier Lastwälzkörpern geformt, die in Richtung auf die jeweiligen Kugeltransfernuten **42**a und **42**b der gekrümmten Schienen **42** gerichtet sind, auf der unteren Oberflächenseite des horizontalen Bereichs **63**a und den inneren Oberflächenseiten der jeweiligen Randbereiche **63**b. Weiterhin sind Kugelrückkehrlöcher **67**a und **67**b, die den jeweiligen Lasttransfernuten **66**a und **66**b entsprechen, in dem horizontalen Bereich **63**a und den Randbereichen **63**b geformt. Die Lasttransfernuten **66**a und **66**b sind mit den entsprechenden Kugelrückkehrlöchern **67**a und **67**b durch einen U-förmigen, die Richtung ändernden Weg verbunden, der in den Deckelkörpern **64** geformt ist, wodurch der unendlich umlaufende Weg für die Kugeln gebildet wird.

Wenn die Kugeln **60**, die die Last zwischen den Kugeltransfernuten **42**a und **42**b der gekrümmten Schienen **42** verteilt haben und den Lasttransfernuten **66**a und **66**b des sich bewegenden Blocks **63**, die Transferbewegung durch die Lasttransfernuten **66**a und **66**n vervollständigt haben, wenn sich die Gleitbasis **43** bewegt, werden die Kugeln von der Last frei gegeben und dringen in den die Richtung ändernden Weg von einem der Deckelkörper **64** ein. Weiterhin machen die Kugeln **60**, die in dem Nichtlastzustand verbleiben, die Transferbewegung durch die Kugelrückkehrlöcher **67**a und **67**b des sich bewegenden Blocks **63** in einer Richtung entgegengesetzt zu der Transferrichtung in den Lasttransfernuten **66**a und **66**b. Weiterhin dringen die Kugeln **60**, die die Transferbewegung durch die Kugelrückkehrlöcher **67**a und **67**b vervollständigt haben, wer zwischen der gekrümmten Schiene und dem sich bewegenden Block **63** über den die Richtung ändernden Weg des anderen Deckelkörpers **64** ein und führen die Transferbewegung durch die Lasttransfernuten **66**a und **66**b aus, wobei sie die Last aufnehmen.

Kugelhalteplatten **68** sind an den unteren Enden der jeweiligen Randbereiche **63**b des sich bewegenden Blocks **63** montiert. Die Kugelhalteplatte **68** ist eine Metallplatte, die geformt wird, indem sie gepresst wird oder die aus hartem Kunstharz durch Spritzguss gefertigt wird, wodurch verhindert wird, dass die Kugeln **60**, die die Transferbewegung durch jede der Lasttransfernuten **66**a und **66**b machen, aus der Gleitbasis **63** rutschen, wenn die Gleitbasis **43** von den gekrümmten Schienen **42** entfernt wird.

Fig. 12 und 13 zeigen die Schwenkwinkel um die X-, Y- und Z-Achsen des Universalgelenks **41**. **Fig.** 12 zeigt einen Zustand, in dem die Verbindungen **53**a und **53**b um 60° um die Y-Achse verschwenkt sind; und **Fig.** 13 zeigt eine Seitenansicht aus **Fig.** 12. Da die gekrümmte Führungseinheit **44** auf dem Z-Achsen-Pendellager **20** montiert ist, wie es in **Fig.** 12 gezeigt ist, ist sie um 360° um die Z-Achse schwenkbar. Die X-Achsen-Pendellager **51** und **52** sind an den gekrümmten Schienen **42** angepasst, und da die gekrümmten Schienen **42** in bezug auf die Gleitbasis **43** gedreht werden, sind die X-Achsen-Pendellager **51** und **52** um die Y-Achse bis zu ±60° schwenkbar. Wie es in **Fig.** 13 weiterhin gezeigt ist, sind die Verbindungen an dem Schaftbereich **50** über die X-Achsen-Pendellager **51** und **52** befestigt, wodurch die Verbindungen um die X-Achse bis zu ±60° verschwenkt werden. Somit ist es möglich, obwohl die drehbare Führungseinheit mit der gekrümmten Führungseinheit **55** geformt ist, den Schwenkwinkel auf jeder Achse ausreichend größer als in dem Universalgelenk **11** in der ersten Ausführungsform der Erfindung zu machen.

In dem Universalgelenk **41** gemäss dieser Ausführungsform der Erfindung wird die zweite drehbare Führungseinheit hergestellt, indem die Vielzahl von Kugeln **60** in bezug auf die gekrümmten Schienen **42** zusammen mit der Gleitbasis **43** verwendet werden, die die relative, gekrümmte Bewegung ausführt, so dass sie die radialen, Schub- und Momentenlasten aufnehmen können. Somit ist ein Universalgelenk **41**, das zur Verwendung in dem parallelen Verbindungsgliedmechanismus passend ist, erreichbar. Da die Kugeln **60** die Wälzbewegung zwischen den Kugeltransfernuten **42**a und **42**b der gekrümmten Schienen **42** und den Lasttransfernuten **66**a und **66**b der Gleitbasis **43** machen, ist es nicht notwendig, ein Spiel zwischen den gekrümmten Schienen **42** und der Gleitbasis vorzusehen, und dies macht es möglich, dass die verlangte Präzision direkt erreichbar ist. Weiterhin wird der Reibungswiderstand ebenfalls durch die Wälzbewegung reduziert und folglich ist ein Universalgelenk, das die Abnutzung minimiert und kaum Wärme erzeugt, erzielbar.

Obwohl die Beschreibung von dem Fall gegeben worden ist, in dem das Universalgelenk **41** verwendet wird, das die drei Freiheitsgrade hat, für den parallelen Verbindungsgliedmechanismus in der zweiten Ausführungsform der Erfindung, ist solch ein Universalgelenk **41** auch für das zu verwenden, was in der Lage ist, eine Rotation zu übertragen, selbst wenn der Winkel, unter dem die zwei Achsen des Universalgelenks sind, frei variiert. In diesem Fall ist es möglich, ein Universalgelenk zu erzielen, das in der Lage ist, eine Rotation stabil zu übertragen, selbst wenn eine axiale Last darauf aufgebracht wird, indem das Universalgelenk nur mit der gekrümmten Führungseinheit **44** und den X-Achsen-Pendellagern **51** und **52** geformt wird, ohne das Z-Achsen-Pendellager **20** zu verwenden, wobei ein Eingangsschaft mit der Seite der Gleitbasenmontageplatte **48** verbunden wird und ein Ausgangsschaft an der Seite der Verbindungen **53**a und **53**b angebracht wird.

Fig. 14 zeigt ein Universalgelenk **71** in einer dritten Ausführungsform der Erfindung. Obwohl das Universalgelenk **71** im wesentlichen gleich in der Konstruktion mit dem Universalgelenk **41** in der zweiten Ausführungsform der Erfindung ist, unterscheidet sich das erstere von dem letzteren in der Länge der gekrümmten Schienen **72** der gekrümmten Führungseinheit **74** und dem Abstand zwischen den Gleitbasen **43**. Die gekrümmten Schienen **72** sind kürzer gemacht als die gekrümmten Schienen **42** in der zweiten Ausführungsform der Erfindung und halbkreisförmig, um den Raum zu verringern. Weiterhin ist der Abstand zwischen den Gleitbasen ebenfalls kürzer, um den Schwenkwinkel des X-Achsen-Pendellagers bis zu ±60° sicherzustellen, obwohl die Breite der gekrümmten Schiene kürzer gemacht wird. Da die verbleibende Anordnung ähnlich zu derjenigen des Universalgelenks **41** in der zweiten Ausführungsform der Erfindung ist, sind gleiche Referenzziffern denselben Komponententeilen in der zweiten Ausführungsform gegeben, wobei deren Beschreibung ausgelassen wird.

Obwohl die Universalgelenke **11**, **41** und **71** auf den parallelen Verbindungsgliedmechanismus aufgebracht werden, wie es in der ersten bis dritten Ausführungsform der Erfindung beschrieben worden ist, sind die Universalgelenke **11**, **41** und **71** gemäss der Erfindung nicht nur auf den parallelen Verbindungsgliedmechanismus anwendbar, sondern auch auf verschiedene andere Mechanismen, solange diese anderen Mechanismen so sind, dass eine Vielzahl von Freiheitsgraden des Schwenkens für solche Universalgelenke **11**, **41** und **71** verlangt wird.

Wie es oben erläutert wurde, wird gemäss der Erfindung, da das Universalgelenk drei Freiheitsgrade des Schwenkens hat, das Universalgelenk stoßfrei und glatt betätigt, wenn die Position und Lage in dem parallelen Verbindungsgliedmechanismus beispielsweise festgelegt sind.

Da das Universalgelenk mit dem Paar von Verbindungskörpern geformt ist, die jeweils die gegabelten Joche haben, kann weiterhin ein großer Auslenkwinkel von dem Paar von

Verbindungskörpern sichergestellt werden, wodurch der Schwenkwinkel der Verbindung in dem parallelen Verbindungsgliedmechanismus beispielsweise vergrößerbar wird.

Weiterhin, da die schwenkbare Führungseinrichtung den äußeren Ring mit den im Querschnitt im wesentlichen V-förmigen Walzentransfernuten auf der inneren Umfangsseite der schwenkbaren Führungseinrichtung hat; den inneren Ring mit den im Querschnitt im wesentlichen V-förmigen Walzentransfernuten auf der äußeren Umfangsseite davon hat, wobei der innere Ring in den äußeren Ring eingepasst ist; und die Vielzahl von Walzen, die zwischen diesen Walzentransfernuten angeordnet sind und gehalten werden, so dass die Schwenkachsen der benachbarten sich senkrecht gegenseitig schneiden können, ist solch ein Universalgelenk in der Lage, die Mischung von radialen, Schub- und Momentenlasten aufzunehmen.

Patentansprüche

1. Universalgelenk, umfassend:
eine erste drehbare Führungseinrichtung;
eine zweite drehbare Führungseinrichtung, die drehbar durch die erste drehbare Führungseinrichtung geführt wird; und
eine dritte drehbare Führungseinrichtung, die drehbar durch die zweite drehbare Führungseinrichtung geführt wird, wobei das Universalgelenk drei Freiheitsgrade des Schwenkens insgesamt hat;
wobei das Universalgelenk ein Paar von Gelenkkörpern umfasst, die jeweils gegabelte Joche haben, und ein kreuzförmige Element, das kreuzförmige Schaftbereiche hat, die mit den jeweiligen Jochen verbunden sind; die zweite drehbare Führungseinrichtung zwischen dem Joch von einem Gelenkkörper und dem Schaftbereich des kreuzförmigen Elements vorgesehen ist; die dritte drehbare Führungseinrichtung zwischen dem Joch des anderen Gelenkkörpers und dem Schaftbereich vorgesehen ist, der den Schaftbereich des kreuzförmigen Elements schneidet; und die erste drehbare Führungseinrichtung an einem von dem Paar von Gelenkkörpern vorgesehen ist.

2. Universalgelenk nach Anspruch 1, wobei mindestens eine der ersten, zweiten und dritten drehbaren Führungseinrichtung einen äußeren Ring hat, der mit einer im Querschnitt im wesentlichen V-förmigen Walzentransfernut auf der inneren Umfangsseite der drehbaren Führungseinrichtung geformt ist; einen inneren Ring, der mit einer im Querschnitt im wesentlichen V-förmigen Walzentransfernut auf seiner äußeren Umfangsseite geformt ist, wobei der innere Ring in den äußeren Ring eingepasst ist; und eine Vielzahl von Walzen, die zwischen diesen Walzentransfernuten angeordnet sind und gehalten werden, so dass die Drehachsen der benachbarten Walzen einander senkrecht schneiden.

3. Universalgelenk, umfassend: ein Paar von Gelenkkörpern, die jeweils gegabelte Joche haben;
ein kreuzförmiges Element, das kreuzförmige Schaftbereiche hat, die mit den jeweiligen Jochen verbunden sind; und
Lager, die jeweils zwischen dem Joch von einem Gelenkkörper und dem Schaftbereich des kreuzförmigen Elements und zwischen dem Joch des anderen Gelenkkörpers und dem Schaftbereich, der den Schaftbereich des kreuzförmigen Elements schneidet, vorgesehen sind;
wobei die Lager äußere Ringe haben, die mit einer im Querschnitt im wesentlichen V-förmigen Walzentransfernut auf der inneren Umfangsseite der drehbaren Führungseinrichtung geformt sind; innere Ringe, die mit einer im Querschnitt im wesentlichen V-förmigen Walzentransfernut auf ihrer äußeren Umfangsseite geformt sind, wobei der innere Ring in den äußeren Ring eingepasst ist; und eine Vielzahl von Walzen, die zwischen diesen Walzentransfernuten angeordnet sind und gehalten werden, so dass die Drehachsen der benachbarten Walzen einander senkrecht schneiden können.

4. Universalgelenk nach Anspruch 1, wobei der Gelenkkörper in zwei Teile geteilt ist und diese so geteilten Teile unabhängig voneinander in bezug auf den Schaftbereich des kreuzförmigen Elements verschwenkt werden.

5. Universalgelenk, umfassend:
eine erste drehbare Führungseinrichtung; und
eine zweite drehbare Führungseinrichtung, die drehbar durch die erste drehbare Führungseinrichtung geführt wird;
wobei zumindest eine der ersten und zweiten drehbaren Führungseinrichtungen gekrümmte Schienen hat, die mit einer vorbestimmten Krümmung geformt sind und Wälzkörpertransferflächen entlang der längeren Richtung; eine Gleitbasis, die mit einem unendlich umlaufenden Weg geformt ist, einschließlich belasteten Wälzkörpertransferflächen, die den Wälzkörpertransferflächen entsprechen, und so hergestellt ist, dass sie eine relative, gekrümmte Bewegung in bezug auf die gekrümmten Schienen durchführen kann; und eine Vielzahl von Wälzkörpern, die angeordnet sind und gehalten werden in dem unendlich umlaufenden Weg und dazu gebracht werden, sich auf einer umlaufenden Bahn zu bewegen, wenn die gekrümmten Schienen die gekrümmte Relativbewegung in bezug auf die Gleitbasis durchführen.

6. Universalgelenk, umfassend:
eine erste drehbare Führungseinrichtung;
eine zweite drehbare Führungseinrichtung, die drehbar durch die erste drehbare Führungseinrichtung geführt wird; und
eine dritte drehbare Führungseinrichtung, die drehbar durch die zweite drehbare Führungseinrichtung geführt wird, wobei das Universalgelenk drei Freiheitsgrade des Schwenkens insgesamt hat;
wobei zumindest eine der ersten, zweiten und dritten drehbaren Führungseinrichtungen gekrümmte Schienen hat, die mit einer vorbestimmten Krümmung geformt sind, und Wälzkörpertransferflächen entlang der längeren Richtung; eine Gleitbasis, die mit einem unendlich umlaufenden Weg einschließlich belasteten Wälzkörpertransferflächen geformt ist, die den Wälzkörpertransferflächen entsprechen, und so hergestellt ist, dass sie eine gekrümmte Relativbewegung in bezug auf die gekrümmten Schienen durchführen kann; und eine Vielzahl von Wälzkörpern, die in der unendlich umlaufenden Bahn angeordnet sind und gehalten werden und dazu gebracht werden, sich auf der umlaufenden Bahn zu bewegen, wenn die gekrümmten Schienen die gekrümmte Relativbewegung in bezug auf die Gleitbasis machen.

7. Universalgelenk nach Anspruch 5, wobei die erste drehbare Führungseinrichtung die gekrümmten Schienen hat, die mit der vorbestimmten Krümmung geformt sind, und Wälzkörpertransferflächen entlang der längeren Richtung; die Gleitbasis, die mit dem unendlichen kreisförmigen Weg geformt ist, einschließlich der belasteten Wälzkörpertransferflächen, die den Wälzkörpertransferflächen entsprechen, und so herge-

stellt ist, dass sie in der Lage ist, die gekrümmte Relativbewegung in bezug auf die gekrümmten Schienen durchzuführen; und eine Vielzahl von Wälzkörpern, die in dem unendlich umlaufenden Weg angeordnet sind und gehalten werden und dazu gebracht werden, sich auf der umlaufenden Bahn zu bewegen, wenn die gekrümmte Schiene die gekrümmte Relativbewegung in bezug auf die Gleitbasis ausführt; und wobei die zweite drehbare Führungseinrichtung auf der inneren Umfangsseite der gekrümmten Schienen vorgesehen ist.

8. Universalgelenk nach einem der Ansprüche 1 bis 7, wobei die Drehachsen der drehbaren Führungseinrichtungen sich unter rechten Winkeln gegenseitig schneiden und weiterhin die Drehachsen sich gegenseitig in einem Punkt schneiden.

Hierzu 14 Seite(n) Zeichnungen

- Leerseite -

Nummer: DE 100 58 317 A1
Int. Cl.[7]: F 16 C 11/06
Offenlegungstag: 31. Mai 2001

FIG. 1

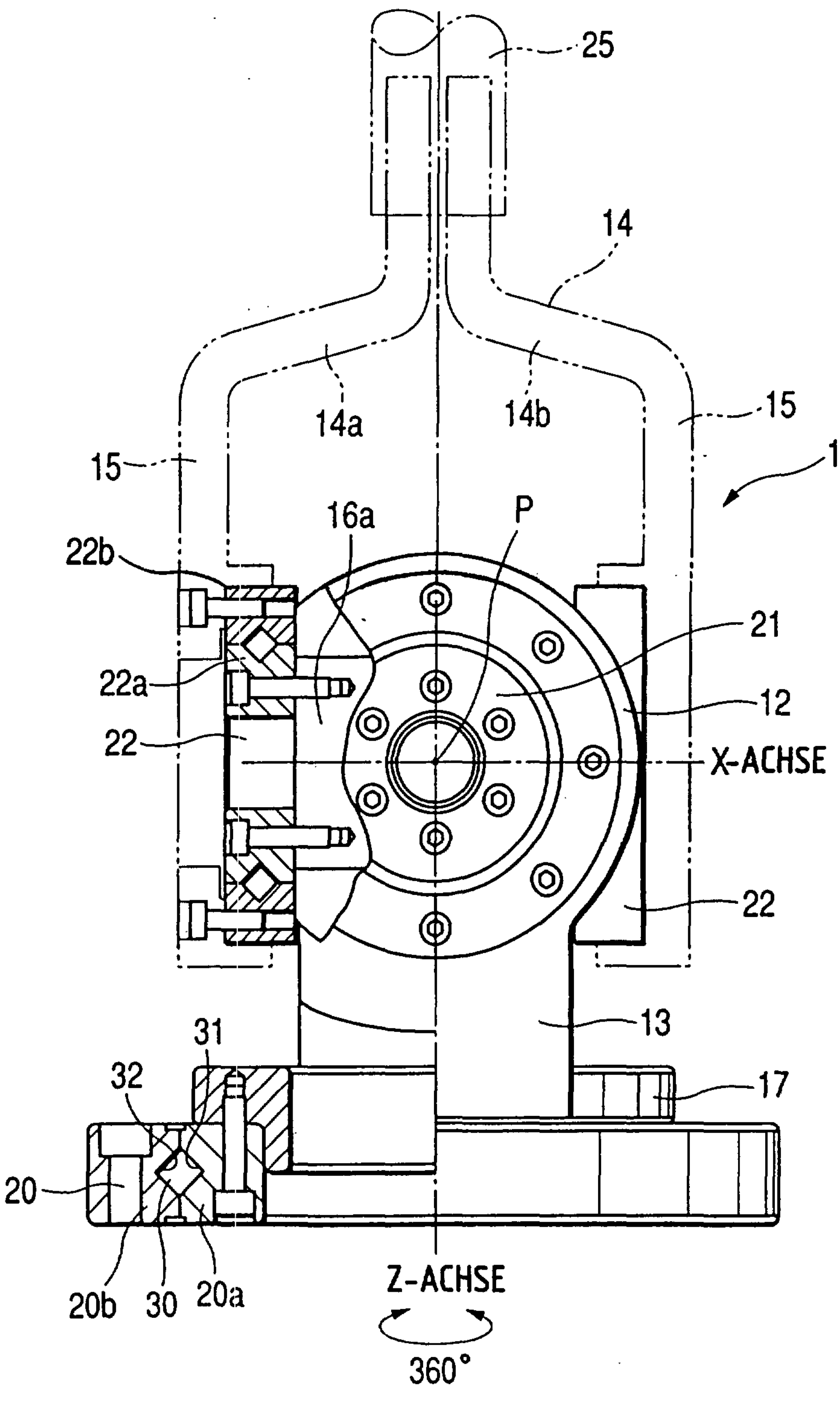
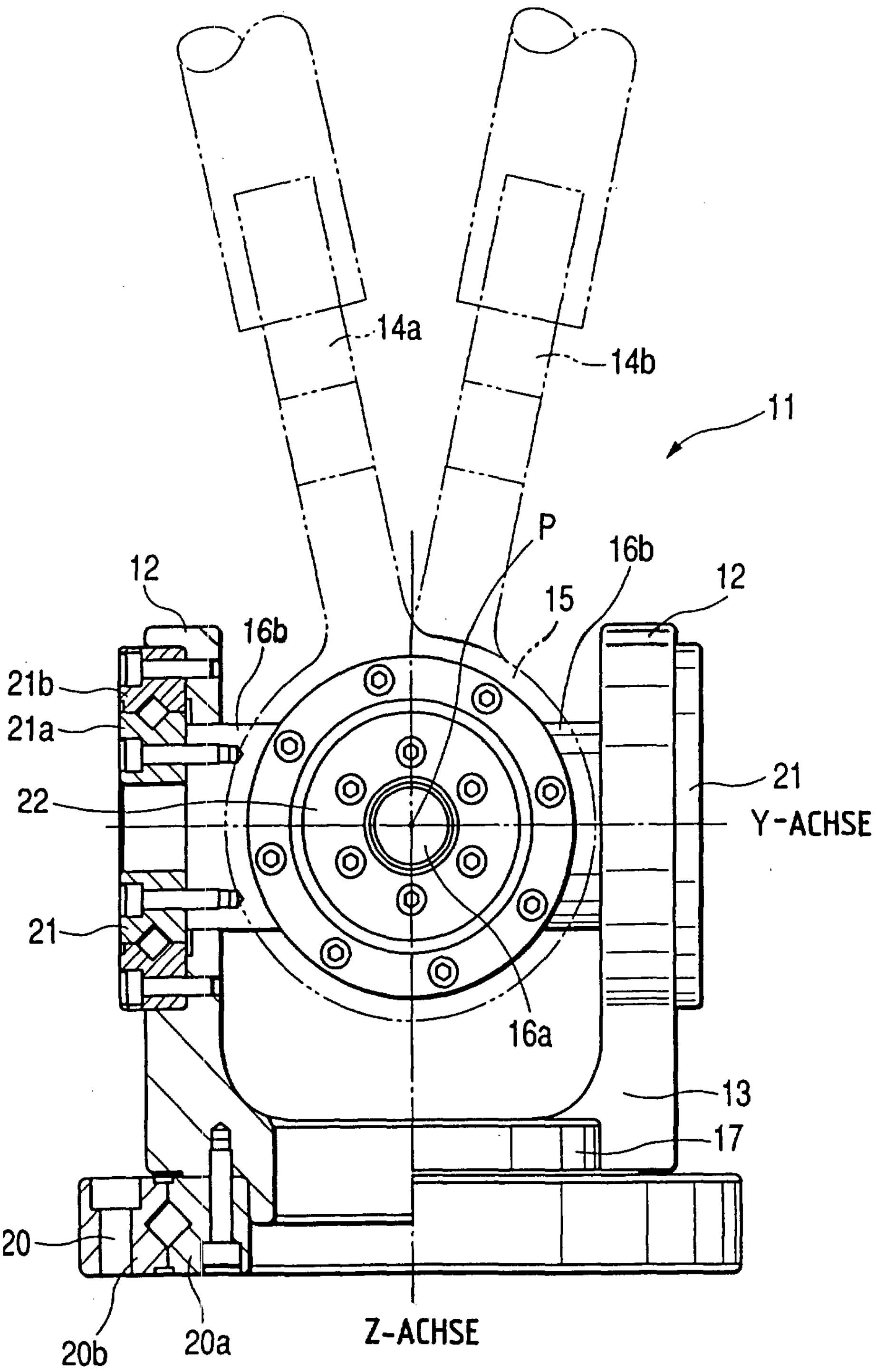


FIG. 2


14a
14b
11
P
16b
12
15
16b
12
21b
21a
21
22
Y-ACHSE
21
16a
13
17
20
20b
20a
Z-ACHSE

Nummer: **DE 100 58 317 A1**
Int. Cl.[7]: **F 16 C 11/06**
Offenlegungstag: 31. Mai 2001

FIG. 3

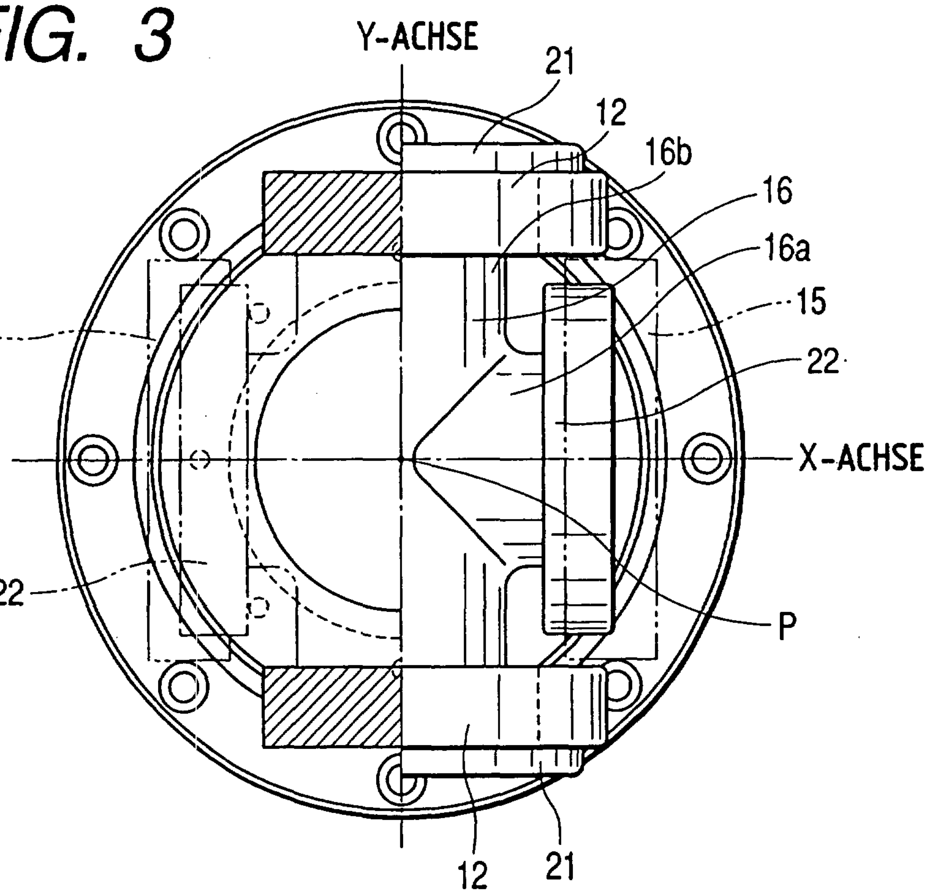
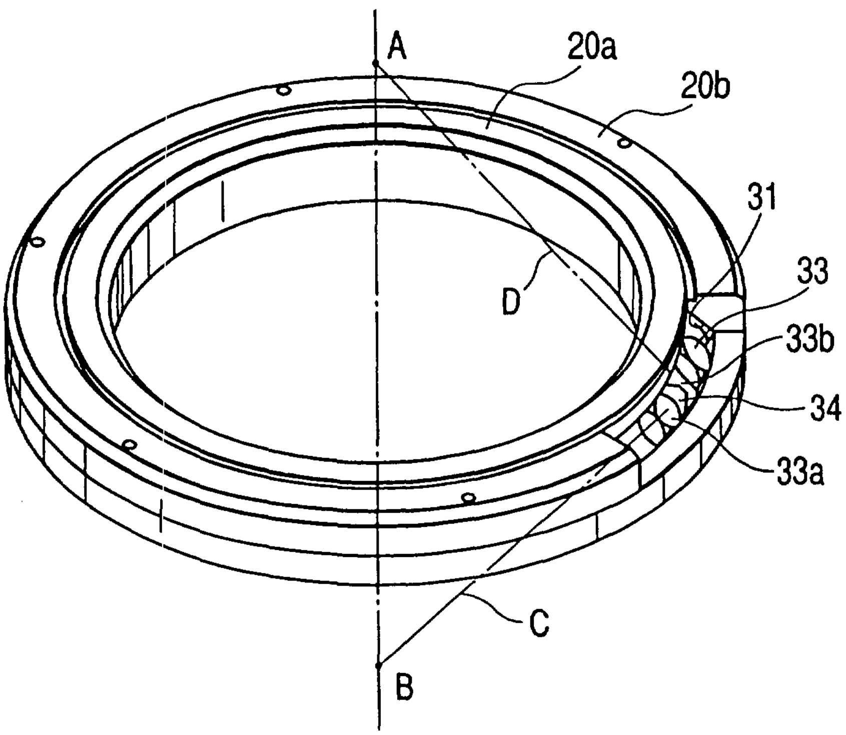
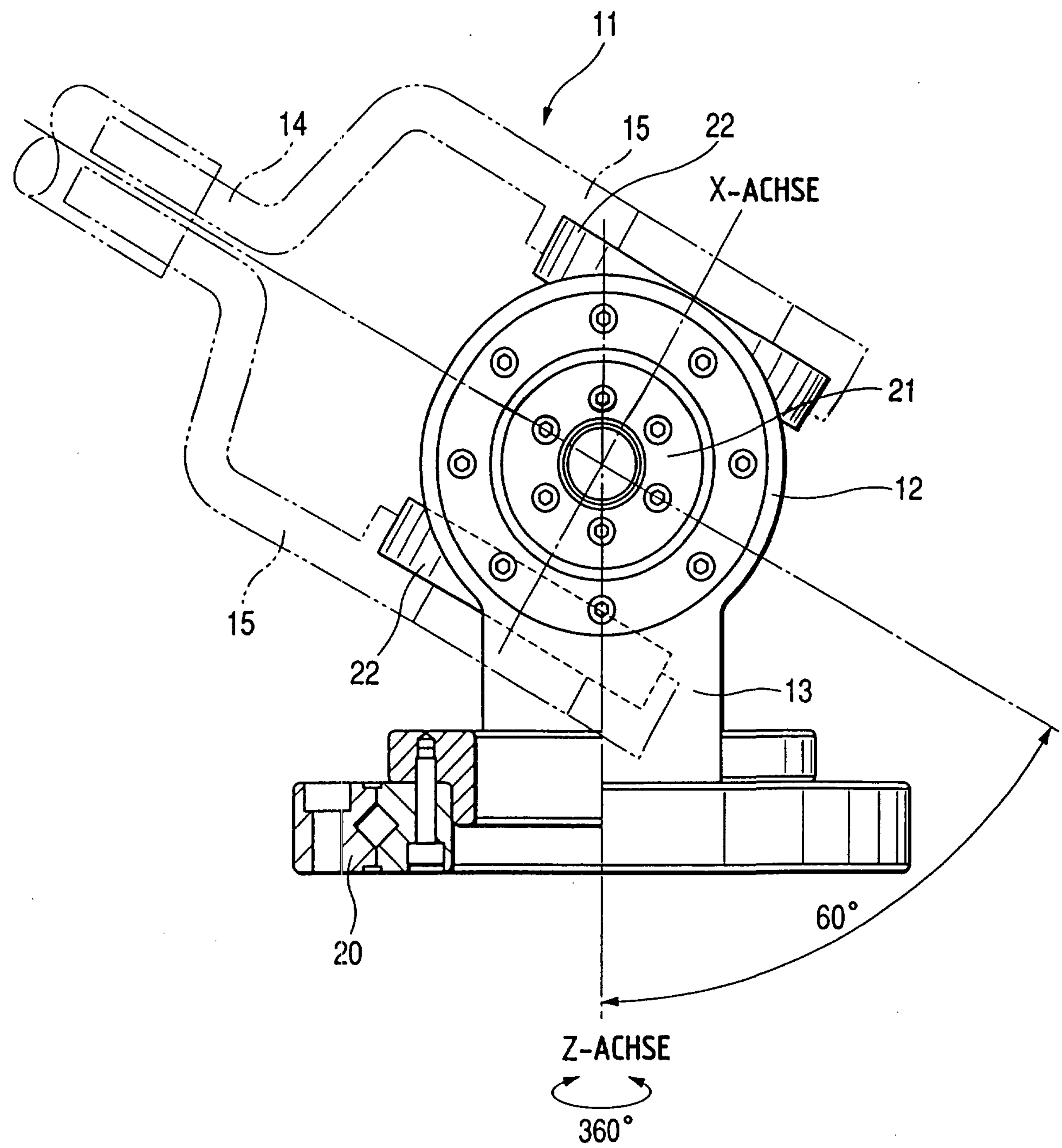


FIG. 4



Nummer: DE 100 58 317 A1
Int. Cl.[7]: F 16 C 11/06
Offenlegungstag: 31. Mai 2001

FIG. 5



Nummer: DE 100 58 317 A1
Int. Cl.7: F 16 C 11/06
Offenlegungstag: 31. Mai 2001

FIG. 6

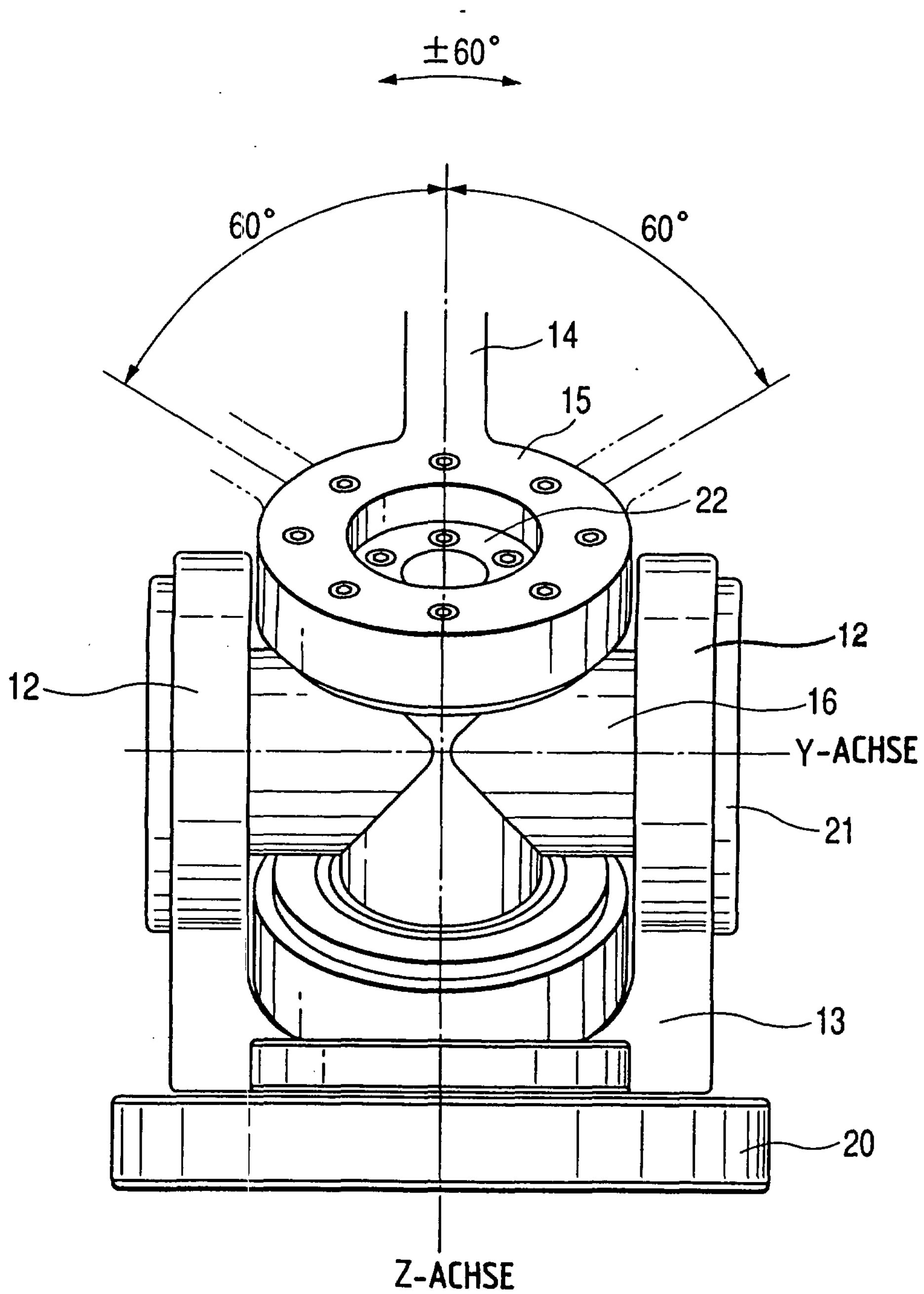


FIG. 7

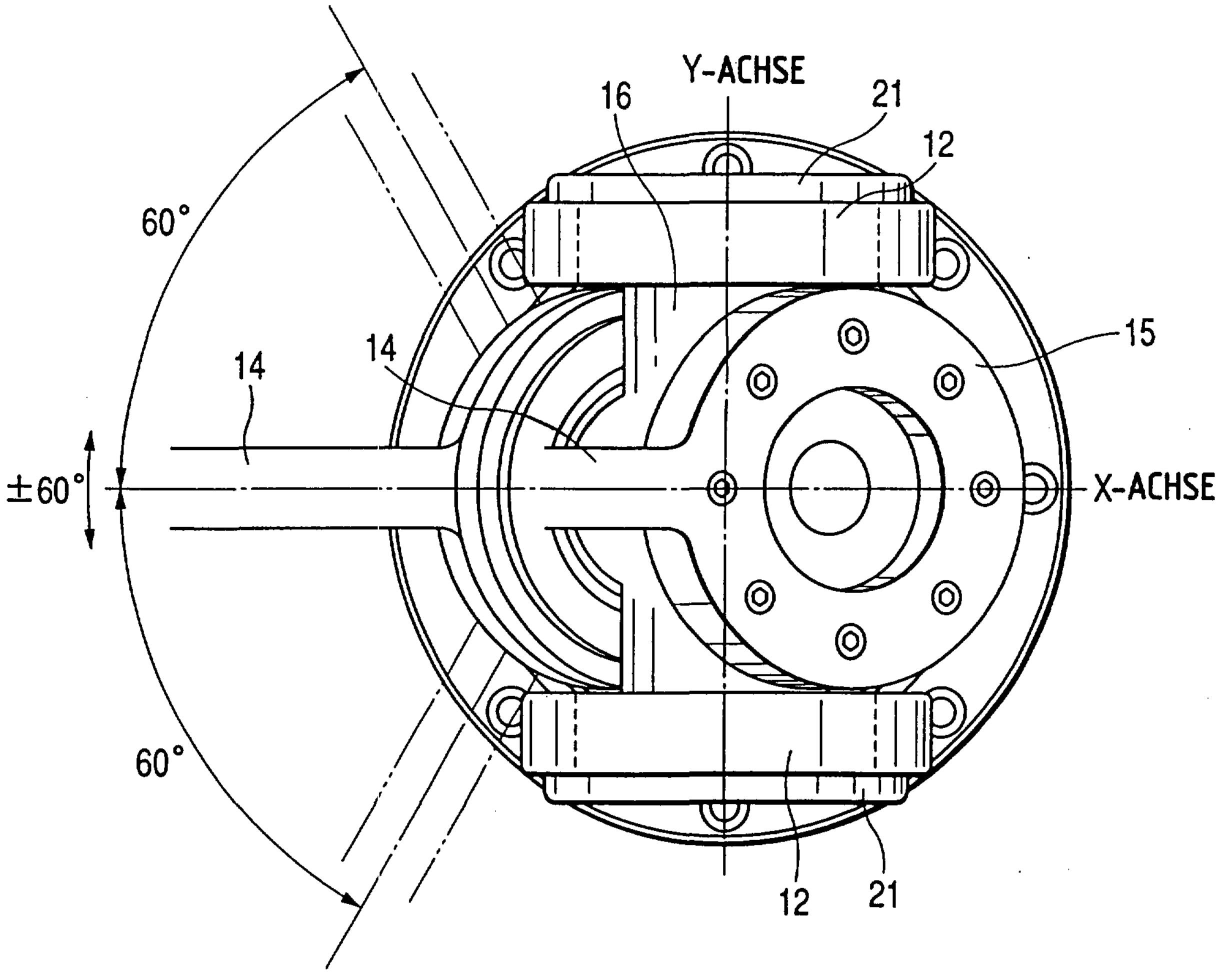
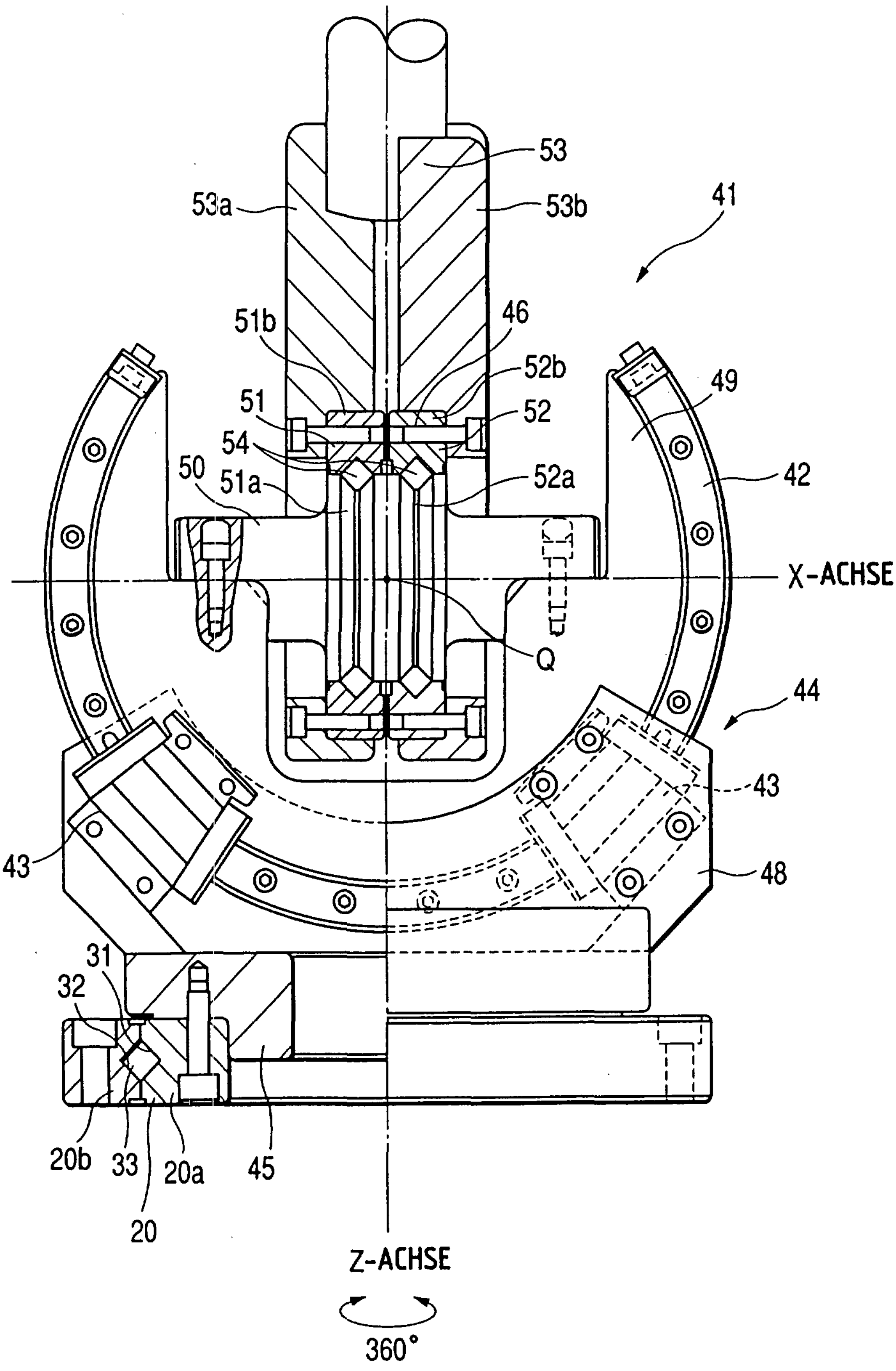


FIG. 8


53
53a
53b
41
51b
46
52b
51
52
54
49
50
51a
52a
42
X-ACHSE
Q
44
43
43
48
31
32
20b
33
20a
45
20
Z-ACHSE
360°

Nummer: **DE 100 58 317 A1**
Int. Cl.[7]: **F 16 C 11/06**
Offenlegungstag: 31. Mai 2001

FIG. 9

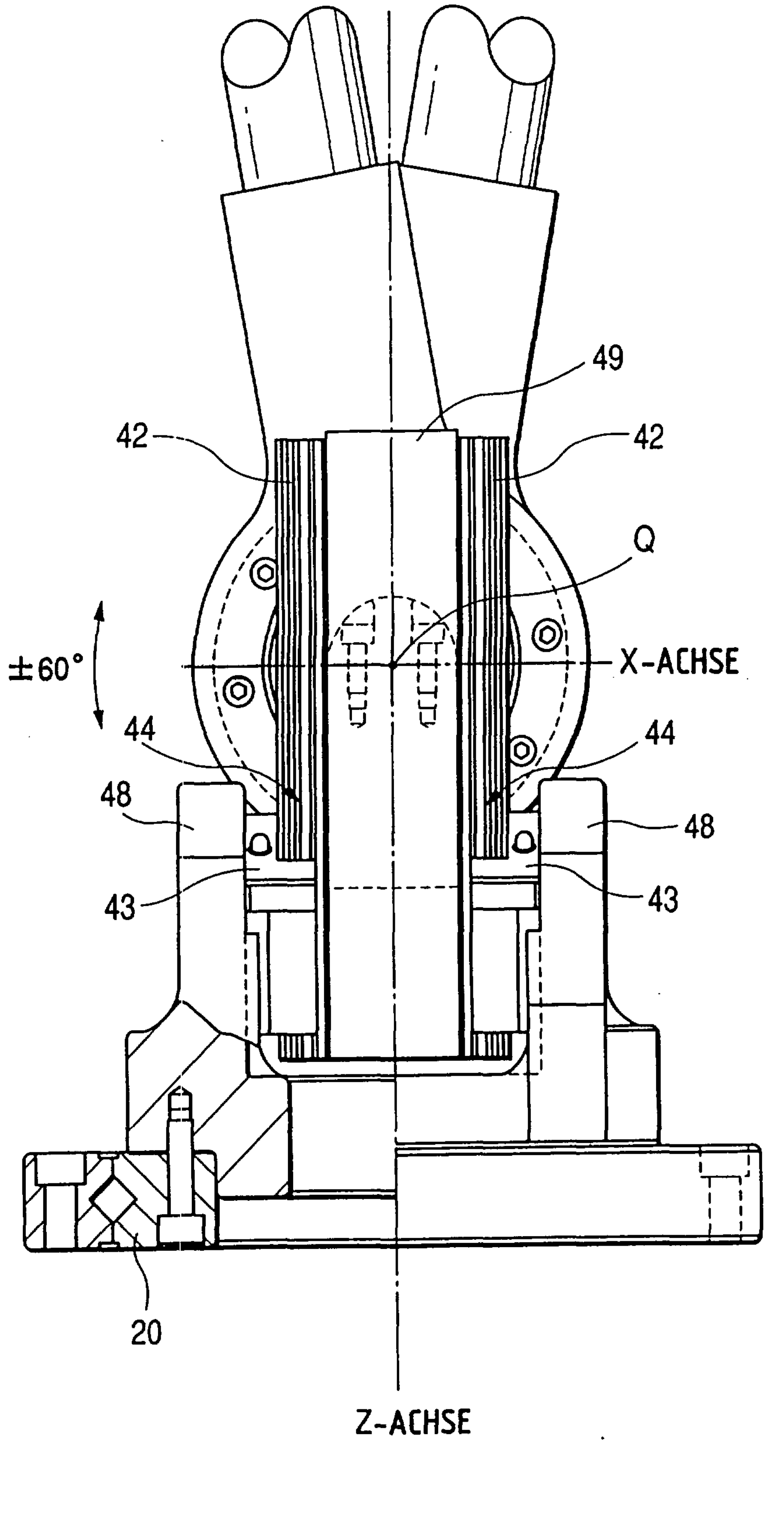
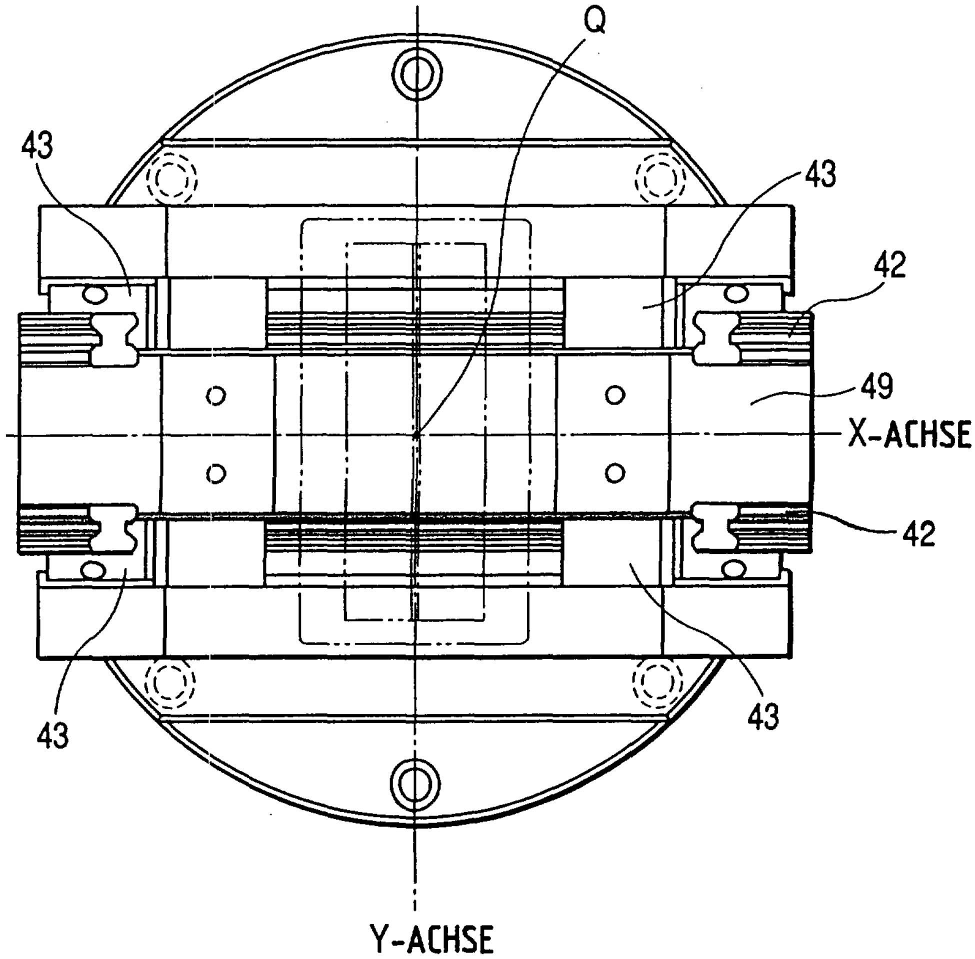
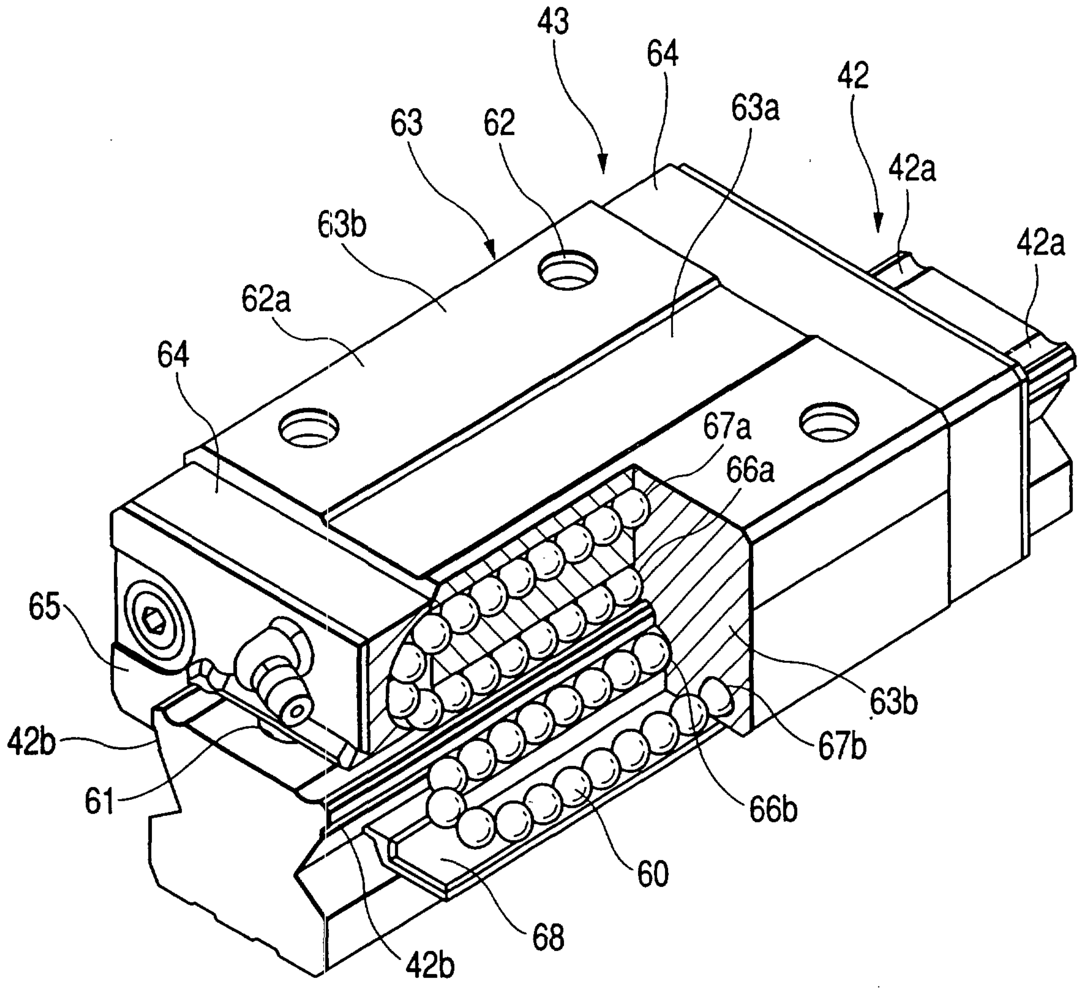


FIG. 10



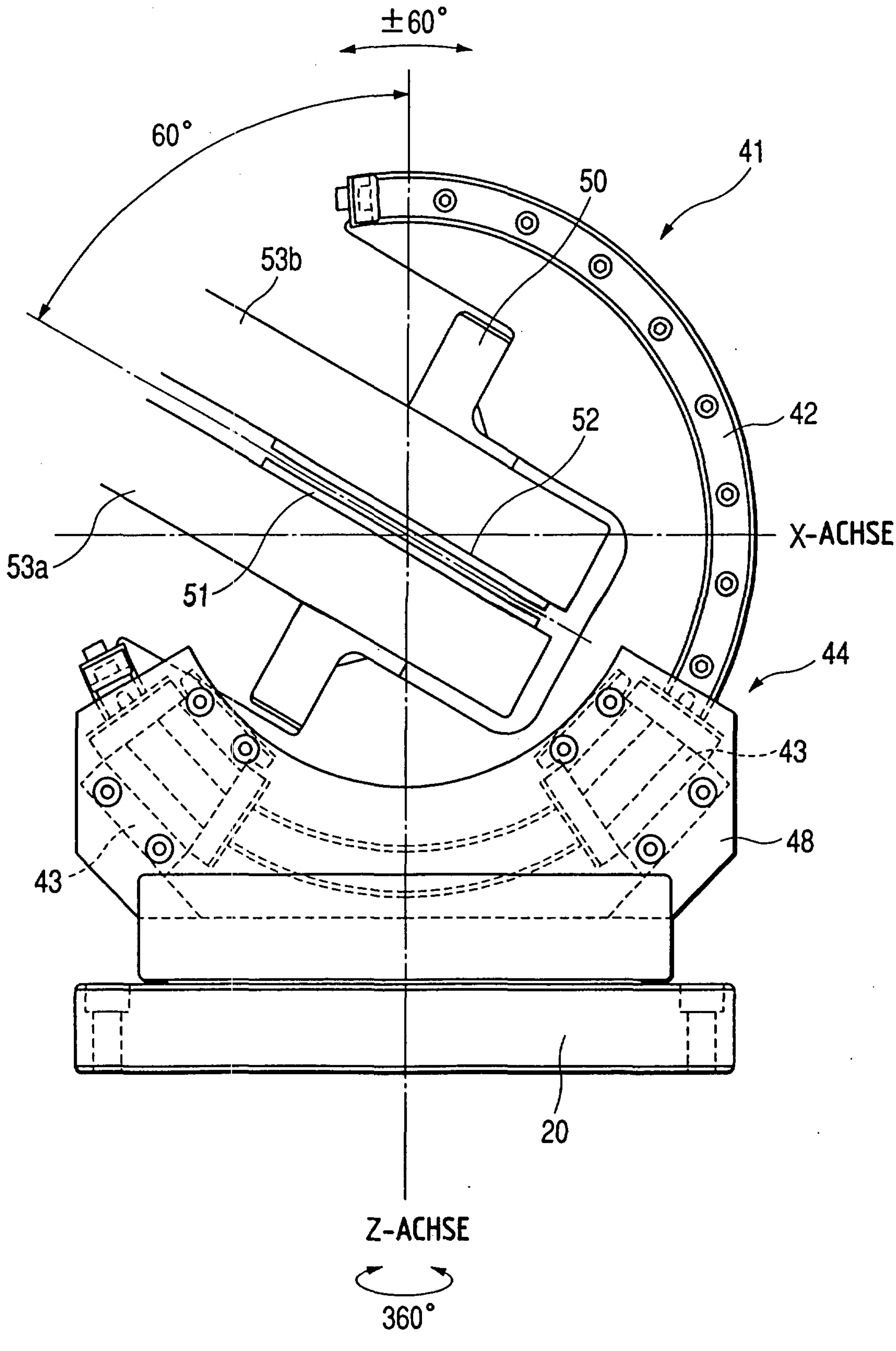
Nummer: DE 100 58 317 A1
Int. Cl.[7]: F 16 C 11/06
Offenlegungstag: 31. Mai 2001

FIG. 11



Nummer: DE 100 58 317 A1
Int. Cl.[7]: F 16 C 11/06
Offenlegungstag: 31. Mai 2001

FIG. 12



Nummer: DE 100 58 317 A1
Int. Cl.[7]: F 16 C 11/06
Offenlegungstag: 31. Mai 2001

FIG. 13

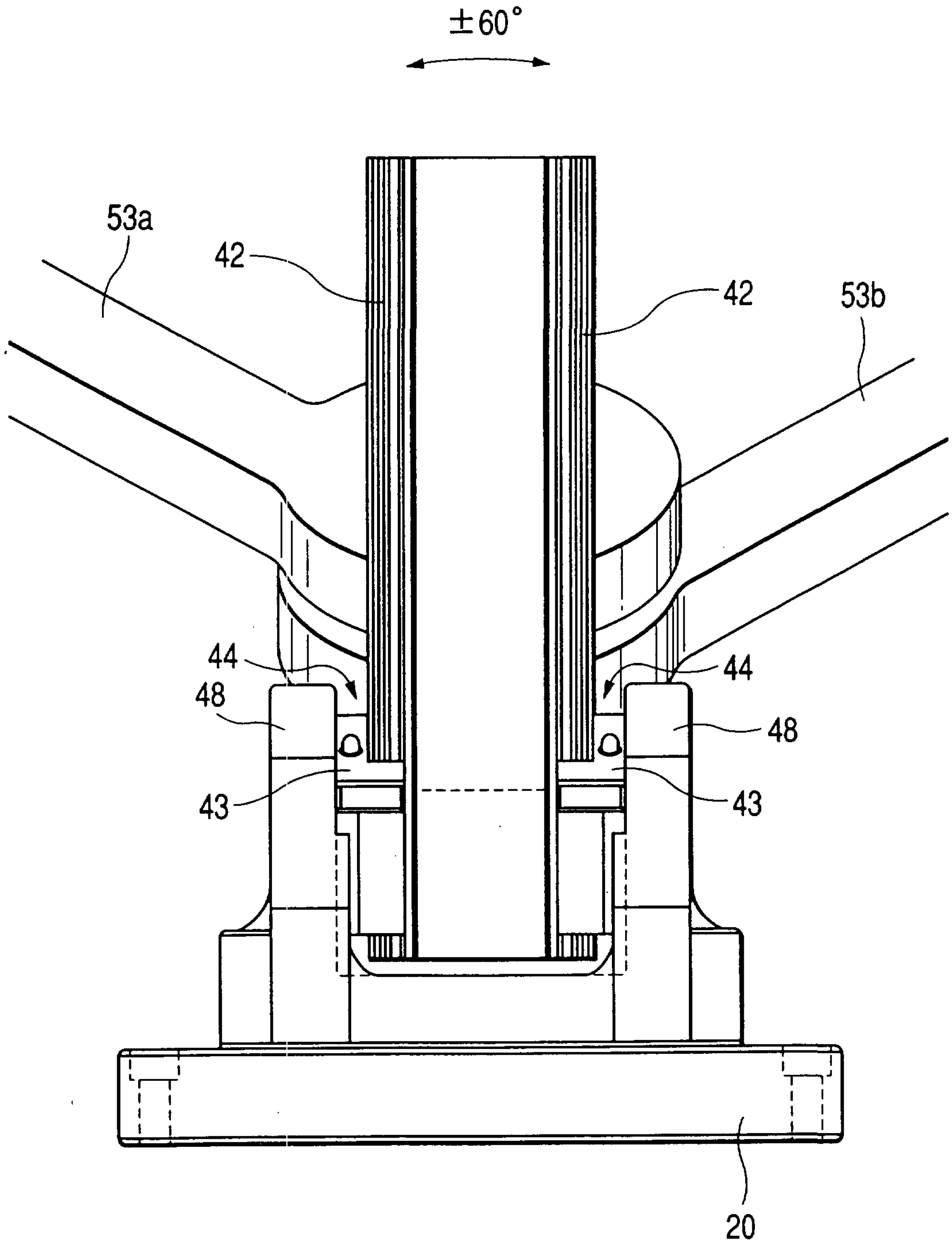
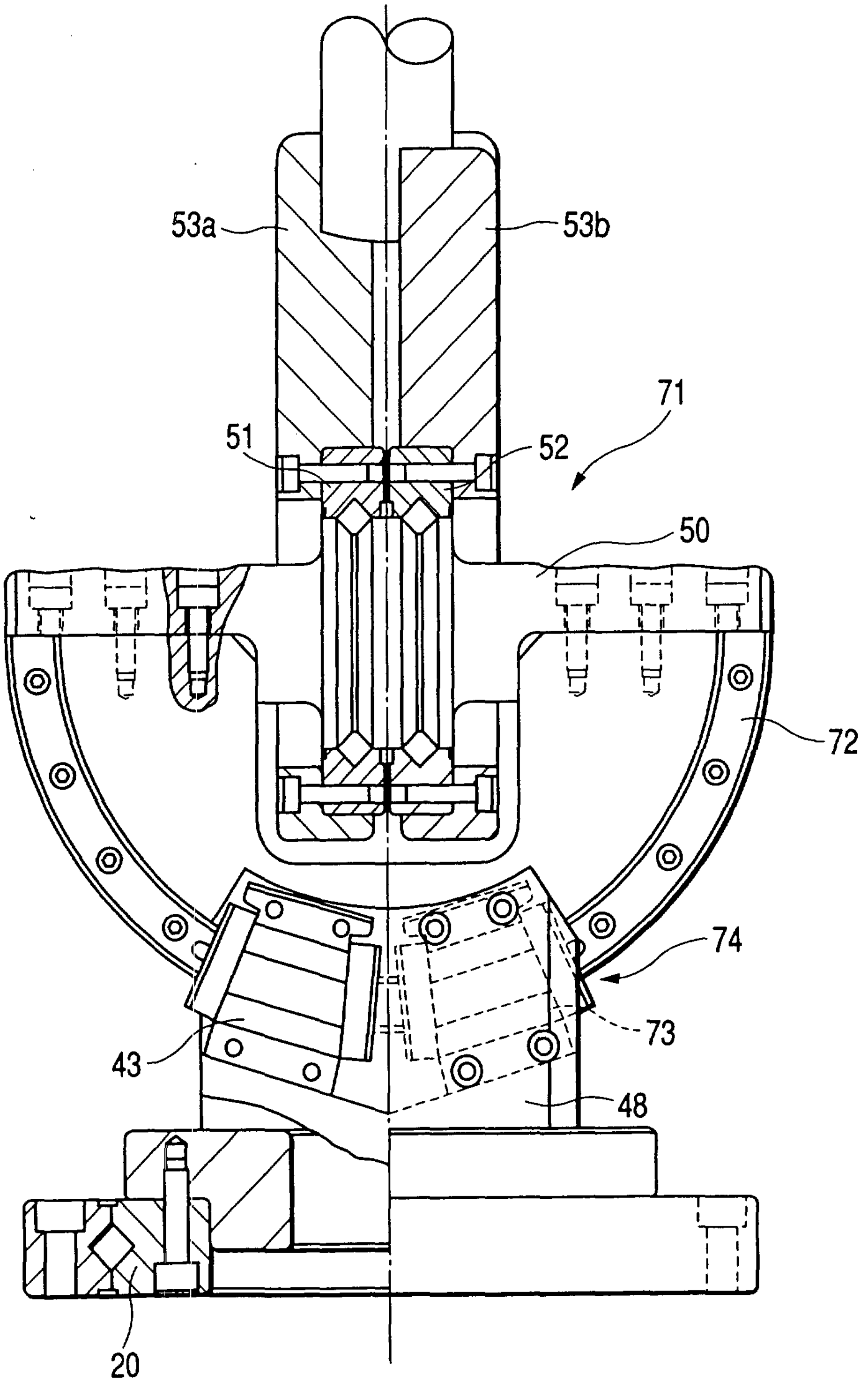


FIG. 14



Nummer: DE 100 58 317 A1
Int. Cl.7: F 16 C 11/06
Offenlegungstag: 31. Mai 2001

FIG. 15

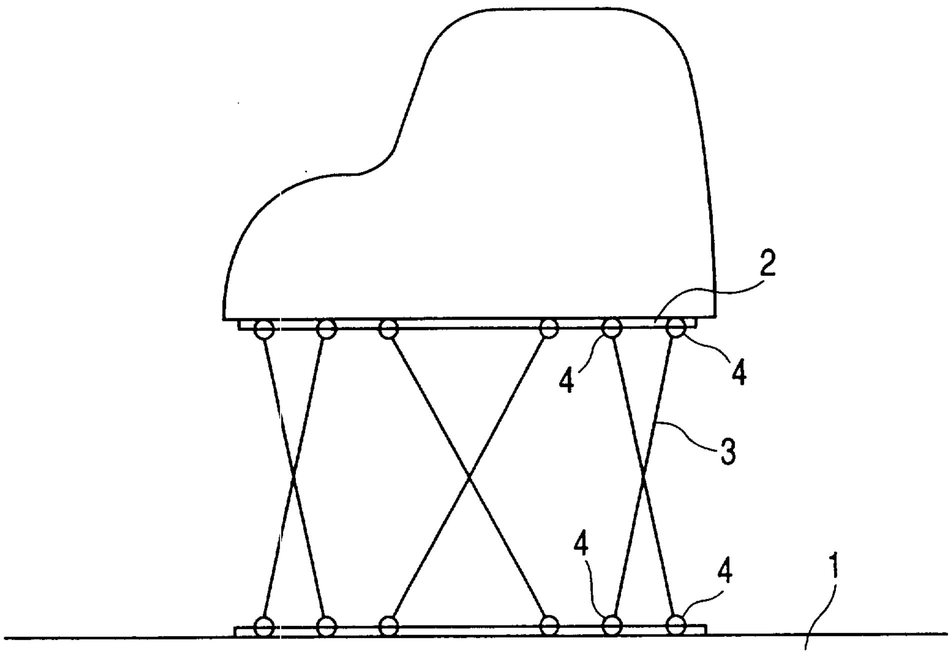


FIG. 16

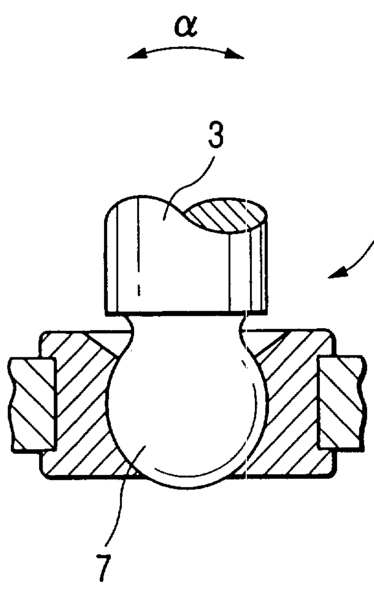
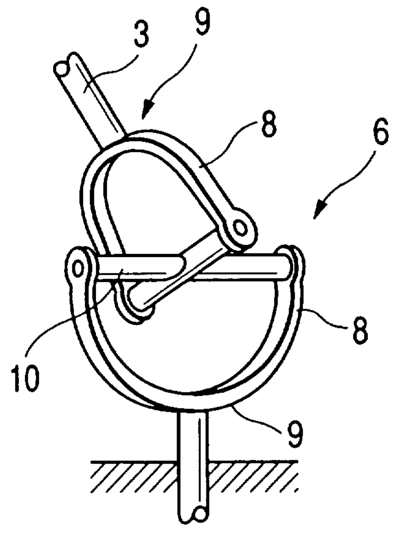


FIG. 17



(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 100 30 140 A 1**

(51) Int. Cl.7:
F 16 H 25/20

(21) Aktenzeichen: 100 30 140.1
(22) Anmeldetag: 20. 6. 2000
(43) Offenlegungstag: 25. 1. 2001

(30) Unionspriorität:
177421/99 23. 06. 1999 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

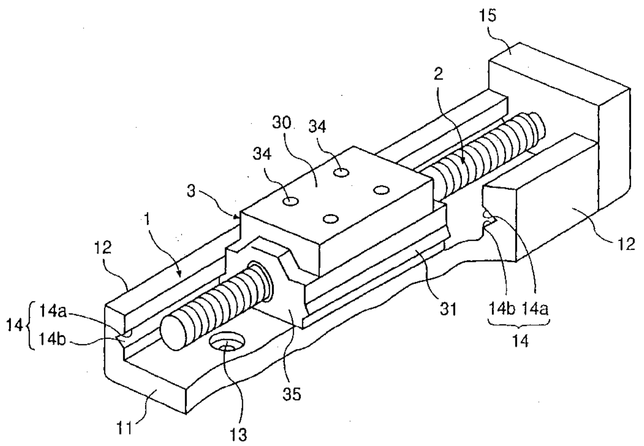
(74) Vertreter:
Vossius & Partner, 81675 München

(72) Erfinder:
Michioka, Hidekazu, Tokio/Tokyo, JP; Hoshide, Kaoru, Tokio/Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Gleitführungseinheit

(57) Durch die vorliegende Erfindung wird eine Gleitführungseinheit bereitgestellt, wobei ein Mutterelement zum Ausüben einer Antriebskraft auf ein Gleitelement und ein Gleitkontaktelement zum Halten des Gleitelementes in Bewegung bezüglich der Laufschiene am Gleitelement stabil befestigt sind, und die auf einfache Weise und kostengünstig ohne eine erhöhte Anzahl von Komponenten herstellbar ist. Das erfindungsgemäße Gleitführungselement ist dadurch gekennzeichnet, daß das Gleitelement aus einem Metallkern mit einer Montagefläche für einen beweglichen Körper und einem durch Gießen um den Kernblock herum ausgebildeten Harzabschnitt besteht, und dadurch, daß das mit der Laufschiene in Gleitkontakt stehende Gleitkontaktelement und der Mutterabschnitt, in dem die Schraubenwelle eingeschraubt ist, als einstückiger Harzabschnitt ausgebildet sind.



DE 100 30 140 A 1

Beschreibung

Die vorliegende Erfindung betrifft eine Gleitschienen- oder Gleitführungseinheit zur Verwendung in einer Halbleiterprüfvorrichtung oder einer ähnlichen Vorrichtung, die einen auf einem Gleitelement angeordneten beweglichen Körper, z. B. einen Tisch, entlang einer Laufschiene linear führt, und insbesondere eine Gleitschienen- oder Gleitführungseinheit mit einer in das Gleitelement geschraubten und sich durch das Gleitelement hindurch erstreckenden Schraubenwelle zum linearen Antreiben des Gleitelements.

In der JP-A-273550/1997 ist eine derartige Gleitführungseinheit beschrieben. Die Gleitführungseinheit weist auf: eine Laufschiene, die in der Form eines Kanals mit einer konkaven Nut ausgebildet ist und eine entlang ihrer Länge ausgebildete Gleitführungsfläche aufweist, eine in der konkaven Nut entlang der Länge der Laufschiene angeordnete Schraubenwelle und ein Gleitelement mit einem Gleitkontaktelement, das dafür vorgesehen ist, mit der Gleitführungsfläche der Laufschiene in Kontakt zu stehen, und einem Mutterelement, das dafür vorgesehen ist, auf die Schraubenwelle geschraubt zu werden, wobei, wenn die Schraubenwelle beispielsweise durch einen Motor gedreht wird, das Gleitelement sich gemäß dem Umdrehungsmaß in der konkaven Nut der Laufschiene bewegt, so daß das Maß der geradlinigen Bewegung des auf dem Gleitelement angeordneten, zu führenden beweglichen Körpers, z. B. eines Tischs, in jede Richtung durch das Umdrehungsmaß der Schraube präzise bestimmt ist.

Das Gleitelement wird durch einen Gleitkontakt zwischen seinem Gleitkontaktelement und der Gleitführungsfläche der Laufschiene beweglich gehalten. Das Gleitkontaktelement besteht aus einem abriebfesten Material, z. B. aus einem kohlenstoffaserhaltigen Harz, Keramik oder einer Sinterlegierung. In der JP-A-273550/1997 wird vorgeschlagen, daß das Gleitkontaktelement an einer Position mit dem Gleitelement verbunden ist, die der Gleitführungsfläche auf der Laufschiene zugewandt ist, und wenn ein Harzmaterial, z. B. Harz mit darin dispergierten Kohlenstoffasern oder Harz mit darin dispergiertem Metallpulver, zum Herstellen des Gleitkontaktelements verwendet wird, kann es durch Spritzgießen auf dem Gleitelement ausgebildet werden.

Andererseits weist der Mutterabschnitt zum Umwandeln der Drehbewegung der Schraubenwelle in die lineare Bewegung des Gleitelements ein Innengewinde auf, das dazu vorgesehen ist, mit dem auf der Schraubenwelle ausgebildeten Außengewinde in Gleitkontakt zu stehen, und der Mutterabschnitt besteht aus einem abriebfesten und belastungswiderstandsfähigen Material. Das Mutterelement wird mit dem auf dem Gleitelement ausgebildeten Durchgangsloch verbunden.

Bei der Gleitführungseinheit mit einer solchen Struktur müssen, weil von dem auf die Schraubenwelle aufgeschraubten Mutterabschnitt eine Antriebskraft entlang der Laufschiene auf das Gleitelement ausgeübt wird und das Gleitelement durch den Gleitkontakt mit der Gleitkontaktfläche der Laufschiene frei hin- und herbeweglich gehalten wird, das Mutterelement und das Gleitkontaktelement am Gleitelement stabil bzw. sicher befestigt sein, so daß sie sich nicht vom Gleitelement lösen können.

Bei der in der JP-A-273550/1997 beschriebenen Gleitführungseinheit besteht jedoch, weil das Mutterelement und das Gleitkontaktelement nur durch einen Klebstoff am Gleitelement befestigt sind, der Nachteil, daß das Mutterelement oder das Gleitkontaktelement sich aufgrund einer in Bewegungsrichtung des Gleitelements auf das Mutterelement oder das Gleitkontaktelement ausgeübten großen Kraft zufällig vom Gleitelement lösen kann, wenn die Bewegungsrichtung des Gleitelements plötzlich umgekehrt wird.

Um das Mutterelement und das Gleitkontaktelement so am Gleitelement zu befestigen, daß sie einer solchen Kraft widerstehen, kann ein Paar Abdeckkörper beispielsweise durch Bolzen an der vorderen und der hinteren Stirn- oder Endfläche des Gleitelements befestigt werden, so daß die Abdeckkörper das Mutterlement und das Gleitkontaktelement auf dem Gleitelement halten. Durch Bereitstellen solcher Abdeckkörper auf dem Gleitelement erhöhen sich jedoch der Zeit- und Arbeitsaufwand zum Zusammensetzen oder Montieren des Gleitelements und nimmt die Anzahl der Komponenten zu, wodurch höhere Kosten entstehen. Außerdem nimmt, wenn die Abdeckkörper an der vorderen und der hinteren Endfläche des Gleitelements befestigt sind, wie vorstehend beschrieben, die Länge des Gleitelements um die der Länge dieser Abdeckkörpern entsprechende Länge zu, wodurch die Größe der Einheit selbst bezüglich des Hubwegs der hin- und hergehenden Bewegung des Gleitelements zunimmt.

Es ist Aufgabe der Erfindung, die vorstehend beschriebenen Probleme zu lösen und eine Gleitführungseinheit bereitzustellen, bei der das Mutterelement zum Ausüben einer Antriebskraft auf das Gleitelement und das Gleitkontaktelement, durch das das Gleitelement bezüglich der Laufschiene in Bewegung gehalten wird, stabil bzw. sicher am Gleitelement befestigt sind und das auf einfache Weise, kostengünstig und ohne Erhöhung der Anzahl von Komponenten herstellbar ist.

Um die vorstehend beschriebene Aufgabe zu lösen, weist die erfindungsgemäße Gleitführungseinheit auf: eine Laufschiene mit einer entlang ihrer Länge ausgebildeten Gleitführungsfläche, eine parallel zur Laufschiene angeordnete Schraubenwelle mit einer auf ihrem Außenumfang ausgebildeten schraubenförmigen Führungs- oder Gleitgewinderille bzw. -nut und ein Gleitelement mit einem Gleitkontaktelement, das dafür vorgesehen ist, mit der Gleitführungsfläche der Laufschiene in Kontakt gebracht zu werden, und einem Mutterabschnitt, der dafür vorgesehen ist, auf die Schraubenwelle aufgeschraubt zu werden, um den beweglichen Körper gemäß der Drehbewegung der Schraubenwelle entlang der Laufschiene zu führen, wobei das Gleitelement aufweist: einen Metallkernblock mit einer Oberfläche, auf der der bewegliche Körper angeordnet werden kann, und einen durch Gießen um den Metallkernblock herum ausgebildeten Harzabschnitt, und wobei der Gleitkontaktabschnitt und der Mutterabschnitt in diesem einstückigen Harzabschnitt ausgebildet sind.

Gemäß der vorstehend beschriebenen Struktur sind, weil das Gleitelement durch Gießen eines Harzabschnitts um den Metallkernblock herum gebildet wird, und weil das mit der Laufschiene in Kontakt stehende Gleitkontaktelement und das auf die Schraubenwelle geschraubte Mutterelement in diesem einstückigen Harzabschnitt ausgebildet sind, der Mutterabschnitt und der Gleitkontaktabschnitt relativ zueinander fest integriert, wodurch verhindert wird, daß der Mutterabschnitt und der Gleitkontaktabschnitt sich vom Gleitelement lösen, auch wenn die Bewegungsrichtung des Gleitelements plötzlich umgekehrt wird. Außerdem können, weil das Gleitkontaktelement und das Mutterelement durch Spritzgießen auf dem in einer Metallform eingesetzten Kernblock gleichzeitig hergestellt werden können, die Anzahl von Arbeitsvorgängen und die Anzahl von Komponenten, die zum Herstellen des Gleitelements erforderlich sind, reduziert werden, so daß das Gleitelement kostengünstig herstellbar ist.

Aus dem Gesichtspunkt des stabileren Integrierens des Harzabschnitts und des Gleitkontaktabschnitts relativ zueinander ist es bevorzugt, den Harzabschnitt so auf dem Kernblock so auszubilden, daß er die vordere, die hintere, die rechte und die linke Seite des Gleitelements umschließt. Bei einer solchen Struktur kann der Kernblock in der Bewegungsrichtung des Gleitelements nicht vom Harzabschnitt getrennt werden, so daß das Gleitkontaktelement und der Mutterabschnitt, die im Harzabschnitt ausgebildet werden, einstückig in das Gleitelement integrierbar sind.

Aus dem Gesichtspunkt des Eliminierens des Ratterns des Gleitelements bezüglich der Laufschiene und des Gang- oder Bewegungsfehlers während der hin- und hergehenden Bewegung ist es vorteilhaft, das Gleitelement so zu konstruieren, daß das Gleitkontaktelement und/oder der Mutterabschnitt des Gleitelements mit der Gleitführungsfläche der Laufschiene und der Gleitgewinderille der Schraubenwelle elastisch in Kontakt kommen. Beispielsweise kann dem Gleitkontaktelement und/oder dem Mutterabschnitt Elastizität verliehen werden, indem im Gleitkontaktelement und/oder im Mutterabschnitt entlang der Länge des Gleitelements ein Schlitz ausgebildet wird.

Wie vorstehend beschrieben wurde, sind erfindungsgemäß, weil der mit der Laufschiene in Kontakt stehende Gleitkontaktabschnitt und der auf die Schraubenwelle aufzuschraubende Mutterabschnitt durch Gießen eines Harzes um den Metallblock herum ausgebildet sind und das Gleitkontaktelement und der Mutterabschnitt einstückig ausgebildet sind, der Mutterabschnitt und der Gleitkontaktabschnitt fest mit dem Gleitelement integriert, so daß das Mutterelement zum Ausüben einer Antriebskraft auf das Gleitelement und das Gleitkontaktelement, durch das das Gleitelement bezüglich der Laufschiene in Bewegung gehalten wird, stabil am Gleitelement befestigt werden können.

Außerdem wird, weil das Gleitkontaktelement und der Mutterabschnitt durch Spritzgießen gleichzeitig auf dem Gleitelement ausgebildet werden, während der Kernblock in der Metallform eingesetzt ist, die Anzahl von Arbeitsvorgängen und die Anzahl von Komponenten, die zum Herstellen des Gleitelements erforderlich ist, vermindert, so daß das Gleitelement auf einfache Weise und kostengünstig herstellbar ist.

Die Figuren zeigen Beispiele bevorzugter Ausführungsformen der Erfindung:

Fig. 1 zeigt eine perspektivische Ansicht einer ersten Ausführungsform einer erfindungsgemäßen Gleitführungseinheit;

Fig. 2 zeigt eine Vorderansicht der ersten Ausführungsform der Gleitführungseinheit;

Fig. 3 zeigt eine Querschnittansicht der Gleitführungseinheit entlang der Linie III-III in **Fig.** 2;

Fig. 4 zeigt eine Querschnittansicht der Gleitführungseinheit entlang der Linie IV-IV in **Fig.** 3;

Fig. 5 zeigt eine Vorderansicht einer zweiten Ausführungsform einer erfindungsgemäßen Gleitführungseinheit;

Fig. 6 zeigt eine vordere Querschnittansicht der zweiten Ausführungsform der Gleitführungseinheit;

Fig. 7 zeigt eine Vorderansicht einer dritten Ausführungsform einer erfindungsgemäßen Gleitführungseinheit;

Fig. 8 zeigt eine vordere Querschnittansicht der dritten Ausführungsform der Gleitführungseinheit;

Fig. 9 zeigt eine perspektivische Ansicht einer vierten Ausführungsform einer erfindungsgemäßen Gleitführungseinheit;

Fig. 10 zeigt eine Vorderansicht der vierten Ausführungsform der Gleitführungseinheit;

Fig. 11 zeigt eine Querschnittansicht der Gleitführungseinheit entlang der Linie XI-XI in **Fig.** 10; und

Fig. 12 zeigt eine Querschnittansicht der Gleitführungseinheit entlang der Linie XII-XII in **Fig.** 11.

Nachstehend wird die erfindungsgemäße Gleitführungseinheit unter Bezug auf die beigefügten Zeichnungen ausführlich beschrieben.

Fig. 1 und 2 zeigen die erste Ausführungsform einer erfindungsgemäßen Gleitführungseinheit. Bezugszeichen **1** bezeichnet eine Laufschiene in Form eines Kanals mit einer konkaven Nut, 2 eine in der konkaven Nut parallel zur Laufschiene **1** angeordnete Schraubenwelle und 3 ein auf die Schraubenwelle **2** aufzuschraubendes Gleitelement, das in der konkaven Nut der Laufschiene **1** hin- und hergehend beweglich ist.

Die Laufschiene **1** ist definiert durch einen unteren Abschnitt **11** und ein Paar Seitenwände **11** und **12**, die sich von beiden Rändern des unteren Abschnitts **11** vertikal nach oben erstrecken, um einen D-förmigen Querschnitt zu bilden, und Bolzeneinführöffnungen **13** sind in vorgegebenen Abständen auf dem unteren Abschnitt **11** in Längsrichtung ausgebildet, um die Laufschiene **1** auf einem festen Abschnitt, z. B. einem Bett, zu befestigen. Die Innenfläche jeder Seitenwand **12** weist eine entlang ihrer Länge annähernd V-förmig ausgebildete Führungsnut **14** auf, und jede Führungsnut wird durch ein Paar Gleitführungsflächen **14**a und **14**b gebildet, die bezüglich der beide Flächen schneidenden horizontalen Linie um 45° geneigt sind.

Die Schraubenwelle **2** ist in der konkaven Nut angeordnet, die durch ein Paar Seitenwände **12** auf der Laufschiene **1** gebildet wird, und wird durch eine an einem Ende der Laufschiene **1** befestigte Halteplatte und durch das Gleitelement **3** drehbar gehalten. Auf dem Außenumfang der Schraubenwelle **2** ist eine schraubenförmige Gleitgewinderille **21** ausgebildet, so daß, wenn die Schraubenwelle **2** durch den nicht dargestellten Motor gedreht wird, der über die Halteplatte **15** an der Laufschiene **1** befestigt ist, das darauf geschraubte Gleitelement **3** sich gemäß der Drehbewegung der Schraubenwelle **2** in der konkaven Nut auf der Laufschiene bewegt.

Andererseits ist das Gleitelement **3** näherungsweise rechteckig ausgebildet und mit einem gewissen Spiel ebenfalls in die konkave Nut auf der Führungsschiene **1** eingepaßt. Der obere Abschnitt des Gleitelements **3** weist eine Montagefläche **30** zum Befestigen des beweglichen Körpers (nicht dargestellt), z. B. eines Tischs, auf, und die Montagefläche **10** weist Gewindelöcher **34** zum Befstigen des beweglichen Körpers durch Schraubenbolzen auf. Auf beiden Seitenflächen des Gleitelements **3**, d. h. auf der linken und der rechten Seite bezüglich seiner Bewegungsrichtung, sind Gleitkontaktelemente **31** angeordnet, die näherungsweise V-förmig ausgebildet sind, um sie jeweils in die auf der Laufschiene **1** ausgebildeten Führungsnuten **14** enganliegend einzupassen, und die schräg nach oben verlaufende Fläche und die schräg nach unten verlaufende Fläche des Gleitkontaktelements **31** werden mit den Gleitführungsflächen **14**a, **14**b der Führungsnut **14** in Kontakt gehalten. Dadurch bilden die Führungsnut **14** und das Gleitkontaktelement **31** einen Gleitführungsmechanismus, wobei das Gleitelement **3** sich durch Ausüben einer Kraft auf das Gleitelement **3** von irgendeiner Richtung parallel zur Ebene von **Fig.** 2 in der konkaven Nut auf der Laufschiene **1** hin- und hergehend bewegen kann.

Das Gleitelement **3** weist einen auf die Schraubenwelle **2** aufzuschraubenden Mutterabschnitt **32** auf. Wie in **Fig.** 3 dargestellt, weist der Mutterabschnitt **32** ein Durchgangsloch **33** zum Aufnehmen der Schraubenwelle **2** auf, und die Innenumfangsfläche des Durchgangslochs **33** weist ein Innengewinde auf, das dazu vorgesehen ist, mit der auf der Schraubenwelle **2** als Außengewinde ausgebildeten Gleitgewinderille **11** in Eingriff zu kommen.

Wie in den **Fig.** 3 und 4 dargestellt, weist das Gleitelement **4** einen Metallkernblock **4** mit einer Montagefläche **30** für einen beweglichen Körper und einen durch Spritzgießen um den Kernblock **4** herum ausgebildeten Harzabschnitt **5** auf. Weil die Montagefläche **30** hochgradig präzise starr sein muß, um den beweglichen Körper präzise zu befestigen bzw. zu fixieren, und die Gewindelöcher **34** mechanisch fest bzw. stabil sein müssen, sind sie auf dem Metallblock **4** ausgebildet. Weil andererseits der Gleitkontaktabschnitt **31** und der Mutterabschnitt **32** in Gleitkontakt mit den Gleitführungsflächen **14**a, **14**b der Laufschiene **1** und der auf der Schraubenwelle **2** ausgebildeten Gleitgewinderille gehalten werden, müssen sie abriebfest sein und einen kleinen Reibungskoeffizienten aufweisen, so daß sie aus dem Harzabschnitt **5** gebildet sind. Als Material für den Harzabschnitt **5** kann ein Harz verwendet werden, das darin in einem vorgegebenen Verhältnis dispergierte Kohlenstoffasern oder Metallpulver enthält, um die mechanische Festigkeit zu verbessern. Außerdem kann beispielsweise ein Oleoresin oder Ölharz verwendet werden, um eine Schmierung der Gleitführungsflächen **14**a, **14**b und der Gleitgewinderille zu ermöglichen.

Wie in **Fig.** 4 dargestellt, weist der Kernblock **4** einen die Montagefläche **30** definierenden horizontalen Abschnitt **40** und ein Paar Randabschnitte **41, 41** auf, die sich von beiden Enden des horizontalen Abschnitts **40** nach unten erstrekken, und der den Mutterabschnitt **32** bildende Harzabschnitt **5** ist in der Vertiefung **42** ausgebildet, die vom horizontalen Abschnitt **40** und den Randabschnitten **41, 41** umgeben ist. Außerdem ist eine Vertiefung **43** auf der Außenseite jedes Randabschnitts **41** entlang der Bewegungsrichtung des Gleitelements **3** ausgebildet, und in der Vertiefung **43** ist der das Gleitkontaktelement **31** bildende Harzabschnitt **5** ausgebildet. Bei dieser Ausführungform werden das Gleitkontaktelement und der Mutterabschnitt so ausgebildet, daß die Wellenmitte der Schraubenwelle **2** und die Mitte des näherungsweise V-förmigen Gleitkontaktelements **31** auf der gleichen Höhe horizontal zueinander angeordnet sind.

Obwohl der Mutterabschnitt **32** und der Gleitkontaktabschnitt **31** jeweils in Vertiefungen **42, 43** des Kernblocks eingepaßt sind, könnten sie beispielsweise bei einer plötzlichen Umkehr der Bewegungsrichtung des Gleitelements **3** auch vom Kernblock **4** gelöst werden, wenn am vorderen und am hinteren Ende des Gleitelements **3** keine Elemente vorgesehen sind, um sie zu halten. Daher ist, wie in **Fig.** 2 dargestellt, das Gleitelement **3** bei dieser Ausführungsform so konstruiert, daß sowohl auf der vorderen als auch auf der hinteren Endfläche des Kernblocks **4** plattenförmige Verbindungsabschnitte **35** durch Harz gebildet sind, so daß das Gleitkontaktelement **31** und der Mutterabschnitt **32** über einen Verbindungsabschnitt **35** einen einstückigen Harzabschnitt **5** bilden.

Daher sind bei dieser Ausführungsform das Gleitelement **3**, der Mutterabschnitt **32** und das Gleitkontaktelement **31**, die durch Gießen eines Harzes gebildet werden, so integriert, daß sie den Randabschnitt **41** des Kernblocks umgeben, und der Harzabschnitt **5** ist auf dem Kernblock so ausgebildet, daß er die vordere, die hintere, die linke und die rechte Seite des Gleitelements umschließt. Dadurch sind der Kernblock **4** und das Gleitkontaktelement **31** und der Mutterabschnitt **43**, die durch Gießen eines Harzes gebildet werden, fest integriert, und dadurch wird eine Trennung des Mutterabschnitts **32** und des Gleitkontaktabschnitts **31** vom Gleitelement **3** auch dann zuverlässig verhindert, wenn eine hohe Kraft auf das Gleitelement **3** ausgeübt wird, wenn z. B. die Bewegungsrichtung der Schraubenwelle **2** plötzlich umgekehrt wird.

Außerdem können das Gleitkontaktelement **31** und der Mutterabschnitt **32** gleichzeitig gegossen werden, indem der Spritzgießvorgang des Harzabschnitts **5** ausgeführt wird, während der Kernblock **4** in der Metallform eingesetzt ist, und die Trennung oder Ablösung des Harzabschnitts **5** und des Kernblocks **4** kann verhindert werden, indem das Gleitkontaktelement **31** und der Mutterabschnitt **32** einstückig ausgebildet werden. Dadurch kann die Anzahl von Arbeitsvorgängen und der Komponenten im Vergleich mit dem Fall, wenn das Gleitkontaktelement **31** und der Mutterabschnitt **32** einzeln mit dem Gleitelement **3** verbunden werden, vermindert werden, so daß die Gleitführungseinheit wesentlich kostengünstiger herstellbar ist.

Außerdem kann die Halteplatte **15** bei dieser Ausführungsform der Gleitführungseinheit durch Spritzgießen eines Harzes an einem Ende der Laufschiene **1** fixiert ausgebildet werden. D. h., die Halteplatte **15** kann an einem Ende der Laufschiene **1** gegossen und fixiert werden, indem ein Ende der Laufschiene **1** in die Metallform eingesetzt und dort fixiert wird und anschließend ein Harz in die Metallform eingespritzt wird. Bei dieser Struktur muß die Halteplatte **15** nicht nachträglich an der Laufschiene **1** fixiert werden, so daß der zum Ausrichten der Wellenmitte der Schraubenwelle **2**, die durch die Halteplatte **15** bezüglich der Laufschiene drehbar gehalten wird, erforderliche Zeit- und Arbeitsaufwand reduziert wird.

Fig. 5 und 6 zeigen die zweite Ausführungsform einer erfindungsgemäßen Gleitführungseinheit.

Während die Vertiefung **42** des Kernblocks **4**, wo der Mutterabschnitt ausgebildet ist, bei der ersten Ausführungsform auf der Unterseite des Kernblocks **4** angeordnet ist, ist die Vertiefung **44** in der zweiten Ausführungsform in der Mitte auf der Oberseite des Kernblocks ausgebildet, und der Mutterabschnitt **32** ist durch Spritzgießen innerhalb der Vertiefung **44** ausgebildet. Daher stimmen in der zweiten Ausführungsform die horizontale Höhe der Wellenmitte der Schraubenwelle **2** und der Mitte des Gleitkontaktelements **31** anders als bei der ersten Ausführungsform nicht miteinander überein. Andere Merkmale, z. B., daß die vordere und die hintere Endfläche des Kernblocks **4** mit dem aus Harz hergestellten Verbindungsabschnitt bedeckt sind, und daß der Gleitkontaktabschnitt **31** und der Mutterabschnitt **32** als einstückiger Harzabschnitt **5** ausgebildet sind, sind die gleichen wie bei der ersten Ausführungsform. Daher werden die in Verbindung mit der ersten Ausführungsform verwendeten Bezugszeichen auch in den **Fig.** 5 und 6 verwendet, und eine detaillierte Beschreibung wird weggelassen.

Fig. 7 und 8 zeigen eine dritte Ausführungsform einer erfindungsgemäßen Gleitführungseinheit.

Wenn zwischen den Gleitführungsflächen **14**a, **14**b und dem Gleitkontaktelement **31** des Gleitelements **3** und zwischen der Gleitgewinderille **21** der Schraubenwelle **2** und dem darauf aufzuschraubenden Mutterabschnitt **32** Spiel vorhanden ist, können durch die durch die Drehbewegung der Schraubenwelle **2** verursachte hin- und hergehende Bewegung des Gleitelements **3** Rattern des Gleitelements **3** oder wiederholte Fehlausrichtungen verursacht werden, so daß der am Gleitelement **3** befestigte bewegliche Körper, z. B. ein Tisch, nicht präzise geführt werden kann.

Daher ist in der dritten Ausführungsform in der Mitte des näherungsweise V-förmigen Gleitkontaktelements **31** entlang seiner Länge ein Schlitz **36** ausgebildet, so daß das Gleitkontaktelement **31** sich zu jeder der Gleitführungsflächen **14**a, **14**b hin elastisch öffnet, um das Spiel zwischen dem Gleitkontaktelement **31** und den Gleitführungsflächen **14**a, **14**b zu eliminieren. D. h., das Gleitkontaktelement **31** auf der Seite des Gleitelements **3** ist etwas größer ausgebildet als die V-förmige Führungsnut **14** auf der Seite der Laufschiene **1**, und das Gleitelement **3** wird in die Laufschiene **1** eingesetzt, indem das Gleitkontaktelement **31** zusammengedrückt wird, um die Breite des Schlitzes **36** zu vermindern.

Dadurch wird das Gleitkontaktelement **31** mit den jeweiligen Gleitführungsflächen **14**a, **14**b elastisch in Kontakt gebracht, wodurch das Spiel dazwischen eliminiert und das Rattern des Gleitelements **3** verhindert werden kann.

Andererseits ist, um das Spiel zwischen der auf der Schraubenwelle **2** ausgebildeten Gleitgewinderille **21** und dem Mutterabschnitt **32** zu eliminieren, auf dem Mutterabschnitt **32** entlang der Länge des Gleitelements **3** ein Schlitz **37** ausgebildet, so daß der Mutterabschnitt **32** die Schraubenwelle **2** elastisch zusammendrückt. Um die Flexibilität des Mutterabschnitts **32** zu vergrößern, wird der Mutterabschnitt **32** nicht so gegossen, daß er die Vertiefung **42** des Kernblocks **4** füllt, wie in der ersten Ausführungsform, sondern so ausgebildet, daß er die Schraubenwelle **2** ringförmig umschließt. D. h., der Mutterabschnitt **32** wird so gegossen, daß der Innendurchmesser des Mutterabschnitts **32** etwas kleiner ist als der Außendurchmesser der Schraubenwelle **2**, so daß, wenn die Schraubenwelle **2** in den Mutterabschnitt **32** geschraubt wird, veranlaßt wird, daß der Schlitz **37** sich öffnet. Dadurch kommt der Mutterabschnitt **32** mit der auf der Schraubenwelle **2** ausgebildeten Gleitgewinderille elastisch in Kontakt, so daß das Spiel dazwischen eliminiert wird und die Präzision der wiederholten Ausrichtungen während einer hin- und hergehenden Bewegung des Gleitelements **3** verbessert werden kann. Weil die von dem vorstehend dargestellten Punkt verschiedene Struktur die gleiche ist wie bei der ersten Ausführungsform, werden in den Figuren die gleichen Bezugszeichen verwendet, und eine ausführliche Beschreibung wird weggelassen.

Die **Fig.** 9 und 10 zeigen die vierte Ausführungsform eines erfindungsgemäßen Gleitführungselements.

Bei der in **Fig.** 1 dargestellten ersten Ausführungsform einer Gleitführungseinheit ist die Laufschiene **1** in Form eines Kanals ausgebildet, und das Gleitelement **3** ist so konstruiert, daß es sich durch die Drehbewegung der Schraubenwelle **2** in der konkaven Nut der Laufschiene **1** hin- und hergehend bewegt, die Laufschiene **6** der vierten Ausführungsform ist jedoch so ausgebildet, daß sie einen näherungsweise rechteckigen Querschnitt hat, und das Gleitelement **7** ist quer über die Laufschiene **6** angeordnet. Außerdem wird die Schraubenwelle **8** durch die auf der Laufschiene befestigte Halteplatte **62** drehbar gehalten und ist in das Gleitelement **7** geschraubt.

Auf beiden Seiten der Laufschiene **6**, die einen rechteckigen Querschnitt hat, sind näherungsweise V-förmige Führungsnuten **61** ausgebildet, so daß die nach unten geneigte Fläche und die nach oben geneigte Fläche, die die Führungsnut **61** definieren, als Gleitführungsflächen **61**a, **61**b zum Führen des Gleitelements **7** dienen.

Andererseits wird, wie in den **Fig.** 11 und 12 dargestellt, das Gleitelement **7** durch Ausbilden eines Harzabschnitts **10** durch Spritzgießen auf dem Metallkernblock **9** ausgebildet. Das zum Spritzgießen verwendete Harz kann das gleiche sein wie das in der ersten Ausführungsform dargestellte Harz. Der Kernblock **9** hat einen H-förmigen Querschnitt mit konkaven Nuten auf seinem oberen Abschnitt und auf seinem unteren Abschnitt entlang der Länge des Gleitelements. In der unteren konkaven Nut **90** ist die Laufschiene **6** mit einem geringen Spiel lose eingepaßt, und in der oberen konkaven Nut **91** ist der Mutterabschnitt, in den die Schraubenwelle **8** eingeschraubt wird, durch ein Harz gegossen. Die obere Fläche des Kernblocks **9** auf der rechten und der linken Seite der oberen konkaven Nut dient als Montagefläche **92** für den beweglichen Körper, z. B. einen Tisch, und auf der Montagefläche **92** sind Gewindelöcher **93** zum Befestigen des beweglichen Körpers ausgebildet.

Auf den Innenflächen eines Paars von Randabschnitten **94**, **94**, die die untere konkave Nut **90** auf dem Kernblock **9** bilden, ist entlang der Länge des Gleitelements **7** eine Vertiefung **95** ausgebildet, und in der Vertiefung **95** ist ein V-förmiges, hervorstehendes Gleitkontaktelement **72** durch ein Harz gegossen. Das Gleitkontaktelement **72** wird in die Führungsnut **61** auf der Laufschiene **6** enganliegend angepaßt und bildet einen Gleitführungsmechanismus zum Halten des Gleitelements **7** in seiner hin- und hergehenden Bewegung zwischen dem Paar Gleitführungsflächen **61**a, **61**b.

Außerdem sind in der vierten Ausführungsform der Gleitführungseinheit, um den aus Harz gegossenen Mutterabschnitt und das Gleitkontaktelement **72** fest am Kernblock **9** zu fixieren, plattenförmige Verbindungsabschnitte **73** auf der vorderen und der hinteren Endfläche des Gleitelements **7** aus Harz so gegossen, daß der Kernblock **9** bedeckt wird, wodurch der Mutterabschnitt **71** und der Gleitkontaktabschnitt **72** einstückig ausgebildet sind. D. h., weil der Mutterabschnitt **71** und das Gleitkontaktelement **72** als ein Teil des Harzabschnitts **10** so integriert sind, daß sie den Kernblock **9** umgeben, sind der Kernblock **9** und das Gleitkontaktelement **72** und der Mutterabschnitt **71**, die aus einem Harz gegossen sind, fest integriert, wodurch sicher verhindert wird, daß der Mutterabschnitt **71** und das Gleitkontaktelement **72** sich vom Gleitelement **7** lösen, auch wenn durch eine plötzliche Änderung der Bewegungsrichtung der Schraubenwelle **8** eine größere Last auf das Gleitelement **7** ausgeübt wird.

Patentansprüche

1. Gleitführungseinheit mit:
einer Laufschiene mit einer Gleitführungsfläche entlang ihrer Länge;
einer Schraubenwelle, die parallel zur Laufschiene angeordnet ist und auf ihrem Außenumfang eine schraubenförmige Gleitgewinderille aufweist; und
einem Gleitelement mit einem Gleitkontaktelement, das dazu vorgesehen ist, mit der Gleitführungsfläche der Laufschiene in Kontakt gebracht zu werden, und einem auf die Schraubenwelle aufzuschraubenden Mutterabschnitt zum Führen eines beweglichen Körpers durch die Drehbewegung der Schraubenwelle entlang der Laufschiene;
dadurch gekennzeichnet, daß das Gleitelement einen Metallkernblock mit einer Montagefläche aufweist, auf der ein beweglicher Körper montierbar ist, und einen um den Kernblock herum durch Gießen ausgebildeten Harzabschnitt, und dadurch, daß das Gleitkontaktelement und der Mutterabschnitt in diesem einstückigen Harzabschnitt ausgebildet sind.
2. Gleitführungseinheit nach Anspruch 1, dadurch gekennzeichnet, daß der Harzabschnitt auf dem Kernblock so ausgebildet ist, daß er die vordere, die hintere, die linke und die rechte Seite des Gleitelements umgibt.
3. Gleitführungseinheit nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß das Gleitkontaktelement und/oder der Mutterabschnitt des Gleitelements so konstruiert sind, daß sie mit der Gleitführungsfläche der Laufschiene oder mit der Gleitgewinderille der Schraubenwelle elastisch in Kontakt gebracht werden können.
4. Gleitführungseinheit nach Anspruch 3, dadurch gekennzeichnet, daß das Gleitkontaktelement und/oder der Mutterabschnitt des Gleitelements einen Schlitz entlang der Länge des Gleitelements aufweisen, wodurch dem Gleitkontaktelement und/oder dem Mutterabschnitt Elastizität verliehen wird.
5. Gleitführungseinheit nach einem der vorangehen-

den Ansprüche, dadurch gekennzeichnet, daß eine Halteplatte aus Harz an einem Ende der Laufschiene in ihrer Breitenrichtung angeordnet ist, um die Schraubenwelle drehbar zu halten, und die Halteplatte durch Gießen auf der Laufschiene ausgebildet ist.

Hierzu 10 Seite(n) Zeichnungen

Nummer: DE 100 30 140 A1
Int. Cl.[7]: F 16 H 25/20
Offenlegungstag: 25. Januar 2001

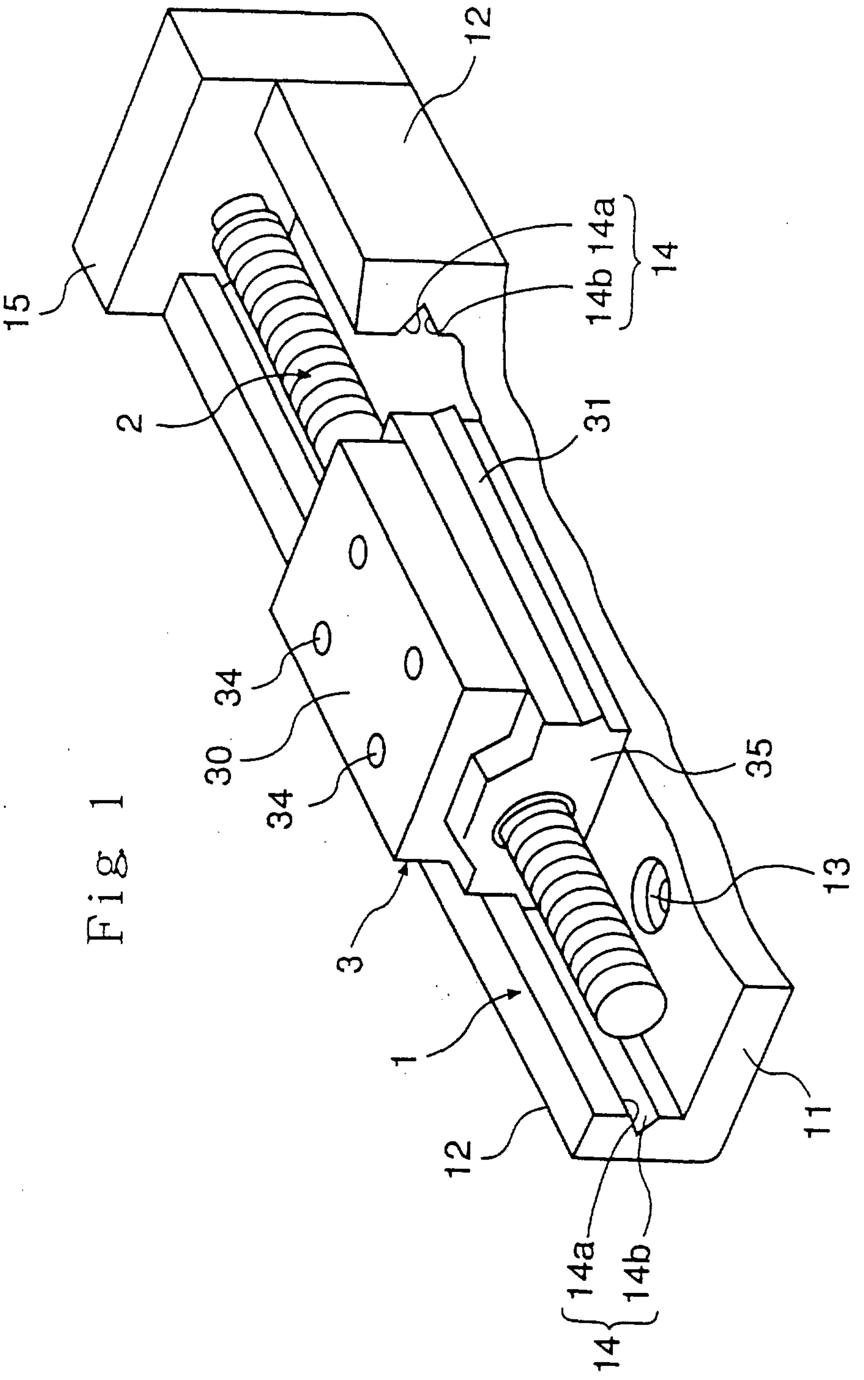


Fig 1

Nummer: DE 100 30 140 A1
Int. Cl.[7]: F 16 H 25/20
Offenlegungstag: 25. Januar 2001

Fig 2

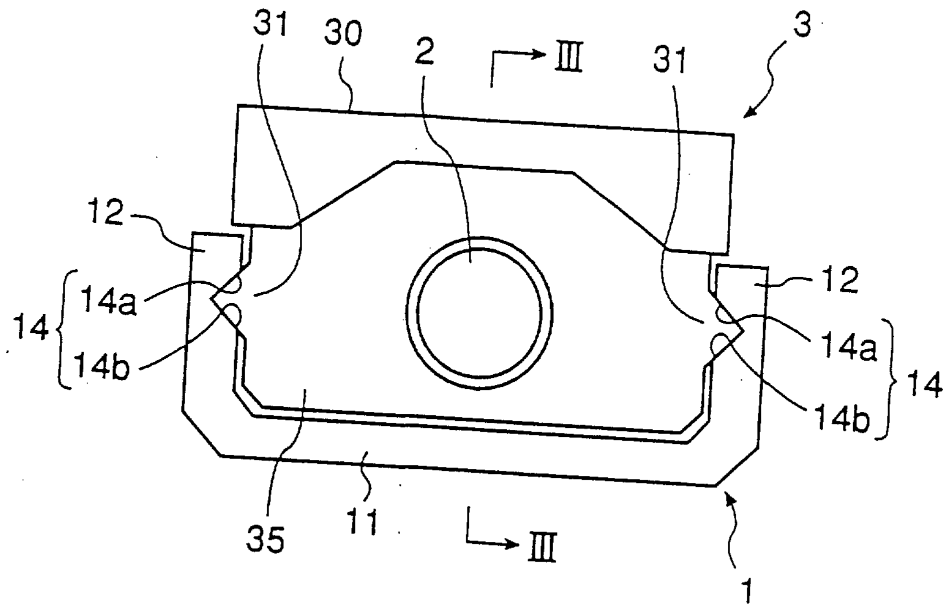


Fig 3

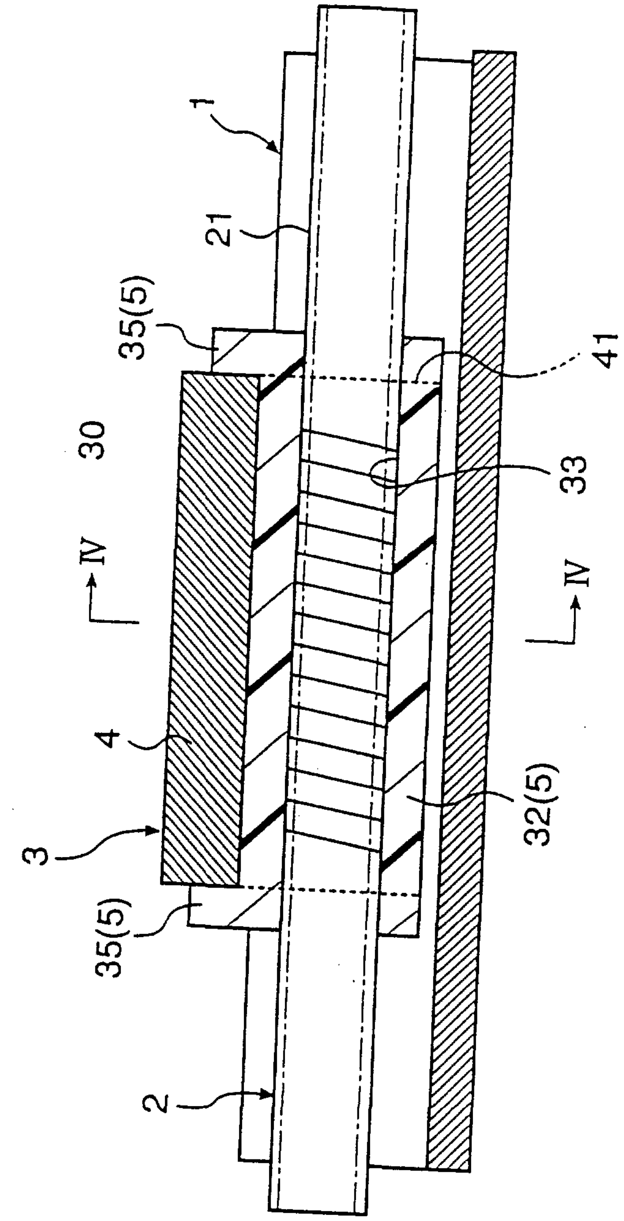
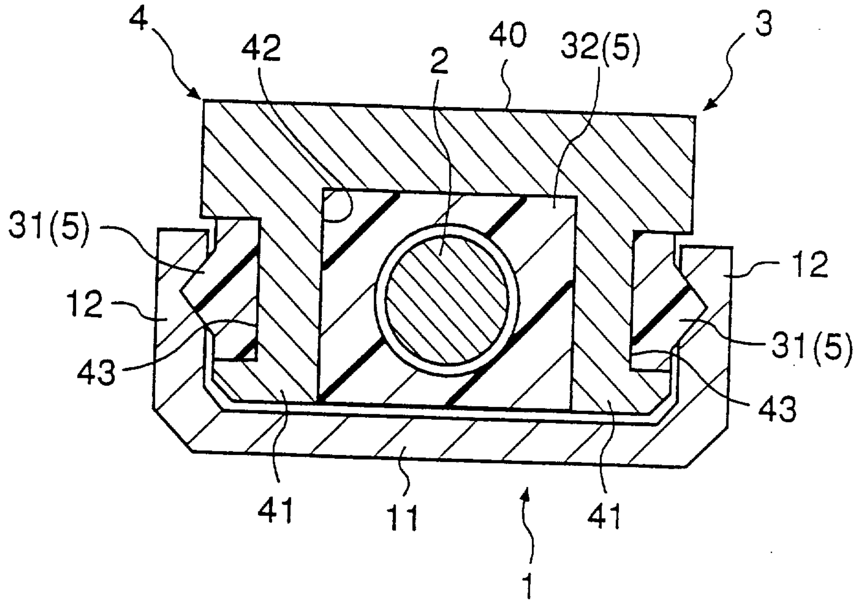


Fig 4



Nummer: DE 100 30 140 A1
Int. Cl.[7]: F 16 H 25/20
Offenlegungstag: 25. Januar 2001

Fig 5

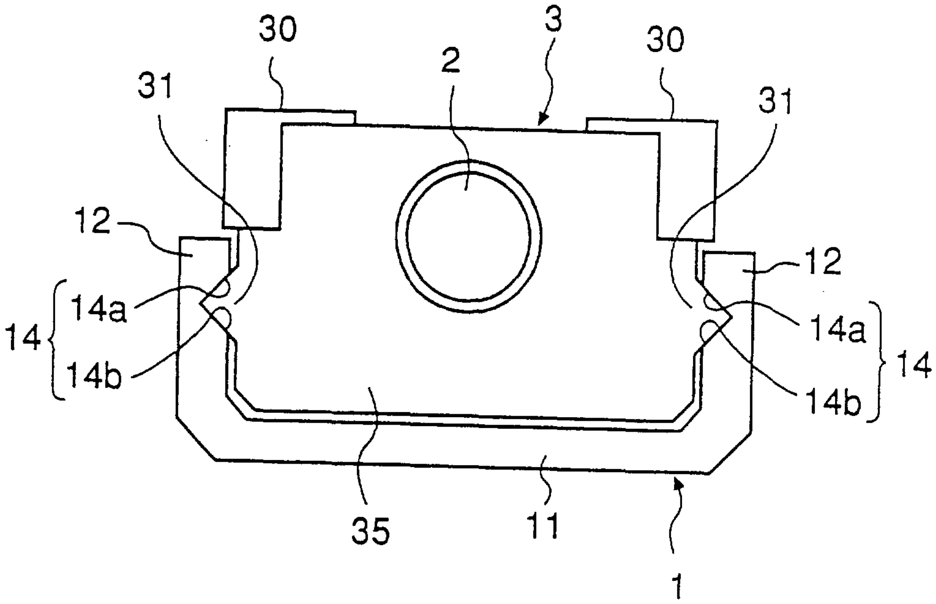
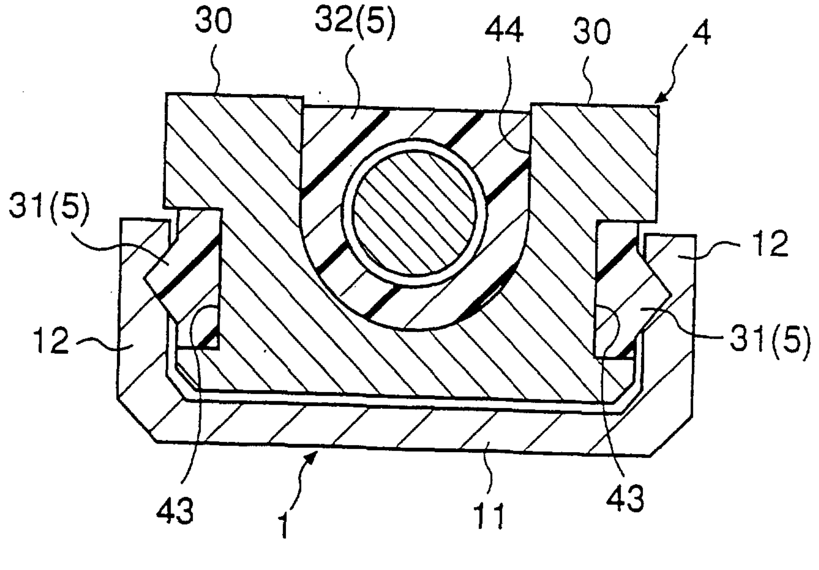


Fig 6



Nummer: **DE 100 30 140 A1**
Int. Cl.[7]: **F 16 H 25/20**
Offenlegungstag: 25. Januar 2001

Fig 7

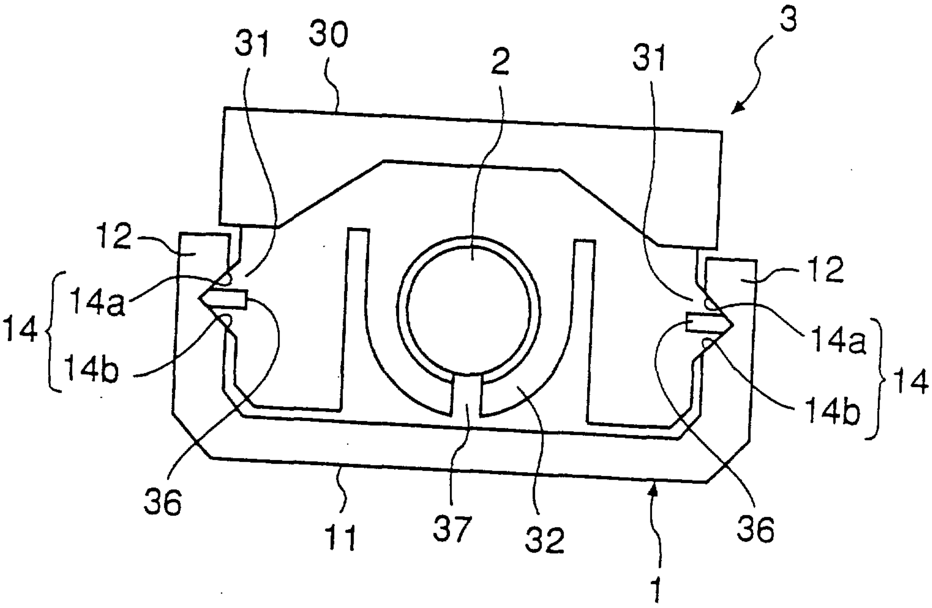
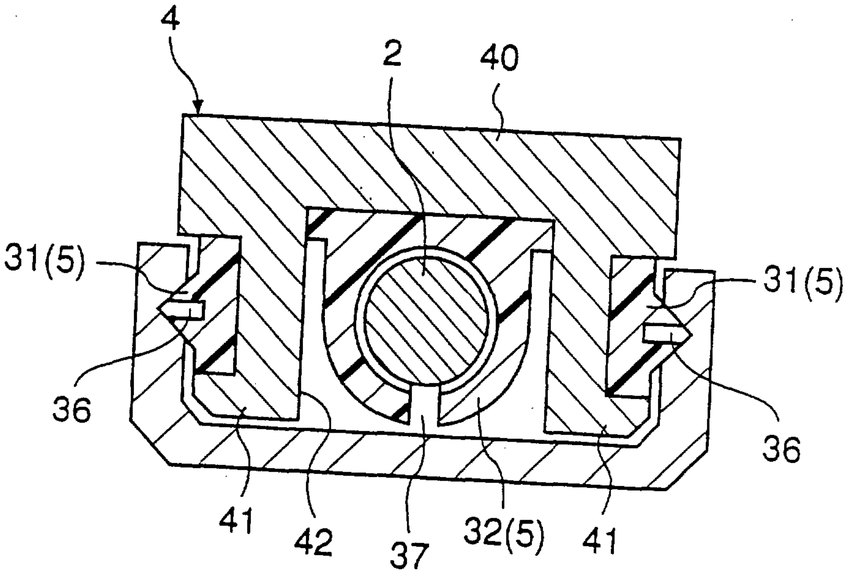
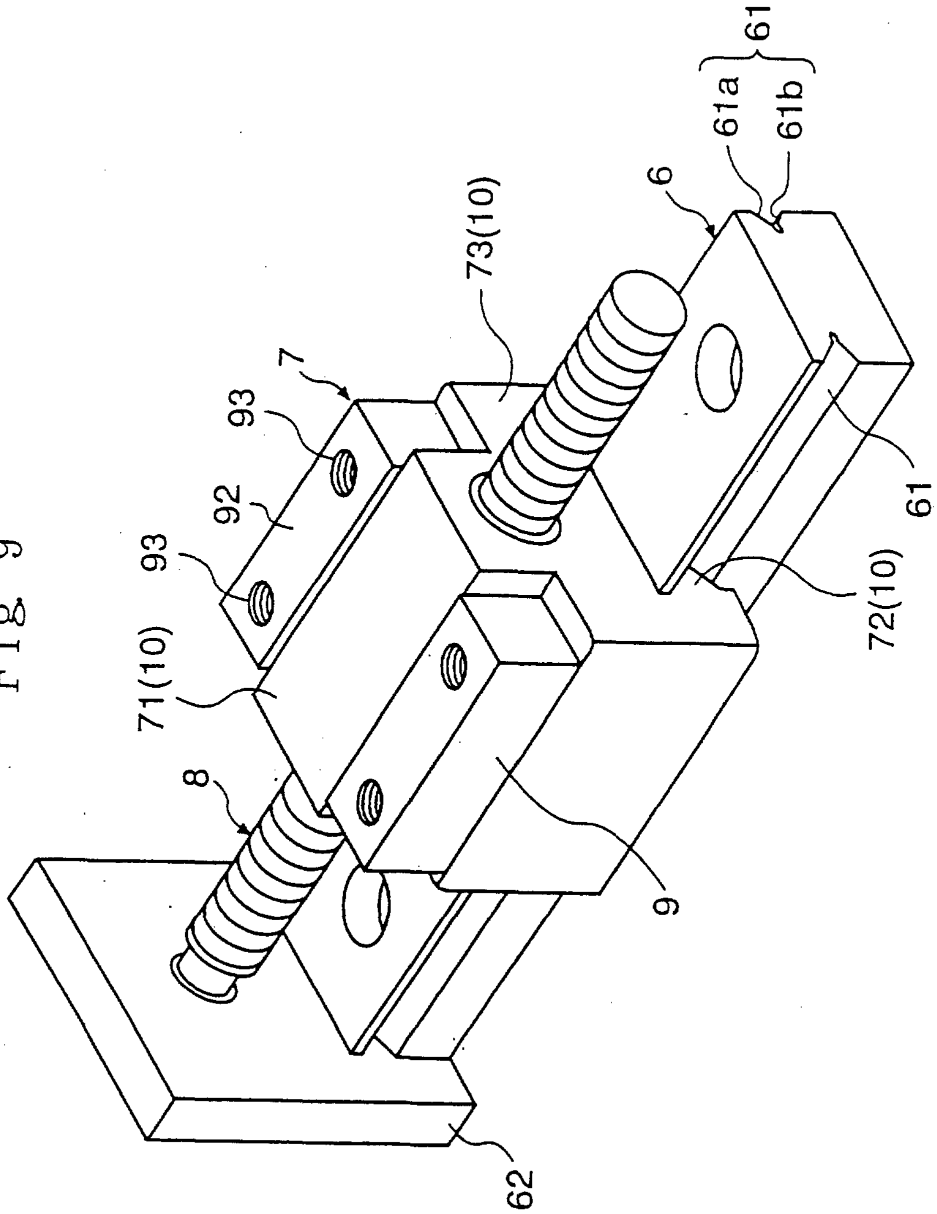


Fig 8



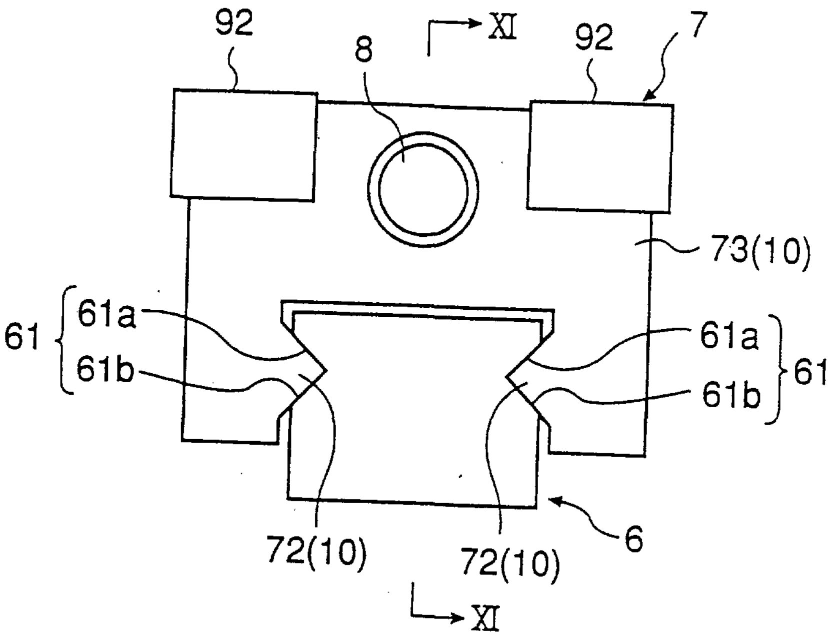
Nummer: DE 100 30 140 A1
Int. Cl.7: F 16 H 25/20
Offenlegungstag: 25. Januar 2001

Fig 9



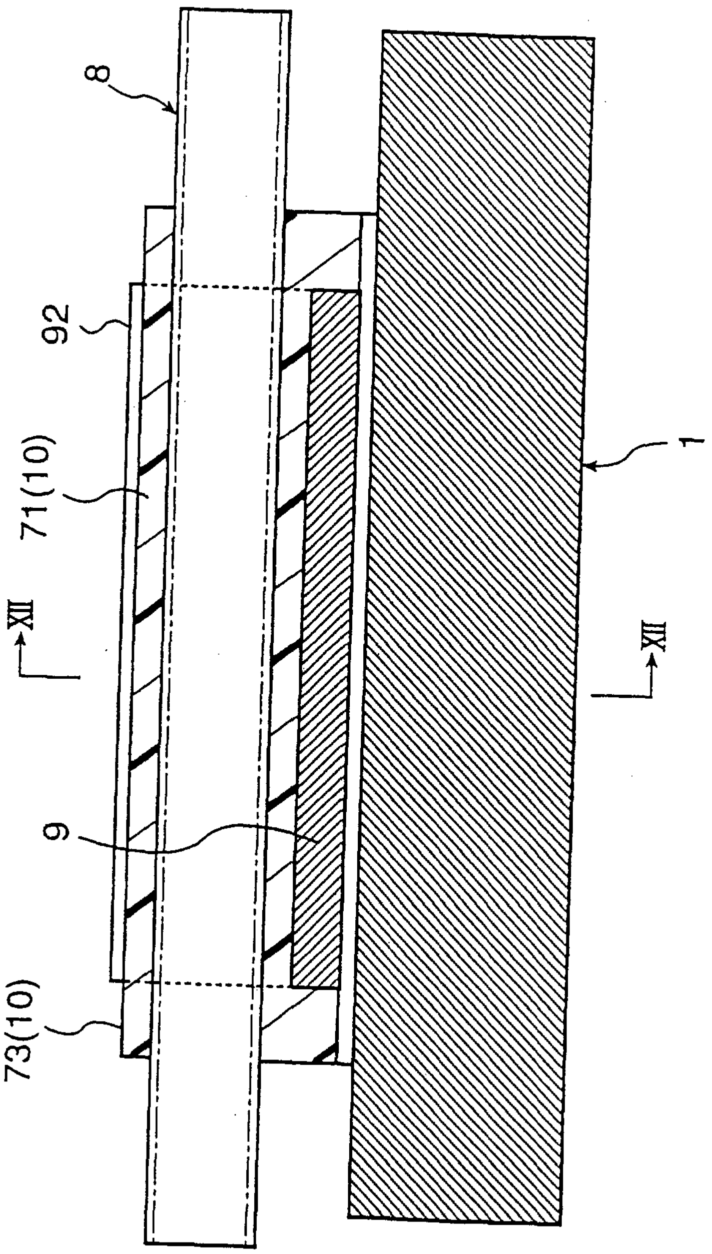
Nummer: DE 100 30 140 A1
Int. Cl.[7]: F 16 H 25/20
Offenlegungstag: 25. Januar 2001

Fig 10



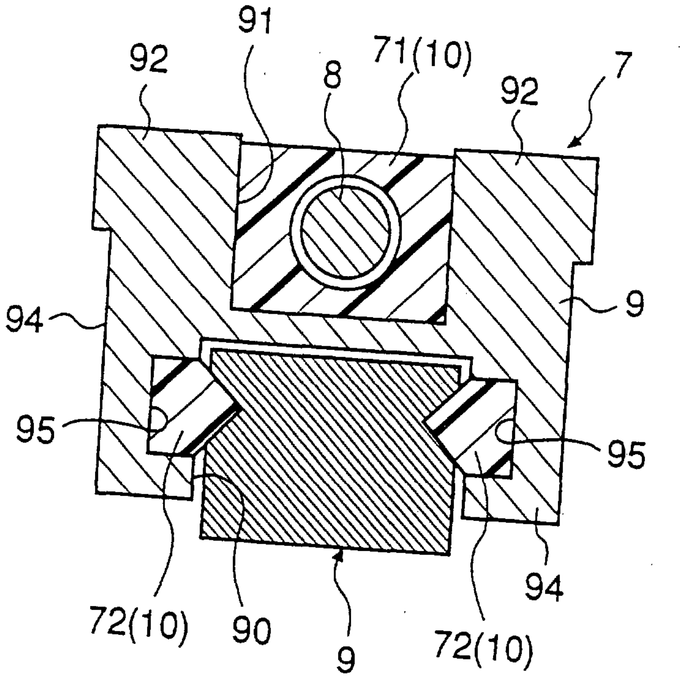
Nummer: DE 100 30 140 A1
Int. Cl.[7]: F 16 H 25/20
Offenlegungstag: 25. Januar 2001

Fig 11



Nummer: DE 100 30 140 A1
Int. Cl.[7]: F 16 H 25/20
Offenlegungstag: 25. Januar 2001

Fig 12



(19) **BUNDESREPUBLIK DEUTSCHLAND**

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 100 26 587 A 1**

(51) Int. Cl.[7]:
F 16 C 29/04
F 16 C 33/66

(21) Aktenzeichen: 100 26 587.1
(22) Anmeldetag: 29. 5. 2000
(43) Offenlegungstag: 7. 12. 2000

DE 100 26 587 A 1

(30) Unionspriorität:
11-153838 01. 06. 1999 JP

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

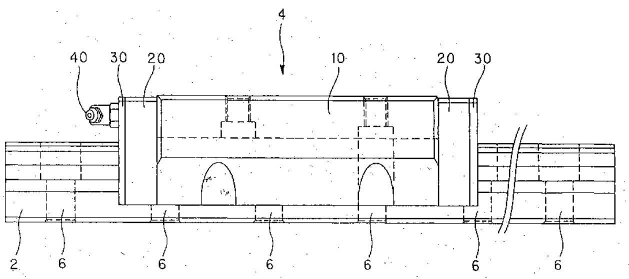
(74) Vertreter:
Viering, Jentschura & Partner, 80538 München

(72) Erfinder:
Mochizuki, Hiroaki, Tokio/Tokyo, JP

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Lineare Bewegungsvorrichtung

(57) Die Erfindung betrifft eine lineare Bewegungsvorrichtung, die eine Führungsschiene (2) mit Laufflächen (5) für Laufrollen (3) und einen auf der Führungsschiene bewegbaren Block (4), Endplatten (20), die an einander gegenüberliegenden Enden des Blocks in seiner Bewegungsrichtung vorgesehen sind und ein Endabdichtelement (30) aufweist, das an der Außenseite an jeder Endplatte vorgesehen ist. Ein Schmiermittel-Speicherelement (28), in dem sich Schmiermittel befindet, ist an jeder Endplatte (20) vorgesehen. Ein Auftragelement (31) zum Auftragen des von dem Schmiermittel-Speicherelement kommenden Schmiermittels auf die Führungsschiene ist an dem Endabdichtelement (30) vorgesehen.



DE 100 26 587 A 1

Beschreibung

Die Erfindung betrifft eine lineare Bewegungsvorrichtung, wie beispielsweise für eine Linearführung, eine Kugelspindel, eine Kugelwellennute oder dergleichen, in der eine Führungsschiene und ein Gleitkörper miteinander über Rollenelemente, wie beispielsweise Kugeln, Walzen oder dergleichen, kombiniert sind, um so eine Relativbewegung ausführen zu können, und insbesondere eine Verbesserung in einer linearen Bewegungsvorrichtung, die mit einer Schmiermittel-Zuführvorrichtung zum Aufbringen eines Schmiermittels auf die Oberfläche der Führungsschiene versehen ist.

Hinsichtlich einer Vorrichtung zum präzisen und reibungslosen Führen eines Tisches eines Maschinenwerkzeugs ist eine lineare Bewegungsvorrichtung bekannt, bei der ein Block durch eine Mehrzahl an Rollenelementen (z. B. Kugeln) auf einer Führungsschiene angeordnet ist (siehe z. B. Vorveröffentlichung des japanischen Patents Nr. H8-305,861).

In einer derartigen linearen Bewegungsvorrichtung ist der Block durch die Rollenelemente (z. B. Kugeln) bewegbar auf der Führungsschiene angeordnet, die Laufflächen für die Rollenelemente aufweist. An den gegenüberliegenden Enden des Blocks sind in Bewegungsrichtung Endplatten vorgesehen. Eine Schmiermittel-Zuführvorrichtung ist an der anderen Seite einer jeden Endplatte vorgesehen.

Die Schmiermittel-Zuführvorrichtung ist mit einem Schmiermittel-Speicherelement zum Aufnehmen eines auf die Führungsschiene aufzutragenden Schmiermittels versehen, einem Auftragelement zum Auftragen des Schmiermittels aus dem Schmiermittel-Speicherelement auf die Führungsschiene und einer Schmiermittel-Steuervorrichtung zwischen dem Schmiermittel-Speicherelement und dem Auftragelement, um die Menge des von dem Schmiermittel-Speicherelements an das Auftragelement zu führenden Schmiermittels zu steuern. Das Schmiermittel-Speicherelement, die Schmiermittel-Steuervorrichtung und das Auftragelement sind einstückig miteinander ausgebildet.

Nach dem Stand der Technik ist die Schmiermittel-Zuführvorrichtung mit einer Behälterform separat an der Außenfläche des Blocks der linearen Bewegungsvorrichtung angeordnet und dort befestigt. Wenn die Bewegungslänge für den Block in der linearen Bewegungsvorrichtung nicht ausreicht, kann keine Schmiermittel-Zuführvorrichtung an den Block hinzugefügt werden oder nur eine Schmiermittel-Zuführvorrichtung kann auf den einander gegenüberliegenden Seiten des Blocks vorgesehen werden, wodurch dann im Gegensatz zum Normalzustand, in dem ein Paar Schmiermittel-Zuführvorrichtungen jeweils auf den gegenüberliegenden Seiten des Blocks vorgesehen sind, Probleme auftauchen. Die Schmiermittel-Zuführvorrichtung ist mit dem Auftragelement für das Schmiermittel einstückig gebildet. Demzufolge ist es in dem Fall, wenn das Auftragelement verschlissen ist und durch ein neues ersetzt werden muss, notwendig, das Auftragelement zusammen mit dem Schmiermittel-Speicherelement auszuwechseln, selbst wenn in dem Schmiermittel-Speicherelement noch Schmiermittel vorhanden ist.

Eine Aufgabe der Erfindung ist es somit, eine lineare Bewegungsvorrichtung zu schaffen, die es ermöglicht, das Schmiermittel-Speicherelement und das Auftragelement für das Schmiermittel separat auswechseln zu können und das Schmiermittel auffüllen zu können und die Vorrichtung in einer kleinen Größe vorzusehen.

Zur Lösung dieser Aufgabe weist eine lineare Bewegungsvorrichtung der Erfindung auf:
eine Führungsschiene mit Laufflächen für Rollenelemente;
einen auf dieser Schiene bewegbaren Block;
Endplatten, die an einander gegenüberliegenden Enden des Blocks in seiner Bewegungsrichtung vorgesehen sind; und
ein Endabdichtelement, das auf einer Außenseite von jeder der Endplatten vorgesehen ist, wobei ein Schmiermittel-Speicherelement zum Aufbewahren eines Schmiermittels an jeder der Endplatten, und ein Auftragelement zum Auftragen des von dem Schmiermittel-Speicherelement geführten Schmiermittels auf die Führungsschiene an dem Endabdichtelement vorgesehen sind.

Gemäß dem oben erwähnten Aufbau der Erfindung ist es möglich, das Schmiermittel-Speicherelement und das Auftragelement separat auszuwechseln. Die Einarbeitung des Schmiermittel-Speicherelements in die Endplatten ermöglicht es, die lineare Bewegungsvorrichtung in geringer Größe vorzusehen.

Die Zuführleitung zum Zuführen des Schmiermittels an das Schmiermittel-Speicherelement kann auf jeder der Endplatten vorgesehen sein. Gemäß einem derartigen Aufbau ist es möglich, das Schmiermittel leicht aufzufüllen, ohne die Endplatte abzunehmen, wenn das in dem Schmiermittel-Speicherelement aufbewahrte Schmiermittel zur Neige geht.

Das Schmiermittel-Speicherelement und das Auftragelement können aus einem Fasermaterial hergestellt sein. Das Fasermaterial des Auftragelements hat vorzugsweise eine größere Dichte als das Fasermaterial des Schmiermittel-Speicherelements.

Eine Vorrichtung zum Justieren der Menge des von dem Schmiermittel-Speicherelement abgeführten Schmiermittels an das Auftragelement kann zwischen dem Schmiermittel-Speicherelement und dem Auftragelement vorgesehen sein.

Die Erfindung wird nun in Bezug auf die beigefügte Zeichnung näher beschrieben. In dieser zeigen:

Fig. 1 eine Seitenansicht einer erfindungsgemäßen linearen Bewegungsvorrichtung;

Fig. 2 einen Querschnitt einer Führungsschiene der erfindungsgemäßen linearen Bewegungsvorrichtung;

Fig. 3 eine Frontansicht eines Blocks der erfindungsgemäßen linearen Bewegungsvorrichtung, wobei der linke Abschnitt in Bezug auf die Schnittlinie III-III im Querschnitt gezeigt ist;

Fig. 4 eine Frontansicht der erfindungsgemäßen linearen Bewegungsvorrichtung, wobei der linke Abschnitt in Bezug auf die Schnittlinie IV-IV im Querschnitt gezeigt ist;

Fig. 5 eine vergrößerte Ansicht des Abschnitts "V" aus **Fig.** 4;

Fig. 6 eine rückwärtige Ansicht der Endplatte der erfindungsgemäßen linearen Bewegungsvorrichtung;

Fig. 7 einen Querschnitt, der die Endplatte und das Endabdichtelement der erfindungsgemäßen linearen Bewegungsvorrichtung zeigt; und

Fig. 8 eine Frontansicht des Endabdichtelements der linearen Bewegungsvorrichtung der Erfindung, wobei der linke Abschnitt in Bezug auf die Schnittlinie IV-IV im Querschnitt dargestellt ist.

Im Folgenden wird nun eine Ausführungsform einer erfindungsgemäßen linearen Bewegungsvorrichtung mit Bezug auf die beigefügte Zeichnung im Detail beschrieben.

Die **Fig.** 1 bis 8 zeigen die lineare Bewegungsvorrichtung der Erfindung. Die lineare Bewegungsvorrichtung **1** ist mit einer als Führungsschiene dienenden Schiene **2** und einem als Block dienenden Gleitkörper **4** versehen, der durch eine Mehrzahl an Rollen (Rollenelemente) **3** auf der Schiene **2** befestigt ist, um so in der Längsrichtung der Schiene **2** bewegbar zu sein. Die Schiene **2** ist mit vier Rollenelement-Laufflächen **5** versehen, die sich über die gesamte Länge der Schiene **2** in ihrer Längsrichtung erstrecken, und mit Bolzenlöchern **6**, durch die hindurch Bolzen zum Befestigen der

Schiene **2** eingesetzt sind. Die dargestellte Schiene **2** hat eine geradlinige Form. Ebenso kann eine Schiene mit einer gekrümmten Form verwendet werden. Die Anzahl der Rollenelement-Laufflächen **5** ist nicht auf vier begrenzt (d. h., zwei Laufflächen an der rechten Seite und zwei Laufflächen an der linken Seite). Eine einzelne Rollenelement-Lauffläche **5** kann an jeder Seite der rechten und linken Schiene vorgesehen sein. Die Gesamtzahl der Rollenelement-Laufflächen kann drei oder vier betragen. Die Anzahl kann entsprechend der Verwendung der linearen Bewegungsvorrichtung variieren.

Wie in den **Fig.** 1 und 3 gezeigt, hat der Gleitkörper **4** einen Gleitblock **10**, genauso wie Endplatten **20** und Endabdichtelemente **30**, die an den einander gegenüberliegenden Enden des Gleitblocks **10** vorgesehen sind. Der Gleitblock **10** hat eine ausreichende Festigkeit um eine auf dem Gleitkörper **4** aufliegende Last zu tragen. Der Gleitblock **10** ist normalerweise aus Stahl gefertigt. Ein Kunstharz-Körper kann in Abschnitten des Gleitblocks **10** eingearbeitet sein, an denen die Last nicht direkt aufgebracht wird. Der Gleitblock **10** hat einen vertieften Abschnitt **11**, der an der Unterseite des Gleitblocks angeordnet ist, um die Schiene **2** aufzunehmen. Die Wandflächen des Gleitblocks **10**, die den vertieften Abschnitt **11** definieren, weisen Rollenelement-Gegenlaufflächen **12** auf, die die Gegenfläche entsprechend den Rollenelement-Laufflächen **5** der Schiene **2** darstellen.

Gemäß den **Fig.** 4 und 5 laufen die Rollen **3** zwischen den Rollenelement-Laufflächen **5** und den Rollenelement-Gegenlaufflächen **12**, wenn der Gleitkörper **4** entlang der Schiene **2** bewegt wird. Die Laufrolle **3**, die das Ende der Rollenelement-Gegenlauffläche **12** erreicht, wird an einen Richtungswechsel-Abschnitt **21** (siehe **Fig.** 6) geführt, der an der Innenseite der Endplatte **20** vorgesehen ist, die sich an einer Seite des Gleitblocks **10** befindet. Dann läuft die Laufrolle **3** durch einen Umkehrdurchgang **13** und einen Richtungswechselabschnitt **21**, der an der Innenseite der Endplatte vorgesehen ist, die sich an der anderen Seite des Gleitblocks **10** befindet, wodurch sie das andere Ende der Rollenelement-Gegenlauffläche **12** erreicht. Der Zwischenraum zwischen der Rollenelement-Lauffläche **5** und der Rollenelement-Gegenlauffläche **12** wird normalerweise als "Lastlaufbereich" für die Laufrollen **3** bezeichnet. Die Kombination der Richtungswechselabschnitte **21** der Endplatte **20** mit dem Umkehrdurchgang **13** des Gleitblocks wird als "unbelasteter Laufbereich" bezeichnet. Die Kombination des Lastlaufbereichs mit dem unbelasteten Laufbereich wird als "Endlos-Schleifendurchlauf" bezeichnet. Wie in **Fig.** 6 gezeigt, hat der Richtungswechselabschnitt **21** ein Paar Richtungswechseldurchgänge **21**a und **21**b, die ein zweiarmiges Kreuz im Inneren der Endplatte **20** bilden. Die Richtungswechseldurchgänge **21**a und **21**b, die das Zweiarm-Kreuz bilden, führen zu einer dicken Erhöhung der Endplatte **20**, wodurch es möglich ist, die Speicherkapazität des Schmiermittel-Speicherelements **28** zu erhöhen, die nachfolgend beschrieben wird. Im Ergebnis ist es möglich, die Anzahl der Rückführ-Verfahrensschritte des Schmiermittels zu reduzieren.

Die Endplatte **20** hat ein Paar Flügelabschnitte **20**b, **20**b und einen Trägerabschnitt **20**a, der die Flügelabschnitte **20**b, **20**b miteinander verbindet, wodurch eine gemäß **Fig.** 6 gezeigte U-Gestalt gebildet wird. Der Trägerabschnitt **20**a der Endplatte **20** hat in seinem mittleren Bereich eine Schmiermittelöffnung **22**, in die ein Schmiernippel **40** eingepasst ist. Die Flügelabschnitte **20**b weisen jeweils die oben erwähnten Richtungswechselabschnitte **21** auf. Die Endplatte **20** hat Schmiermittelleitungen **23**, um das in die Schmiernippel **40** eingespritzte Fett in Richtung der Wechselabschnitte **21** zu führen. Die Endplatte **20** hat einen vertieften Abschnitt **24**, der auf der Unterfläche des Trägerabschnitts **20**a ausgebildet ist, um sich so in einer Querrichtung gemäß **Fig.** 7 zu erstrecken. Verbindungslöcher **25** verbinden den unteren Anteil des vertieften Abschnitts **24** mit der Außenseite der Endplatte **20**. Um die Verbindungslöcher **25** sind O-Ringe **26** angeordnet. Wie in **Fig.** 6 gezeigt, ist eine Schmiermittel-Zuführleitung **27**, die die eine Seitenfläche des Trägerabschnitts **20**a mit dem vertieften Abschnitt **24** funktional verbindet, durch die Kombination eines Vertikallochs **27**a, das sich von der Oberfläche des Trägerabschnitts **20**a in der Vertikalrichtung erstreckt, um mit dem vertieften Abschnitt **24** funktional zu kommunizieren, mit einem Horizontalloch **27**b vorgesehen, das sich von der Seitenfläche in der Horizontalrichtung erstreckt, um mit dem Vertikalloch **27**a funktional zu kommunizieren. Die gleiche Schmiermittel-Zuführleitung **27** ist ebenso an der anderen Seite gemäß **Fig.** 6 vorgesehen. Verschlußstöpsel **27**c verschliessen die oberen Öffnungen der Vertikallöcher **27**a. Die Einlassabschnitte der Schmiermittel-Zuführleitungen **27** sind mit Gewindebohrlochabschnitten **27**d versehen. Die Verschlußstöpsel **27**e stehen mit den Gewindebohrlochabschnitten **27**d im Eingriff, um die Einlassabschnitte zu schließen. Die Verschlußstöpsel **27**e, **27**e können von den Gewindebohrlochabschnitten **27**d abgenommen werden, wenn Schmiermittel aufgefüllt wird. Das Schmiermittel-Speicherelement **28**, das aus einem Fasermaterial, wie beispielsweise einem Fasernetz, hergestellt ist und eine große Menge an Schmiermittel aufnehmen kann, ist in dem vertieften Abschnitt **24** aufgenommen. Ein Teil des Schmiermittel-Speicherelements **28** wird von jedem der Verbindungslöcher **25** aufgenommen, um so von der Endplatte **20** nach außen hervorzuragen. Eine Trägerplatte **29** ist durch eine geeignete Befestigungsvorrichtung an dem offenen Ende des vertieften Abschnitts **24** eingepasst, in dem das Schmiermittel-Speicherelement **28** aufgenommen ist.

Gemäß den **Fig.** 7 und 8 weist das Endabdichtelement **30** einen Dichtungskörper **32** zum Aufnehmen eines Auftragelements **31**, durch das das Schmiermittel auf die Schiene **2** aufgebracht wird, und eine Abdeckung **33** auf, die entlang des Auftragelements **31** angeordnet ist. Das Auftragelement **31** ist aus einem Fasermaterial, wie beispielsweise einem Fasernetz hergestellt. Das Fasermaterial des Auftragelements **31** hat vorzugsweise eine höhere Dichte als das Fasermaterial des Schmiermittel-Speicherelements **28**. Der Abdichtkörper **32** hat Löcher **32**a, die auf Abschnitten ausgebildet sind, die den Rollenelement-Laufflächen **5** entsprechen, wenn der Gleitkörper **4** auf der Schiene **2** angeordnet ist. Teile des Auftragelements **31** stehen von dem Abdichtkörper **32** aus den Löchern **32**a nach außen hervor. Die Abdeckung **33** ist auf dem Auftragelement **31** angeordnet und an dem Abdichtkörper **32** durch eine geeignete Befestigungsvorrichtung befestigt. Die Teile des Schmiermittel-Speicherelements **28**, die von der Endplatte **20** durch die Schmiermittel-Zuführlöcher **32**b hervorstehen, die an der Wand des Abdichtkörpers **32** vorgesehen sind, treten mit dem Auftragelement **31** in Kontakt. Das Endabdichtelement **30** hat ein Durchgangsloch **34**, durch das das Schmiermittel **40** an die Schmiernippel-Einpassöffnung **22** angeschlossen werden kann, die auf der Endplatte **20** vorgesehen ist.

Nachfolgend werden nun die Verfahren zum Zusammenbau des Gleitkörpers **4**, zur Montage des Gleitkörpers auf der Schiene **2** und die Verwendung der linearen Bewegungsvorrichtung beschrieben. Die Endplatte **20** wird an das Ende des Gleitblocks **10** gesetzt und das Endabdichtelement **30** wird an die Außenfläche der Endplatte **20** gepasst. Die Laufrollen **3** werden in den Umkehrdurchgang **13** gesetzt, der an dem anderen Ende des Gleitblocks **10** angeordnet ist. Jede der Laufrollen **3** besteht aus einem Rollenkörper **3**a und einer Welle **3**b. Die Laufrolle **3** wird in den Umkehrdurchgang **13** gesetzt, so dass eine Wellenaufnahmerille **13**a, die an dem Umkehrdurchgang **13** angeordnet ist, die Welle **3**b der Laufrolle **3** aufnimmt. Der Richtungswechselabschnitt **21** wechselt die Bewegungsrichtung der Laufrollen **3**, die die Endplatte **20** erreichen, mit dem Ergebnis, dass sich die Laufrollen **3** an die Rollenelement-Umkehrlauffläche **12** bewegen. Der Endlos-Schleifendurchgang ist mit den Laufrollen **3** angefüllt und die Endplatte **20** und das Endabdichtelement **30** sind an dem anderen Ende des Gleitblocks **10** eingepasst.

Der Gleitkörper **4** ist auf der Schiene durch Einsetzen des Endes der Schiene **2** in den vertieften Abschnitt **11** des Gleitkörpers **4** befestigt. In diesem Zustand kommen die aus den Löchern **32**a hervorstehenden Teile des Auftragelements **31** mit den Rollenelement-Laufflächen **5** in Kontakt.

Dann wird das Schmiermittel durch die Schmiermittel-Zuführleitung **27** abgegeben. Das abgegebene Schmiermittel fällt dann durch das Vertikalloch **27**a nach unten und wird von dem Schmiermittel-Speicherelement **28** absorbiert. Das Schmiermittel wird durch die Teile des Schmiermittel-Speicherelements **28** an das Auftragelement **31** geführt, welche Teile mit dem Auftragelement **31** durch die Verbindungslöcher **25** und den Schmiermittel-Zuführlöchern **32**b in Kontakt kommen.

Dann wird Schmierfett von dem Schmiernippel **40** abgegeben, der in der Schmiernippel-Passöffnung **22** eingepasst ist. Das somit abgegebene Schmierfett wird durch die Schmierfettleitungen **23** an die Richtungswechselabschnitte **21** geführt. Das Schmierfett wird durch die Richtungswechselabschnitte **21** an den Endlos-Schleifendurchgang geführt.

Wenn sich der Gleitkörper **4** auf der Schiene **2** bewegt, bewegt sich das durch das Auftragelement **31**, das mit den Rollenelement-Laufflächen **5** in Kontakt gerät, zur Verfügung gestellte Schmiermittel aufgrund der Kapillarkraft an die Rollenelement-Laufflächen **5**. Wenn die Menge des in dem Auftragelement **31** befindlichen Schmiermittels weniger wird, läuft das Schmiermittel aufgrund der Kapillarkraft von dem Schmiermittel-Speicherelement **28** durch die Schmiermittel-Zuführlöcher **32**b an das Auftragelement **31**. Der Gleitkörper **4** bewegt sich durch die zwischen dem Gleitkörper **4** und der Schiene **2** befindlichen Laufrollen **3** auf der Schiene **2**. Das in den Endlos-Schleifendurchgang eingebrachte Schmierfett schafft eine reibungslose Rollenbewegung der Laufrollen **3**.

Nach einer langen Inbetriebnahme der linearen Bewegungsvorrichtung verschleißt das Auftragelement **31** aufgrund der Reibung mit den Rollenelement-Laufflächen **5** und muss somit durch ein Neues ersetzt werden. In diesem Fall ist es möglich ausschließlich das Auftragelement **31** auszuwechseln, da das Schmiermittelspeicherelement **28** und das Auftragelement **31** separat ausgebildet sind. Damit ist es unnötig, das Schmiermittel-Speicherelement **28** und das darin befindliche Schmiermittel wegzuwerfen.

Die Erfindung ist jedoch nicht auf die oben gezeigte Ausführungsform beschränkt. In dieser Ausführungsform ist die Kontaktfläche des Schmiermittel-Speicherelements mit dem Auftragelement (d. h., die Bereiche seiner Endflächen) konstant. Eine Vorrichtung zum Justieren der Kontaktfläche des Schmiermittel-Speicherelements mit dem Auftragelement (d. h., die Bereiche der Endflächen) kann zwischen ihnen vorgesehen sein, wodurch es möglich wird, die Menge des an das Auftragelement geführten Schmiermittels einzustellen. In der oben gezeigten Ausführung umfasst der Richtungswechselabschnitt das Paar der Richtungswechseldurchgänge, die ein zweiarmiges Kreuz an der Innenseite der Endplatte bilden. Das Paar Richtungswechseldurchgänge kann jeweils parallel miteinander vorgesehen sein, ohne ein derartiges zweiarmiges Kreuz zu bilden. Die Erfindung kann auf jeden Typ einer Vorrichtung, wie beispielsweise eine Kugelspindel, eine Kugelwellennute oder dergleichen Vorrichtung angewendet werden, in der ein Gleitelement, das mit einer Schmiermittelzuführvorrichtung versehen ist, entlang einer Führungsschiene bewegt werden kann.

Gemäß der Erfindung kann das Schmiermittel-Speicherelement und das Auftragelement für das Schmiermittel separat ausgewechselt werden und das Schmiermittel aufgefüllt und die Vorrichtung in einer kleinen Größe ausgeführt werden.

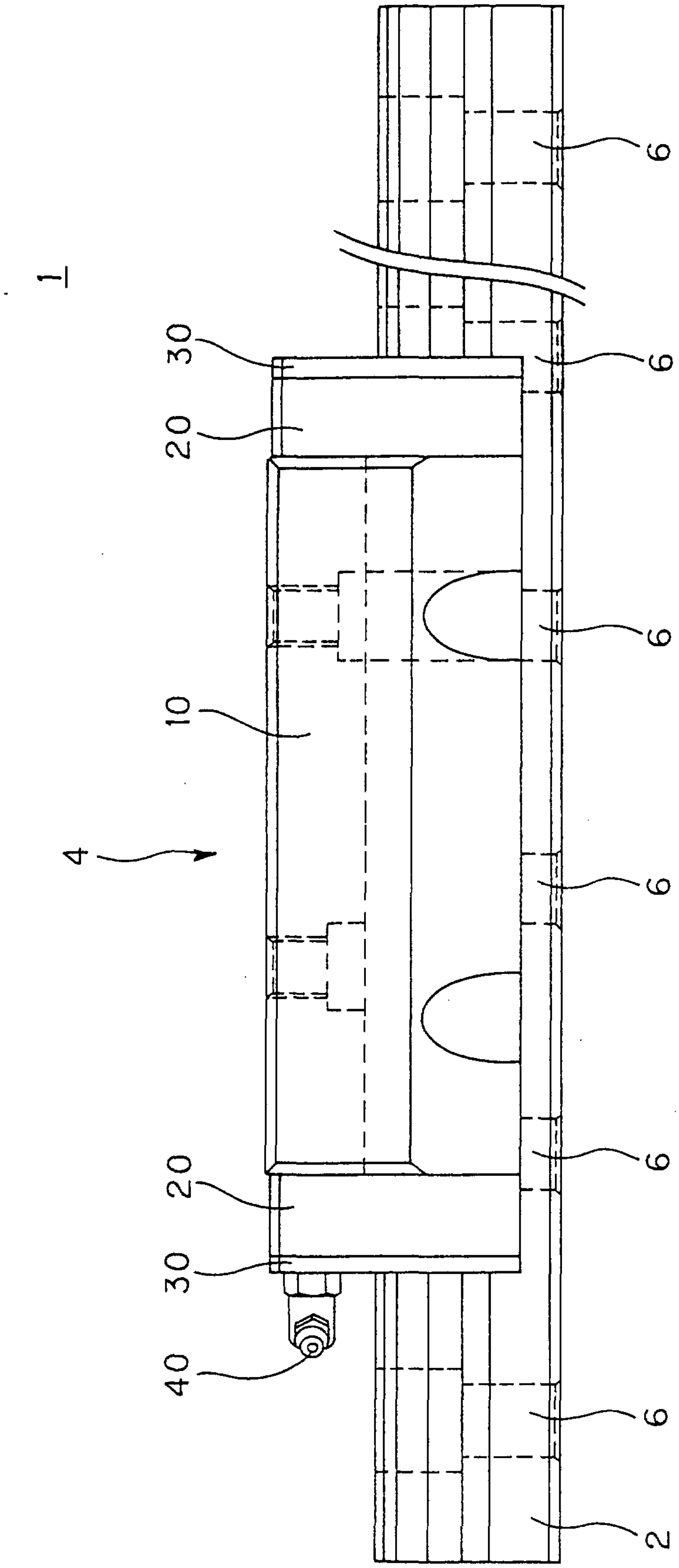
Patentansprüche

1. Lineare Bewegungsvorrichtung, aufweisend:
eine Führungsschiene (**2**) mit Laufflächen (**5**) für Laufrollen (**3**) einen auf der Führungsschiene bewegbaren Block (**4**);
Endplatten (**20**), die an einander gegenüberliegenden Enden des Blocks in seiner Bewegungsrichtung vorgesehen sind; und
ein Endabdichtelement (**30**), das an einer Außenseite an jeder der Endplatten vorgesehen ist, wobei:
zum Aufnehmen eines Schmiermittels ein Schmiermittel-Speicherelement (**28**) an jeder Endplatte (**20**) vorgesehen ist und ein Auftragelement (**31**) an dem Endabdichtelement zum Auftragen des von dem Schmiermittel-Speicherelement abgeführten Schmiermittels auf die Führungsschiene vorgesehen ist.
2. Vorrichtung nach Anspruch 1, wobei eine Zuführleitung (**27**) zum Zuführen des Schmiermittels an das Schmiermittel-Speicherelement (**28**) an jeder Endplatte (**20**) vorgesehen ist.
3. Vorrichtung nach Anspruch 1 oder 2, wobei das Schmiermittel-Speicherelement (**28**) und das Auftragelement (**31**) aus einem Fasermaterial hergestellt sind.
4. Vorrichtung nach Anspruch 3, wobei das Fasermaterial des Auftragelements (**31**) eine höhere Dichte als das Fasermaterial des Schmiermittel-Speicherelements (**28**) hat.
5. Vorrichtung nach einem der Ansprüche 1 bis 4, wobei eine Vorrichtung zum Justieren der Menge des von dem Schmiermittel-Speicherelement (**28**) an das Auftragelement (**31**) geführten Schmiermittels zwischen dem Schmiermittel-Speicherelement und dem Auftragelement vorgesehen ist.

Hierzu 8 Seite(n) Zeichnungen

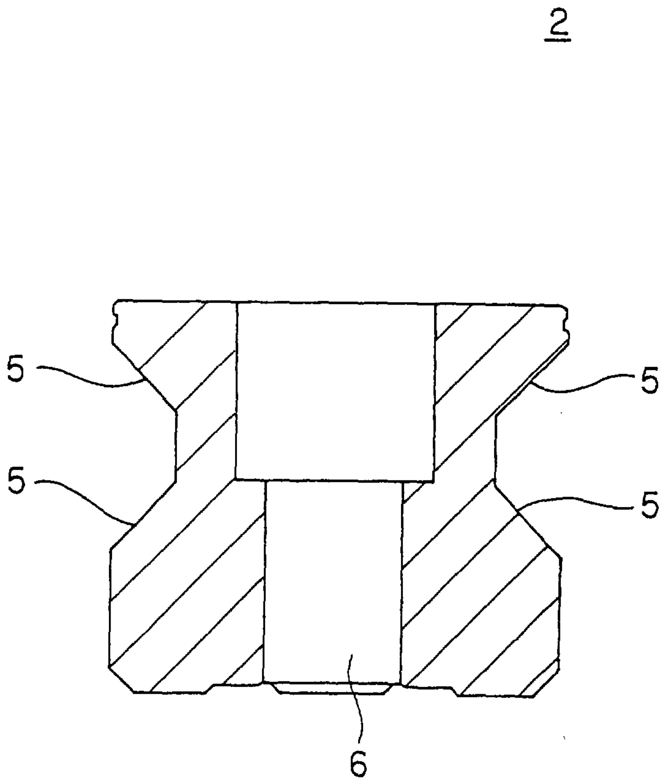
Nummer: **DE 100 26 587 A1**
Int. Cl.[7]: **F 16 C 29/04**
Offenlegungstag: 7. Dezember 2000

FIG. 1



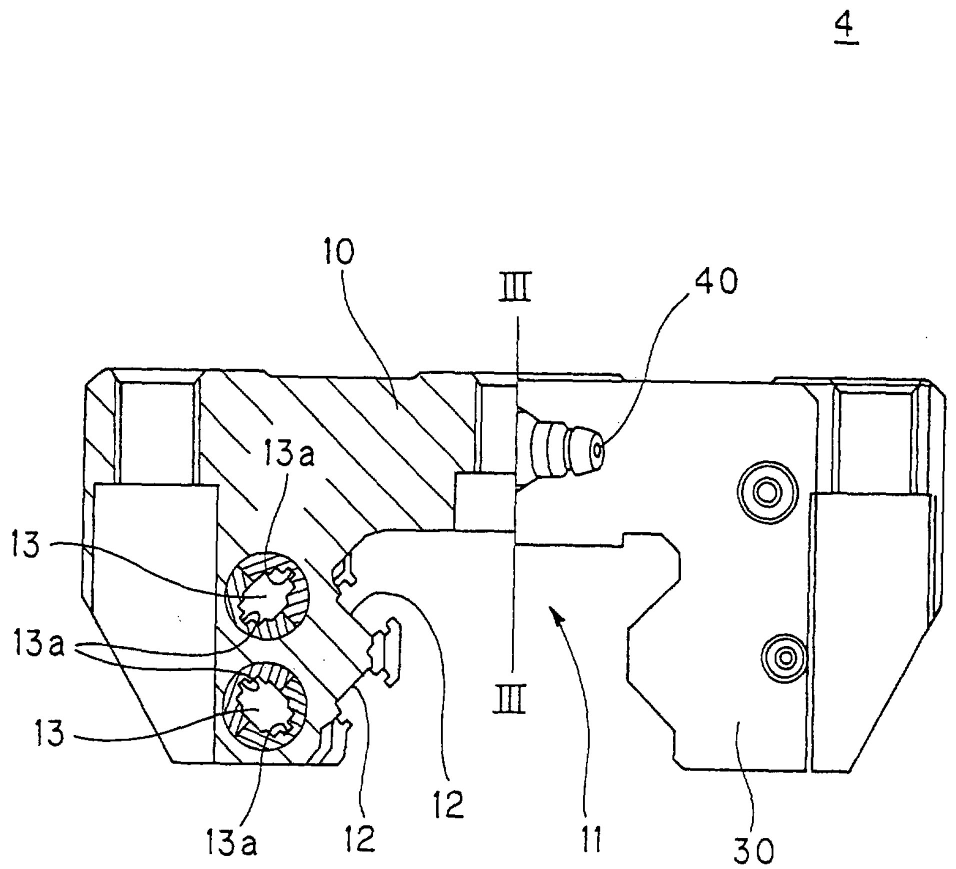
Nummer: **DE 100 26 587 A1**
Int. Cl.^{7}: **F 16 C 29/04**
Offenlegungstag: 7. Dezember 2000

FIG. 2



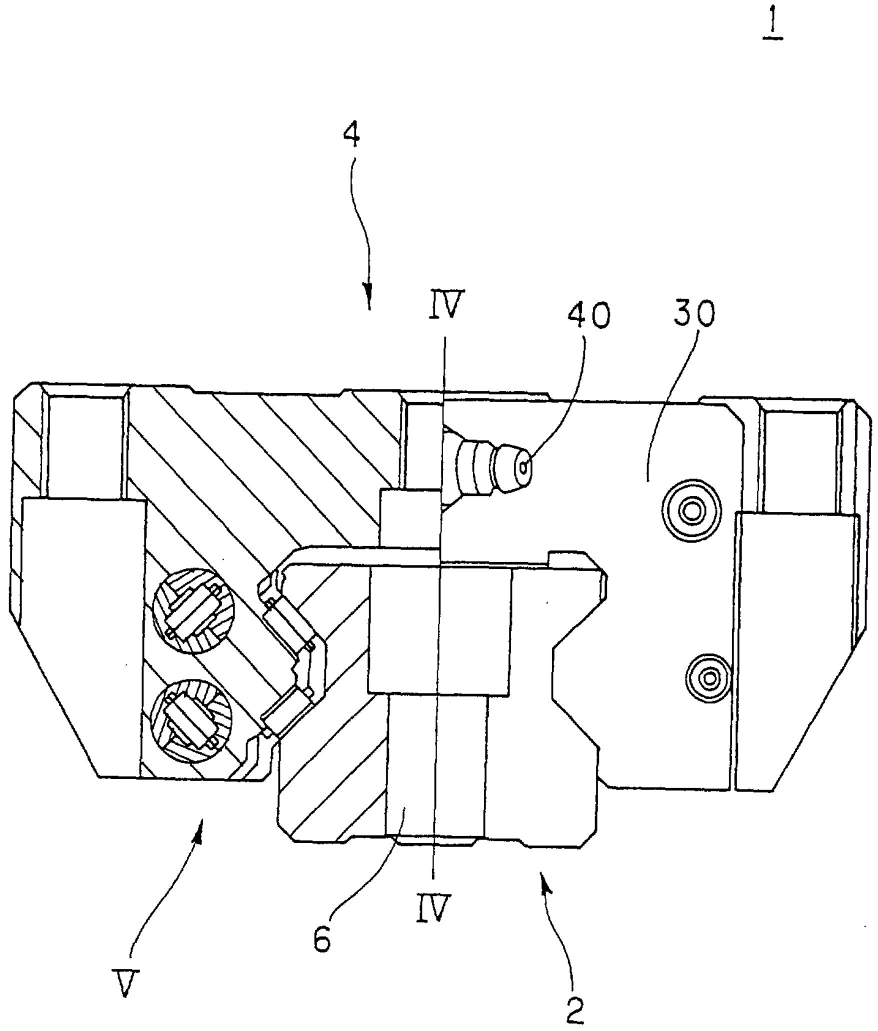
Nummer: DE 100 26 587 A1
Int. Cl.[7]: F 16 C 29/04
Offenlegungstag: 7. Dezember 2000

FIG. 3



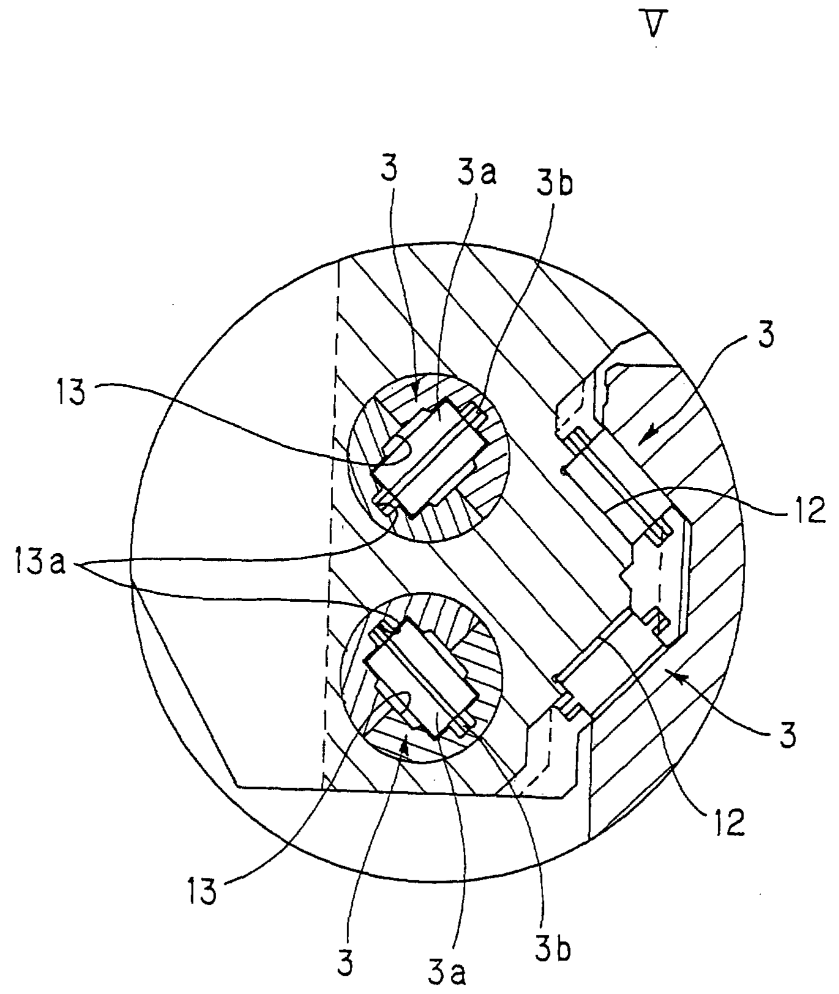
Nummer: **DE 100 26 587 A1**
Int. Cl.[7]: **F 16 C 29/04**
Offenlegungstag: 7. Dezember 2000

FIG. 4



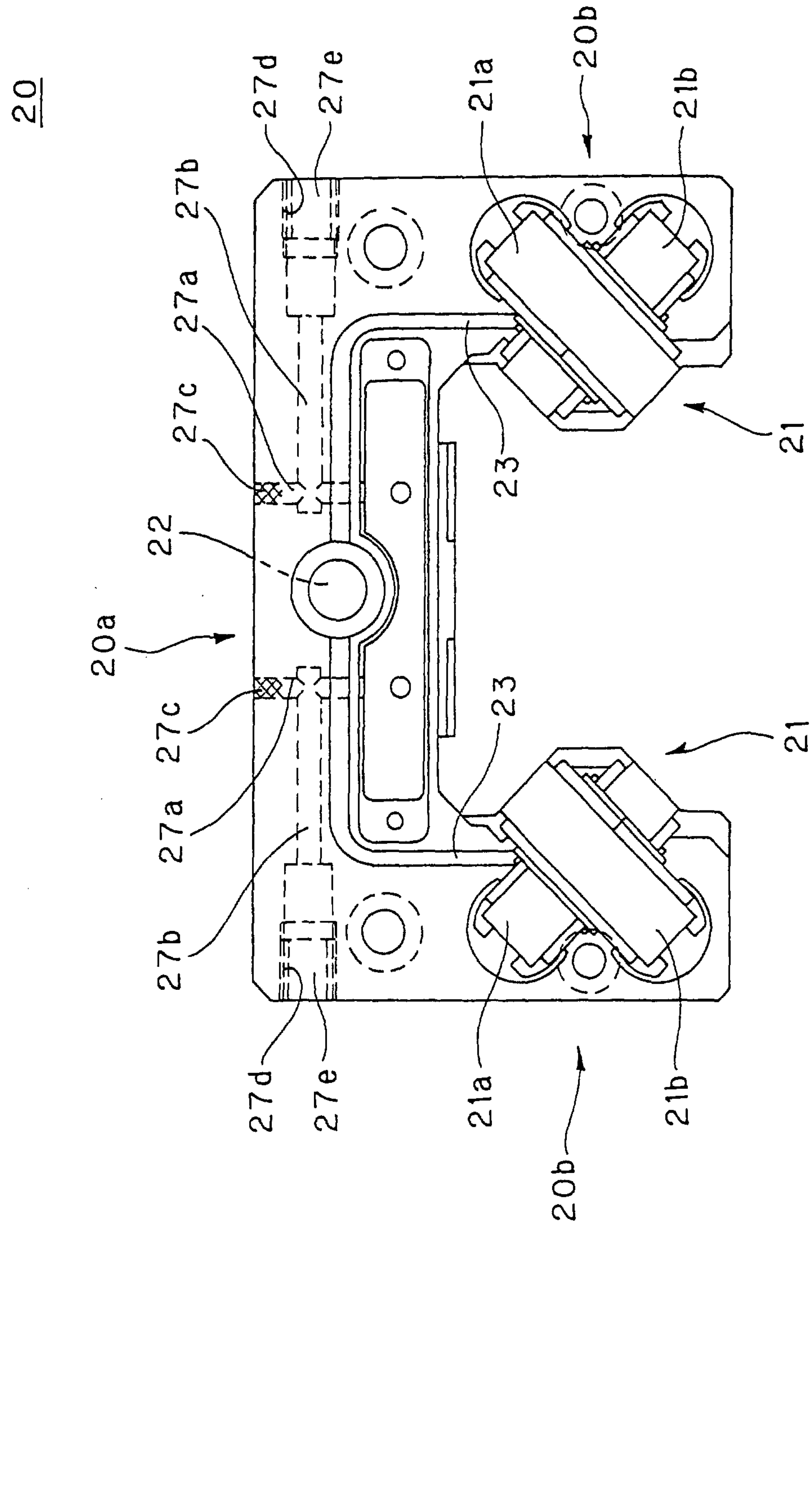
Nummer: DE 100 26 587 A1
Int. Cl.[7]: F 16 C 29/04
Offenlegungstag: 7. Dezember 2000

FIG. 5



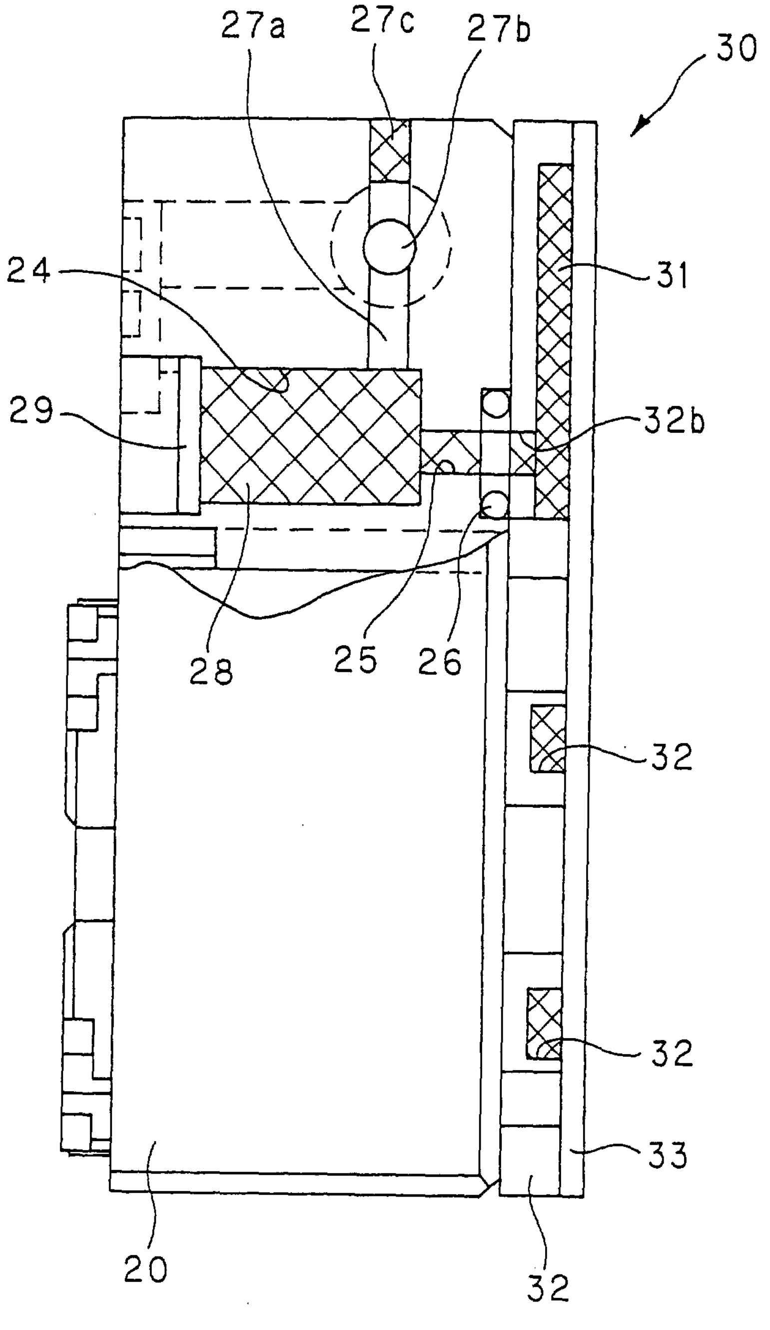
Nummer: **DE 100 26 587 A1**
Int. Cl.[7]: **F 16 C 29/04**
Offenlegungstag: 7. Dezember 2000

FIG. 6



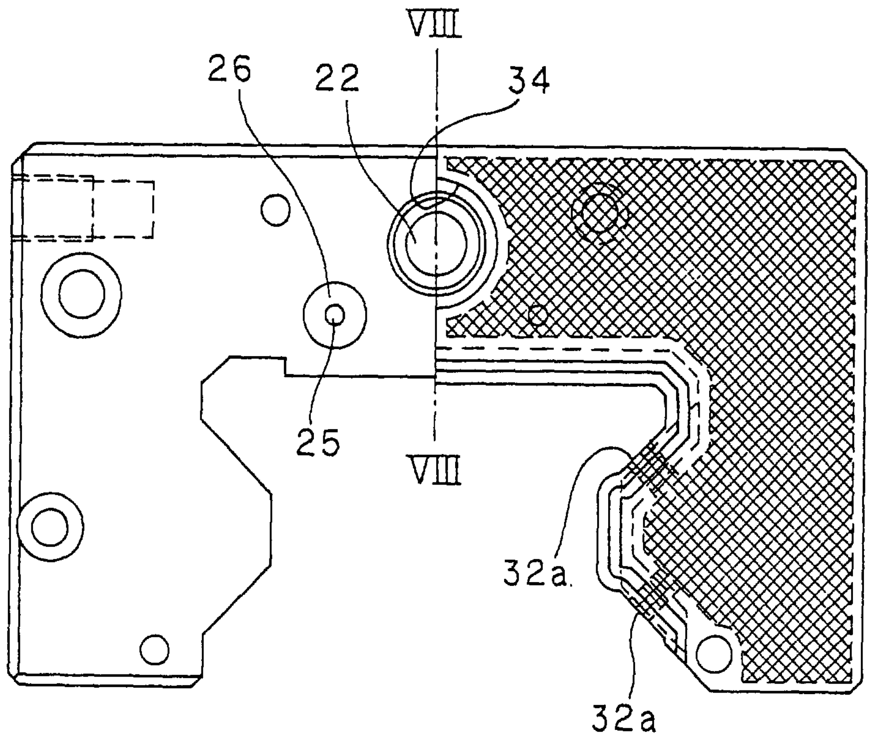
Nummer: DE 100 26 587 A1
Int. Cl.[7]: F 16 C 29/04
Offenlegungstag: 7. Dezember 2000

FIG. 7



Nummer: DE 100 26 587 A1
Int. Cl.7: F 16 C 29/04
Offenlegungstag: 7. Dezember 2000

FIG. 8



(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENTAMT

(12) Offenlegungsschrift

(10) DE 42 27 599 A 1

(51) Int. Cl.[5]:
F 16 C 29/04
B 23 Q 1/18
// B65G 25/00,47/82

(21) Aktenzeichen: P 42 27 599.7
(22) Anmeldetag: 20. 8. 92
(43) Offenlegungstag: 4. 3. 93

DE 42 27 599 A1

(30) Unionspriorität: (32) (33) (31)
21.08.91 JP 234068/91

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Tauchner, P., Dipl.-Chem. Dr.rer.nat.; Heunemann, D., Dipl.-Phys. Dr.rer.nat.; Rauh, P., Dipl.-Chem. Dr.rer.nat.; Hermann, G., Dipl.-Phys. Dr.rer.nat.; Schmidt, J., Dipl.-Ing.; Jaenichen, H., Dipl.-Biol. Dr.rer.nat., Pat.-Anwälte; Tremmel, H., Rechtsanw., 8000 München

(72) Erfinder:
Teramachi, Hiroshi, Tokio/Tokyo, JP

(54) Lineargleitlager

(57) Die Erfindung befaßt sich mit einem linearen Bewegungslager, welches eine extrem hohe Steifigkeit gegenüber einem Belastungsmoment und eine stabile Arbeitsweise hat. Es wird von einer Schienenbahn und einem Gleitstück bzw. einem Schlitten gebildet, welche auf der Schienenbahn angeordnet ist, wobei eine große Anzahl von Kugeln zwischengeschaltet sind. Das Gleitstück hat eine kanalähnliche Gestalt mit einem horizontalen Abschnitt und einem Paar von Randabschnitten, die sich von den gegenüberliegenden Seiten des horizontalen Abschnittes weg erstrecken. Jeder Randabschnitt ist an seiner inneren Seite mit einer Kugelwälzfläche versehen, welche nach oben weist und der horizontale Abschnitt ist in der Nähe des Mittelteils seiner inneren Seite mit wenigstens zwei Kugelwälzflächen versehen, welchen nach unten weisen.

DE 42 27 599 A1

Beschreibung

Die Erfindung befaßt sich mit einem Linearbewegungslager der Bauart für eine gleichförmige Belastung in vier Richtungen, welches als eine Gleitfläche, beispielsweise eines Bearbeitungszentrums und eines Tischschlittens einer Werkzeugmaschine eingesetzt wird, und welches auch an einer Stelle zum hin- und hergehenden Tragen eines schweren Gegenstandes bei einer Transport-Vorrichtung eingesetzt wird.

Ein gegebenes Linearbewegungslager ist in den **Fig.** 6 und 7 gezeigt, welches eine hohe Steifigkeit gegenüber einem Belastungsmoment hat und eine stabile Arbeitsleistung erzielen kann. Insbesondere wird das Lager von einer Schienenbahn **60** gebildet, welche eine große Breite hat und die mit einer Bezugsfläche R mittels Befestigungsschrauben in mehreren Reihen zum Tragen eines Belastungsmomentes fest verbunden ist und ferner umfaßt das Lager ein Gleitstück **50**, welches auf der Schienenbahn **60** angeordnet ist, und eine große Anzahl Kugeln **70**, welche zwischen dem Gleitstück **50** und der Schienenbahn **60** derart angeordnet sind, daß das Gleitstück **50** entlang der Schienenbahn **60** gleitbeweglich ist.

Die Schienenbahn **60** ist an jeder Seitenfläche mit zwei Kugelwälzflächen **61** versehen, welche in eine axiale Richtung verlaufen, und sie ist auch mit Befestigungsöffnungen **62** in mehreren Reihen versehen, über welche die Befestigungsschrauben eingesetzt werden können.

Das Gleitstück **50** wird von einem Lagerkörper **51** und einem Paar von endseitigen Kappen **52** gebildet, welche an den gegenüberliegenden Endflächen des Körpers **51** festgelegt sind. Der Lagerkörper **51** hat einen horizontalen Abschnitt **51**a und ein Paar von Randabschnitten **51**b, welche von den gegenüberliegenden Seiten des horizontalen Abschnittes **51**a ausgehen und somit eine kanalähnliche Gestalt haben. Jeder Randabschnitt **51**b ist an seiner inneren Fläche mit zwei Kugelwälzflächen **51**d versehen, welche den Kugelwälzflächen **61** der Schienenbahn **60** gegenüberliegen. Auch ist jeder Randabschnitt mit Kugelaustrittsöffnungen **51**e versehen, welche axial das massive Teil durchsetzen. Der horizontale Abschnitt **51**a des Lagerkörpers ist an jeder Seite und an jedem Mittelteil mit zwei Befestigungsöffnungen **51**f zum Anbringen und Befestigen eines Tisches T mit Hilfe von sechs Schrauben versehen.

Ferner ist die Endkappe mit Kugelrücklaufausnehmungen versehen, welche die Kugelwälzflächen **51**d des Lagerkörpers **51** mit den Kugelaustrittsöffnungen **51**e verbinden. Endlose Bahnen für die Kugeln werden dadurch gebildet, daß die endseitigen Kappen am Lagerkörper fest angebracht werden.

Halter **80**, welche ein Herausfallen der Kugeln **70** verhindern, wenn das Gleitstück **50** der Schienenbahn **60** abgenommen wird, sind an einem Hohlraum **51**c angebracht, welcher an einer inneren Seite des Lagerkörpers **51** ausgebildet ist und in dem jeweiligen Randabschnitt **51**b endet.

Da ein derart ausgebildetes lineares Bewegungslager eine große Steifigkeit gegenüber dem Belastungsmoment hat, kann es als eine Ein-Achs-Konstruktion bei einem Gleitteil eingesetzt werden, bei dem Lagerungen in zwei oder mehr Achsen infolge eines großen Belastungsmomentes bei den üblichen Auslegungen erforderlich sind, und somit läßt sich ein Raum für das Gleitteil im Vergleich zu den üblichen Auslegungsformen verkleinern.

Bei dem vorstehend beschriebenen, üblichen linearen

Bewegungslager jedoch ist der Abstand W zwischen den Kugeln **70**, welche an den gegenüberliegenden Seiten der Schienenbahn **60** liegen, groß, wie dies in **Fig.** 6 gezeigt ist, so daß ein Mittelteil des horizontalen Abschnitts **51**a des Lagerkörpers **51** sich leicht nach unten auslenken kann.

Bei dem linearen Bewegungslager wird daher die Dikke des horizontalen Abschnittes **51**a des Lagerkörpers **51** vergrößert, um die Steifigkeit zu erhöhen, wodurch aber in unzweckmäßiger Weise ein Abstand von der Bezugsfläche R zu einer Befestigungsfläche des Tisches T, d. h. eine Höhe des Lagers, größer wird.

Um Kugelwälzflächen **51**d in zwei Reihen an dem jeweiligen Randabschnitt **51**b des Lagerkörpers **51** auszubilden, muß ein Raum zwischen den beiden Kugelwälzflächen **51**d größer als ein Durchmesser der Kugel sein, und ferner ist ein gewisser Abstand zwischen dem horizontalen Abschnitt **51**a und der jeweiligen Kugelwälzfläche **51**d, welche in dessen Nähe liegt, im Hinblick auf die maschinelle Bearbeitung mittels einer Schleifmaschine erforderlich. Aus diesen Gründen läßt sich die Höhe des so ausgebildeten linearen Bewegungslagers nicht reduzieren.

Wenn die Höhe des Lagers größer wird, nimmt in unvermeidbarer Weise die Steifigkeit gegenüber dem Belastungsmoment ab, und daher läßt sich die Steifigkeit gegenüber dem Belastungsmoment bei dem linearen Bewegungslager gemäß der üblichen und zuvor beschriebenen Bauform nicht in ausreichender Weise erhöhen.

Ferner sind bei einem so ausgebildeten linearen Bewegungslager die Schrauben zum Befestigen des Tisches T derart angeordnet, daß sie mit dem horizontalen Abschnitt **51**a des Lagerkörpers **51** zusammenarbeiten, so daß eine Verformung des horizontalen Abschnitts **51** in Richtung nach unten verhindert wird. Jedoch läßt sich die Zugkraft durch die Schrauben nicht in einem großen Maße vergrößern, so daß man Vorteile bei dieser Konstruktion nicht in ausreichendem Maße erwarten kann.

Die Erfindung wurde zur Überwindung der vorstehend genannten Schwierigkeiten geschaffen und zielt darauf ab, ein lineares Bewegungslager bereitzustellen, welches eine extrem große Steifigkeit gegenüber dem Belastungsmoment hat sowie die Fähigkeit hat, ein stabiles Arbeitsvermögen beizubehalten.

Nach der Erfindung wird hierzu ein lineares Bewegungslager bereitgestellt, welches ein Gleitstück bzw. einen Schlitten mit einer kanalähnlichen Gestalt aufweist, das einen horizontalen Abschnitt und ein Paar von Randabschnitten hat, die von den gegenüberliegenden Seiten des horizontalen Abschnitts ausgehen, wobei eine Kugelwälzfläche nach oben weist, welche an einer inneren Seite des jeweiligen Randabschnittes ausgebildet ist, und wobei wenigstens zwei Kugelwälzflächen, welche nach unten weisen, in der Nähe eines Mittelteils einer inneren Fläche des horizontalen Abschnittes ausgebildet sind; ferner eine Schienenbahn aufweist, auf der das Gleitstück angeordnet ist, wobei die Schienenbahn an ihren gegenüberliegenden Seitenflächen mit Kugelwälzflächen versehen ist, welche nach unten in Richtung auf die oberen Kugelwälzflächen des Gleitstücks weisen und an ihren oberen Flächen mit Kugelwälzflächen versehen sind, welche nach unten in Richtung auf die unteren Kugelwälzflächen des Gleitstückes weisen; und eine große Anzahl von Kugeln aufweisen, welche in endlosen Bahnen im Gleitstück sich bewegen und zwischen den oberen Wälzflächen des Gleitstücks und den unteren Gleitflächen der Schienenbahn und zwischen den unteren Wälzflächen des Gleitstücks und den oberen Wälzflächen der Schienenbahn zur Lastaufnahme vorgesehen sind.

Nach der Erfindung wird der horizontale Abschnitt des Gleitstücks in Richtung nach oben durch die Kugel in Reihen abgestützt, welche sich auf den zwei oder mehr Kugelwälzflächen abwälzen, die nach unten weisen und in der Nähe des Mittelteils der inneren Seite vorgesehen sind, so daß das Mittelteil des horizontalen Abschnittes durch eine Belastung nicht nach unten ausgelenkt bzw. verformt wird. Bei dem linearen Bewegungslager, auf welches sich die Erfindung bezieht, ist es daher möglich, in positiver Weise die Breiten des Gleitstücks und der Schienenbahn größer zu machen, und daher lassen sich ein Leistungsvermögen und eine Steifigkeit gegenüber einem Belastungsmoment des Lagers beträchtlich verbessern.

Da das Mittelteil des horizontalen Abschnitts des Gleitstücks nicht nach unten verformt wird, läßt sich die Dicke des horizontalen Abschnitts des Gleitstücks im Vergleich zu dem linearen Bewegungslager nach dem Stand der Technik kleiner machen, und somit läßt sich die Höhe des Lagers insgesamt verkleinern. Ferner ist nur eine Kugelwälzfläche, welche nach unten weist, an dem Randabschnitt des Gleitstückes ausgebildet, und die nach unten weisenden Kugelwälzflächen sind in der Nähe des Mittelteils des horizontalen Abschnitts des Gleitstücks ausgebildet. Daher läßt sich die Länge des Randabschnittes reduzieren, ohne daß man wechselseitige Behinderungen zwischen den Kugeln erhält, welche sich auf den oberen und unteren Kugelwälzflächen abwälzen, wodurch sich auch die Höhe des Lagers reduzieren läßt.

Da wie vorstehend angegeben ist, die Höhe des linearen Bewegungslagers nach der Erfindung beträchtlich herabgesetzt werden kann, läßt sich die Steifigkeit gegenüber einem Belastungsmoment beträchtlich erhöhen.

Da das Mittelteil des horizontalen Abschnitts des Gleitstücks sich nicht nach unten verformt, wenn eine Belastung hierauf einwirkt, verlaufen die Randabschnitte des Gleitstückes nicht divergierend nach außen und daher läßt sich die große Steifigkeit gegenüber der Belastung in jeglicher Richtung einhalten.

Weitere Einzelheiten, Merkmale und Vorteile der Erfindung ergeben sich aus der nachstehenden Beschreibung von bevorzugten Ausführungsformen unter Bezugnahme auf die beigefügte Zeichnung.

Darin zeigt:

Fig. 1 eine Schnittansicht zur Verdeutlichung einer ersten bevorzugten Ausführungsform eines linearen Bewegungslagers nach der Erfindung,

Fig. 2 eine Draufsicht auf ein lineares Bewegungslager nach einer ersten Ausführungsform der Erfindung,

Fig. 3 eine Schnittansicht zur Verdeutlichung einer zweiten bevorzugten Ausführungsform eines linearen Bewegungslagers nach der Erfindung,

Fig. 4 eine Draufsicht auf ein lineares Bewegungslager gemäß einer zweiten bevorzugten Ausführungsform nach der Erfindung,

Fig. 5 eine Ansicht zur Verdeutlichung der Verteilung einer Reaktionskraft und der Verformung eines Gleitstückes, wenn Belastungen in verschiedenen Richtungen auf das lineare Bewegungslager gemäß der zweiten bevorzugten Ausführungsform einwirken,

Fig. 6 eine Schnittansicht zur Verdeutlichung eines linearen Bewegungslagers einer üblichen Bauform, und

Fig. 7 eine Draufsicht auf ein lineares Bewegungslager gemäß einer üblichen Bauform.

Ein lineares Bewegungslager bzw. ein lineares Gleitlager nach der Erfindung wird nachstehend unter Bezugnahme auf die Zeichnungen näher erläutert.

Die **Fig.** 1 und 2 zeigen ein lineares Bewegungslager gemaß einer ersten bevorzugten Ausführungsform nach der Erfindung. Das lineare Bewegungslager gemäß dieser bevorzugten Ausführungsform wird von einer Schienenbahn **20** gebildet, welche fest mit einer Bezugsfläche mit Hilfe von nicht dargestellten Befestigungsschrauben in mehreren Reihen verbunden ist sowie von einem Gleitstück **10**, welches auf der Schienenbahn angeordnet ist, und mit einer großen Anzahl Kugeln **30**, welche zwischen dem Gleitstück **10** und der Schienenbahn **20** angeordnet sind, und dazu dienen, das Gleitstück **10** in einer axialen Richtung zu der Schienenbahn **20** (senkrecht zur Zeichenebene in **Fig.** 1) gleitbeweglich zu führen.

Die Schienenbahn **20** hat einen etwa länglichen Querschnitt, welcher eine Breite hat, die größer als die Höhe ist. Die Schienenbahn ist an jeder Seitenfläche mit einer Kugelwälzfläche **21** versehen, welche axial verläuft und nach unten weist, und sie ist auch in der Nähe des Mittelteils der oberen Fläche mit zwei Kugelwälzflächen **22** versehen, welche axial verlaufen und nach oben weisen. Diese nach unten und oben gerichteten Kugelwälzflächen **21** und **22** sind in Querrichtung symmetrisch zueinander bezüglich eines Schnittes C-C angeordnet, welche eine Achse der Schienenbahn **20** enthält. Bei dieser ersten bevorzugten Ausführungsform ist ein Abstand L_1 zwischen der Kugelwälzfläche **21** und dem Schnitt C-C etwa doppelt so lang als ein Abstand L_2 zwischen der nach oben weisenden Kugelwälzfläche **22** und dem Schnitt C-C. Jede Kugelwälzfläche **21** und **22** bildet eine einzige, pumpenförmige Ausnehmung, welche einen Krümmungsradius hat, welcher etwa gleich einem Krümmungsradius der Kugel **30** ist. Mit dem Bezugszeichen **23** werden Befestigungsöffnungen bezeichnet, durch die sich Befestigungsschrauben einsetzen lassen.

Das Gleitstück **10** wird von einem Lagerblock **11** gebildet, welcher aus Metall hergestellt ist und einem Paar von endseitigen Kappen **12**, welche aus Kunststoff hergestellt sind, und die an den gegenüberliegenden Endflächen des Blockes **11** fest angebracht sind. Der Lagerblock **11** hat eine kanalähnliche Gestalt und umfaßt einen horizontalen Abschnitt **11a** und ein Paar von Randabschnitten **11b**, welche von den gegenüberliegenden Seitenrändern des Abschnitts **11a** nach unten verlaufen. Ferner hat er auch eine kanalförmige Ausnehmung **11c**, welche über der Schienenbahn **20** liegt und komplementär zu der Gestalt der Schiene **20** ausgelegt ist. Jeder Randabschnitt **11b** ist an seiner inneren Seite mit einer nach oben weisenden Kugelwälzfläche **13** versehen, welche der nach unten weisenden Kugelwälzfläche **21** auf der Schienenbahn **20** zugewandt ist. Der horizontale Abschnitt **11a** ist in der Nähe des Mittelteils der inneren Seite mit zwei Kugelwälzflächen **14** versehen, welche in Richtung auf die nach unten weisenden Kugelwälzflächen **22** der Schienenbahn **20** weisen. Diese Kugelwälzflächen **13** und **14** bilden einzelne, bogenförmige Ausnehmungen ähnlich wie die Kugelwälzflächen **21** und **22** der Schienenbahn **20**.

Die zugeordneten Kugelwälzflächen **13** und **14** sind in Querrichtung symmetrisch bezüglich des Schnitts C-C angeordnet, welche die Achse des Lagerblocks **11** enthält. Bei dieser bevorzugten Ausführungsform ist ein Abschnitt L_1 zwischen der nach oben gerichteten Kugelwälzfläche **13** des Randabschnitts **11b** und des

Schnitts C-C etwa doppelt so groß als ein Abschnitt L_2 zwischen der nach unten weisenden Kugelwälzfläche **14** des horizontalen Abschnitts **11**a und des Schnitts C-C. Dieser Zusammenhang von $L_1 = 2L_2$ wird bestimmt, um die Verformung bzw. Auslenkung des horizontalen Abschnitts **11**a nach unten so klein wie möglich zu machen, wenn eine nach unten wirkende Belastung auf den Lagerblock **11** einwirkt. Diese Bestimmung erfolgt aufgrund von mechanischen Berechnungen, bei denen der horizontale Abschnitt als ein an bei den Enden abgestützter Balken angenommen wird.

Bei dieser bevorzugten Ausführungsform ist nur eine Kugelwälzfläche **13**, welche nach oben weist, an dem Randabschnitt **11**b des Lagerblocks **11** ausgebildet, und die nach unten weisenden Kugelwälzflächen **14** sind in der Nähe des Mittelteils des horizontalen Abschnittes **11**a ausgebildet. Selbst wenn daher die Länge des Randabschnitts **11**b kurz bemessen ist, behindern die Kugeln **30**, welche sich auf der nach oben weisenden Kugelwälzfläche **13** abwälzen, nicht die Kugeln **30**, welche sich auf der nach unten weisenden Kugelwälzfläche **14** abwälzen. Folglich lassen sich die Höhen des Lagerblocks **11** und somit des Gleitstücks **10** kleiner machen.

Ferner sind die Kugeln **30** zwischen der nach unten weisenden Kugelwälzfläche **21** der Schienenbahn **20** und der nach oben weisenden Kugelwälzfläche des Lagerblocks **11** oder zwischen der nach oben weisenden Kugelwälzfläche **22** der Schienenbahn **20** und der nach unten weisenden Kugelwälzfläche **14** des Lagerblocks **11** eingespannt und wälzen sich auf diesen Wälzflächen während der Lastaufnahme ab.

Bei dieser Arbeitsweise schließt eine Kontaktrichtung der Kugel **30** zu der nach oben weisenden Kugelwälzfläche **13** des Randabschnitts **11**b, d. h. in eine Richtung der Kugelkontaktlinie, etwa einen Winkel von 45° zur Horizontalen ein. Auch schließt eine Richtung der Kugelkontaktlinie an der nach unten weisenden Kugelwälzfläche **14** des horizontalen Abschnittes **11**a etwa einen Winkel von 45° zur horizontalen Richtung ein.

Somit kann das lineare Bewegungslager gemäß dieser bevorzugten Ausführungsform die Belastung gleichmäßig in vertikaler Richtung und in Querrichtung tragen. Vorausgesetzt, daß die Richtung der Kugelkontaktlinie an den jeweiligen Kugelwälzflächen **13** und **14** zur Horizontalen in einem Bereich von $45 \pm 10°$ liegt, kann das lineare Bewegungslager die Belastung im wesentlichen gleichförmig in den vier Richtungen tragen.

Kugelaustrittsöffnungen **15**, welche den Kugelwälzflächen **13** und **14** zugeordnet sind, durchsetzen in axialer Richtung die massiven Teile der Randabschnitte **11**b und des horizontalen Randabschnittes **11**a. Die gegenüberliegenden Enden jeder Kugelaustrittsöffnung **15** sind in den Enden der zugeordneten Kugelwälzflächen über Kugelrückausnehmungen (nicht gezeigt) bzw. Kugelrücklaufkanäle verbunden, so daß die Kugeln **30** endlos über die Kugelwälzflächen und die Kugelaustrittsöffnungen **15** laufen.

Kugelhalter **40**, **41** und **42**, welche von Stahlplatten gebildet werden, sind an den Enden der inneren Flächen der Randabschnitte **11**b und der unteren Fläche des horizontalen Randabschnittes **11**a des Lagerblocks **11** vorgesehen, so daß ein Herausfallen der Kugel **30** verhindert werden kann, wenn das Gleitstück bzw. der Schlitten **10** von der Schienenbahn **20** abgenommen wird. Diese Halter **40**, **41** und **42** sind fest mit dem Lagerblock **11** beispielsweise mit Hilfe von Schrauben verbunden.

Der horizontale Abschnitt **11**a des Lagerblocks **11** ist an den gegenüberliegenden Seitenteilen und am Mittelteil mit Befestigungsflächen **17** und **18** zum Anbringen eines Tisches versehen. Die Montagefläche **17** an jeder Seite ist mit zwei Befestigungsöffnungen **16** versehen. Somit läßt sich das Gleitstück **10** an dem Tisch mit Hilfe von vier Schrauben festlegen. Bei der Erfindung ist es nicht erforderlich, eine Befestigungsöffnung im Mittelteil der Befestigungsfläche **18** des horizontalen Abschnittes **11**a vorzusehen. Der horizontale Abschnitt **11**a wird von der Unterseite mittels Kugeln **30** abgestützt, welche zwischen den nach oben weisenden Kugelwälzflächen **22** der Schienenbahn **20** und den nach unten weisenden Kugelwälzflächen **14** des horizontalen Abschnittes **11**a sich abwälzen. Hierdurch erhält man eine Konstruktion, welche die Fähigkeit hat, daß Verformungen bzw. Auslenkungen des Mittelteils des horizontalen Abschnittes **11**a verhindert oder wesentlich vermindert werden. Da bei der dargestellten Ausführungsform die Kugeln **30** den horizontalen Abschnitt **11**a in Richtung nach oben unterstützen, kann der horizontale Abschnitt **11**a eine kleine Dicke haben, ohne daß Verformungen bzw. Auslenkungen zu befürchten sind.

Die **Fig.** 3 und 4 zeigen eine bevorzugte Ausführungsform nach der Erfindung. Bei dem linearen Bewegungslager gemäß dieser Ausführungsform sind Befestigungsöffnungen **19** zum Anbringen des Tisches an Stellen in der Nähe des Mittelteils des horizontalen Abschnittes **11**a des Lagerblocks **11** vorgesehen. Die weiteren Einzelheiten dieser Auslegungsform sind ähnlich wie bei der ersten bevorzugten Ausführungsform ausgelegt und werden daher nachstehend nicht nochmals näher beschrieben.

Wenn Belastungen in verschiedenen Richtungen auf das lineare Bewegungslager nach der Erfindung einwirken, werden Reaktionskräfte in verschiedenen Richtungen und Verformungen des Lagerblocks **11** wie nachstehend beschrieben hervorgerufen.

a) Wenn das Gleitstück **10** eine nach unten wirkende Belastung (1) aufnimmt, und wenn der Tisch T eine nach unten gerichtete Belastung P auf das Gleitstück **10** aufbringt, wird die Belastung P in den Befestigungsflächen **17** und **18** des Lagerblocks **11** verteilt, wie dies in **Fig.** 5(a) gezeigt ist und man erhält eine gleichmäßige Verteilungsbelastung P_1 und P_2, welche jeweils auf die Befestigungsflächen **17** und **18** wirken, wobei $P = 2P_1 + P_2$.

(2) Die Kugeln, welche die Belastungen tragen, sind Kugeln (wie dies mit durchgezogenen schwarzen Kreisen in der Figur dargestellt ist), welche auf den nach unten gerichteten Kugelwälzflächen **14** des Lagerblocks **11** eine Abwälzbewegung ausführen. Da diese Kugeln in der Nähe des Mittelteils des horizontalen Abschnittes **11**a liegen, welcher die Belastung trägt, wird der horizontale Abschnitt **11**a durch die Belastung P_2, welche auf die Befestigungsfläche **18** wirkt, nicht verformt oder ausgelenkt und daher haben beide Randabschnitte **11**b keinen nach außen divergierenden Verlauf. Daher erhält man bei dem linearen Bewegungslager nach der Erfindung eine gleichbleibende ausreichende Steifigkeit gegenüber einer nach unten wirkenden Belastung.

b) Wenn das Gleitstück **10** eine nach oben gerichtete Belastung (1) aufnimmt, und wenn der Tisch T die nach oben gerichtete Belastung P gegen das Gleitstück **10** zur Wirkung bringt, wirkt diese Belastung P auf den Lagerblock **11** als eine Belastung P_0, welche über die Schrauben übertragen wird, wie dies in

Fig. 5(b) gezeigt ist, wobei $P = P_0 + P_0$ gilt.

(2) Die Kugeln, welche die Belastungen tragen, sind Kugeln (wie dies mit durchgezogenen schwarzen Kreisen in der Figur verdeutlicht ist), welche eine Abwälzbewegung auf den Kugelwälzflächen **13** des Lagerblocks **11** ausführen. Wenn diese Kugeln die Belastung tragen, versuchen die Randabschnitte **11**b in Richtung nach hinten einen divergierenden Verlauf einzunehmen und gleichzeitig versucht das Mittelteil des horizontalen Abschnittes **11**a sich in Richtung nach unten zu verformen bzw. auszulenken. Da jedoch der horizontale Abschnitt **11**a in Richtung nach oben durch die Kugeln abgestützt ist, welche eine Abwälzbewegung auf den nach unten weisenden Kugelwälzflächen **14** ausführen, wird der horizontale Abschnitt **11**a nicht nach unten verformt. Als Folge hiervon läßt sich die Verschiebung bzw. Verformung der Randabschnitte **11**b unterdrücken. Somit behält das lineare Bewegungslager nach der Erfindung eine ausreichende Steifigkeit gegenüber einer nach oben gerichteten Belastung bei.

c) Wenn das Gleitstück **10** die Querbelastungen (**1**) aufnimmt und wenn der Tisch T die Querbelastung P auf das Gleitstück **10** aufbringt, wird diese Belastung P in die Belastungen P_3, welche auf die Befestigungsflächen **17** des Lagerblocks **11** wirken, aufgeteilt, wie dies in **Fig.** 5(c) gezeigt ist, wobei $P = P_3 + P_3$ gilt.

(2) Die Kugeln, welche die Belastungen tragen, sind Kugeln (wie dies mit durchgezogenen schwarzen Kreisen dargestellt ist), welche eine Abwälzbewegung auf der nach oben weisenden Kugelwälzfläche **13** ausführen, welche am linken Randabschnitt **11**b ausgebildet sind und auf der nach unten weisenden Kugelwälzfläche **14** ausführen, welche auf der rechten Seite im horizontalen Abschnitt **11**a vorgesehen ist.

(3) Zuerst soll eine Beschreibung der bisher üblichen Kugeln erfolgen. Wenn diese Kugeln die Belastung aufnehmen, versucht der linke Randabschnitt **11**b sich in Richtung nach außen zu verformen bzw. auszulenken, wie dies mit einem Pfeil verdeutlicht ist und zugleich versucht das Mittelteil des horizontalen Abschnittes **11**a sich in ähnlicher Weise wie beim vorstehend genannten Fall (b) nach unten zu verformen bzw. auszulenken. Da jedoch der horizontale Abschnitt **11**a in Richtung nach oben durch die Kugeln abgestützt ist, welche eine Abwälzbewegung auf den nach unten weisenden Kugelwälzflächen **14** ausführen, kann sich der horizontale Abschnitt **11**a nicht nach unten verformen bzw. auslenken. Als Folge hiervon läßt sich die Verlagerung des Randabschnittes **11**b unterdrücken.

(4) Dann erfolgt eine Beschreibung der rechten Kugeln. Wenn diese Kugeln die Querbelastung aufnehmen, bewirkt die Reaktionskraft hiervon, daß das Mittelteil des horizontalen Abschnittes **11**a nach oben gedrückt wird. Jedoch ist das Mittelteil des horizontalen Abschnittes **11**a in Kontakt mit dem Tisch T über die Befestigungsfläche **18** des Lagerblocks **11** und kann sich somit durch die Belastung nicht nach oben verformen. Auf diese Weise läßt sich eine Verlagerung des Randabschnittes **11**b unterdrücken.

Somit erhält man bei den linearen Bewegungslagern nach der Erfindung eine konstante ausreichende Steifigkeit gegenüber der Querbelastung.

Die Richtungen der Kugelkontaktlinien in den oberen Kugelwälzflächen **13** und den unteren Kugelwälzflächen **14**, welche im Lagerblock **11** ausgebildet sind, sind nicht auf jene Größenangaben beschränkt, welche zuvor in Zusammenhang mit den bevorzugten Ausführungsformen erläutert wurden. Vielmehr lassen sich diese in beliebiger Weise nach Maßgabe der Richtungen der mit Hilfe des Lagers aufzunehmenden Belastungen bestimmen. Beispielsweise kann die Richtung der Kugelkontaktlinie in der nach unten weisenden Kugelwälzfläche **14** einen Winkel von 90° zur horizontalen Richtung einschließen und die Richtung der Kugelkontaktlinie in der nach oben gerichteten Wälzfläche **13** kann einen Winkel von etwa 30° zur horizontalen Richtung einschließen.

Obgleich hier die vorliegende Erfindung anhand von bevorzugten Ausführungsformen erläutert wurde, ist die Erfindung natürlich nicht auf die dort beschriebenen Einzelheiten beschränkt, sondern sind zahlreiche Abänderungen und Modifikationen möglich, die der Fachmann im Bedarfsfall treffen wird, ohne den Schutzgedanken nach der Erfindung zu verlassen.

Patentansprüche

1. Lineares Bewegungslager, **gekennzeichnet durch**:
   - ein Gleitstück (**10**) mit einer kanalähnlichen Gestalt, welches einen horizontalen Abschnitt (**11**a) und ein Paar von Randabschnitten (**11**b) hat, die sich von den gegenüberliegenden Seiten des horizontalen Abschnitts (**11**a) weg erstrecken, wobei eine Kugelwälzfläche (**13**), welche nach oben weist, an einer inneren Seite jedes Randabschnitts (**11**b) ausgebildet ist, und wenigstens zwei Kugelwälzflächen (**14**), welche nach unten weisen, in der Nähe eines Mittelteils einer inneren Fläche des horizontalen Abschnittes (**11**a) ausgebildet sind;
   - eine Schienenbahn (**20**), auf welcher das Gleitstück (**10**) angeordnet ist, wobei die Schienenbahn (**20**) an ihren gegenüberliegenden Seitenflächen mit Kugelwälzflachen (**21**, **22**) versehen ist, welche nach unten in Richtung auf die nach oben gerichteten Kugelwälzflächen (**13**) des Gleitstücks (**10**) weisen und die an ihrer oberen Fläche mit Kugelwälzflächen (**22**) versehen ist, welche nach oben in Richtung auf die nach unten weisenden Kugelwälzflächen (**14**) des Gleitstücks (**10**) weisen; und
   - eine grobe Anzahl von Kugeln (**30**), welche sich längs endlosen Bahnen im Gleitstück (**10**) bewegen und zwischen den nach oben weisenden Wälzflächen (**13**) des Gleitstücks (**10**) und den nach unten Wälzflächen (**21**) der Schienenbahn (**20**) und zwischen nach unten weisenden Wälzflächen (**14**) des Gleitstücks (**10**) und den nach oben weisenden Wälzflächen (**22**) der Schienenbahn (**20**) zur Aufnahme einer Belastung angeordnet sind.

2. Lineares Bewegungslager nach Anspruch 1, dadurch gekennzeichnet, daß die Richtungen der Kugelkontaktlinien in den nach oben weisenden Kugelwälzflächen (**13**) und den nach unten weisenden Kugelwälzflächen (**14**) des Gleitstücks (**10**) einen Winkel von $45 \pm 10°$ bezüglich der horizontalen Richtung bilden.

3. Lineares Bewegungslager nach Anspruch 1, dadurch gekennzeichnet, daß ein horizontaler Abstand zwischen der nach oben weisenden Kugelwälzfläche (**13**) des Gleitstücks (**10**) und einer Achse des Lagers doppelt so groß als sein horizontaler Abstand zwischen der nach unten weisenden Kugelwälzfläche (**14**) des Gleitstücks (**10**) und der Achse des Lagers ist.
4. Lineares Bewegungslager nach Anspruch 1, dadurch gekennzeichnet, daß ein Abstand in einer Höhenrichtung zwischen der nach oben weisenden Kugelwälzfläche (**13**) und der nach unten weisenden Kugelwälzfläche (**14**) des Gleitstücks (**10**) im wesentlichen gleich oder kleiner als ein Durchmesser der Kugel (**30**) ist.

Hierzu 4 Seite(n) Zeichnungen

Nummer: DE 42 27 599 A1
Int. Cl.⁵: F 16 C 29/04
Offenlegungstag: 4. März 1993

FIG. 1

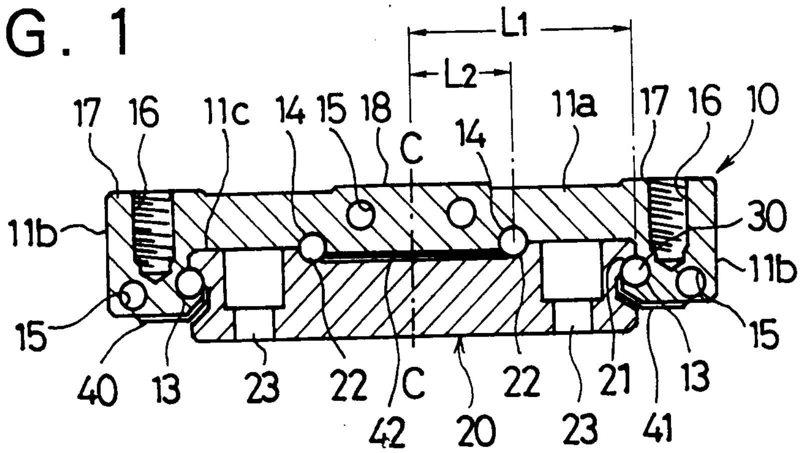


FIG. 2

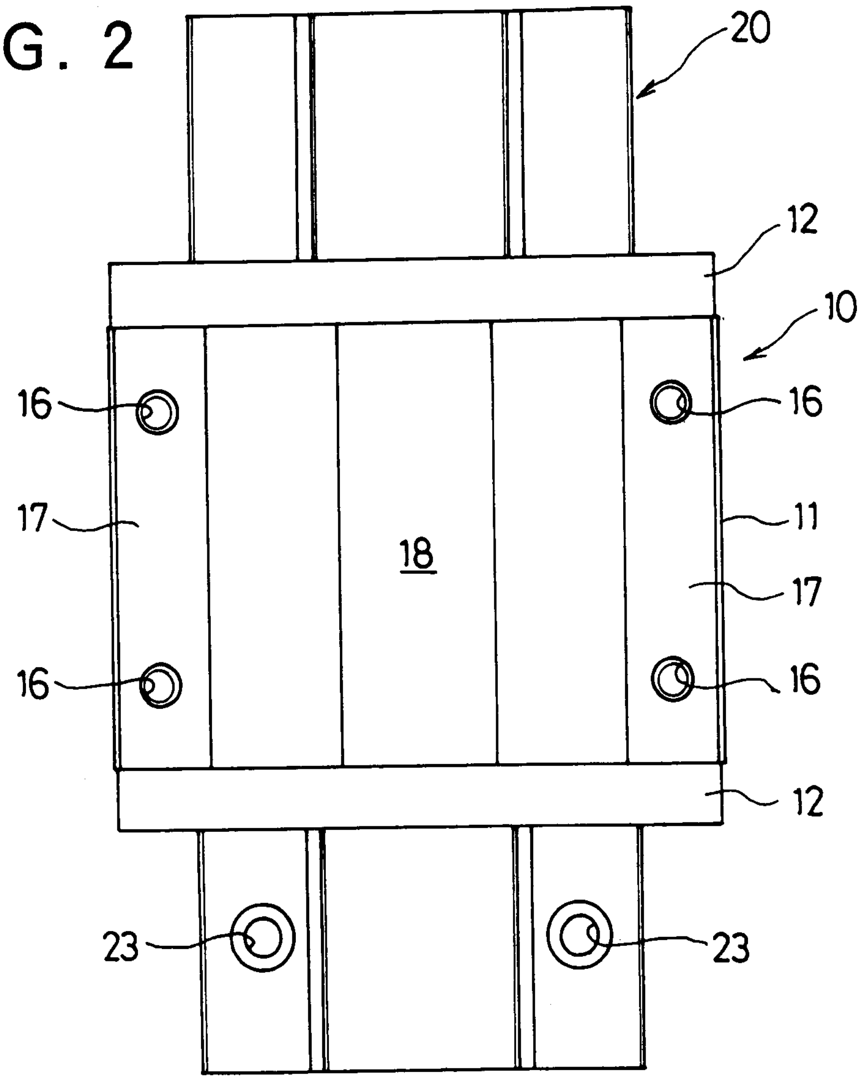


FIG. 3

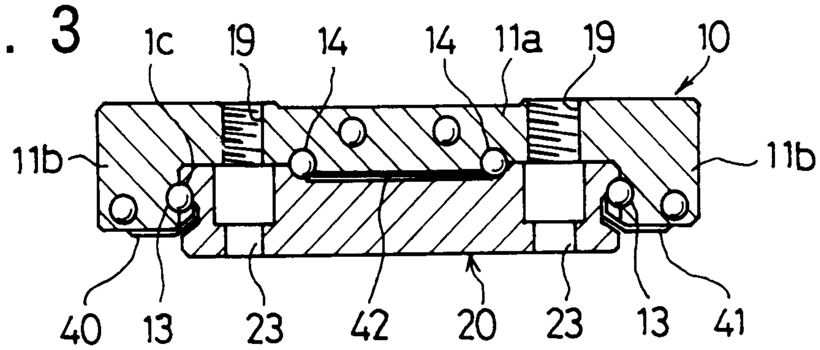
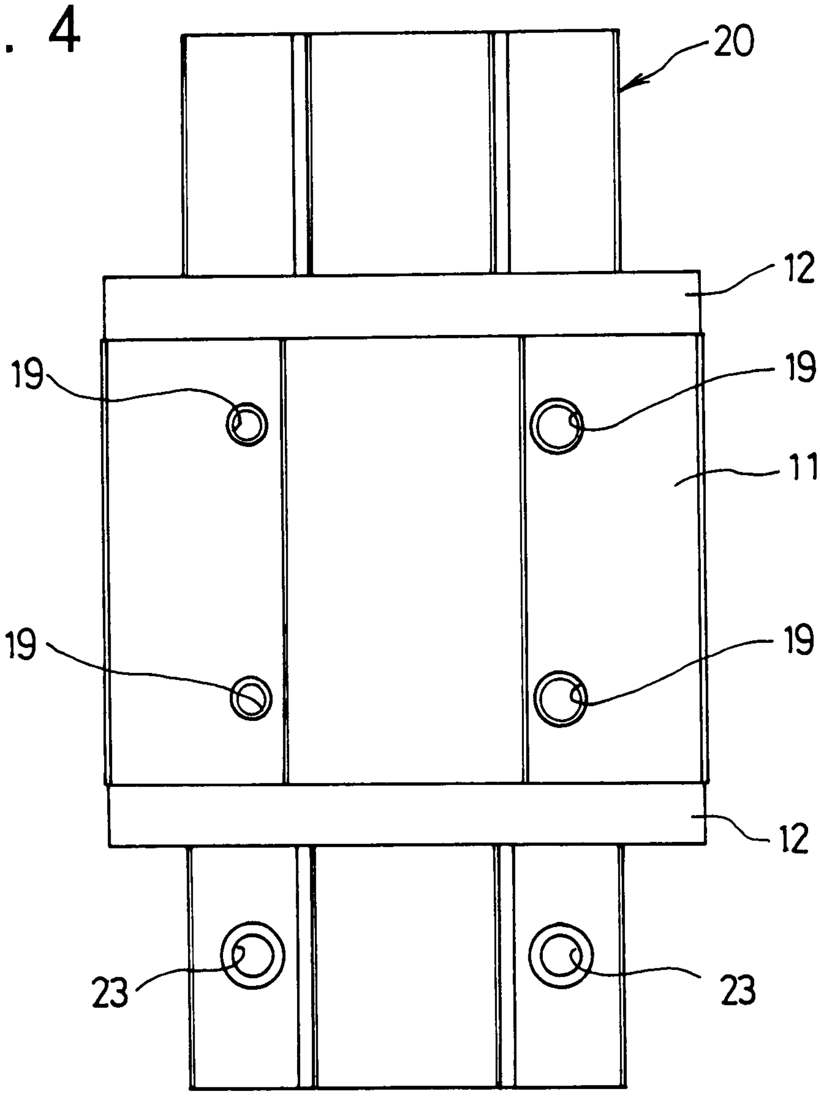
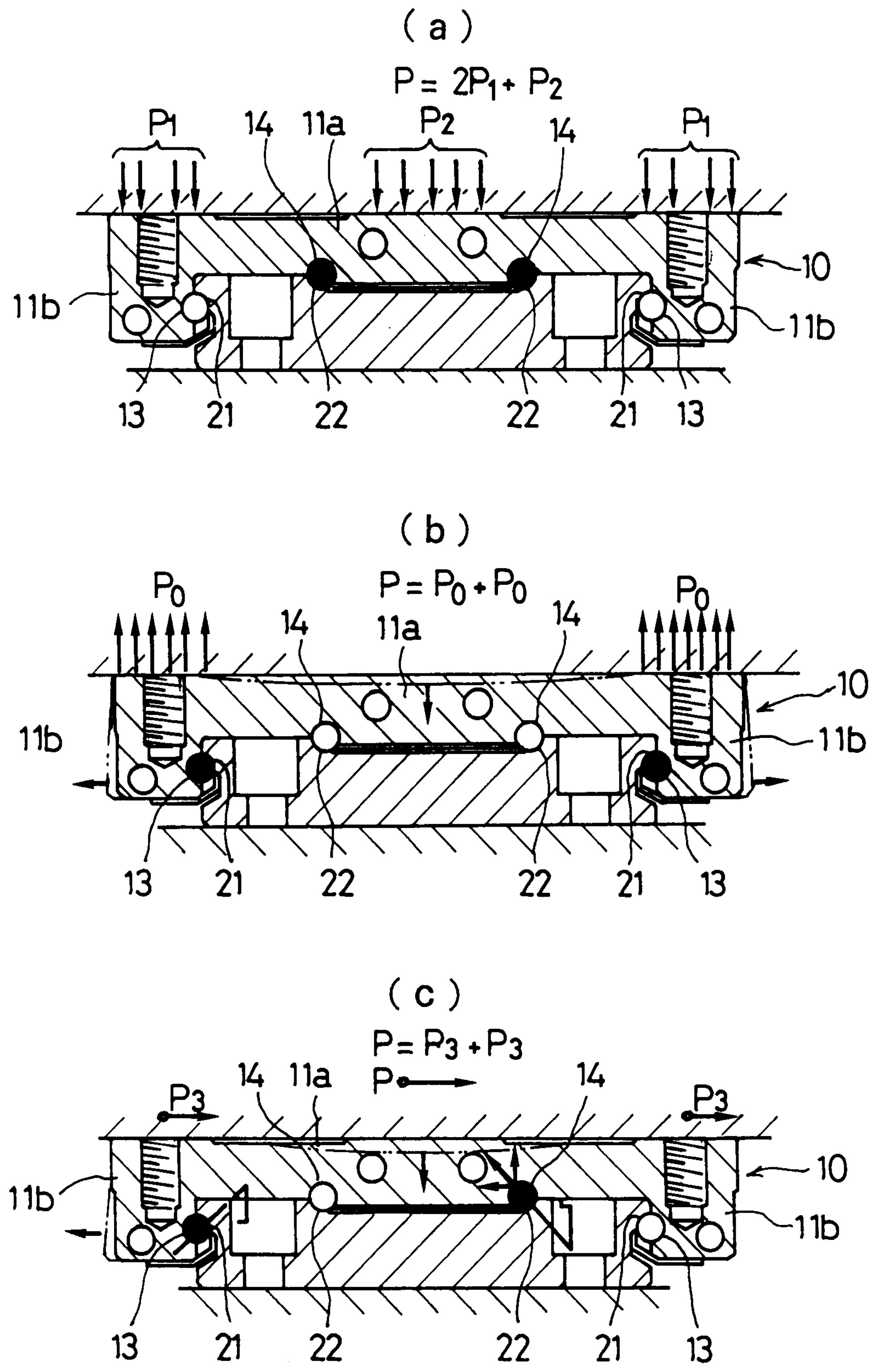

1c
19
14
14
11a
19
10
11b
11b
40
13
23
42
20
23
13
41

FIG. 4


20
12
19
19
11
19
19
12
23
23

Nummer: DE 42 27 599 A1
Int. Cl.[5]: F 16 C 29/04
Offenlegungstag: 4. März 1993

FIG. 5



Nummer: DE 42 27 599 A1
Int. Cl.⁵: F 16 C 29/04
Offenlegungstag: 4. März 1993

FIG. 6

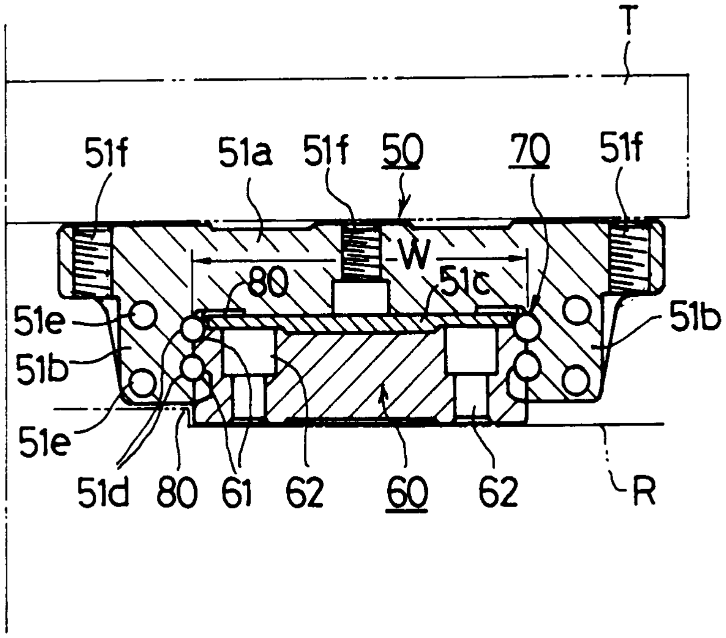
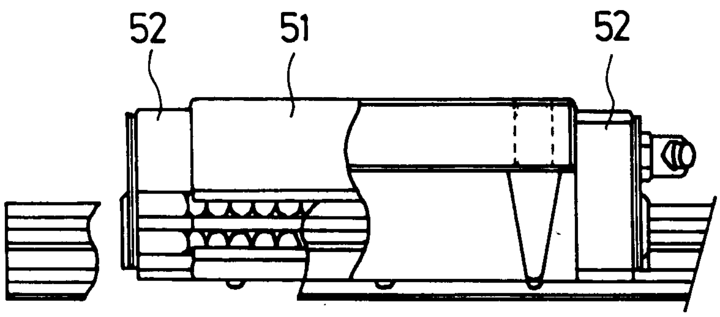


FIG. 7



(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENTAMT

(12) Offenlegungsschrift

(10) DE 42 15 692 A 1

(51) Int. Cl.5:
F 16 C 29/06
B 23 Q 1/18
B 65 G 47/82
B 65 G 25/04

(21) Aktenzeichen: P 42 15 692.0
(22) Anmeldetag: 13. 5. 92
(43) Offenlegungstag: 19. 11. 92

(30) Unionspriorität: (32) (33) (31)
13.05.91 JP 135345/91

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Tauchner, P., Dipl.-Chem. Dr.rer.nat.; Heunemann, D., Dipl.-Phys. Dr.rer.nat.; Rauh, P., Dipl.-Chem. Dr.rer.nat.; Hermann, G., Dipl.-Phys. Dr.rer.nat.; Schmidt, J., Dipl.-Ing.; Jaenichen, H., Dipl.-Biol. Dr.rer.nat., Pat.-Anwälte; Tremmel, H., Rechtsanw., 8000 München

(72) Erfinder:
Ise, Genjiro, Yamaguchi, JP

(54) Hin- und hergehender Tisch und zugehörige Führungsvorrichtung zur gleichmäßigen Lagerung einer Last in vier Richtungen

(57) Es wird eine Führungsvorrichtung zur Lagerung einer Last in vier Richtungen angegeben, welche eine verbesserte Steifigkeit gegenüber einer vertikalen, einer horizontalen oder einer Momentenlast hat, um hierdurch eine verbesserte Positioniergenauigkeit eines Lagerkörpers relativ zu einer Führungsbahn während einer hin- und hergehenden Bewegung beizubehalten. Jede der Kugelwälzflächen wenigstens auf der Führungsbahn und/oder des Lagerkörpers wird von einer Ausnehmung gebildet, welche einen gotischen Bogen im Querschnitt beschreibt und zwei gekrümmte Flächen umfaßt, welche miteinander verbunden sind, und die derart angeordnet ist, daß eine vertikale oder horizontale Last, welche auf die Führungsvorrichtung einwirkt, auf die eine oder die andere der gekrümmten Flächen im wesentlichen in die Richtung wirken kann, in welcher die Last auf die Führungsvorrichtung einwirkt.

DE 42 15 692 A 1

Beschreibung

Die Erfindung befaßt sich mit einer Führungsvorrichtung für die gleichmäßige Lagerung bzw. Abstützung einer Last in vier Richtungen, welche beispielsweise an Gleitflächen eines Tischschlittens oder einem Bearbeitungscenter in einer Werkzeugmaschine eingesetzt wird, oder bei jenem Teil einer Fördervorrichtung eingesetzt wird, welche einen schweren Gegenstand trägt und eine hin- und hergehende Bewegung ausführt, sowie bei einem hin- und hergehenden Tisch eingesetzt wird, welcher eine derartige Führungsvorrichtung umfaßt.

Eine bekannte Führungsvorrichtung zur gleichmäßigen Lagerung einer Last in vier Richtungen ist in JP-C-38 812/1982 angegeben. In **Fig.** 11 der beiliegenden Zeichnungen ist insgesamt mit 40 eine derartige Führungsvorrichtung gezeigt und weist eine Führungsbahn 42 auf, welche zwei Kugelwälzflächen 44 hat, die jeweils in einem Paar von gegenüberliegenden Seiten ausgebildet sind, ferner einen Lagerkörper 46 aufweist, welcher eine konkave Ausnehmung 50 zur passenden Aufnahme der Führungsbahn 42 besitzt und an seiner Innenfläche insgesamt mit vier Kugelwälzflächen 48 versehen ist, welche jeweils einer der Kugelwälzflächen 44 der Führungsbahn 42 zugewandt sind, und eine Mehrzahl von Kugeln 52 aufweist, welche zwischen den Kugelwälzflächen 44 der Führungsbahn 42 und den zugeordneten Kugelwälzflächen 48 des Lagerkörpers 46 gehalten sind.

Jede Kugelwälzfläche 44 und 48 wird von einer Ausnehmung gebildet, welche in Form eines einzigen Bogens im Querschnitt ausgelegt ist und einen Krümmungsradius hat, welcher im wesentlichen gleich dem Radius der Kugeln 52 bemessen ist. Die Kugeln 52 und die Kugelwälzflächen 44 und 48 bilden Lastwirklinien 42, welche jeweils einen Winkel von 45° zur Horizontalen haben.

Fig. 12 zeigt eine weitere bekannte Führungsvorrichtung für die gleichmäßige Lagerung einer Last in vier Richtungen, welche in JP-U-24 258/1988 angegeben ist. Die Führungsvorrichtung weist eine Führungsbahn 62 auf, welche Kugelwälzflächen 64 hat, ferner einen Lagerkörper 66, welcher Kugelwälzflächen 68 hat, und Kugeln 72 auf, welche dazwischen gehalten sind. Jede Kugelwälzfläche 64 der Führungsbahn 62 wird von einer Ausnehmung gebildet, welche in Form eines gotischen Bogens im Querschnitt ausgestaltet ist und zwei gekrümmte Flächen 64a und 64b umfaßt, welche miteinander verbunden sind. In ähnlicher Weise wird jede Kugelwälzfläche 68 des Lagerkörpers 66 von einer Ausnehmung gebildet, die in Form eines gotischen Bogens im Querschnitt ausgestaltet ist und zwei gekrümmte Flächen 68a und 68b umfaßt, welche miteinander verbunden sind. Die Kugeln 72 und die Kugelwälzflächen 64 und 68 bilden Lastwirklinien, welche jeweils einen Winkel von 56° zur Horizontalen einschließen, wie dies bei der Vorrichtung in **Fig.** 11 der Fall ist.

Da jedoch die Lastwirklinien unter einem Winkel von 45° zur Horizontalen liegen, ist die in **Fig.** 11 gezeigte Vorrichtung zu wenig steif gegenüber einer Momentanlast, welche bei einem einachsigen Einsatz in geeigneter Weise auftreten kann, obgleich diese Führungsvorrichtung die Fähigkeit hat, jegliche auf dieselbe in vertikaler oder horizontaler Richtung wirkende Last gleichmäßig zu lagern bzw. aufzunehmen. Darüber hinaus kann es leicht vorkommen, daß eine auf die Führungsvorrichtung in vertikaler oder horizontaler Richtung wirkende Last zu einer Veränderung der Kontaktpunkte zwischen den Kugeln und den Kugelwälzflächen führen kann, und hierdurch kann es vorkommen, daß der Lagerkörper in Richtung der Last und von der genauen Position relativ zur Führungsbahn sich verlagern kann.

Die in **Fig.** 12 gezeigte Führungsvorrichtung hat in ähnlicher Weise diesen Nachteil, welcher auf die Lastwirklinien zurückzuführen ist, welche unter einem Winkel von 45° zur Horizontalen liegen. Eine in vertikaler oder horizontaler Richtung wirkende Last kann in ähnlicher Weise leicht dazu führen, daß der Lagerkörper von der genauen Position relativ zur Führungsbahn wegverlagert wird.

Wenn eine Führungsvorrichtung mit dieser betreffenden Bauart eingesetzt wird, ist ihre Führungsbahn an einem Bett festgelegt, und der Lagerkörper ist ein Tisch. Die Führungsvorrichtung wird eingesetzt, um die hin- und hergehende Bewegung des Tisches längs des Bettes auf einer Geraden zu führen. Keine genaue hin- und hergehende Bewegung des Tisches läßt sich jedoch bei einer der bekannten Führungsvorrichtungen erreichen, da die einwirkende Last zu einer Verlagerung des Lagerkörpers führen kann, wie dies vorstehend angegeben ist. Eine Werkzeugmaschine, welche einen solchen Tisch mit einer derartigen Führungsvorrichtung umfaßt, kann daher leicht einen nennenswerten Maßfehler bei der Bearbeitung eines Werkstückes verursachen.

Unter den vorstehend geschilderten Umständen zielt die Erfindung hauptsächlich darauf ab, eine Führungsvorrichtung zur gleichmäßigen Lastaufnahme in vier Richtungen bereitzustellen, welche eine ausreichend verbesserte Steifigkeit gegen jegliche Momentanlast hat und für einen einachsigen Einsatz geeignet ist, und die eine drastisch verbesserte Genauigkeit hinsichtlich der Relativpositionen eines Lagerkörpers und einer Führungsbahn in Richtung einer beliebigen einwirkenden Last hat.

Ferner bezweckt die Erfindung, einen hin- und hergehenden Tisch bereitzustellen, welcher eine genaue hin- und hergehende Bewegung ausführen kann.

Nach der Erfindung wird dies mittels einer gleichmäßigen Führungsvorrichtung für eine Last in vier Richtungen erreicht, welche eine Führungsbahn aufweist, die eine Mehrzahl von Kugelwälzflächen hat, welche auf der äußeren Fläche ausgebildet sind, einen Lagerkörper aufweist, welcher eine konkave Ausnehmung zur passenden Aufnahme der Führungsbahn besitzt, und an seiner Innenfläche mit einer Mehrzahl von Kugelwälzflächen versehen ist, die jeweils einer der Kugelwälzflächen an der Führungsbahn zugewandt sind, und eine Mehrzahl von Kugeln aufweist, die zwischen den Kugelwälzflächen und der Führungsbahn und den zugeordneten Kugelwälzflächen am Lagerkörper gehalten sind, wobei die jeweilige Kugelwälzfläche wenigstens auf der Führungsbahn oder dem Lagerkörper von einer Ausnehmung gebildet wird, welche in Form eines gothischen Bogens im Querschnitt gestaltet ist und zwei gekrümmte Flächen umfaßt, die miteinander verbunden sind, wobei diese gekrümmten Flächen derart angeordnet sind, daß eine vertikale und eine horizontale Last, die auf die Führungsvorrichtung einwirkt, auf die gekrümmten Flächen jeweils längs Linien einwirken kann, welche in jene Richtungen verlaufen, die im wesentlichen gleich den Richtungen der jeweiligen Lasten sind, die auf der Führungsvorrichtung abgestützt werden.

Die weitere Zielsetzung nach der Erfindung wird durch einen hin- und hergehenden Tisch verwirklicht, welcher ein Bett aufweist, eine Mehrzahl von im wesentlichen parallelen, linearen Führungsvorrichtungen aufweist, welche auf dem Bett vorgesehen sind, und einen Tisch aufweist, welcher derart beschaffen und ausgelegt ist, daß er durch die linearen Führungsvorrichtungen zur Ausführung einer hin- und hergehenden Bewegung auf einer geraden Linie des Bettes geführt ist, wobei jede der linearen Führungsvorrichtungen eine Führungsbahn aufweist, welche fest mit dem Bett verbunden ist, und eine Mehrzahl von Kugelwälzflächen hat, welche auf der äußeren Fläche ausgebildet sind, einen Lagerkörper aufweist, welcher fest mit dem Tisch verbunden ist, und welcher eine konkave Ausnehmung zur passenden Aufnahme der Führungsbahn hat und an seiner inneren Fläche mit einer Mehrzahl von Kugelwälzflächen versehen ist, welche jeweils einer der Kugelwälzflächen auf der Führungsbahn zugewandt sind, und eine Mehrzahl von Kugeln aufweist, welche zwischen den Kugelwälzflächen auf der Führungsbahn und den zugeordneten Kugelwälzflächen an dem Lagerkörper gehalten sind, wobei eine der linearen Führungsvorrichtungen eine Führungsvorrichtung der vorstehend genannten Art zur Lagerung einer Last in vier Richtungen ist und die restlichen Führungsvorrichtungen radiale Lastführungen zur Lagerung von lediglich einer vertikalen Last sind.

Es ist wesentlich, daß jede der Kugelwälzflächen wenigstens der Führungsbahn oder des Lagerkörpers bei der Führungsvorrichtung zur Lagerung in vier Richtungen nach der Erfindung von einer Ausnehmung gebildet wird, welche in Form eines gothischen Bogens im Querschnitt gestaltet ist. Die Kugelwälzflächen auf der Führungsbahn können von Ausnehmungen gebildet werden, welche in Form eines gothischen Bogens im Querschnitt gestaltet sind, während die Kugelwälzflächen am Lagerkörper von außen gebildet werden können, die in Form eines einzigen Bogens im Querschnitt ausgebildet sind, oder die Auslegung auch umgekehrt getroffen werden kann. Alternativ können alle Kugelwälzflächen an der Führungsbahn und dem Lagerkörper von Ausnehmungen gebildet werden, welche im Querschnitt eine gothische Gestalt haben (diese werden nachstehend zur Vereinfachung lediglich bezeichnet mit "Ausnehmungen mit gothischem Bogen").

Jede von einer Ausnehmung mit gothischem Bogen gebildete Kugelwälzfläche umfaßt zwei gekrümmte Flächen, welche miteinander verbunden sind und welche derart angeordnet sind, daß eine Last im wesentlichen vertikal oder horizontal auf die jeweiligen gekrümmten Flächen wirken kann. Diese Auslegung ermöglicht, daß die jeweilige gekrümmte Fläche eine große vertikale oder horizontale Last abstützen kann, da die Richtungen der Linien, längs denen die vertikalen und horizontalen Lasten auf die Führungsvorrichtung wirken, auf die gekrümmten Flächen wirken und im wesentlichen gleich wie die Richtungen der auf die Führungsvorrichtung wirkenden Lasten gerichtet sind. Somit kann die Führungsvorrichtung nach der Erfindung eine große Momentanlast aufnehmen, und sie ist ausreichend starr gegenüber jeglicher Momentanlast bei einem einachsigen Einsatz.

Die Auslegung der gekrümmten Flächen gemäß der voranstehenden Beschreibung ermöglicht auch, daß jegliche Positionsänderung auf ein Minimum eingestellt oder verhindert wird, die ansonsten bei einer auf die Führungsvorrichtung wirkenden Last zu Punktkontakten zwischen den Kugeln und den gekrümmten Flächen führen könnte, da die Tangentenlinien, die durch die Kontaktpunkte gehen, im wesentlichen senkrecht zur Richtung der Last sind. Hierdurch erhält man eine drastisch verbesserte Genauigkeit hinsichtlich der vertikalen oder horizontalen Positionierung des Lagerkörpers relativ zur Führungsbahn.

Der hin- und hergehende Tisch nach der Erfindung umfaßt eine Führungsvorrichtung nach der Erfindung für Lasten in vier Richtungen als eine der linearen Führungsvorrichtungen, welche die Bewegung des Tisches auf einer Geraden führen. Daher ist es möglich, jegliche Verlagerung des Tisches in Richtung einer vertikalen oder horizontalen Last, die hierauf einwirkt, auf ein Minimum einzustellen oder zu verhindern, und hierdurch läßt sich die Bearbeitungsgenauigkeit beispielsweise in einer Werkzeugmaschine drastisch verbessern, bei welcher der Tisch nach der Erfindung eingesetzt wird.

Die restlichen linearen Führungen sind Radiallastführungsvorrichtungen oder Führungseinrichtungen. Die Radiallastführungsvorrichtung ist eine lineare Führung, welche nur eine vertikale Last aufnimmt und kaum eine horizontale Last abstützt. Jede der Kugelwälzflächen auf dem Lagerkörper und der Führungsbahn kann von einer Ausnehmung gebildet werden, die in Form eines einzigen Bogens im Querschnitt ausgestaltet ist (nachstehend wird dies der Einfachheit halber bezeichnet mit "Ausnehmung mit einem einzigen Bogen"), und sie umfaßt eine einzige gekrümmte Fläche, wenn die Richtung einer Linie, längs welcher eine Last auf die gekrümmte Fläche einwirkt, gleich der Richtung einer vertikalen Lastaufnahme an der Führungsvorrichtung ist.

Aus den nachstehend näher angegebenen Gründen wird daher nur für eine der linearen Führungen eine Lastführungsvorrichtung für vier Richtungen eingesetzt, während die restlichen als radiale Lastführungen oder -führungsvorrichtungen ausgelegt sind.

Wenn in einem System, welches eine Mehrzahl von parallelen linearen Führungen zur Führung der hin- und hergehenden Bewegung eines Tisches relativ zu einem Bett umfaßt, sind die Führungen nicht parallel oder wenn irgendeine Wärmedehnungsdifferenz zwischen dem Tisch und dem Bett auftritt, kann es leicht vorkommen, daß sich die Lagerkörper relativ zu den Führungsbahnen horizontal verlagern und hierdurch eine starke Zunahme hinsichtlich des Wälzwiderstandes der Kugeln auftritt. Wenn alle linearen Führungsvorrichtungen Führungsvorrichtungen nach der Erfindung zur Lagerung in vier Richtungen sind, ist keine gleichmäßige hin- und hergehende Bewegung des Tisches zu erwarten, da die Führungsvorrichtungen nach der Erfindung gegenüber einer vertikalen oder horizontalen Last äußerst starr sind.

Nach der Erfindung ist daher nur die lineare Führungsvorrichtung, welche als eine Basis für die Position des Tisches dient, eine Führungsvorrichtung für eine Last in vier Richtungen, um die genaue Positionierung des Tisches sicherzustellen, und die restlichen linearen Führungsvorrichtungen (oder Führungseinrichtungen) sind radiale Lastführungsvorrichtungen, welche jegliche horizontale Verlagerung des Lagerkörpers relativ zur Führungsbahn ausgleichen können. Der hin- und hergehende Tisch nach der Erfindung kann daher eine genaue und gleichmäßige hin- und hergehende Bewegung ausführen.

Weitere Einzelheiten, Merkmale und Vorteile der Erfindung ergeben sich aus der nachstehenden Beschreibung von bevorzugten Ausführungsformen unter Bezugnahme auf die beigefügte Zeichnung. Darin zeigt:

Fig. 1 eine Schnittansicht einer Führungsvorrichtung nach der Erfindung zur gleichmäßigen Lagerung einer Last in vier Richtungen,

Fig. 2 eine vergrößerte Ansicht eines Ausschnitts A von Fig. 1,

Fig. 3 eine Schnittansicht einer modifizierten Ausführungsform der in Fig. 1 gezeigten Führungsvorrichtung,

Fig. 4 eine Schnittansicht einer weiteren bevorzugten Ausführungsform einer Führungsvorrichtung zur gleichmäßigen Lagerung einer Last in vier Richtungen nach der Erfindung,

Fig. 5 eine vergrößerte Ansicht des Ausschnitts B in Fig. 4,

Fig. 6 eine Schnittansicht eines hin- und hergehenden Tisches, welcher nach der Erfindung ausgelegt ist,

Fig. 7 eine Schnittansicht einer Ausführungsform einer Führungsvorrichtung für eine radiale Last, welche bei dem hin- und hergehenden Tisch nach der Erfindung eingesetzt wird,

Fig. 8 eine vergrößerte Ausschnittsansicht des Teils C in Fig. 7,

Fig. 9 eine Schnittansicht einer weiteren Ausführungsform einer Führungsvorrichtung zur Lagerung einer radialen Last, welche bei dem hin- und hergehenden Tisch nach der Erfindung eingesetzt ist,

Fig. 10 eine vergrößerte Ausschnittsansicht des Teils D in Fig. 9,

Fig. 11 eine Schnittansicht einer an sich bekannten Führungsvorrichtung zur gleichmäßigen Lagerung einer Last in vier Richtungen, und

Fig. 12 eine Schnittansicht einer weiteren Ansicht einer bekannten Führungsvorrichtung zur gleichmäßigen Lagerung einer Last in vier Richtungen.

Nachstehend erfolgt eine detaillierte Beschreibung einer Führungsvorrichtung zur gleichmäßigen Lagerung einer Last in vier Richtungen und eines hin- und hergehenden Tisches nach der Erfindung unter Bezugnahme auf die beigefügte Zeichnung.

Zuerst wird auf Fig. 1 Bezug genommen, welche eine Ausführungsform einer Führungsvorrichtung nach der Erfindung für die gleichmäßige Lagerung einer Last in vier Richtungen zeigt. Die Führungsvorrichtung 10 stimmt hinsichtlich ihrer Auslegung im wesentlichen mit der bekannten Führungsvorrichtung überein, welche in JP-C-38 812/1982 angegeben ist und die voranstehend beschrieben wurde. Sie weist somit eine Führungsbahn, einen Lagerkörper 16 und eine Mehrzahl von Kugeln 22 auf, welche ermöglichen, daß der Lagerkörper 16 eine gleichmäßige hin- und hergehende Bewegung längs der Führungsbahn 12 ausführt.

Die Führungsbahn 12 hat zwei Kugelwälzflächen 14, die jeweils auf einem Paar von gegenüberliegenden Seiten hiervon ausgebildet sind. Jede Kugelwälzfläche 14 wird von einer Ausnehmung mit einem gothischen Bogen gebildet, welche zwei gekrümmte Flächen 14a und 14b umfaßt, welche miteinander verbunden sind, wie dies in Fig. 2 verdeutlicht ist. Jede der gekrümmten Flächen 14a und 14b ist im Querschnitt kreisförmig und hat einen Krümmungsradius, welcher geringfügig größer als der Radius der Kugeln 22 ist.

Der Lagerkörper 16 hat eine konkave Ausnehmung 20, welche am Boden offen ist und welche im allgemeinen komplementär zur Querschnittsgestalt der Führungsbahn 12 ausgelegt ist. Der Führungskörper 16 hat eine innere Fläche, welche von der konkaven Ausnehmung 20 gebildet wird und die insgesamt vier Kugelwälzflächen 18 umfaßt, die jeweils einer der Kugelwälzflächen 14 auf der Führungsbahn 12 zugewandt sind. Die Kugelwälzflächen 18 haben die gleiche Gestalt wie die Kugelwälzflächen 14. In anderen Worten ausgedrückt bedeutet dies, daß jede Kugelwälzfläche 18 von einer Ausnehmung mit einem gothischen Bogen gebildet wird und zwei gekrümmte Flächen 18a, 18b umfaßt, die miteinander verbunden sind, wie dies in Fig. 2 gezeigt ist. Der Lagerkörper hat auch Kugeldurchgänge 23, welche einen Umlauf der Kugeln 22 bei einer fehlenden Last von einem Ende einer der Kugelwälzflächen 18 zu dem anderen Ende derselben ermöglicht.

Die Führungsbahn 12 hat auf jeder Seite einen Vorsprung 12a, an welchem zwei der Kugelwälzflächen 14 ausgebildet sind. Andererseits hat der Lagerkörper 16 auf den jeweils beiden von der konkaven Ausnehmung 20 gegenüberliegenden Seiten eine Ausnehmung 20a, in welcher zwei der Kugelwälzflächen 18 ausgebildet sind, und in welche der Vorsprung 12a auf einer Seite der Führungsbahn 12 passend eingesetzt ist.

Eine modifizierte Ausführungsform der Führungsvorrichtung nach Fig. 1 ist in Fig. 3 gezeigt. Diese erhält man dadurch, daß die Auslegung der Vorsprünge und Ausnehmungen nach Fig. 1 umgekehrt getroffen ist. Eine Führungsbahn 13 hat ein Paar von Ausnehmungen 13a, welche jeweils auf gegenüberliegenden Seiten ausgebildet sind, und ein Lagerkörper 17 hat ein Paar von Vorsprüngen 21a, welche jeweils auf gegenüberliegenden Seiten von der konkaven Ausnehmung 21 ausgebildet sind und die jeweils in eine der Ausnehmungen 13a der Führungsbahn 13 passen.

Wiederum bezugnehmend auf Fig. 2 sind die gekrümmte Fläche 14a, welche eine Hälfte der jeweiligen Kugelwälzfläche 14 bildet, und die gekrümmte Fläche 18a, welche eine Hälfte der zugeordneten Kugelwälzfläche 18 bildet, in vertikaler Richtung zur Führungsvorrichtung 10 einander zugewandt, während die gekrümmte Fläche 14b, die die andere Hälfte der Kugelwälzfläche 14 bildet und die gekrümmte Fläche 18b, welche die andere Hälfte der Kugelwälzfläche 18 bildet, in horizontaler Richtung der Führungsvorrichtung 10 einander zugewandt sind. Somit sind die Kugeln zwischen den gekrümmten Flächen 14a und 18a in vertikaler Richtung der Führungsvorrichtung 10 und zwischen den gekrümmten Flächen 14b und 18b in horizontaler Richtung derselben gehalten.

Wenn daher eine vertikale Last auf die Führungsvorrichtung 10 einwirkt, ergibt sich somit, daß die Richtung einer Lastwirklinie L, welche durch die gekrümmten Flächen 14a und 18a geht, gleich der Richtung der Lagerung der Last auf der Führungsvorrichtung 10 ist. In ähnlicher Weise ist die Richtung einer Lastwirklinie L', welche durch die gekrümmten Flächen 14b und 18b geht wenn eine horizontale Last auf die Führungsvorrichtung 10 einwirkt, im wesentlichen gleich der Wirkrichtung der Last. Die Richtung der jeweiligen Lastwirklinien bedeutet die Richtung, in welcher die Last auf die gekrümmten Flächen wirkt.

Wenn beispielsweise eine nach unten gerichtete Last F auf die Führungsvorrichtung 10 nach Fig. 1 wirkt, wird die Last F von den gekrümmten Flächen 18a auf die Kugeln 22 übertragen, ohne daß man eine Kraftkomponente hierbei erzeugt, da die Richtung der Lastwirklinie L, welche durch die jeweilige gekrümmte Fläche 18a geht, im wesentlichen gleich der Wirkrichtung der Last ist. Die Last F wird dann von den Kugeln 22 auf die gekrümmten Flächen 14a ohne die Erzeugung einer Kraftkomponente übertragen. Da die Richtungen aller Lastwirklinien L, die durch die gekrümmten Flächen 14a und 18a gehen, im wesentlichen gleich der Wirkrichtung der Last sind, kann die Führungsvorrichtung 10 eine große, nach unten wirkende Last aufnehmen. In ähnlicher Weise kann sie eine große, in horizontaler Richtung wirkende Last f lagern, da die Richtungen aller Lastwirklinien L', welche durch die gekrümmten Flächen **14**b und **18**b gehen, im wesentlichen gleich der Wirkrichtung der Last f sind.

Die Last F führt zu keiner Verlagerung der Kontaktpunkte zwischen den Kugeln **22** und den gekrümmten Flächen **14**a und **18**a, da die Lastwirklinien L im wesentlichen gleich der Wirkrichtung der Last F ist. Auch bewirkt die Last f keine Verlagerung bei den Kontaktpunkten zwischen den Kugeln **22** und den gekrümmten Flächen **14**b und **18**b, da die Lastwirklinien L' im wesentlichen gleich der Wirkrichtung der Last f sind. Somit ist die Führungsvorrichtung **10** äußerst starr gegenüber jeglicher vertikaler oder horizontaler Last und bildet eine optimale Führungsvorrichtung als eine Basis für die Positionierung eines hin- und hergehenden Tisches.

Nunmehr sei auf **Fig.** 4 Bezug genommen, welche eine weitere Führungsvorrichtung **9** zur gleichmäßigen Lagerung einer Last in vier Richtungen zeigt, welche gemäß einer bevorzugten Ausführungsform nach der Erfindung ausgelegt ist. Diese Führungsvorrichtung umfaßt eine Führungsbahn **11**, welche hinsichtlich der Auslegungsform mit der Führungsbahn **12** übereinstimmt, die zuvor unter Bezugnahme auf **Fig.** 1 erläutert wurde. Daher kann eine nähere Beschreibung der Führungsbahn **11** entfallen. Sie umfaßt auch einen Lagerkörper **15**, welcher im wesentlichen mit dem Lagerkörper **16** übereinstimmt, der in **Fig.** 1 gezeigt ist. Der einzige Unterschied zwischen denselben ist darin zu sehen, daß die jeweilige Kugelwälzfläche **19**, welche am Lagerkörper **15** ausgebildet ist, von einer Ausnehmung mit einem einzigen Bogen gebildet wird und eine einzige gekrümmte Fläche umfaßt.

Jede Kugelwälzfläche **24**, welche auf der Führungsbahn **11** ausgebildet ist, umfaßt zwei gekrümmte Flächen **24**a und **24**b, wie dies in **Fig.** 5 gezeigt ist. Die gekrümmte Fläche **24**a weist nach oben oder unten, während die gekrümmte Fläche **24**b in horizontaler Richtung verläuft. Jede Kugelwälzfläche **19** auf dem Lagerkörper **15** ist derart ausgebildet, daß eine Lastwirklinie m, welche durch dieselbe geht, einen Winkel von etwa 45° zu den Richtungen einer vertikalen und einer horizontalen Last einschließen kann, welche auf die Führungsvorrichtung **9** wirkt. Die gekrümmten Flächen **24**a und **24**b und die Kugelwälzflächen **19** halten dazwischen Kugeln **22** in Wälzeingriff.

Die Lastwirklinien l zusammen mit einer nach unten wirkenden Last F wirken auf die gekrümmten Flächen **24**a in gleicher Richtung wie die Last F ein und in ähnlicher Weise wirken die Lastwirklinien l' zusammen mit einer horizontalen Last f auf die gekrümmten Flächen **24**b ein und stimmen im wesentlichen mit der Last f überein. Die Führungsvorrichtung **9** kann daher sowohl eine große vertikale als auch eine große horizontale Last lagern bzw. aufnehmen.

Die vertikale oder horizontale Last, welche auf die Führungsvorrichtung **9** einwirkt, wird von dem Führungskörper **15** zu den Kugeln **22** längs den Lastwirklinien m, welche durch die Kugelwälzflächen **19** gehen, übertragen und drückt hierbei die Kugeln **22** gegen die gekrümmten Flächen **24**a und **24**b, welche die Kugelwälzflächen **24** bilden, und zwar längs den Lastwirklinien l und l'. Daher tritt keine Verlagerung an den Kontaktpunkten zwischen den Kugeln **22** und den gekrümmten Flächen **24**a und **24**b auf, sondern die Führungsvorrichtung **9** hat eine hohe Steifigkeit sowohl gegenüber vertikalen als auch gegenüber horizontalen Lasten.

Es ist jedoch leicht möglich, daß, wenn die vertikale oder die horizontale Last F oder f eine gewisse Größe überschreitet, eine Verlagerung an den Kontaktpunkten zwischen den Kugeln **22** und den Kugelwälzflächen **19** bewirkt wird, da die Richtung der Lastwirklinien m nicht mit jener der Last übereinstimmen. Somit läßt sich feststellen, daß die Führungsvorrichtung **9** hinsichtlich der Steifigkeit schwächer als die in **Fig.** 1 gezeigte Führungsvorrichtung **10** ist.

Nunmehr wird auf **Fig.** 6 Bezug genommen, welche einen hin- und hergehenden Tisch (Schlitten) **1** gemäß einer Ausführungsform nach der Erfindung zeigt. Der Tisch **1** weist ein Bett **80**, einen Tisch **82** und zwei parallele, lineare Führungsvorrichtungen auf, welche mittels Schrauben **81** fest am Bett **80** angebracht sind und zur Führung bei der hin- und hergehenden Bewegung des Tisches **82** auf einer Geraden längs des Bettes **80** eingesetzt werden. Eine der linearen Führungsvorrichtungen ist eine Führungsvorrichtung **10** zur gleichmäßigen Lagerung einer Last in vier Richtungen, welche die Auslegungsform nach **Fig.** 1 aufweist und eine Basis für die Positionierung des Tisches **82** bildet. Die andere ist eine radiale Lastführungsvorrichtung **30**, welche nur eine vertikale Last aufnimmt bzw. lagert, welche auf den Tisch **82** wirkt.

Die Führungsvorrichtung **10** hat eine hohe Steifigkeit gegenüber jeglichen vertikalen oder horizontalen Lasten und ermöglicht somit die Aufrechterhaltung einer hohen Positioniergenauigkeit, wie dies voranstehend angegeben wurde. Daher wird ermöglicht, daß der hin- und hergehende Tisch **1** selbst beim Einwirken einer großen vertikalen oder horizontalen Last auf den Tisch **82** gelagert wird, ohne daß eine nennenswerte Verlagerung in Richtung der Last auftritt. Im allgemeinen ist es zutreffend, daß, wenn irgendein Unterschied hinsichtlich der Wärmedehnung zwischen einem hin- und hergehenden Tisch und einem stationären Bett vorhanden ist, oder wenn zwei lineare Führungen zur Führung des Tisches nicht in zufriedenstellender Weise parallel zueinander sind, die Lagerkörper in den linearen Führungen, welche fest mit dem Tisch verbunden sind, in horizontaler Richtung von den Führungsbahnen, welche auf dem Bett befestigt sind, verlagert werden, woraus eine starke Zunahme des Bewegungswiderstandes des Tisches durch die Führungen resultiert. Daher kann keine gleichmäßige hin- und hergehende Bewegung bei dem Tisch mehr erwartet werden.

Die radiale Lastführungsvorrichtung **30** jedoch nimmt kaum eine horizontale Last auf, sondern gleicht jede horizontale Verlagerung des Lagerkörpers **31** gegenüber der Führungsbahn **32** aus. Die Kombination aus radialer Lastführungsvorrichtung **30** mit der Führungsvorrichtung **10** für Lasten in vier Richtungen ermöglicht, daß der hin- und hergehende Tisch **1** eine gleichmäßige hin- und hergehende Bewegung ausführt, ohne daß ein nennenswerter Bewegungswiderstand vorhanden ist. Die Positionsgenauigkeit des Tisches **82** wird durch die Führungsvorrichtung **10** aufrechterhalten.

Nunmehr soll auf **Fig.** 7 Bezug genommen werden, welche in detaillierter Weise eine Ausbildungsform einer radialen Lastführungsvorrichtung zeigt. Die radiale Lastführungsvorrichtung **2** stimmt im wesentlichen hinsichtlich des Aufbaus mit der Führungsvorrichtung **10** zur gleichmäßigen Lagerung einer Last in vier Richtungen überein, welche in **Fig.** 1 gezeigt ist. Jede Kugelwälzfläche **25** auf einer Führungsbahn **3** wird von einer Nut mit einem gothischen Bogen gebildet und umfaßt zwei gekrümmte Flächen **25**a und **25**b, welche miteinander verbunden sind. Jede Kugelwälzfläche **26** an einem Lagerkörper **4** wird ebenfalls von einer Ausnehmung mit einem gothischen Bogen gebildet und umfaßt zwei gekrümmte Flächen **26**a und **26**b, wie dies in **Fig.** 8 gezeigt ist. Die Auslegung der gekrümmten Flächen **25**a, **25**b, **26**a und **26**b stimmt mit jener der gekrümmten Flächen **14**a, **14**b, **18**a und **18**b an der Führungsvorrichtung **10** überein, welche in **Fig.** 2 gezeigt ist.

Die radiale Lastführungsvorrichtung 2 unterscheidet sich von der Führungsvorrichtung **10** dahingehend, daß die gekrümmten Flächen **25**b und **26**b, welche einander zugewandt sind, einen Abstand dazwischen haben, welcher größer als jener zwischen den weiteren gekrümmten Flächen **25**a und **26**a ist, die einander zugewandt ist. Daher berühren die Kugeln **22**, welche zwischen den Kugelwälzflächen **25** auf der Führungsbahn **3** und den Kugelwälzflächen **26** auf dem Lagerkörper **4** gelagert sind, die gekrümmten Flächen **25**a und **26**a, berühren aber die gekrümmten Flächen **25**b und **26**b nicht. Diese Verhältnisse werden erreicht, da die horizontal im Abstand vorgesehenen gekrümmten Flächen **26**a an dem Lagerkörper **4** einen Abstand P_1 dazwischen haben, welcher größer als der Abstand P_2 zwischen den horizontal im Abstand angeordneten, gekrümmten Flächen **25**a auf der Führungsbahn **3** ist. Wenn der Abstand P_1 gleich P_2 wäre, würden die Kugeln **22** alle gekrümmten Flächen **25**a, **25**b, **26**a und **26**b berühren, und die Führungsvorrichtung **2** würde mit der Führungsvorrichtung **10** übereinstimmen, welche in **Fig.** 1 gezeigt ist. Die Richtung der Lastwirklinie L, welche durch das jeweilige Paar von gekrümmten Flächen **25**a und **26**a geht, welche die Kugeln **22** berühren, ist gleich der Richtung, in welcher eine vertikale Last auf die Führungsvorrichtung **2** einwirkt. Die Führungsvorrichtung **2** kann daher eine große vertikale Last lagern bzw. aufnehmen, ohne daß man eine nennenswerte Änderung hinsichtlich der Höhe hat, da keine Verlagerung zu den Kontaktpunkten zwischen den Kugeln **22** und den gekrümmten Flächen **25**a und **26**a auftritt.

Wenn eine horizontale Last auf die Führungsvorrichtung **2** wirkt, gestatten die Zwischenräume zwischen den Kugeln **22** und den gekrümmten Flächen **25**b und **26**b eine geringfügige horizontale Verlagerung des Lagerkörpers **4** gegenüber der Führungsbahn **3**. Diese Verlagerung behindert die gleichmäßige Wirkung der Führungsvorrichtung **2** nicht.

Fig. 9 zeigt eine weitere Ausführungsform einer radialen Lastführungsvorrichtung. Die radiale Lastführungsvorrichtung **5** weist eine Führungsbahn **6** auf, welche insgesamt vier Kugelwälzflächen **27** hat, ferner einen Lagerkörper **7** auf, welcher insgesamt vier Kugelwälzflächen **28** hat, welche jeweils einer der Kugelwälzflächen **27** auf der Führungsbahn **6** zugewandt ist, und eine Mehrzahl von Kugeln **22** auf, welche in Wälzeingriff zwischen den Kugelwälzflächen **27** und **28** gehalten sind, wie dies bei der Führungsvorrichtung **2** der Fall ist, welche in **Fig.** 7 gezeigt ist.

Jede Kugelwälzfläche **27** und **28** wird jedoch von einer Ausnehmung mit einem einzigen Boden gebildet und umfaßt eine einzige gekrümmte Fläche, wie dies in **Fig.** 10 gezeigt ist. Die Richtung der Lastwirklinie L, welche durch das jeweilige Paar von Kugelwälzflächen **27** und **28** geht, stimmt mit der Richtung überein, in welcher eine vertikale Last auf die Führungsvorrichtung **5** einwirkt. Die Führungsvorrichtung **5** kann daher eine große vertikale Last lagern bzw. aufnehmen, ohne daß eine nennenswerte Höhenänderung vorhanden ist.

Die Führungsvorrichtung **5** hat keine Kugelwälzfläche, welche die horizontale Bewegung der Kugeln **22** einschränkt.

Wenn daher eine horizontale Last auf die Führungsvorrichtung **5** einwirkt, wird eine Verlagerung der Kontaktpunkte zwischen den Kugeln **22** und den Kugelwälzflächen **27** und **28** bewirkt, und hierdurch eine horizontale Verlagerung des Lagerkörpers **7** gegenüber der Führungsbahn **6**. Diese Verlagerung behindert die gleichmäßige Bewegung der Führungsvorrichtung **5** nicht.

Patentansprüche

1. Führungsvorrichtung zur Lagerung einer Last in vier Richtungen, mit einer Führungsbahn (**12**), welche eine Mehrzahl von Kugelwälzflächen (**14**) hat, die auf ihrer Außenfläche ausgebildet sind, einem Lagerkörper (**16**), welcher eine konkave Ausnehmung (**20**) hat, in welche die Führungsbahn (**12**) paßt, wobei der Lagerkörper (**16**) eine Mehrzahl von Kugelwälzflächen (**14**) hat, welche auf seiner inneren Fläche ausgebildet sind und die jeweils einer der Kugelwälzflächen (**14**) auf der Führungsbahn (**12**) zugewandt sind, und mit einer Mehrzahl von Kugeln (**22**), welche zwischen den Kugelwälzflächen (**14**) auf der Führungsbahn (**12**) und den Kugelwälzflächen (**14, 18**) auf dem Lagerkörper (**16**) gehalten sind, welche den Kugelwälzflächen (**14**) auf der Führungsbahn (**12**) zugewandt sind, **dadurch gekennzeichnet,** daß die jeweiligen Kugelwälzflächen (**14, 18**) auf wenigstens der Führungsbahn (**12**) oder des Lagerkörpers (**16**) von einer Ausnehmung gebildet werden, welche in Form eines gothischen Bogens im Querschnitt ausgestaltet ist, und zwei gekrümmte Flächen (**14a, 14b; 18a, 18b**) umfaßt, welche miteinander verbunden sind, und daß die gekrümmten Flächen (**14a, 14b; 18a, 18b**) derart angeordnet sind, daß eine vertikale oder horizontale Last, welche auf die Führungsvorrichtung (**10**) einwirkt, auf die eine oder die andere gekrümmte Fläche (**14a, 14b; 18a, 18b**) im wesentlichen in die Richtung wirken kann, in welche die Last auf die Führungsvorrichtung (**10**) einwirkt.
2. Führungsvorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die jeweiligen Kugelwälzflächen (**14, 18**) sowohl auf der Führungsbahn (**12**) als auch auf dem Lagerkörper (**16**) von dieser Ausnehmung gebildet werden.
3. Führungsvorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Kugelwälzflächen (**14a, 14b**) auf der Führungsbahn (**12**) von dieser Nut gebildet werden, während die jeweiligen Kugelwälzflächen (**19**) auf dem Lagerkörper (**15**) von einer Ausnehmung gebildet werden, die in Form eines einzigen Bogens im Querschnitt ausgelegt ist und eine einzige gekrümmte Fläche umfaßt, welche derart angeordnet ist, daß die vertikale oder horizontale Last, welche auf die Führungsvorrichtung (**9**) einwirkt, auf die einzige gekrümmte Fläche unter einem Winkel von etwa 45° zu jener Richtung wirken kann, in welcher die Last auf die Führungsvorrichtung (**9**) einwirkt (**Fig.** 4 und 5).
4. Hin- und hergehender Tisch, welcher ein stationäres Bett (**80**), eine Mehrzahl von im wesentlichen parallelen, linearen Führungsvorrichtungen, die an dem Bett (**80**) angebracht sind und einen hin- und hergehenden Tisch (**1**) aufweist, welcher auf einer

geraden Linie längs des Bettes (**80**) durch die linearen Führungsvorrichtungen hin- und hergehend bewegbar ist, wobei jede Führungsvorrichtung eine Führungsbahn (**12**) aufweist, welche fest mit dem Bett (**80**) verbunden ist, und eine Mehrzahl von Kugelwälzflächen (**14**) hat, welche auf der äußeren Fläche ausgebildet sind, einen Lagerkörper (**16**) aufweist, welcher fest mit dem Tisch (**82**) verbunden ist, und eine Ausnehmung hat, in welche die Führungsbahn (**12**) paßt, wobei der Lagerkörper (**16**) eine Mehrzahl von Kugelwälzflächen (**18**) hat, welche auf der inneren Fläche ausgebildet sind und jeweils einer der Kugelwälzflächen (**14**) auf der Führungsbahn (**12**) zugewandt sind, und eine Mehrzahl von Kugeln (**22**) aufweist, welche zwischen den Kugelwälzflächen (**14**) auf der Führungsbahn (**12**) und den Kugelwälzflächen (**18**) auf dem Lagerkörper (**16**) gehalten sind, welche den Kugelwälzflächen (**14**) auf der Führungsbahn (**12**) zugewandt sind, dadurch gekennzeichnet, daß eine der linearen Führungsvorrichtungen eine Führungsvorrichtung (**10**) zur Lagerung einer Last in vier Richtungen ist, bei der die jeweiligen Kugelwälzflächen (**14**a, **14**b) wenigstens der Führungsbahn (**12**) oder des Lagerkörpers (**16**) von einer Ausnehmung gebildet werden, die in Form eines gothischen Bogens im Querschnitt ausgestaltet ist, und zwei gekrümmte Flächen (**14**a, **14**b; **18**a, **18**b) umfaßt, welche miteinander verbunden sind, und daß die gekrümmten Flächen (**14**a, **14**b; **18**a, **18**b) derart angeordnet sind, daß eine vertikale oder eine horizontale Last,· welche auf die lineare Führungsvorrichtung (**10**) wirkt, auf die eine oder die andere gekrümmte Fläche (**14**a, **14**b,; **18**a, **18**b) im wesentlichen in jener Richtung einwirken kann, in der die Last auf diese eine lineare Führungsvorrichtung (**10**) einwirkt, während die restlichen linearen Führungsvorrichtungen von einer Führungsvorrichtung (**30**) für eine radiale Last gebildet werden, welche lediglich eine vertikale Last aufnimmt. (**Fig.** 6 und 7).

5. Vorrichtung nach Anspruch 4, dadurch gekennzeichnet, daß die jeweiligen Kugelwälzflächen (**14**, **18**) sowohl auf der Führungsbahn (**12**) als auch auf dem Lagerkörper (**16**) bei einer linearen Führungsvorrichtung (**10**) von dieser Ausnehmung gebildet werden.

6. Vorrichtung nach Anspruch 4, dadurch gekennzeichnet, daß die jeweiligen Kugelwälzflächen (**14**, **18**) auf der Führungsbahn (**12**) bei dieser einen linearen Führungsvorrichtung (**10**) von dieser Ausnehmung gebildet werden, während die jeweiligen Kugelwälzflächen auf dem Lagerkörper (**16**) bei dieser einen linearen Führungsvorrichtung (**10**) von einer Ausnehmung gebildet wird, die in Form eines einzigen Bogens im Querschnitt ausgelegt ist und eine einzige gekrümmte Fläche aufweist, welche derart angeordnet ist, daß die vertikale oder horizontale Last auf die einzige gekrümmte Fläche unter einem Winkel von etwa 45° zu jener Richtung einwirken kann, in welcher die Last auf diese eine lineare Führungsvorrichtung (**10**) einwirkt.

7. Vorrichtung nach Anspruch 5 oder 6, dadurch gekennzeichnet, daß die jeweiligen Kugelwälzflächen (**14**, **18**) sowohl auf der Führungsbahn (**12**) als auch auf den Lagerkörper (**16**) bei dieser Führungsvorrichtung (**10**) für radiale Belastungen von einer Ausnehmung gebildet werden, welche in Form eines gothischen Bogens im Querschnitt ausgelegt ist und zwei gekrümmte Flächen (**14**a, **14**b; **18**a, **18**b) umfaßt, welche miteinander verbunden sind, und die derart angeordnet sind, daß eine vertikale oder horizontale Last, welche auf die Führungsvorrichtung zur Lagerung einer radialen Last einwirkt, auf die eine oder die andere letztgenannte gekrümmte Fläche (**14**a, **14**b; **18**a, **18**b) im wesentlichen in jene Richtung einwirken kann, in welcher die Last auf die Führungsvorrichtung (**10**) zur Lagerung der radialen Last einwirkt, wobei eine der gekrümmten Flächen auf der Führungsbahn (**12**) und eine der gekrümmten Flächen (**18**) auf dem Lagerkörper (**16**) einander zugewandt sind und vertikal im Abstand voneinander angeordnet sind, während die andere der gekrümmten Flächen auf der Führungsbahn (**12**) und die andere der gekrümmten Flächen auf dem Lagerkörper (**16**) einander zugewandt sind und horizontal in einem Abstand voneinander derart vorgesehen sind, daß dieser Abstand größer als der Abstand ist, um den die vertikal im Abstand angeordneten gekrümmten Flächen voneinander beabstandet sind, so daß die Kugeln (**22**) nur die vertikal im Abstand angeordneten gekrümmten Flächen berühren können. (**Fig.** 7 und 8).

8. Vorrichtung nach Anspruch 5 oder 6, dadurch gekennzeichnet, daß die jeweiligen Kugelwälzflächen (**27**, **28**) sowohl auf der Führungsbahn (**6**) als auch auf dem Lagerkörper (**7**) bei der Führungsvorrichtung (**5**) zur Lagerung einer radialen Last von einer Ausnehmung gebildet werden, welche im Querschnitt einen einzigen Bogen hat und eine einzige gekrümmte Fläche aufweist, welche derart angeordnet ist, daß eine vertikale Last, welche auf die Führungsvorrichtung (**5**) zur Lagerung einer radialen Last einwirkt, auf die einzige gekrümmte Fläche im wesentlichen in die Richtung wirken kann, in die die Last auf die Führungsvorrichtung (**5**) zur Lagerung einer radialen Last einwirkt. (**Fig.** 9 und 10).

Hierzu 7 Seite(n) Zeichnungen

Nummer: DE 42 15 692 A1
Int. Cl.⁵: F 16 C 29/06
Offenlegungstag: 19. November 1992

FIG. 1

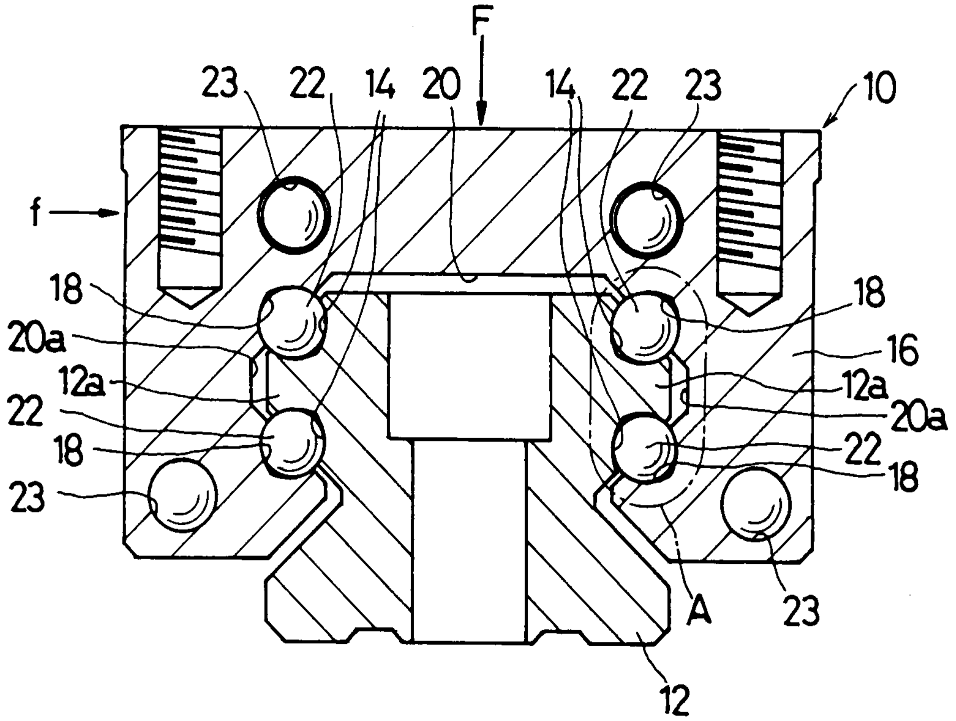
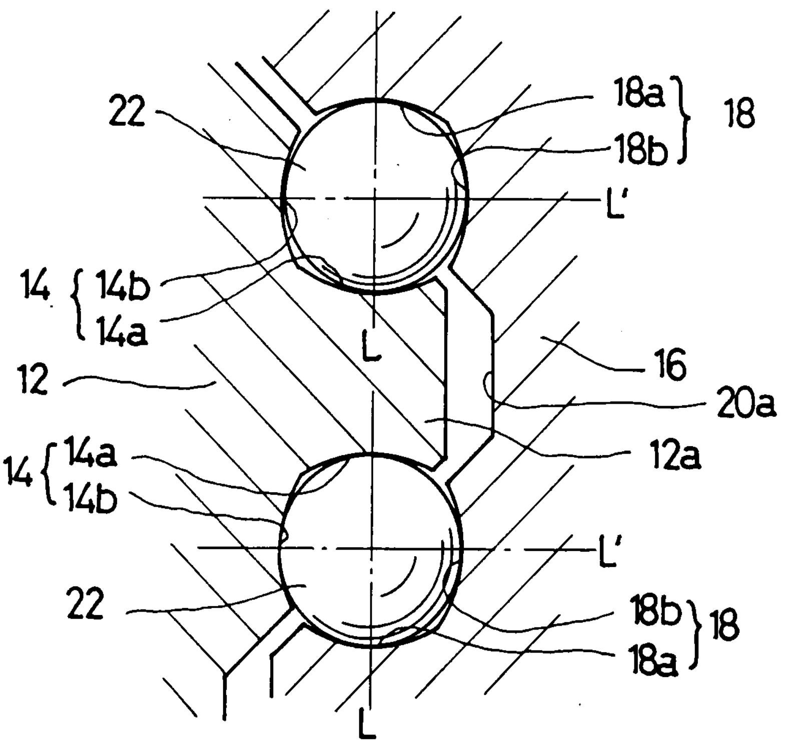


FIG. 2



Nummer: DE 42 15 692 A1
Int. Cl.⁵: F 16 C 29/06
Offenlegungstag: 19. November 1992

FIG. 3

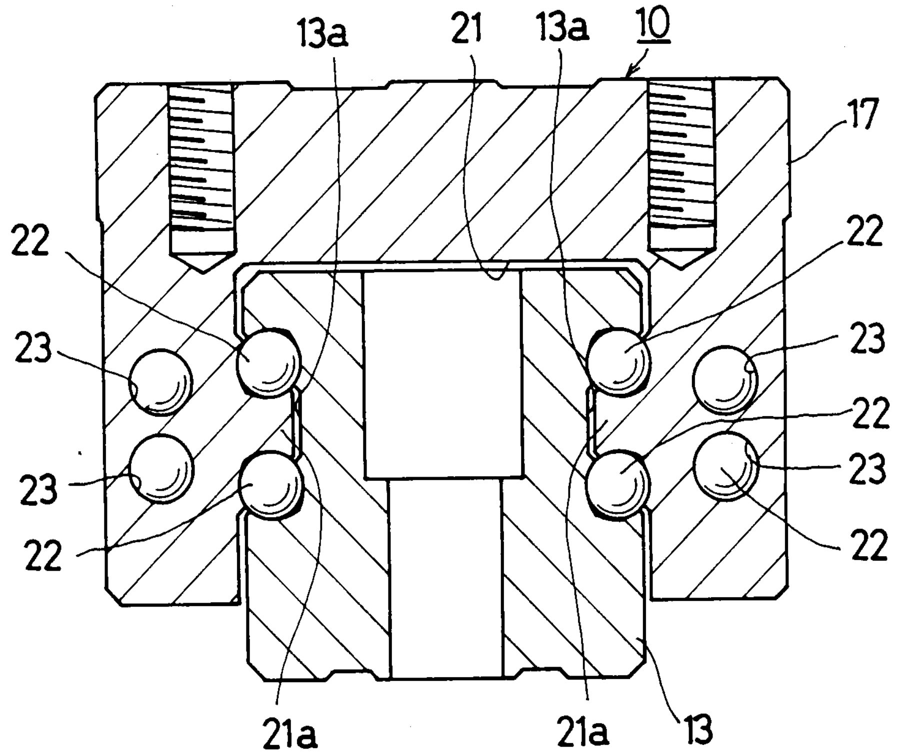
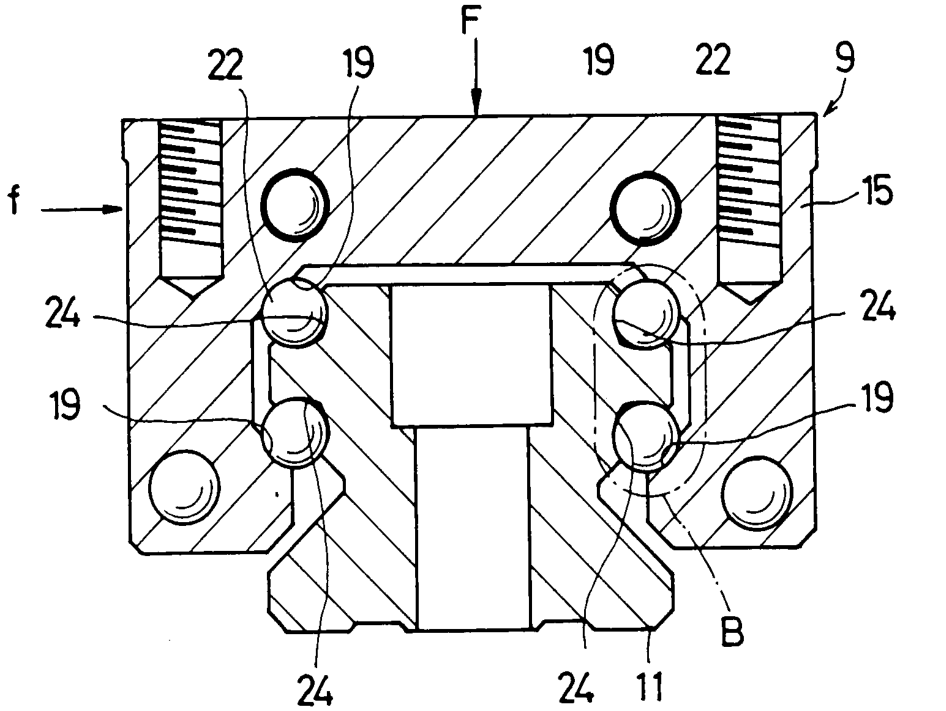
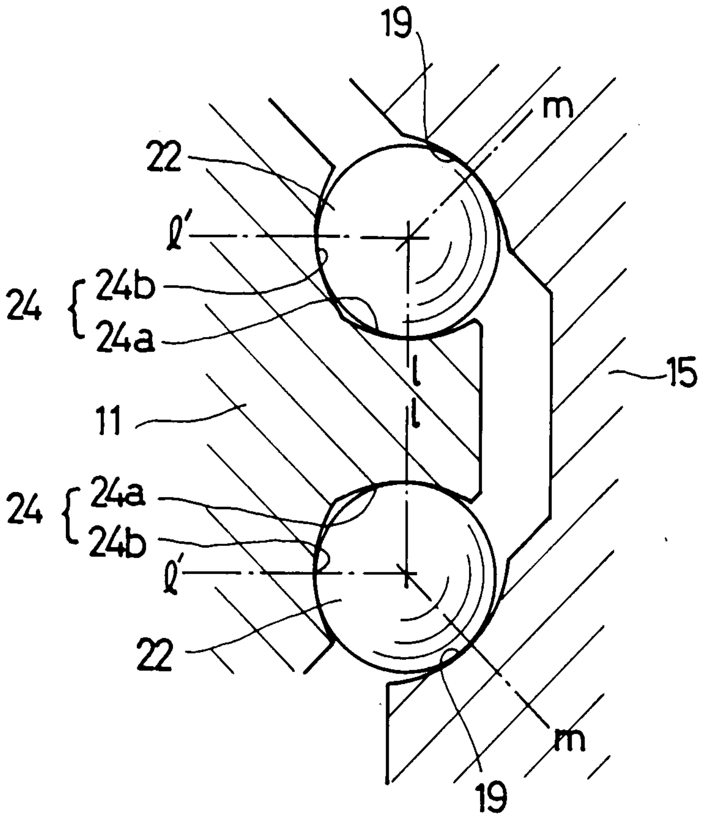


FIG. 4



Nummer: DE 42 15 692 A1
Int. Cl.⁵: F 16 C 29/06
Offenlegungstag: 19. November 1992

FIG. 5



Nummer: DE 42 15 692 A1
Int. Cl.5: F 16 C 29/06
Offenlegungstag: 19. November 1992

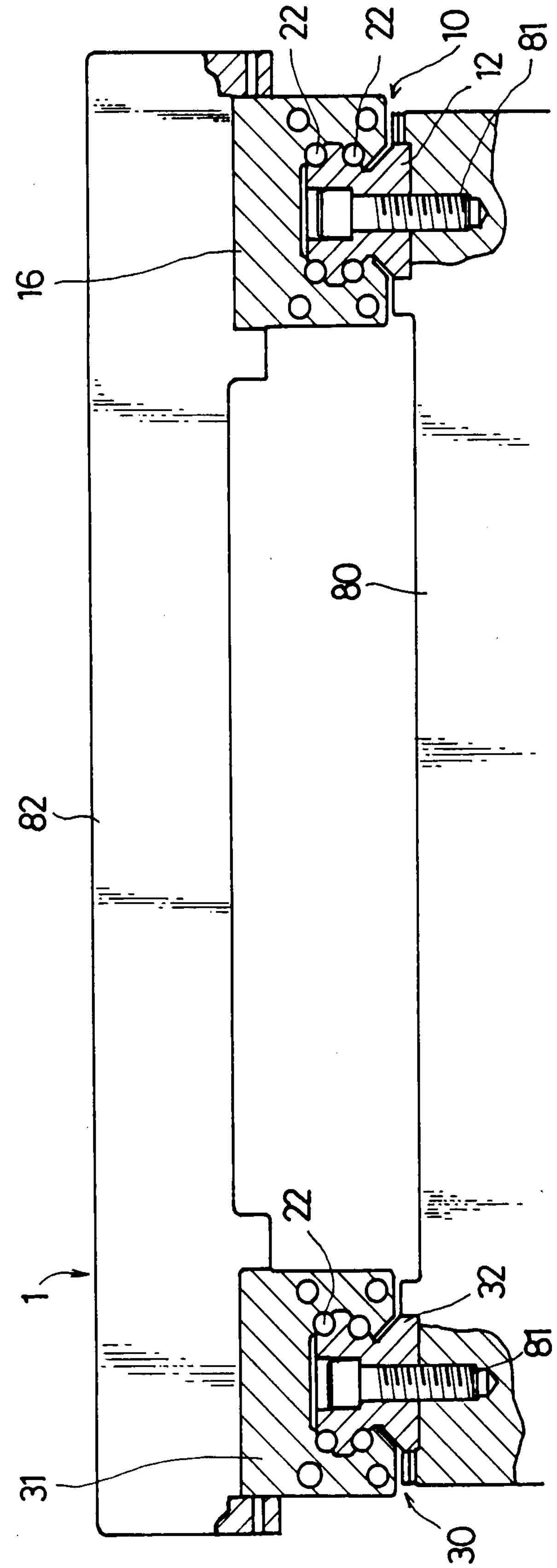


FIG. 6

Nummer: DE 42 15 692 A1
Int. Cl.^{5}: F 16 C 29/06
Offenlegungstag: 19. November 1992

FIG. 7

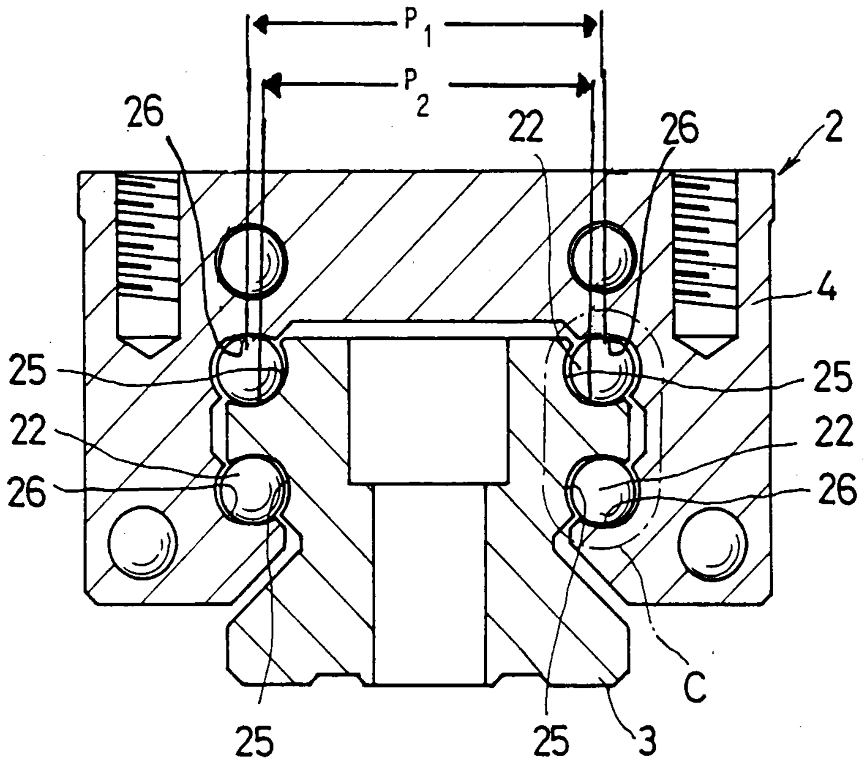
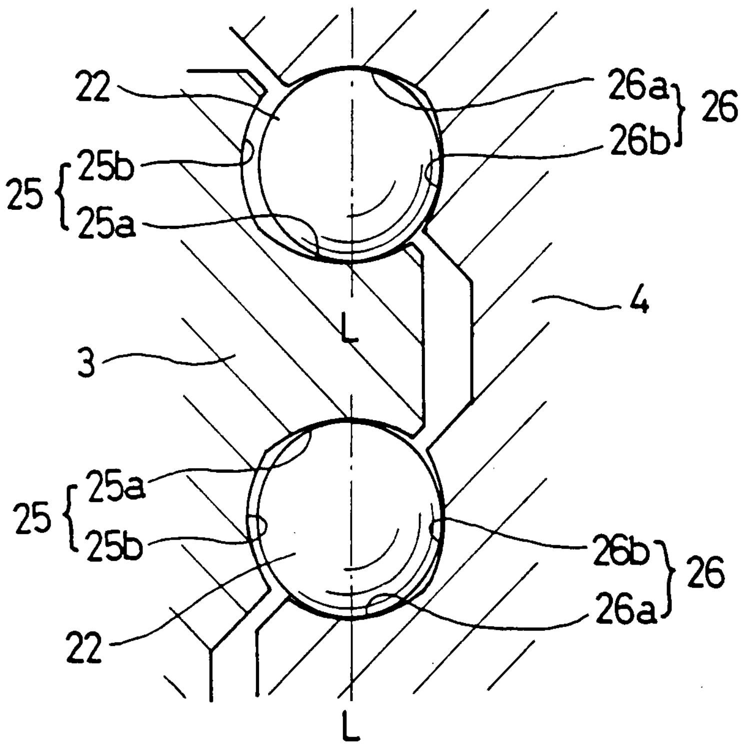


FIG. 8



Nummer: DE 42 15 692 A1
Int. Cl.^{5}: F 16 C 29/06
Offenlegungstag: 19. November 1992

FIG. 9

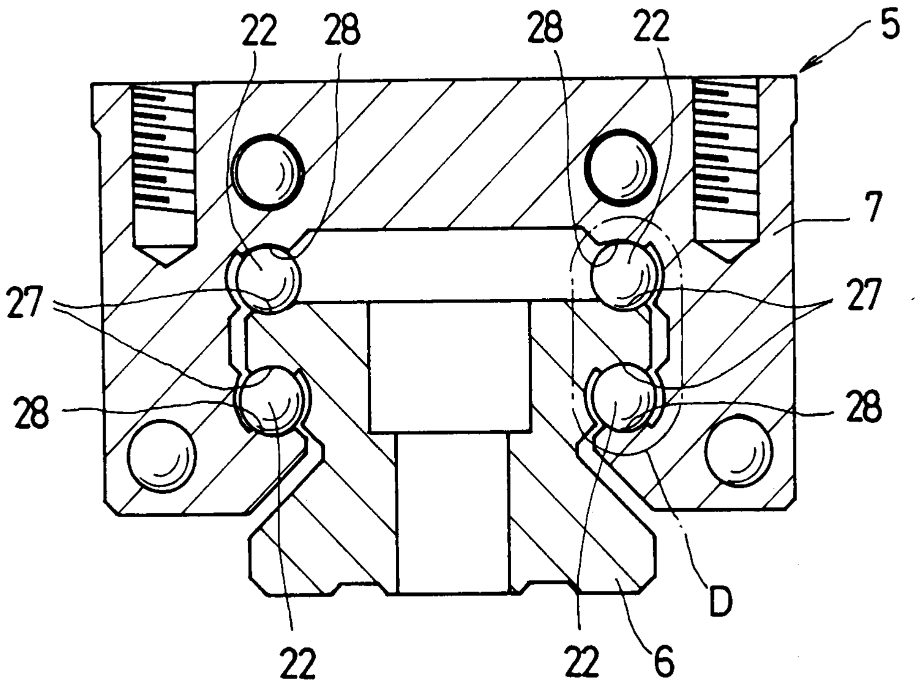


FIG. 10

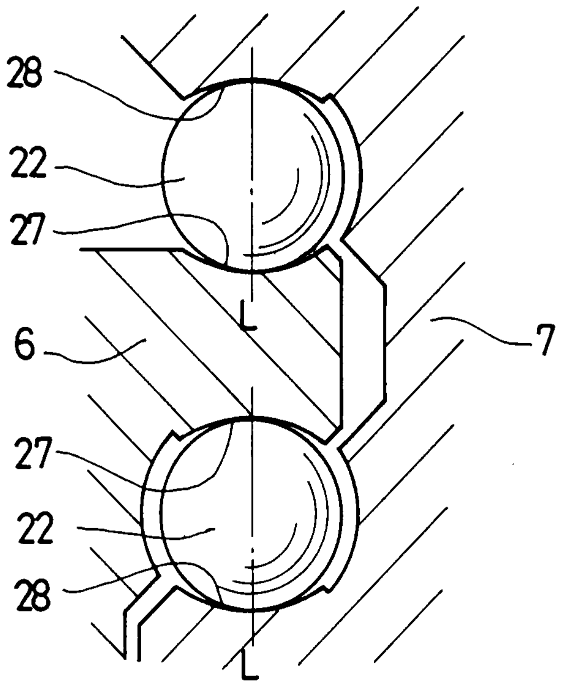


FIG. 11

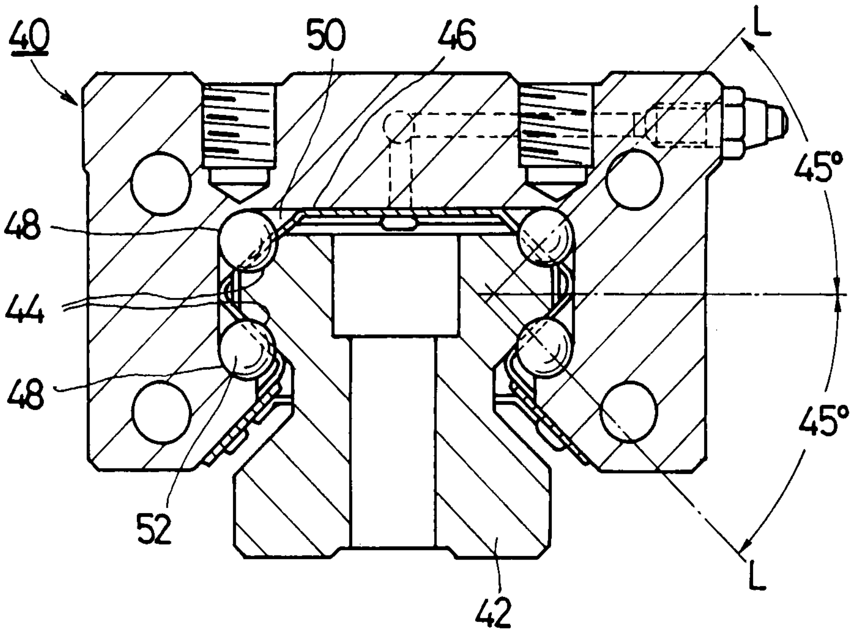
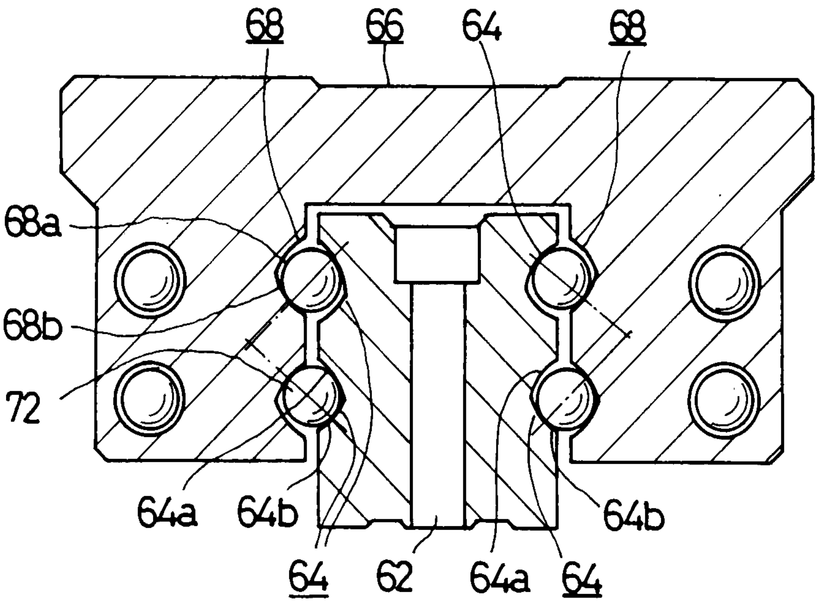

40
50
46
L
45°
48
44
48
45°
52
42
L

FIG. 12


68
66
64
68
68a
68b
72
64a
64b
64b
64
62
64a
64

(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENTAMT

(12) **Offenlegungsschrift**

(10) **DE 42 10 655 A 1**

(51) Int. Cl.5:
F 16 C 29/06

(21) Aktenzeichen: P 42 10 655.9
(22) Anmeldetag: 31. 3. 92
(43) Offenlegungstag: 8. 10. 92

DE 42 10 655 A 1

(30) Unionspriorität: (32) (33) (31)
02.04.91 JP 94931/91

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Vossius, V., Dipl.-Chem. Dr.rer.nat.; Tauchner, P., Dipl.-Chem. Dr.rer.nat.; Heunemann, D., Dipl.-Phys. Dr.rer.nat.; Rauh, P., Dipl.-Chem. Dr.rer.nat.; Hermann, G., Dipl.-Phys. Dr.rer.nat.; Schmidt, J., Dipl.-Ing.; Jaenichen, H., Dipl.-Biol. Dr.rer.nat., Pat.-Anwälte; Tremmel, H., Rechtsanw., 8000 München

(72) Erfinder:
Imai, Katsuhito, Yamanashi, JP; Konomoto, Masahi, Yokohama, Kanagawa, JP

(54) Mit Flansch versehenes, lineares Kugellager

(57) Es wird ein mit einem Flansch versehenes, lineares Kugellager angegeben, bei dem ein Kugelkäfig zur Anordnung von Kugeln zwischen einem Lagergehäuse und einer Lagerwelle vorgesehen ist, welcher mit einem Flansch zum Festlegen an einem Befestigungsteil, wie einem Bett oder einem Tisch, versehen ist. Somit kann dem Lagergehäuse eine zylindrische Gestalt verliehen werden, welche keinen Flansch hat, so daß eine einfache Bearbeitung möglich ist, um die Herstellungskosten zu senken und die Produktivität beträchtlich zu steigern.

DE 42 10 655 A 1

Beschreibung

Die Erfindung bezieht sich auf ein lineares Kugellager, wie ein Kugel-Loslager oder eine Kugel-Keilverbindung, welche bei linearen Führungsteilen bei unterschiedlichen Industriemaschinen eingesetzt werden, und insbesondere befaßt sich die Erfindung mit einer Weiterentwicklung eines linearen Kugellagers mit einer Bauart, die einen Flansch zum Fixieren des Lagers hat.

Das lineare Kugellager sowie das Kugel-Loslager oder eine Kugel-Keilverbindung wird in großem Umfang bei linearen Führungsteilen von unterschiedlichen Industriemaschinen eingesetzt, so daß es unterschiedliche Erzeugnisse gibt, welche an eine Vielzahl von unterschiedlichen Einsatzarten angepaßt sind.

Fig. 10 zeigt eine bevorzugte Ausführungsform eines sogenannten "mit Flansch versehenem Kugel-Loslager", welches einen Flansch zum Fixieren des Lagers an einem Befestigungsteil, wie einem Bett oder einem Tisch, hat.

Insbesondere ist das mit Flansch versehene Kugel-Loslager so ausgelegt, daß es folgendes umfaßt: ein Lagergehäuse **101**, welches derart ausgebildet ist, daß es ein im wesentlichen zylindrisches Teil hat und an welchem integral ein Flansch **103** ausgeformt ist, welcher Befestigungsschrauböffnungen **102** am Außenumfang derart hat, daß er sich linear um eine Lagerwelle bzw. Lagerachse **105** über eine Mehrzahl von endlos umlaufenden Kugeln **104** bewegen kann; und einen Kugelkäfig **107**, welcher mit Kugelführungsnuten **106** ausgebildet ist, um die Kugeln **104** endlos zwischen der Lagerwelle **105** und dem Lagergehäuse **101** umlaufen zu lassen, und welches fest passend in einem hohlen Teil des Lagergehäuses **101** vorgesehen ist. Somit wird dieses Kugel-Loslager so eingesetzt, daß der Flansch **103** an einem Befestigungsteil **109** beispielsweise mit Hilfe von Befestigungsschrauben **108** angebracht wird, und daß das Befestigungsteil **109** und die Lagerwelle **105** relativ zueinander eine Gleitbewegung ausführen können.

Bei dem linearen Kugellager dieser Bauart ist es erforderlich, daß das Lagergehäuse mittels einer Härtungsbehandlung behandelt wird, so daß die Verschleißfestigkeit des inneren Umfangs des Lagergehäuses verbessert wird, auf welchem die Kugeln bei der Ausführung einer Abwälzbewegung geführt sind. Diese Härtungsbehandlung jedoch bringt große Schwierigkeiten bei der Herstellung des vorstehend angegebenen, mit einem Flansch versehenen Kugel-Loslagers mit sich. Der Grund hierfür wird nachstehend näher beschrieben. Da der Flansch dicker als die anderen Teile des Lagergehäuses ausgelegt sind, bleibt ein Wärmeverzug im Lagergehäuse erhalten, wenn der Flansch gehärtet wurde und nachdem er abgeschliffen wurde, so daß das Lagergehäuse nicht genau fertiggestellt werden kann. Wenn hingegen der auszubildende Flansch nach der Härtungsbehandlung erstellt wird, ist das Material zu hart, um geschliffen zu werden.

Andererseits bringt der Flansch am Lagergehäuse eine gewisse Schwierigkeit dahingehend mit sich, daß das Schleifen wesentlich umständlicher als beim Schleifen eines gerad-zylindrischen Gehäuseteils wird, welches keinen Flansch hat. Ein derartiges gerad-zylindriges Lagergehäuse läßt sich effektiv in einem Schritt unter Verwendung einer spitzenlosen Rundschleifmaschine abschleifen, aber ein mit Flansch versehenes Lagergehäuse kann nicht mittels einer spitzenlosen Rundschleifmaschine bearbeitet werden, so daß es auf eine zyklische Weise durch Schleifen bearbeitet werden muß. Insbesondere macht ein solches Schleiferverfahren zwei Stufen erforderlich, d. h. die Stufen zum Schleifen des zylindrischen Teils und des Flansches.

Daher wurde zur Überwindung dieser Schwierigkeit ein lineares Kugellager vorgeschlagen, welches dadurch hergestellt ist, daß ein im allgemeinen ringförmiges Flanschteil und ein Lagergehäuse gesondert voneinander ausgeformt bzw. gegossen sind und daß der Flansch und das Lagergehäuse mittels Preßsitz oder Hartlöten nach der Härtungsbehandlung des Lagergehäuses verbunden werden. Hierdurch ergibt sich jedoch eine weitere Schwierigkeit hinsichtlich der Anzahl von Bearbeitungsschritten zum Herstellungszeitpunkt oder der Anzahl der Teile, und daher ist eine derartige Lösung im Hinblick auf die Herstellungskosten und die Herstellungseffizienz nicht zufriedenstellend.

Die Erfindung zielt daher darauf ab, unter Überwindung der zuvor geschilderten Schwierigkeiten ein mit einem Flansch versehenes lineares Kugellager bereitzustellen, bei welchem sich die Herstellungskosten senken lassen und sich die Herstellungsleistung beträchtlich verbessern läßt.

Um die vorstehend angegebene Zielsetzung zu erreichen, wird nach der Erfindung ein mit einem Flansch versehenes, lineares Kugellager bereitgestellt, welches folgendes aufweist: ein Lagergehäuse, welches einen hohlen Teil darin hat und mittels eines Lagerschaftes oder einer Lagerwelle zur Ausführung von linearen Bewegungen geführt ist; eine Mehrzahl von Kugeln, welche zwischen dem Lagergehäuse und der Lagerwelle zur Ausführung einer Abwälzbewegung unter einer Belastung gehalten sind; und einen Kugelkäfig, welcher passend in dem hohlen Teil des Lagergehäuses angeordnet und die Kugeln in ihrer Anordnung hält, wobei sich die Weiterentwicklung dadurch auszeichnet, daß ein Flansch von dem Kugelkäfig zum Fixieren des Lagers an einem Befestigungsteil, wie einem Bett oder einem Tisch, vorsteht.

Bei dieser technischen Auslegung kann der Flansch, der von dem vorstehend genannten Kugelkäfig vorstehen muß, dadurch gebildet werden, daß ein ringförmiges Flanschteil an den äußeren Umfang des Kugelkäfigs geschweißt wird. Vorzugsweise sind jedoch der Flansch und der Kugelkäfig integral mittels Spritzgießen oder Verspritzens eines Kunstharzes einteilig ausgebildet.

Ferner läßt sich das Kugellager, bei welchem derartige technische Einrichtungen vorgesehen sind, dadurch beispielhaft näher beschreiben, daß eine Mehrzahl von endlos umlaufenden Kugeln zwischen einem zylindrischen Lagergehäuse und einer Lagerwelle derart gehalten sind, daß sie relative Linearbewegungen aufnehmen. Die technische Einrichtung kann nicht nur bei Kugel-Loslager der üblichen Bauart, sondern auch bei Kugel-Keilverbindungen eingesetzt werden, welche die Fähigkeit haben, eine Drehmomentübertragung zwischen dem Lagergehäuse und der Lagerwelle zu ermöglichen.

Da der Flansch am Kugelkäfig ausgebildet ist, um dem Lagergehäuse eine gerad-zylindrische Gestalt entsprechend den vorstehend angegebenen technischen Einzelheiten zu verleihen, kann die Härtungsbehandlung des Lagergehäuses beträchtlich vereinfacht werden und insbesondere wird auch das Schleifen mittels einer spitzenlosen Rundschleifmaschine ermöglicht. Als Folge hiervon läßt sich die Schleifbehandlung auf effektive Weise mit vertretbaren Kosten vornehmen, wodurch sich die Ausstoßleistung verbessern läßt und sich die Herstellungskosten drastisch senken lassen.

Wenn man ferner den Flansch von dem Lagergehäuse wegläßt, läßt sich das Lagergehäuse des linearen Kugellagers ohne Flansch leicht in ein solches für ein mit einem Flansch versehenes lineares Kugellager umwandeln, so daß die Teile für unterschiedliche Produkte gemeinsam genutzt werden können. Auch hierdurch wird es möglich, die Herstellungseffizienz zu verbessern und die Herstellungskosten zu senken.

Wenn ferner der Flansch und der Kugelkäfig einteilig mittels Spritzgießen aus einem Kunstharz hergestellt sind, kann eine weitere Verbesserung hinsichtlich der Herstellungseffizienz erwartet werden, da ein zusätzlicher Schritt bei der Herstellung des Flansches erforderlich wird.

Weitere Einzelheiten, Merkmale und Vorteile der Erfindung ergeben sich aus der nachstehenden Beschreibung von bevorzugten Ausführungsformen unter Bezugnahme auf die beigefügte zeichnung. Darin zeigt:

Fig. 1 eine Seitenansicht zur Verdeutlichung einer ersten bevorzugten Ausführungsform eines mit einem Flansch versehenen, linearen Kugellagers nach der Erfindung,

Fig. 2 eine Schnittansicht längs der Linie II-II in **Fig.** 1,

Fig. 3 eine Seitenansicht zur Verdeutlichung eines Kugelkäfigs gemäß einer ersten bevorzugten Ausführungsform nach der Erfindung,

Fig. 4 eine Schnittansicht längs der Linie IV-IV in **Fig.** 3,

Fig. 5 eine Seitenansicht zur Verdeutlichung eines Lagergehäuses gemäß der ersten bevorzugten Ausführungsform nach der Erfindung,

Fig. 6 eine Vorderansicht zur Verdeutlichung einer achteckigen Klammer bei der ersten bevorzugten Ausführungsform nach der Erfindung,

Fig. 7 eine Seitenansicht zur Verdeutlichung der achteckigen Klammer bei der ersten bevorzugten Ausführungsform nach der Erfindung,

Fig. 8 eine Vorderansicht zur Verdeutlichung eines Verbindungszustandes von Lagergehäuse und Kugelkäfig unter Verwendung der achteckigen Klammer,

Fig. 9 eine Seitenansicht zur Verdeutlich einer zweiten bevorzugten Ausführungsform eines mit einem Flansch versehenen, linearen Kugellagers nach der Erfindung, und

Fig. 10 eine Seitenansicht zur Verdeutlichung eines mit einem Flansch versehenen, linearen Kugellagers üblicher Bauform.

Ein mit einem Flansch versehenes, lineares Kugellager nach der Erfindung wird nachstehend unter Bezugnahme auf die Zeichnungen näher erläutert.

Fig. 1 ist eine Seitenansicht zur Verdeutlichung einer ersten bevorzugten Ausführungsform eines mit einem Flansch versehenen Kugel-Loslagers nach der Erfindung. Das mit einem Flansch versehene Kugel-Loslager gemäß dieser bevorzugten Ausführungsform umfaßt hinsichtlich der Konstruktion folgendes: ein Lagergehäuse **2**, das mittels einer Lagerwelle bzw. einer Lagerachse **1** zur Ausführung von linearen Bewegungen geführt ist; eine Mehrzahl von Kugeln **3**, welche eine Abwälzbewegung ausführen, wenn das Lager eine Belastung zwischen der Lagerwelle **1** und dem Lagergehäuse **2** aufnimmt, und einen Kugelkäfig **5**, welcher eine äußere Umfangsfläche hat, welche mit einem vorspringenden Flansch **4** versehen ist und passend in einem hohlen Teil **21** des Lagergehäuses **2** zum Halten und Anordnen der Kugeln **3** vorgesehen ist.

Vor allem ist das Lagergehäuse **2** derart ausgebildet, daß es eine im allgemeinen zylindrische Gestalt derart hat, daß es lose mit einem vorbestimmten Zwischenraum um die Lagerwelle **1** passend angeordnet ist, und daß der Innenumfang wie in **Fig.** 5 gezeigt mit fünf lasttragenden Wälzflächen **22** versehen ist, die in regelmäßigen Umfangsabständen zum Halten der Kugeln **3** mit der Lagerwelle **1** und den nichtlasttragenden Wälznuten **23** angeordnet sind, welche jeweils zwischen zwei benachbarten, lasttragenden Wälzflächen **22** zur Ausführung einer Abwälzbewegung der Kugeln angeordnet sind, welche von der Lastaufnahme freikommen. Ferner ist das hohle Teil **21** an einem Öffnungsrand mit einer ringförmigen Nut **24** versehen, welche in Umfangsrichtung zur Aufnahme einer später noch zu beschreibenden, achteckigen Klammer **6** verläuft.

Andererseits ist der Kugelkäfig **5** in den **Fig.** 3 und 4 gezeigt derart ausgebildet, daß er eine im allgemeinen zylindrische Gestalt und eine Durchgangsöffnung **51** hat, um in passender Weise die Lagerwelle **1** darin aufzunehmen und die eine äußere Umfangsfläche hat, welche mit einem Flansch **4** versehen ist, welcher seinerseits mit Schraubkopföffnungen **41** versehen ist. Der Kugelkäfig **5** ist einteilig mit einem Flansch **4** mittels Spritzgießen eines Kunstharzes ausgebildet. Der Kugelkäfig **5** hat an seinem äußeren Umfang eine derartige Ausbildung, daß sie den einzelnen, lasttragenden Wälzflächen **22** entspricht, wozu folgendes vorgesehen ist: mit Schlitzen versehene, lasttragende Kugelführungsnuten **52**, welche verhindern, daß die Kugeln **3** auf den vorstehend angegebenen, lasttragenden Wälzflächen **22** eine Abwälzbewegung ausführen und aus den Nuten heraustreten, wenn das Lagergehäuse **2** von der Lagerwelle **1** abgezogen wird; nichtlasttragende Kugelführungsnuten **53** zum Anordnen der entlasteten Kugeln, welche eine Abwälzbewegung in den nichtlasttragenden Wälznuten **23** ausführen; und Kugelwendenuten **54** zur Herstellung von Verbindungen und Verbindungseinrichtungen zwischen den lasttragenden Kugelführungsnuten **52** und den nichtlasttragenden Kugelführungsnuten **53**, um die Kugeln **3** endlos zwischen den beiden Nuten **52** und **53** umlaufen zu lassen. Andererseits ist der äußere Umfang des Kugelkäfigs **5** mit einer ringförmigen Nut **55** versehen, welche der ringförmigen Nut **24** des vorstehend angegebenen Lagergehäuses **2** zugeordnet ist. Somit ist ein Raum zwischen der ringförmigen Nut **24** des Lagergehäuses **2** und der ringförmigen Nut **55** des Kugelkäfigs **5** ausgebildet, welche einander gegenüberliegen, wenn der Kugelkäfig **5** passend auf dem Lagergehäuse **2** vorgesehen ist.

Bei der vorliegenden bevorzugten Ausführungsform sind das Lagergehäuse **2** und der Kugelkäfig **5** mit Hilfe einer achteckförmigen Klammer **6** verbunden, wie dies in den **Fig.** 6 und 7 gezeigt ist. Eine spezielle Kupplungsverbindung wird nachstehend näher beschrieben. Zuerst wird die achteckige Klammer **6** passend in die ringförmige Nut **24** eingesetzt, welche in dem inneren Umfang des Lagergehäuses **2** ausgebildet ist und dann wird der Kugelkäfig **5** mittels Preßsitz in das hohle Teil **21** des Lagergehäuses **2** eingesetzt. Dann kommt das Endteil des Kugelkäfigs **5** in Anlageberührung gegen die einzelnen, mittleren Seitenteile **61** der achteckigen Klammer **6**, so daß diese Klammer **6** elastisch verformt oder gedehnt wird. Wenn die Preßpassungsverbindung für den Kugelkäfig **5** fortgesetzt wird, kommt die ringförmige Nut **55** zur Ausrichtung mit der ringförmigen Nut **24** des Lagergehäuses **2**. Dann hat die achteckige Klammer **6** mittlere Seitenteile **61**, welche stufenförmig in die ringförmige Nut **55** des Kugelkäfigs **5** gehen, bis ihre Ecken **62** in die ringförmige Nut **24** passen, während die mittleren Seitenteile **61** in die ringförmige Nut **55** passen. Somit sind das Lagergehäuse **2** und der Kugelkäfig **5** miteinander gekoppelt bzw. verbunden.

Wenn darüber hinaus das mit einem Flansch versehene Kugel-Loslager mit dem vorstehend genannten Aufbau und gemäß der bevorzugten Ausführungsform nach der Erfindung zusammengesetzt ist, hat der Flansch **4** des Kugelkäfigs **5**, welcher an einem (nicht gezeigten) Teil mit Hilfe von (nicht gezeigten) Schrauben angebracht ist, eine solche Auslegung, daß man relativ lineare Bewegungen zwischen dem Flanschbefestigungsteil und der Lagerwelle **1** erhält, wie dies auch bei dem mit einem Flansch versehenen Kugel-Loslager üblicher Bauart der Fall ist.

Dank des Flansches **4**, welcher von dem Kugelkäfig **5** bei der bevorzugten Ausführungsform nach der Erfindung vorsteht, lassen sich jedoch zeitraubende Arbeitsschritte, die bei der Ausbildung des Flansches **4** an dem Lagergehäuse **2** bei der üblichen Ausführungsform erforderlich sind, vermeiden, um das maschinelle Bearbeiten des Lagergehäuses **2** beträchtlich zu vereinfachen und hierdurch die Herstellungsleistung zu verbessern und die Herstellungskosten zu senken.

Insbesondere ist bei der bevorzugten Ausführungsform nach der Erfindung der Flansch **4** integral mit dem Kugelkäfig **5** mittels Spritzgießen aus einem Kunstharz derart ausgebildet, daß der Schritt zum Ausbilden des Flansches **4** nicht vorsätzlich vorgesehen zu sein braucht, wodurch man die Produktivität weiter steigern kann.

Fig. 9 zeigt eine zweite bevorzugte Ausführungsform eines mit einem Flansch versehenen Kugel-Loslagers nach der Erfindung.

Der Flansch **4** und der Kugelkäfig **5** sind einteilig bei dieser bevorzugten Ausführungsform ebenfalls ausgeformt, aber das Verfahren zum Verbinden von Kugelkäfig **5** und Lagergehäuse **2** unterscheidet sich von jenem nach der ersten bevorzugten Ausführungsform. Nach dem passenden Einsetzen des Kugelkäfigs **5** in das Lagergehäuse **2** wird insbesondere gemäß dieser bevorzugten Ausführungsform ein Anschlagring **7** passend auf die äußere Umfangsfläche des Endabschnitts des Kugelkäfigs **5** gesetzt, welcher von dem Lagergehäuse **2** vorsteht, und der Anschlagring **7** und das Lagergehäuse **2** werden so in Eingriff gebracht, daß der Kugelkäfig **5** und das Lagergehäuse **2** miteinander verbunden sind. Ansonsten stimmt die restliche Auslegung mit jener bei der voranstehend beschriebenen bevorzugten Ausführungsform überein und die Beschreibung kann daher entfallen, da insbesondere für gleiche oder ähnliche Teile die gleichen Bezugszeichen verwendet werden.

Bei diesem mit einem Flansch versehenen Kugel-Loslager ist der Flansch **4** ebenfalls integral mit dem Kugelkäfig **5** ausgebildet, wodurch ermöglicht wird, daß sich die Herstellungsleistung verbessern läßt und sich die Herstellungskosten senken lassen.

Patentansprüche

1. Mit einem Flansch versehenes, lineares Kugellager, welches aufweist: ein Lagergehäuse **(2)**, welches ein hohles Teil **(21)** darin hat und mittels einer Lagerwelle **(1)** zur Ausführung von linearen Bewegungen geführt ist, eine Mehrzahl von Kugeln **(8)**, welche zwischen dem Lagergehäuse **(2)** und der Lagerwelle **(1)** zur Ausführung einer Abwälzbewegung unter einer Belastung gehalten sind, und einen Kugelkäfig **(5)**, welcher passend in das hohle Teil **(21)** des Lagergehäuses **(2)** zum Halten und Anordnen der Kugeln **(3)** eingesetzt ist, **dadurch gekennzeichnet,** daß ein Flansch **(4)** von dem Kugelkäfig **(5)** zum Fixieren des Lagers an einem Befestigungsteil, wie einem Bett oder einem Tisch, vorsteht.

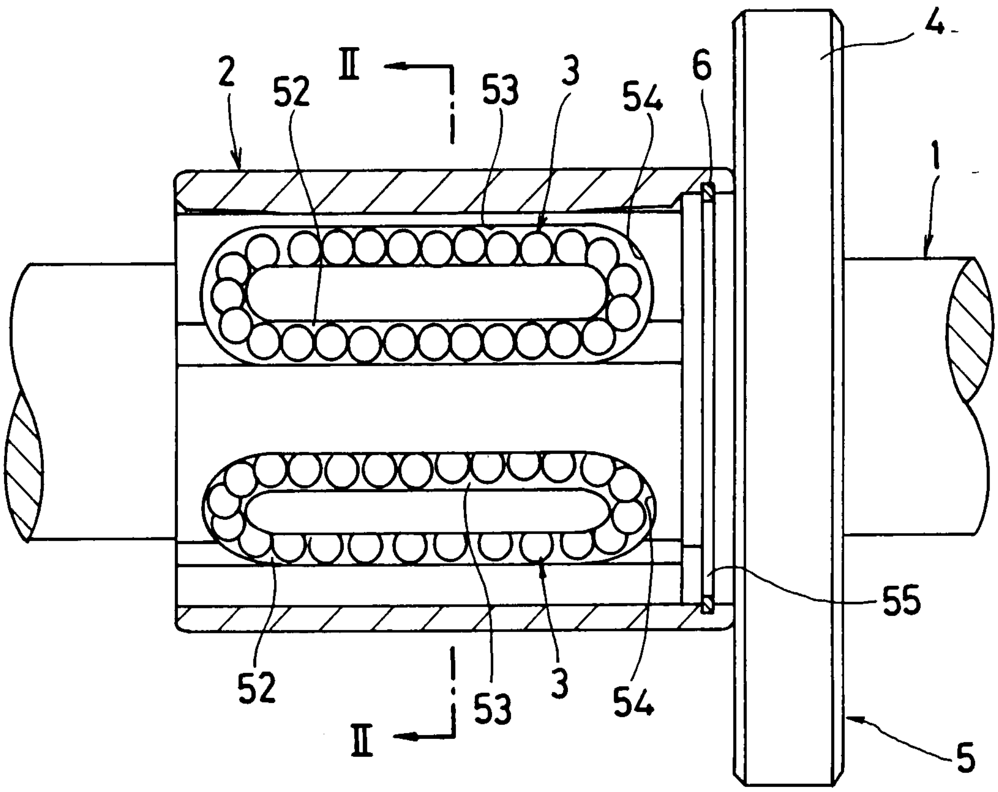
2. Mit einem Flansch versehenes, lineares Kugellager nach Anspruch 1, dadurch gekennzeichnet, daß der Flansch **(4)** einteilig mit dem Kugelkäfig **(5)** mittels Spritzgießen eines Kunstharzes ausgebildet ist.

3. Mit einem Flansch versehenes, lineares Kugellager, gekennzeichnet durch: ein Lagergehäuse **(2)**, welches ein hohles Teil **(21)** darin hat und mittels einer Lagerwelle **(1)** zur Ausführung von linearen Bewegungen geführt ist, eine Mehrzahl von Kugeln **(3)**, welche zwischen dem Lagergehäuse **(2)** und der Lagerwelle **(1)** zur Ausführung einer Abwälzbewegung und einer Belastung gehalten sind, einen Kugelkäfig **(5)**, welcher einen Flansch hat, der von dem äußeren Umfang desselben zum Fixieren des Lagers an einem Befestigungsteil, wie einem Bett oder einem Tisch, vorsteht und passend in das hohle Teil **(21)** des Lagergehäuses **(2)** zum Halten und Anordnen der Kugeln **(3)** eingesetzt ist, und eine vieleckige Klammer **(6)**, welche Ecken hat, welche in eine ringförmige Nut **(24)** passen, die in dem inneren Umfang des Lagergehäuses **(2)** ausgebildet sind, und die Mittelteile an den Seiten hat, welche mit den Ecken verbunden sind, welche in eine ringförmige Nut **(54)** passen, welche in dem äußeren Umfang des Kugelkäfigs **(5)** ausgebildet ist, um das Lagergehäuse **(2)** und den Kugelkäfig **(5)** fest zu verbinden.

Hierzu 8 Seite(n) Zeichnungen

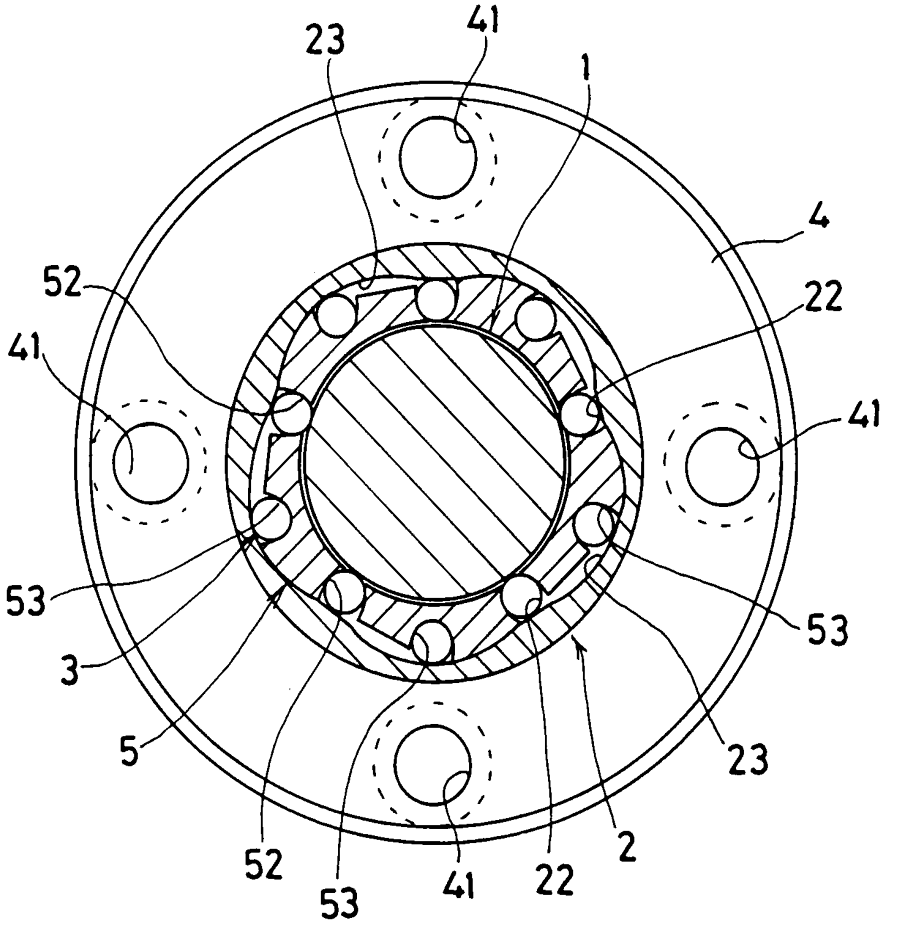
Nummer: DE 42 10 655 A1
Int. Cl.^{5}: F 16 C 29/06
Offenlegungstag: 8. Oktober 1992

FIG. 1



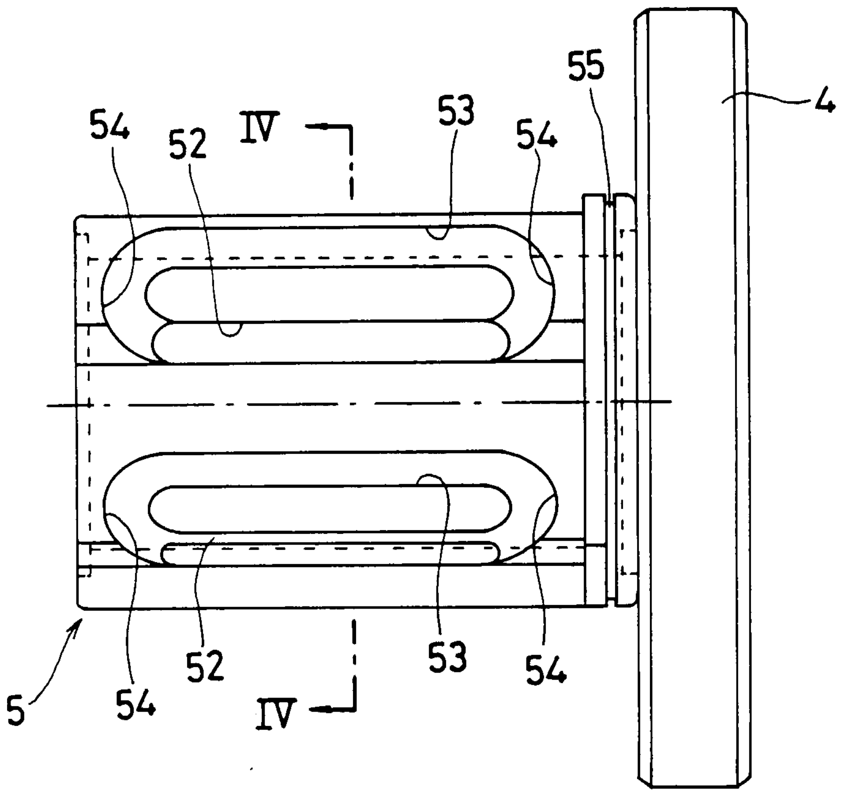
Nummer: DE 42 10 655 A1
Int. Cl.⁵: F 16 C 29/06
Offenlegungstag: 8. Oktober 1992

FIG. 2



Nummer: DE 42 10 655 A1
Int. Cl.5: F 16 C 29/06
Offenlegungstag: 8. Oktober 1992

FIG. 3



Nummer: DE 42 10 655 A1
Int. Cl.^{5}: F 16 C 29/06
Offenlegungstag: 8. Oktober 1992

FIG. 4

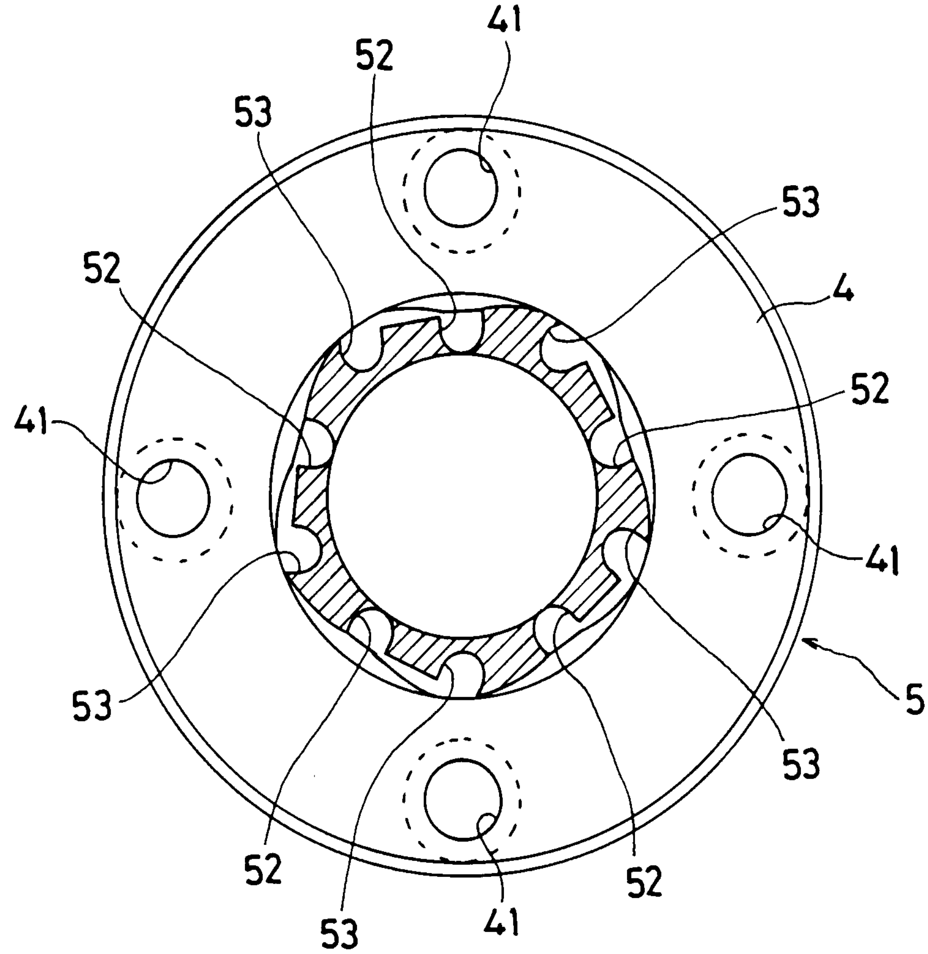


FIG. 5

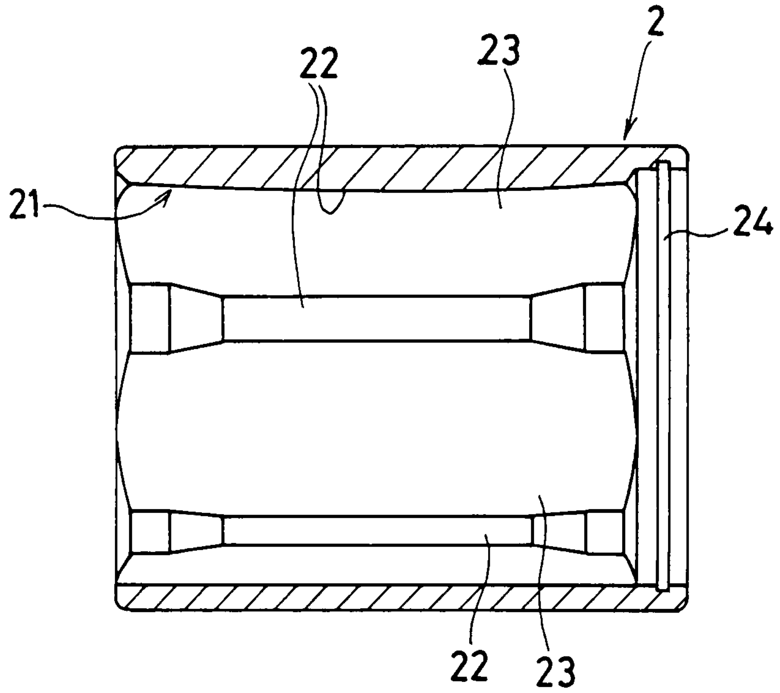
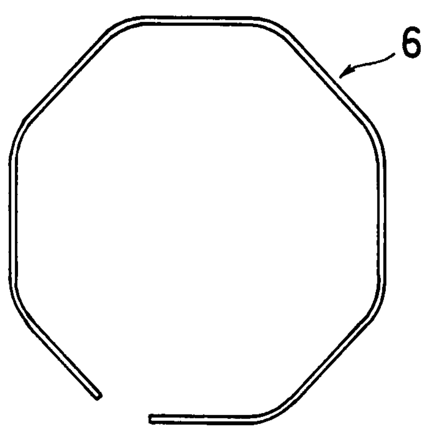


FIG. 6



Nummer: DE 42 10 655 A1
Int. Cl.⁵: F 16 C 29/06
Offenlegungstag: 8. Oktober 1992

FIG. 7

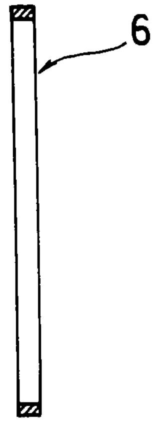


FIG. 8

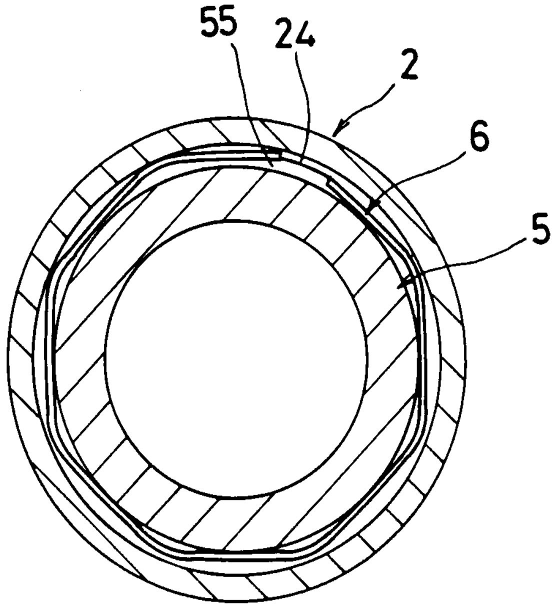
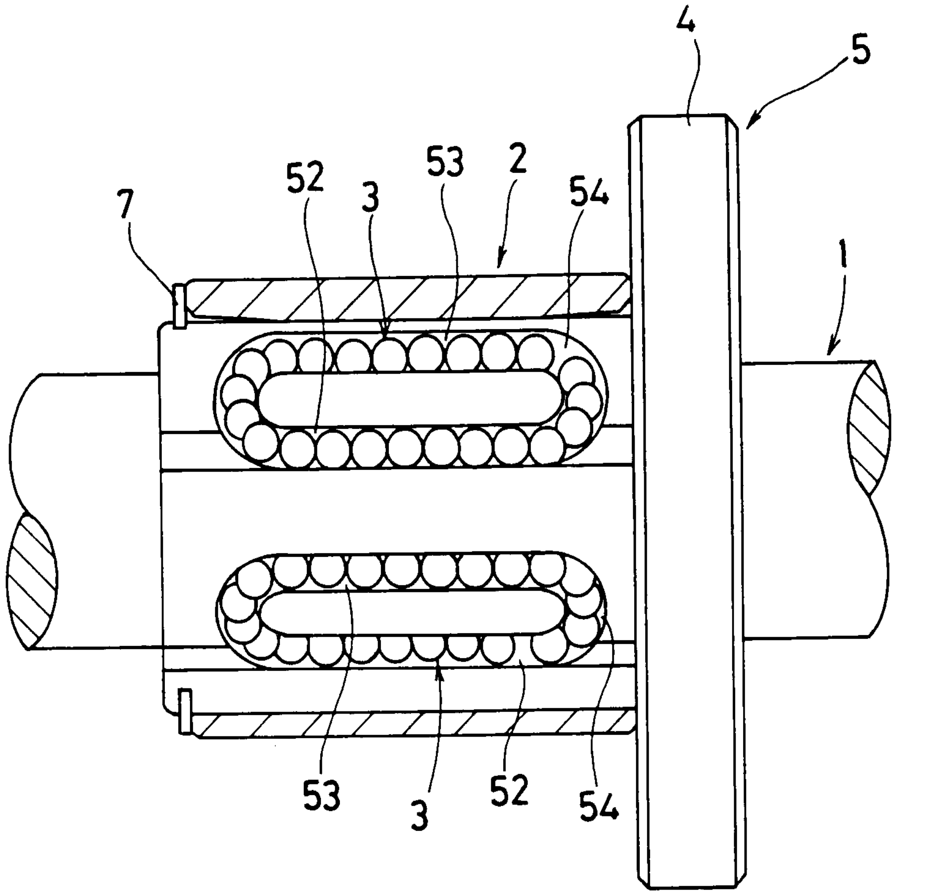
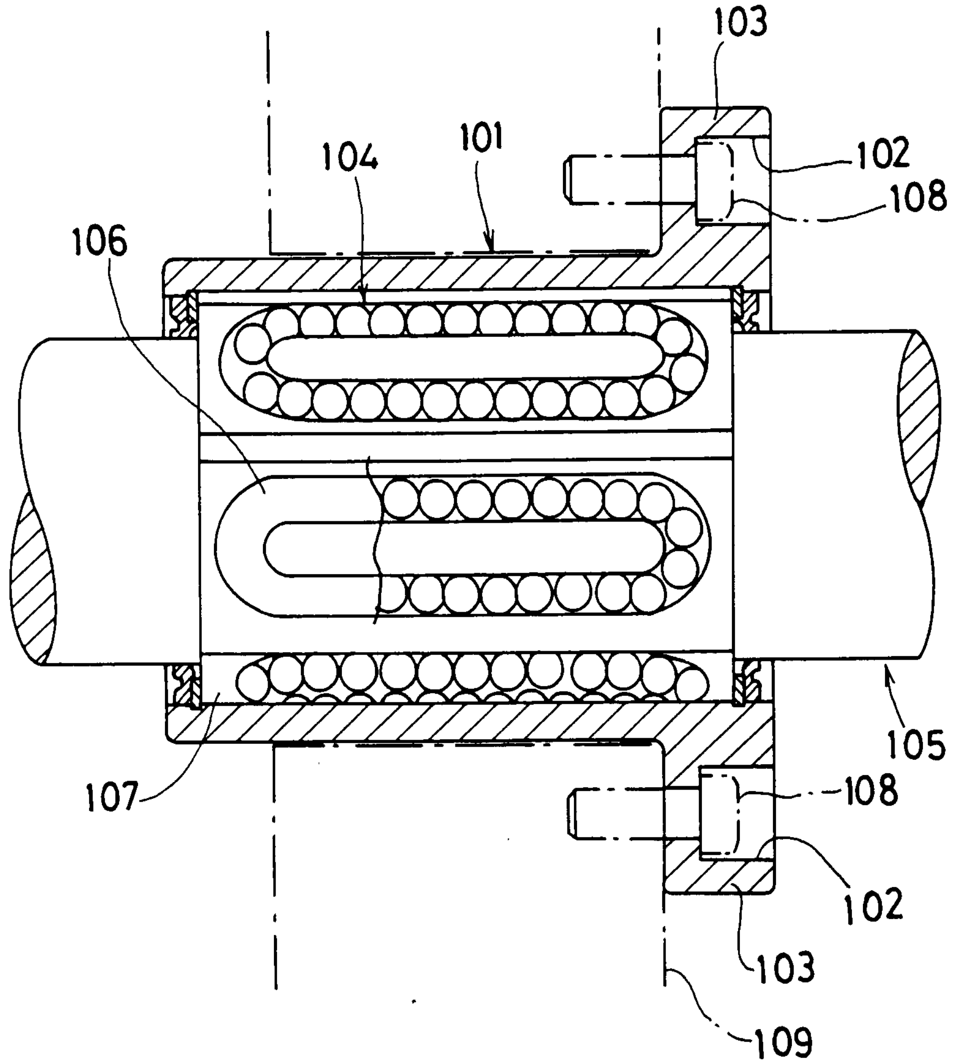


FIG. 9



Nummer: DE 42 10 655 A1
Int. Cl.5: F 16 C 29/06
Offenlegungstag: 8. Oktober 1992

FIG. 10



(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENTAMT

(12) Offenlegungsschrift

(10) DE 41 35 167 A1

(51) Int. Cl.⁵:
F 16 H 25/22
F 16 C 29/06
B 23 Q 5/40
B 23 Q 1/14
B 65 G 47/82

(21) Aktenzeichen: P 41 35 167.3
(22) Anmeldetag: 24. 10. 91
(43) Offenlegungstag: 21. 5. 92

DE 41 35 167 A1

(30) Unionspriorität: (32) (33) (31)
25.10.90 JP 287832/90

(71) Anmelder:
THK Co., Ltd., Tokio/Tokyo, JP

(74) Vertreter:
Vossius, V., Dipl.-Chem. Dr.rer.nat.; Tauchner, P., Dipl.-Chem. Dr.rer.nat.; Heunemann, D., Dipl.-Phys. Dr.rer.nat.; Rauh, P., Dipl.-Chem. Dr.rer.nat.; Hermann, G., Dipl.-Phys. Dr.rer.nat.; Schmidt, J., Dipl.-Ing.; Jaenichen, H., Dipl.-Biol. Dr.rer.nat., Pat.-Anwälte; Tremmel, H., Rechtsanw., 8000 München

(72) Erfinder:
Shirai, Takeki, Ichikawa, Chiba, JP

(54) Kugelumlaufspindel-Führungseinheit und Fördertisch mit Verwendung desselben

(57) Da bei der Kugelumlaufspindel-Führungseinheit nach der Erfindung eine Führungsschiene von einem U-Materialteil mit einer Ausnehmung gebildet wird, und eine Kugelumlaufspindelwelle mit einem beweglichen Teil zusammenarbeitet, welches hin- und hergehend beweglich in der Ausnehmung längs einer Längsrichtung der Führungsschiene derart ist, daß der Flächenschwerpunkt der Führungsschiene in der Nähe der Achse der Kugelumlaufspindelwelle liegt. Wenn daher eine Vorspannung auf die Kugelumlaufspindelwelle aufgebracht wird, wird eine Geradlinigkeit der Führungsschiene hierdurch nicht beeinträchtigt, und eine Vorschubgenauigkeit des beweglichen Teils läßt sich aufrecht erhalten. Ferner kann die Führungsschiene an ihren unteren Flächen und Seitenflächen mit Bezugsebenen versehen sein, welche zur Einstellung der Parallelität zwischen der Führungsschiene und der Achse der Kugelumlaufspindelwelle genutzt werden, wobei sich die Montage und die Einstellung des Tisches vereinfachen lassen.

DE 41 35 167 A1

Beschreibung

Die Erfindung bezieht sich allgemein auf eine Kugelumlaufspindel-Führungseinheit bei Anwendung in einem linear beweglichen Teil, beispielsweise einer Werkzeugmaschine und eines Roboters, und sie bezieht sich auch auf einen Fördertisch unter Einsatz einer solchen Einheit.

Eine Fördereinrichtung unter Einsatz einer Kugelumlaufspindel hat Auslegungsformen, die beispielsweise in **Fig.** 24 gezeigt sind (siehe offengelegte japanische Patentanmeldung No. 62-2 00 016 und weitere). In dieser Figur ist ein bewegliches Teil **11** mittels eines Paars von Führungsschienen **101** gelagert und in eine Längsrichtung hiervon beweglich. Eine Kugelumlaufspindelwelle **102** ist in Gewindeeingriff in dem beweglichen Teil **100**, um das bewegliche Teil **100** bei der Drehung der Welle **102** hin- und hergehend zu bewegen. Das bewegliche Teil **100** ist an gegenüberliegenden Seiten mittels Führungsschienen **101** unter Zwischenlage von Kugeln **103** gelagert. Durch die direkte Einschraubbewegung der Kugelumlaufspindelwelle **102** in das bewegliche Teil **100** wird eine kompakte Auslegung der Vorrichtung erreicht. Bei einer üblichen Auslegungsform, bei welcher eine Kugelumlaufspindel zum Antreiben eines Tisches auf allgemeine Weise eingesetzt wird, kann eine Vorspannung auf die Kugelumlaufspindelwelle aufgebracht werden, um Genauigkeitsabweichungen verursacht durch eine Wärmedehnung auszugleichen. Bei der in **Fig.** 24 gezeigten Vorrichtung bewirkt die auf die Kugelumlaufspindel **102** aufgebrachte Vorspannung ein Biegemoment, welches auf die Führungsschienen **101** einwirkt, wodurch ein Verziehen der Führungsschienen **101** bewirkt werden kann und somit ein Bett und/oder ein Tisch, an welchem die Führungsschienen **101** angebracht sind, sich biegen können, wodurch man eine Herabsetzung einer Vorschubgenauigkeit des beweglichen Teiles erhält.

Da das bewegliche Teil **100**, mit dem die Kugelumlaufspindelwelle **102** über eine Gewindeverbindung verbunden ist, von den Führungsschienen **101** getragen wird, dient das bewegliche Teil **100** dazu, eine Beschleunigung der Kugelumlaufspindelwelle **102** zu verhindern. Wenn jedoch die Vorspannung aufgebracht ist, wird die Kugelumlaufspindelwelle **102** ebenfalls durch eine Reaktionskraft gebogen, welche durch die gebogenen Führungsschienen **101** einwirkt, und somit kann man bei der Kugelumlaufspindelwelle **102** nicht eine vorbestimmte Geradlinigkeit einhalten, so daß sich Verzerrungen ergeben.

Um diese durch die Vorspannung verursachten Schwierigkeiten zu vermeiden, können die Abmessungen der Führungsschienen **101** vergrößert werden, um eine höhere Steifigkeit bei dem Stand der Technik zu erzielen. Hierdurch nehmen jedoch die Gesamtabmessungen der Vorrichtung und das Gewicht der Vorrichtung sowie die Kosten hierfür zu.

Bei der vorstehend beschriebenen Vorrichtung ist ein Tisch, der mittels den linearen Lagern zur Ausführung einer hin- und hergehenden Bewegung gelagert ist, am beweglichen Teil **100** vorgesehen, und die hin- und hergehende Bewegung des beweglichen Teils **100** wird durch die Drehbewegung der Kugelumlaufspindelwelle **102** bewirkt und dann von dem beweglichen Teil auf den Tisch übertragen. Bei dieser Vorrichtung ist ein Nachteil darin zu sehen, daß zeitraubende Arbeiten zur Einstellung der Parallelität zwischen den Führungsflächen der linearen Lager, an denen der Tisch festgelegt ist, und der Kugelumlaufspindelwelle **102** erforderlich sind. Genauer gesagt sollte die Einstellung der Parallelität zwischen den Führungsflächen der linearen Lager und der Kugelumlaufspindelwelle **102** unter Verwendung eines Zeigers vorgenommen werden, welche auf die äußere Umfangsfläche der Kugelumlaufspindel **102** aufgebracht wird, wodurch die Einstellung erschwert wird. Ferner ist es bei dem in **Fig.** 24 gezeigten Stand der Technik zusätzlich zu der Einstellung der Parallelität zwischen den Führungsschienen **101** und der Kugelumlaufspindelwelle **102** erforderlich, die Parallelität zwischen der Kugelumlaufspindelwelle **102** und den Führungsflächen an einer Tischseite einzustellen, wodurch die Arbeiten äußerst schwierig werden.

Die Erfindung zielt daher darauf ab, eine Kugelumlaufspindel-Führungseinheit bereitzustellen, bei welcher die vorstehend genannten Schwierigkeiten überwunden werden und bei der eine Vorspannung aufgebracht werden kann, ohne daß eine Geradlinigkeit der Kugelumlaufspindelwelle beeinträchtigt wird.

Ferner zielt die Erfindung darauf ab, eine Kugelumlaufspindel-Führungseinheit und einen Fördertisch unter Einsatz derselben bereitzustellen, wobei ein Tisch von einem linearen Lager getragen wird, welches an der Kugelumlaufspindel-Führungseinheit vorgesehen ist, um einen Fördertisch zu bilden, und wobei die Parallelität zwischen einer Führungsfläche eines linearen Lagers und einer Kugelumlaufspindelwelle sich auf einfache Weise einstellen läßt.

Hierzu wird nach der Erfindung eine Kugelumlaufspindel-Führungseinheit bereitgestellt, welche folgendes aufweist: eine Führungsschiene, welche von einem U-Stahlmaterial mit einer Ausnehmung gebildet wird; ein bewegliches Teil, welches passend zwischen den Seitenflächen der Ausnehmung und den dazwischenliegenden Kugeln angeordnet ist und das längs einer Längsrichtung der Führungsschiene beweglich ist; eine Kugelumlaufspindelwelle, die drehbeweglich mittels der Führungsschiene gelagert und über eine Gewindeverbindung in dem beweglichen Teil zur Ausführung einer hin- und hergehenden Bewegung des beweglichen Teils längs der Führungsschiene verbunden ist; und eine Vorspanneinrichtung zum Aufbringen einer axialen Zugbelastung auf einen Teil der Kugelumlaufspindelwelle zwischen den Lagerteilen, die an den gegenüberliegenden Enden der Führungsschiene vorgesehen sind.

Da bei der Kugelumlaufspindel-Führungseinheit mit dem vorstehend genannten Aufbau die Führungsschiene von einem U-Stahlmaterial mit einer Ausnehmung gebildet wird, liegt der Flächenschwerpunkt der Schiene in der Nähe der Ausnehmung, und die Kugelumlaufspindelwelle, welche mit dem beweglichen Teil zusammenarbeitet, liegt ebenfalls in der Nähe der Ausnehmung, so daß der Flächenschwerpunkt der Führungsschiene in der Nähe der Achse der Kugelumlaufspindelwelle liegt. Wenn daher die Vorspanneinrichtung eine Zugbelastung auf die Kugelumlaufspindelwelle aufbringt, wirkt eine Reaktionskraft als eine Druckbelastung an einer Stelle in der Nähe des Flächenschwerpunkts der Führungsschiene, so daß ein auf die Führungsschiene wirkendes Biegemoment klein ist. Daher läßt sich die Geradlinigkeit der Führungsschiene aufrecht erhalten, und die Vorschubgenauigkeit des beweglichen Teils läßt sich erhöhen.

Insbesondere wenn die Achse der Kugelumlaufspindelwelle im wesentlichen mit dem Flächenschwerpunkt der Führungsschiene übereinstimmt, bewirkt die auf die Kugelumlaufspindelwelle aufgebrachte Vorspannung kein Biegemoment in der Führungsschiene, und somit läßt sich die Geradlinigkeit der Führungsschiene perfekt einhalten.

Da das U-Stahlmaterial selbst, welches die Führungsschiene bildet, eine hohe Steifigkeit gegenüber einer Biegung in Folge ihrer Gestalt hat, ist es nicht erforderlich, eine Dicke der Führungsschiene zur Erhöhung der Steifigkeit zu vergrößern, wie dies bisher beim Stand der Technik vorgenommen wurde, so daß die Abmessungen und das Gewicht der Führungsschiene herabgesetzt werden können.

Selbst wenn die Kugelumlaufspindelwelle beschleunigt wird, wirkt eine Reaktion durch die Beschleunigung der Kugelumlaufspindelwelle nicht auf den Tisch, welcher dem beweglichen Teil zugeordnet ist, da das bewegliche Teil von der Führungsschiene getragen wird, welche die hohe Steifigkeit hat. Daher läßt sich eine genaue Bewegung des Tisches sicherstellen.

Ein Fördertisch kann eine solche Auslegung haben, daß das bewegliche Teil der Kugelumlaufspindel-Führungseinheit an einem Tisch angebracht ist, welcher mittels eines linearen Lagers gelagert ist und der sich auf einem Bett hin- und hergehend bewegen kann, wobei die Führungsschiene am Bett fest vorgesehen ist, und der Tisch in Richtung nach vorne und nach hinten um eine Größe entsprechend einer Drehgröße der Kugelumlaufspindelwelle bewegt werden. Bei dieser Auslegungsform kann die Führungsschiene vorzugsweise an ihren unteren und seitlichen Flächen mit Bezugsflächen versehen sein, welche zur Einstellung der Parallelität zwischen der Führungsschiene und der Achse der Kugelumlaufspindelwelle dienen.

Gemäß der voranstehend beschriebenen Auslegungsform läßt sich die Parallelität zwischen der Führungsschiene und der Achse der Kugelumlaufspindelwelle im voraus unter Verwendung der Bezugsfläche einstellen, die auf der Seitenfläche der Führungsschiene ausgebildet ist. Daher läßt sich die Parallelität zwischen der Achse der Kugelumlaufspindelwelle und der Führungsfläche des linearen Lagers lediglich dadurch einhalten, daß die Parallelität zwischen der Bezugsfläche, die an der Führungsschiene vorgesehen ist, und der Führungsfläche des linearen Lagers eingestellt wird, wodurch sich die Montage und der Zusammenbau des Tisches vereinfachen.

Weitere Einzelheiten, Merkmale und Vorteile der Erfindung ergeben sich aus der nachstehenden Beschreibung von bevorzugten Ausführungsformen unter Bezugnahme auf die beigefügte Zeichnung. Darin zeigt:

Fig. 1 eine Längsschnittansicht eines Hauptteils eines ersten Lagerteils einer Kugelumlaufspindelwelle in einem freien Zustand vor dem Aufbringen einer Zugbelastung auf dieselbe mittels einer Vorbelastungseinrichtung,

Fig. 2 eine Längsschnittansicht eines Hauptteils eines Endes einer in **Fig.** 1 gezeigten Welle, auf welche eine Zugbelastung aufgebracht wird,

Fig. 3 eine Seitenansicht zur Verdeutlichung einer Gesamtauslegungsform einer Fördereinrichtung, wobei Teile ausgeschnitten dargestellt sind,

Fig. 4 eine Draufsicht auf die in **Fig.** 3 gezeigte Einrichtung,

Fig. 5 eine Seitenansicht der in **Fig.** 3 gezeigten Einrichtung, bei welcher gewisse Teile weggebrochen sind,

Fig. 6 eine Vorderansicht eines Hauptteils,

Fig. 7 eine Draufsicht auf den in **Fig.** 6 gezeigten Teil,

Fig. 8 eine Längsschnittansicht eines Teils eines Tisches in **Fig.** 3,

Fig. 9 eine Seitenansicht einer Einrichtung nach **Fig.** 1,

Fig. 10 eine Schnittansicht einer Führungsschiene einer Einrichtung nach **Fig.** 3,

Fig. 11 bis 13 einen Tischkörper einer Einrichtung nach **Fig.** 3,

Fig. 11 eine Vorderansicht derselben,

Fig. 12 eine Seitenansicht hiervon,

Fig. 13 eine Unteransicht hiervon,

Fig. 14 bis 18 eine Endplatte,

Fig. 14 eine Vorderansicht,

Fig. 15 eine Rückansicht,

Fig. 16 eine vergrößerte Schnittansicht längs der Linie XI-XI in **Fig.** 15,

Fig. 17 eine Draufsicht auf ein Rückführungsstück,

Fig. 18 eine Seitenansicht eines Rückführungsstücks,

Fig. 19 eine Vorderansicht eines Halters,

Fig. 20 eine Schnittansicht längs der Linie XV-XV in **Fig.** 19,

Fig. 21 und 22 schematische Schnittansichten zur Verdeutlichung einer Ausgestaltungsform einer Führungsschiene gemäß einer weiteren bevorzugten Ausführungsform nach der Erfindung.

Fig. 23 eine schematische Schnittansicht zur Verdeutlichung eines Fördertisches, welcher mit einer Kugelumlaufspindel-Führungseinheit nach der Erfindung versehen ist, und

Fig. 24 eine Schnittansicht einer Kugelumlaufspindeleinheit gemäß einer üblichen Auslegungsform.

Die Erfindung wird nachstehend anhand von bevorzugten Ausführungsformen unter Bezugnahme auf die Zeichnung näher erläutert. In den **Fig.** 1 bis 22 wird eine Kugelumlaufspindel-Führungseinheit gemäß einer bevorzugten Ausführungsform nach der Erfindung gezeigt. Mit **1** ist allgemein eine Kugelumlaufspindel-Führungseinheit bezeichnet, welche im wesentlichen von einer Führungsschiene **2**, einem beweglichen Teil **3**, welches beweglich mit Hilfe der Schiene **2** gelagert ist, einer Kugelumlaufspindelwelle **7**, welche in Gewindeeingriff in dem beweglichen Teil **3** ist, einem Paar von Lagerteilen **410** und **420** zur Lagerung der Kugelumlaufspindelwelle **7**, einem Motor **18** zum Antreiben der Kugelumlaufspindelwelle **7** und einer Vorspanneinrichtung **50** gebildet wird, welche eine Zugvorspannung auf die Kugelumlaufspindelwelle **7** aufbringt.

Die Führungsschiene **2** wird von einem U-Stahlmaterial mit einem U-förmigen Querschnitt gebildet, welcher eine konkave Ausnehmung **21** hat und eine Bodenwand **23**, welche einen Grund einer Ausnehmung **21** bildet, und Seitenwände **22** umfaßt, die senkrecht von den gegenüberliegenden Seiten der Bodenwand **23** wegverlaufen.

Das bewegliche Teil **3** ist zwischen den inneren Seitenflächen **22a** der Ausnehmung **21** in der Führungsschiene **2**, d. h. zwischen den beiden Seitenwänden **22**, gehalten und gelagert. Das bewegliche Teil **3** ist nahezu über die gesamte Höhe in die Ausnehmung **21** eingesetzt und hat eine obere Fläche, welche geringfügig über die oberen Flächen der Seitenwände **22** vorsteht.

Die Seitenflächen der Ausnehmung **21** in der Führungsschiene **2** weisen zu den rechten und linken Flächen des beweglichen Teils **3** jeweils. Jede dieser rechten und linken Seitenflächen ist mit zwei Kugelwälzflächen **4a** und **4b** oder **5a** und **5b** versehen, auf welchen Wälzkörper, d. h. Kugeln **6**, bei der Ausführung einer Abwälzbewegung geführt sind.

Die Kugelwälzflächen **4a**, **4b**, **5a** und **5b**, welche in der Führungsschiene **2** vorgesehen sind, sind insgesamt mit einer Anzahl von vier vorhanden, und sie liegen an den Ecken der breiten Ausnehmungen **22**b, welche in den inneren Seitenflächen **22**a der Seitenwände **22** ausgebildet sind.

Das bewegliche Teil 3 wird von einem beweglichen Teilkörper **31** und Endplatten **32** gebildet, welche an gegenüberliegenden Endflächen des Körpers **31** befestigt sind. Der bewegliche Teilkörper **31** ist an den gegenüberliegenden Seiten insgesamt mit vier ausgenommenen Kugelwälzflächen 5a, 5b, 5c und 5d versehen, welche den Kugelwälzflächen **4**a, **4**b, **4**c und **4**d der Führungsschiene **2** jeweils zugeordnet sind. Eine große Anzahl von Kugeln **6** sind drehbeweglich zwischen den gegenüberliegenden Kugelwälzflächen **4**a und **5**a, **4**b und **5**b, **4**c und **5**c, **4**d und **5**d angeordnet.

Gegenüberliegende Enden **71** und **72** der Kugelumlaufspindelwelle **7** sind drehbeweglich mittels ersten und zweiten Lagerteilen **410** und **420** gelagert, welche an gegenüberliegenden Enden der Führungsschiene **2** angeordnet sind.

Der erste Lagerabschnitt **410** umfaßt eine erste Endplatte **412**, welche fest mit einer Endfläche der Führungsschiene **2** mit Hilfe von Schrauben **411** verbunden ist, und ein erstes Kugellager **415**, welches einen doppelreihigen Winkelkontakt hat und in eine axiale Öffnung **414** passend eingesetzt ist, welche an einem Mittelteil der ersten Endplatte **412** ausgebildet ist. Ein erstes axiales Ende **71** der Kugelumlaufspindelwelle **7** ist passend in die axiale Öffnung **414** der ersten Endplatte **412** mittels des ersten Kugellagers **415** eingesetzt.

Der zweite Lagerabschnitt **412** wird von einem Gehäuse **423** gebildet, welches eine zweite Endplatte **422** hat, welche fest mit der anderen Endfläche der Führungsschiene **2** mit Hilfe von Schrauben **421** verbunden ist, und einem zweiten Kugellager **425**, welches einen doppelreihigen Winkelkontakt hat und passend in einer axialen Öffnung **424** eingesetzt ist, die an einem Mittelteil der zweiten Endplatte **422** ausgebildet ist. Ein zweites Ende **72** der Kugelumlaufspindelwelle **7** ist in einer Axialöffnung **424** der zweiten Endplatte **422** unter Zwischenlage eines zweiten Lagers **425** eingesetzt.

Das zweite axiale Ende **72** ist mit einem Verbindungswellenabschnitt **723**, einem Gewindeabschnitt **722** und einem Lagerabschnitt **721** versehen, welcher axial fluchtgerecht in dieser Anordnung ausgehend von dem Ende des Endabschnitts **72** angeordnet ist. Der Lagerabschnitt **721** ist passend in dem zweiten Kugellager **425** angeordnet, und der Verbindungswellenabschnitt **723** und der Gewindeabschnitt **722** gehen durch die axiale Öffnung **424** und erstrecken sich in Richtung auf einen Motor **18**. Die Verbindungswelle **723** ist mit einer Antriebswelle **181** des Motors **18** über eine Kupplung **19** verbunden.

Der Motor **18** ist fest mit einer dritten Endplatte **426** verbunden, welche am Gehäuse **423** ausgebildet ist, und zwar mittels Schrauben **182**. Die Antriebswelle **181** ist koaxial zu der Kugelumlaufspindelwelle **7**. Die dritte Endplatte ist der zweiten Endplatte **422** unter Einhaltung eines vorbestimmten axialen Zwischenraumes zugewandt. Der Zwischenraum zwischen der zweiten und dritten Endplatte **422** und **426** wird genutzt, um die Kupplung **19** aufzunehmen. Die Kupplung **19** ist mit Öffnungen **191** und **192** versehen. Die Antriebswelle **181** des Motors **18** und der Verbindungswellenabschnitt **723** der Kugelumlaufspindelwelle **7** sind die Öffnungen **191** und **192** jeweils eingesetzt und sie sind fest mit der Kupplung mit Hilfe von Schrauben **193** und **194** verbunden. Eine obere Öffnung des Gehäuses **423** des Motors **18** ist mit oberen und unteren Stützabdeckungen **427** und **428** abgedeckt. Eine Verbindungseinrichtung **429** zur Herstellung einer elektrischen Verbindung mit dem Motor **18** ist an der unteren Stützabdeckung **428** angebracht.

Die Positionen der ersten Endplatte **413** des ersten Lagerabschnitts **410** und der zweiten Endplatte **422** des zweiten Lagerabschnitts **420** lassen sich in einer Richtung senkrecht zu der Kugelumlaufspindelwelle **7** einstellen. Die Seitenfläche der Führungsschiene **2** bildet eine Bezugsfläche A für die Einstellung der Parallelität zwischen einer Achse der Kugelumlaufspindelwelle **7** und der Führungsschiene. Die Positionseinstellung der ersten Endplatte **413** läßt sich unter Verwendung eines kleinen Spiels zwischen den Schrauben **411** und den Schrauböffnungen **411**a vornehmen. In ähnlicher Weise erfolgt die Positionseinstellung der zweiten Endplatte **422** unter Verwendung eines geringfügigen Spieles zwischen den Schrauben **421** und den Schrauböffnungen **421**a.

Eine Vorspanneinrichtung **50** wird von ersten und zweiten Lagerhaltermuttern **511** und **512** gebildet, welche mit den Kugellagern **415** und **425** in den ersten und zweiten Lagerabschnitten **71** und **72** jeweils zusammenarbeiten. Bei der dargestellten bevorzugten Ausführungsform ist die Lagerhaltermutter **512** des zweiten Lagerabschnittes **420** zu Beginn so angezogen, daß der Motor **18** und weitere Teile angeordnet sind und abschließend wird die erste Lagerhaltermutter **511** des ersten Lagerabschnittes **410** unabhängig von dem Motor und weiteren Teilen festgelegt, so daß eine Zugbelastung auf die Kugelumlaufspindelwelle **7** aufgebracht wird.

Das zweite Kugellager **425** ist in die Axialöffnung **424** von einem offenen Ende her eingesetzt, welches der Führungsschiene **2** zugewandt ist. Ein Teil der axialen Öffnung **424** in der Nähe des Motors **18** hat einen Durchmesser, welcher kleiner als ein Außendurchmesser des zweiten Kugellagers **425** ist, so daß die axiale Öffnung **425** mit einem stufenförmig abgesetzten Abschnitt versehen ist, gegen welchen das zweite Lager **425** zur Anlage kommt und der Lagerhalter **522** ist in die axiale Öffnung **424** geschraubt.

Die ersten und zweiten Bundteile **532** und **542** sind passend um den Lagerabschnitt **721** des zweiten Lagerabschnittes **72** angeordnet, wobei das zweite Kugellager **425** dazwischenliegt. Das erste Bundteil **531** ist zwischen einer Endfläche des zweiten Kugellagers **425** in der Nähe der Führungsschiene **2** und einem stufenförmig abgesetzten Abschnitt **73** angeordnet, welcher in einem Basisende des Lagerabschnittes **721** der Kugelumlaufspindelwelle **7** ausgebildet ist. Das zweite Bundteil **54** ist zwischen der weiteren Endfläche des zweiten Kugellagers **425** und der Lagerhaltermutter **512** angeordnet.

Das erste Kugellager **415** ist in die axiale Öffnung **414** ausgehend von einer endseitigen Öffnung eingesetzt, welche der Führungsschiene **2** zugewandt ist. Ein Teil der axialen Öffnung **414**, welcher von dem Motor **18** entfernt liegt, hat einen Durchmesser, welcher kleiner als ein Außendurchmesser des ersten Kugellagers **415** ist, so daß die axiale Öffnung **425** mit einem stufenförmig abgesetzten Abschnitt **4141** versehen ist, gegen welchen das erste Lager **415** zur Anlage kommt, wenn der Lagerhalter **521** in die axiale Öffnung **414** geschraubt ist.

Die ersten und zweiten Bundteile **531** und **541** sind passend um den Lagerabschnitt **711** des ersten Lagerabschnittes **71** angeordnet, wobei das erste Kugellager **415** dazwischenliegt. Das erste Bundteil **531** ist zwischen einer Endfläche des ersten Kugellagers **415** in der Nähe der Führungsschiene 2 und einem stufenförmig abgesetzten Abschnitt **74** angeordnet, der an einem Basisende des Lagerabschnittes der Kugelumlaufspindelwelle **7** ausgebildet ist. Das zweite Bundteil **541** ist zwischen dem ersten Kugellager **415** und der ersten Lagerhaltermutter **511** angeordnet.

Die Kugelumlaufspindelwelle **7** befindet sich zu Beginn in einem freien Zustand während eines Montagevorganges, wie dies in **Fig.** 1 gezeigt ist. Das erste Kugellager **415** und die stufenförmig abgesetzte Fläche **74** der Kugelumlaufspindelwelle **7** liegen derart, daß ein Spalt g entsprechend einer Größe einer Vorspannung vorhanden ist, und anschließend wird die Lagerhaltermutter **511** angezogen, um die Kugelumlaufspindelwelle **7** um eine Größe zu expandieren, welche dem Spalt g entspricht, um eine Zugbelastung bzw. Zugkraft F aufzubringen. Daher läßt sich nur durch das Festziehen der Lagerhaltermutter **511** die Zugbelastung auf eine geeignete Größe einstellen.

Da bei der dargestellten bevorzugten Ausführungsform ein Flächenschwerpunkt des in etwa U-förmig ausgelegten Querschnitts der Führungsschiene **2** mit einer Achse O der Kugelumlaufspindelwelle **7** übereinstimmt, bewirkt eine Druckbelastung, die man als eine Reaktionskraft der Vorspannung der Kugelumlaufspindelwelle **7** erhält, nicht als eine abweichende Belastung gegenüber der Führungsschiene **2**.

Im Hinblick auf die Auslegung des beweglichen Teils **3** ist der bewegliche Teilkörper in seiner Mitte mit einer sie durchsetzende Kugelumlaufspindel **8** versehen, welche mit einer Vorschubspindel, d. h. einer Kugelumlaufspindelwelle **7**, zusammenarbeitet. Die Kugelumlaufspindelöffnung **8** liegt auf einer Linie, die im wesentlichen die Mitten der überbrückenden Teile zwischen der oberen und unteren Kugelwälzfläche **5a** und **5b** verbindet. Bei dieser bevorzugten Ausführungsform hat die Kugelumlaufspindelöffnung einen Durchmesser ähnlich den Überbrückungsteilen zwischen den Kugelwälzflächen **5a, 5b, 5c** und **5d**.

Zwischen der Kugelumlaufspindelöffnung **8** und den Seitenflächen des beweglichen Teilkörpers **31** sind vier Kugelaustrittsöffnungen **6a, 6b, 6c** und **6d** für den Austritt der Kugeln aus den Belastungsbereichen versehen. Die Kugelöffnungen **6a, 6b, 6c** und **6d** sind den Kugelwälzflächen **5a, 5b, 5c** und **5d** zugeordnet, und zwei derselben sind in einem Abstand von den anderen beiden Öffnung angeordnet, wobei die Kugelumlaufspindelöffnung **8** dazwischenliegt. Die Kugelumlaufspindelöffnungen **6a, 6b, 6c** und **6d** liegen auf horizontalen Linien, die durch die Kugelwälzflächen **5a, 5b, 5c** und **5d** jeweils gehen. Eine Vorbelastung wird auf jede Kugel **6** aufgebracht. Diese Vorbelastung erhält man dadurch, daß die Kugeln **6** in einem komprimierten Zustand in dem jeweiligen Zwischenraum passend eingesetzt sind, welche von vier Sätzen von wechselseitig zugewandten Kugelwälzflächen **4a** und **5a, 4b** und **5b, 4c** und **5c** und **4d** und **5d** gebildet werden.

Zwischen den Kugelaustrittsöffnungen **6a, 6b, 6c** und **6d** und den Seitenflächen des beweglichen Teilkörpers **31** sind Bolzenöffnungen **9** zum Anbringen eines zu transportierenden Gegenstandes an dem beweglichen Teilkörper **31** vorgesehen.

Die Kugelumlaufspindelöffnung **8**, die durch die Mitte des beweglichen Teilkörpers **31** geht, hat eine Gewindeausnehmung in einem Bereich in jener Nähe, welche einer Hälfte eines Bereiches entspricht, an welcher eine Öffnung **33** vorgesehen ist, die den beweglichen Teilkörper **31** durchsetzt. Ein Rücklaufrohr **10** ist mit der Öffnung **8** verbunden, um einen Kugelrücklaufkanal zu bilden. Das Rücklaufrohr **10** wird mittels eines Halters **10a** gehalten. Die Vorbelastung wirkt auch auf die Kugeln **6**, die zwischen der Kugelumlaufspindel **7** und der Kugelumlaufspindelöffnung **8** liegen, so daß ein Rattern verhindert wird, welches in axialer Richtung der Kugelumlaufspindelwelle auftreten könnte. Um die Vorbelastung aufzubringen, kann eine Differenz zwischen der Steigung der Gewindeausnehmung in der Kugelumlaufspindelöffnung **8** unter der Steigung des Gewindes der Kugelumlaufspindelwelle **7** oder mittels anderen Auslegungsformen erreicht werden.

Die Kugeln **6**, die zwischen den Seitenflächen des beweglichen Teilkörpers **31** und den inneren Seitenflächen der Führungsschiene **2** angeordnet sind, berühren die zugeordneten Kugelwälzflächen **4a** und **5a, 4b** und **5b, 4c** und **5c** oder **4d** und **5d** in Kontaktrichtungen, welche derart bestimmt sind, daß man nach außen divergierend verlaufende Anordnungen erhält, und welche insbesondere derart bestimmt sind, daß imaginäre Linien La, Lb, Lc und Ld, die durch die Kontaktpunkte zwischen den zugeordneten Kugeln **6** und den zugeordneten Kugelwälzflächen **4a** und **5a, 4b** und **5b, 4c** und **5c** und **4d** und **5d** und durch die Kugeln gehen, einen konvergierenden Verlauf zu der Mitte der Kugelumlaufspindelwelle **7** bezüglich einer horizontalen Linie H haben können, die durch die Mitte der Kugelumlaufspindelwelle **7** geht. Die Winkel zwischen den imaginären Linien La, Lb, Lc und Ld und der horizontalen Linie H können sich gegebenenfalls etwa auf 45° belaufen.

Die Endplatte **32** ist ein viereckförmiges Teil, welches eine ähnliche Gestalt wie die Endfläche des beweglichen Teilkörpers **31** hat, und sie ist in ihrer Mitte mit einer Durchgangsöffnung **32a** zum Einführen der Kugelumlaufspindelwelle **7** versehen. Bolzenöffnungen **32b** sind in Querrichtung an den gegenüberliegenden Seiten der Einschuböffnung **32a** zum Fixieren des beweglichen Teilkörpers **31** angeordnet.

Eine Befestigungsfläche der Endplatte **32** für den beweglichen Teilkörper **31** ist mit vier Rücklaufkanälen **11a, 11b, 11c** und **11d** zum Rückführen der Kugeln **6** versehen, welche im Belastungsbereich zwischen dem beweglichen Teilkörper **31** und der Führungsschiene **2** angeordnet sind, um dieselben zu den Kugelaustrittsöffnungen **6a, 6b, 6c** und **6d** zu leiten. Der Rücklaufkanal **11a** wird von einer ausgenommenen Aussparung **12** mit einem halbkreisförmigen Querschnitt in der Endplatte **32** gebildet, und ein Rücklaufstück **13**, welches halbkreisförmig ausgebildet ist, ist konzentrisch bezüglich der Ausnehmung **12** angeordnet. Das Rücklaufstück **13** ist an seinem Außenumfang mit einer bogenförmigen Ausnehmung **13a** versehen, welche komplementär hinsichtlich ihrer Gestalt zu dem äußeren Umfang der Kugel **6** ausgelegt ist, so daß die bogenförmige Ausnehmung **13a** und die ausgenommene Aussparung **32a** in der Endplatte **32** die rohrförmigen Rücklaufkanäle **11a, 11b, 11c** und **11d** mit einer halbkreisförmigen Gestalt bilden. Es ist erwünscht, daß eine Krümmung jedes Rücklaufkanales **11a, 11b, 11c** und **11d** nahezu das Dreifache des Durchmessers der Kugel oder größer beträgt.

Kugelhalter **14** zum Halten der Kugeln **6** sind zwischen den Seitenflächen des beweglichen Teilkörpers **31** und den inneren Seitenflächen der Führungsschiene **2** angeordnet. Jeder Kugelhalter **14** ist ein Plattenteil, welches in einer Ausnehmung **22b** aufgenommen ist, in einer inneren Seitenfläche der jeweiligen Seitenwand **22** der Führungsschiene **2** ausgebildet ist. Der Halter **14** wird an einer seiner Fläche gegen die Seitenfläche des beweglichen Teilkörpers **31** gedrückt und mit Hilfe von Schrauben **15** festgelegt.

Jeder Halter **14** ist an seinen gegenüberliegenden Seitenrändern mit Ausnehmungen **16** mit bogenförmigem Querschnitt versehen, welche entsprechend der Krümmung der Kugel **6** gekrümmt sind, so daß die Kugeln **6** in den oberen und unteren Reihen durch die bogenförmigen Ausnehmungen **16** gehalten sind ohne von dem beweglichen Teilkörper **31** freizukommen.

Die Halter **14** sind in Räumen zwischen den oberen und unteren Kugelwälzflächen angeordnet, welche Brückenteile haben, die bis zu einem Größenwert größer werden und sie sind in diesen Räumen angeordnet. Somit haben die Halter **14** Breitenabmessungen, welche nahezu gleich den Gesamtbreitenabmessungen der Überbrückungsteile sind und die bogenförmigen Ausnehmungen **16** an den gegenüberliegenden Seitenrändern liegen in der Nähe der Kugeln **6**. Die Kugeln **6** in den Belastungsbereichen führen eine Abwälzbewegung ohne eine Berührung dieser bogenförmigen Ausnehmungen **16** aus.

Die Kugelumlaufspindelwelle **7**, welche in der Kugelumlaufspindelöffnung **8** im beweglichen Teil **3** in Gewindeeingriff ist, ist drehbeweglich an einem Ende mittels eines Lagerabschnittes **17** gelagert, welcher an einem Ende der Führungsschiene **2** vorgesehen ist, und sie ist antriebsverbunden am anderen Ende über die Kupplungen **19** mit dem Motor **18**, welcher am anderen Ende der Führungsschiene **2** angebracht ist.

In den **Fig.** 3 bis 5 ist mit der Bezugsziffer **80** eine Befestigungsplatte zum Anbringen eines Sensors (nicht gezeigt) bezeichnet. Die Platte **80** kann fest an einer beliebigen Position auf einer Schiene **81** angebracht werden, die auf und längs der äußeren Seitenfläche der Führungsschiene **2** angeordnet ist. Der Sensor ist an der Sensorbefestigungsplatte **80** über ein Befestigungsstück **82** angebracht. Wenn eine Deckplatte **83**, die am beweglichen Teil **3** angebracht ist, den Sensor überfährt, wird festgestellt, daß das bewegliche Teil **3** in einer vorbestimmten Position (beispielsweise einer Anfangsposition) ist.

Eine Bezugsziffer **84** bezeichnet einen ringförmigen, ersten Anschlag, welcher passend in der Axialöffnung **413** in dem ersten Lagerabschnitt **71** angeordnet ist, und mit einer Bezugsziffer **85** wird ein zweiter Anschlag bezeichnet, welcher im zweiten Lagerabschnitt **72** vorgesehen ist. Diese Anschläge berühren die Endflächen des beweglichen Teils **3** zur Begrenzung eines Bewegungsbereiches des beweglichen Teils **3**.

Wenn bei der Kugelumlaufspindel-Führungseinheit mit dem vorstehend beschriebenen Aufbau der Motor **18** drehangetrieben wird, wird die Kugelumlaufspindelwelle **7** gedreht und die Drehbewegung derselben wird über die Kugelumlaufspindelöffnung **8** auf das bewegliche Teil **3** übertragen, so daß das bewegliche Teil **3** längs der Führungsschiene **2** eine hin- und hergehende lineare Bewegung ausführt. Bei dieser Arbeitsweise ist die Zugbelastung F auf der Kugelumlaufspindel **7** durch die ersten und zweiten Lagerhaltermuttern **511** und **512** zum Ausgleich der Wärmedehnung der Kugelumlaufspindelwelle **7** aufgebracht, welche bei einer Hochgeschwindigkeitsdrehbewegung auftreten kann. Als eine Reaktion hierauf wirkt eine Druckbelastung auf die Führungsschiene **2** über der ersten und zweiten Endplatte **412** und **422** des ersten und zweiten Lagerabschnittes **410** und **420** ein. Die Führungsschiene **2** jedoch wird von einem U-förmigen U-Stahlmaterial gebildet, welches eine höhere Steifigkeit gegenüber Biegebelastungen hat, so daß die Seitenwände **22** als Versteifungsträger wirken und eine Verformung, wie ein Durchbiegen, verhindert werden kann. Da der Flächenschwerpunkt der Führungsschiene **2** und die Achse O der Kugelumlaufspindel **7** miteinander zusammenfallen verlagert sich die Druckbelastung, welche auf die Führungsschiene **2** wirkt, nicht bezüglich der Achse der Kugelumlaufspindelwelle, so daß ein unnötiges Biegemoment nicht auf die Führungsschiene **2** einwirkt.

Da entsprechend der vorstehenden Beschreibung das Biegemoment nicht auf die Führungsschiene **2** einwirkt, wird die Kugelumlaufspindelwelle **7** in einem geraden Zustand gehalten. Diese Tatsache sowie die Tatsache, daß die gegenüberliegenden Seiten des beweglichen Teils **3** mit Hilfe den Kugeln **6** abgestützt und gelagert sind, dienen dazu, daß ein Verwerfen der Kugelumlaufspindelwelle **7** verhindert wird, so daß man eine genaue Steuerung der Förderbewegung erhält.

Bei dieser bevorzugten Ausführungsform sind die Kontaktrichtungen der Kugeln **6**, die zwischen dem Tisch **3** und der Führungsschiene **2** angeordnet sind, derart geneigt, daß sie einen nach außen divergierenden Verlauf bezüglich der horizontalen Linie H haben, welche durch die Mitte der Kugelumlaufspindelwelle geht, so daß die vertikalen und horizontalen Belastungen, nämlich auf das bewegliche Teil **3** wirken, effektiv von den Kugeln **6** aufgenommen werden. Wenn insbesondere der Neigungswinkel sich auf etwa 45° beläuft, können die Belastungen in den vier Richtungen, d. h. vertikale und horizontale Richtungen, in gleicher Weise aufgenommen werden. Ferner kann in wirksamer Weise verhindert werden, daß die auf die Kugeln **6** einwirkende Vorbelastung ein Rattern des beweglichen Teils **3** verursacht.

Da entsprechend der voranstehenden Beschreibung das Rattern des beweglichen Teils **3** verhindert werden kann, ist es unmöglich, Vibrationen zu verhindern, welche während den Fördervorgängen auftreten können, und insbesondere während den Anfahr- und Anhaltevorgängen auftreten können, d. h. Neigungsbewegungen (Schwingungen des beweglichen Teils **3**, welche um eine Achse senkrecht zur Zeichenebene in **Fig.** 3 erregt werden), eine Wälzbewegung (eine Schwingung des beweglichen Teils **3**, welches um eine Achse senkrecht zur Zeichenebene in **Fig.** 5 erregt wird) und eine Seitenbewegung (eine Schwingung des beweglichen Teils **3**, welche um eine Achse senkrecht zu der Zeichenebene von **Fig.** 4 erregt wird), so daß das bewegliche Teil **3** gleichförmig bewegt bzw. gefördert werden kann. Da das Überbrückungsteil zwischen den oberen und unteren Kugelwälzflächen soweit wie möglich vergrößert wird, hat die Auslegung eine hohe Festigkeit bezüglich eines Belastungsmomentes, welches derart wirkt, daß das bewegliche Teil **3** um die Förderachse gedreht wird.

Es ist noch zu erwähnen, daß der Querschnitt der Führungsschiene **2** nicht auf eine U-förmige Gestalt gemäß der bevorzugten Ausführungsform beschränkt ist, sondern wie es in **Fig.** 21 gezeigt ist, kann eine mit einem Flansch versehene U-förmige Gestalt vorgesehen sein, bei der die Seitenwände **22** an ihren Enden mit horizontal vorspringenden Flanschen **24** versehen sind. Ferner kann nach **Fig.** 22 eine U-förmige Gestalt vorgesehen sein, welche mit Lippen **25** versehen ist, die an den oberen Wänden der Seitenwände **22** ausgebildet sind und welche nach innen verlaufen, um die Öffnung der Ausnehmung **21** zu verkleinern.

Wenn man die U-förmige Gestalt vorsieht, welche die

Flansche oder die Lippen hat, läßt sich die Steifigkeit der Führungsschiene **2** weiter erhöhen, so daß die Vorspannung effektiver auf die Kugelumlaufspindelwelle **7** aufgebracht werden kann. Bei der Auslegung mit einer U-förmigen Gestalt, welche Lippen hat, ist das bewegliche Teil **3** in der Führungsschiene **2** aufgenommen, und das bewegliche Teil **3** ist an seiner oberen Fläche mit einem stufenförmig abgesetzten Vorsprung **33** versehen, welcher zwischen den Lippen **25** vorsteht. Der stufenförmig abgesetzte Vorsprung **33** bildet eine Befestigungsfläche **34**.

Fig. 23 zeigt einen Fördertisch, welcher mit der Kugelumlaufspindel-Führungseinheit **1** mit der vorstehend beschriebenen bevorzugten Ausführungsform ausgestattet ist. Ein stationäres Bett **1000** lagert einen Tisch **1002** mittels eines Paars von rechten und linken linearen Lagern **1001**, um eine hin- und hergehende Bewegung desselben zu ermöglichen. Die linearen Lager **1001** können von unterschiedlichen, an sich bekannten Führungseinrichtungen gebildet werden. Jedes lineare Lager wird von einem Schienenbett **1003** und einem Lagerkörper **1005** gebildet, welcher gleitbeweglich längs der Längsrichtung des Schienenbetts **1003** über die Wälzteile **1004** geführt ist.

Die Kugelumlaufspindel-Führungseinheit **1** ist zwischen den beiden linearen Lagern **1001** angeordnet, und die Führungsschiene **2** der Kugelumlaufspindel-Führungseinheit **1** ist fest mit dem stationären Bett **1000** verbunden. Das bewegliche Teil **3** ist fest mit dem Tisch **1002** verbunden. Die Parallelität zwischen der Achse der Kugelumlaufspindelwelle **7** und eine Führungsfläche des linearen Lagers **1001** wird unter Nutzung der Bezugsebene A eingestellt, welche auf der unteren Fläche und den Seitenflächen der Führungsschiene **2** ausgebildet ist.

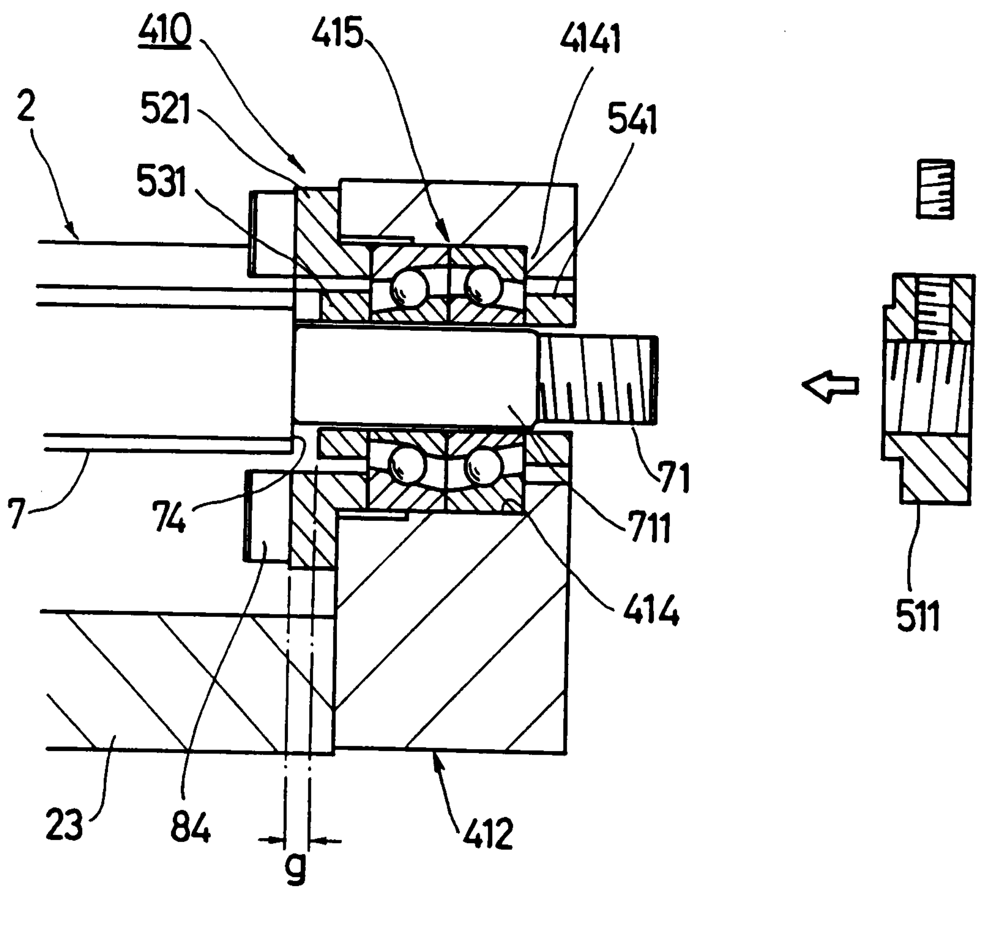
Bei der vorstehend beschriebenen Kugelumlaufspindel-Führungseinheit **1** kann vor dem Montageschritt zum Festlegen der Führungsschiene **2** an dem Bett **1000** die Parallelität zwischen der Achse der Kugelumlaufspindelwelle **7** und der Führungsschiene **2** auf der Basis der Bezugsfläche A eingestellt werden. Daher kann die Einstellung der Parallelität zwischen der Achse der Kugelumlaufspindelwelle **7** und der Führungsfläche des linearen Lagers **1001** nur dann abgeschlossen werden, wenn die Einstellung der Parallelität zwischen dem Schienenbett **1003** des linearen Lagers und der Bezugsfläche A erfolgt ist, welche auf der Führungsschiene **2** ausgebildet ist. Selbst wenn bei dem Fördertisch die Kugelumlaufspindelwelle **7** eine Versetzung hat, wird der Einfluß durch diese Versetzung nicht auf den Tisch **102** übertragen, welcher dem beweglichen Teil **3** zugeordnet ist, da das bewegliche Teil **3** durch die Führungsschiene **2** abgestützt gelagert ist. Somit kann man eine genaue Bewegung sicherstellen.

Patentansprüche

1. Kugelumfaufspindel-Führungseinheit (**1**), **gekennzeichnet durch** eine Führungsschiene (**2**), welche aus einem U-Stangenmaterial hergestellt ist, welches eine Ausnehmung (**21**) hat,
ein bewegliches Teil (**3**), welches passend zwischen den Seitenflächen der Ausnehmung (**21**) unter Zwischenlage von Kugeln (**6**) angeordnet ist und längs einer Längsrichtung der Führungsschiene (**2**) beweglich ist,
eine Kugelumlaufspindelwelle (**7**), welche drehbeweglich durch die Führungsschiene (**2**) gelagert ist und in Gewindeeingriff mit dem beweglichen Teil (**3**) zur Ausführung einer hin- und hergehenden Bewegung des beweglichen Teils (**3**) längs der Führungsschiene (**2**) ist, und
eine Vorspanneinrichtung (**50**) zum Aufbringen einer axialen Zugbelastung (F) auf einen Teil der Kugelumlaufspindelwelle (**7**) zwischen den Lagerabschnitten (**71**, **72**), die an den gegenüberliegenden Enden der Führungsschiene (**2**) vorgesehen sind.
2. Kugelumlaufspindel-Führungseinheit nach Anspruch 1, dadurch gekennzeichnet, daß eine Achse (O) der Kugelumlaufspindelwelle (**7**) im wesentlichen mit einem Flächenschwerpunkt eines Querschnitts der Führungsschiene (**2**) übereinstimmt.
3. Kugelumlaufspindel-Führungseinheit nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Führungsschiene (**2**) an ihren unteren Flächen und Seitenflächen mit einer Bezugsebene (A) zur Einstellung der Parallelität zwischen der Führungsschiene (**2**) und der Kugelumlaufspindelwelle (**7**) versehen ist.
4. Fördertisch, welcher einen Tisch (**1002**) umfaßt, der mittels eines linearen Lagers (**1001**) gelagert ist, welches fest an einem Bett (**1000**) angebracht ist, um eine hin- und hergehende Bewegung auszuführen, dadurch gekennzeichnet, daß eine Antriebseinrichtung zum Bewegen des Tisches (**1002**) um einen beliebigen Weg in Vorwärts- und Rückwärtsrichtung vorgesehen ist, daß die Antriebseinrichtung eine Führungsschiene (**2**), die aus einem U-Stangenmaterial mit einer Ausnehmung (**21**) ausgebildet und fest mit dem Bett (**1000**) verbunden ist, ein bewegliches Teil (**3**), welches passend zwischen den Seitenflächen der Ausnehmung (**21**) unter Zwischenlage von Kugeln (**6**) angeordnet ist und längs einer Längsrichtung der Führungsschiene (**2**) beweglich ist, eine Kugelumlaufspindelwelle (**7**), die drehbeweglich durch die Führungsschiene (**2**) gelagert und in Gewindeeingriff in dem beweglichen Teil (**3**) zur Ausführung einer hin- und hergehenden Bewegung des beweglichen Teils (**3**) und des Tisches (**1002**) längs der Führungsschiene (**2**) ist, und eine Vorspanneinrichtung (**50**) zum Aufbringen einer axialen Zugbelastung auf einen Abschnitt der Kugelumlaufspindelwelle (**7**) zwischen den Lagerabschnitten (**71**, **72**) aufweist, welche an den gegenüberliegenden Enden der Führungsschiene (**2**) vorgesehen sind, wobei die Führungsschiene (**2**) an ihren unteren Flächen und Seitenflächen mit einer Bezugsebene (A) zur Einstellung der Parallelität zwischen der Führungsschiene (**2**) und der Kugelumlaufspindelwelle (**7**) versehen ist.
5. Kugelumlaufspindel-Führungseinheit nach Anspruch 4, dadurch gekennzeichnet, daß eine Achse (O) der Kugelumlaufspindelwelle (**7**) im wesentlichen mit einem Flächenschwerpunkt eines Querschnitts der Führungsschiene (**2**) übereinstimmt.

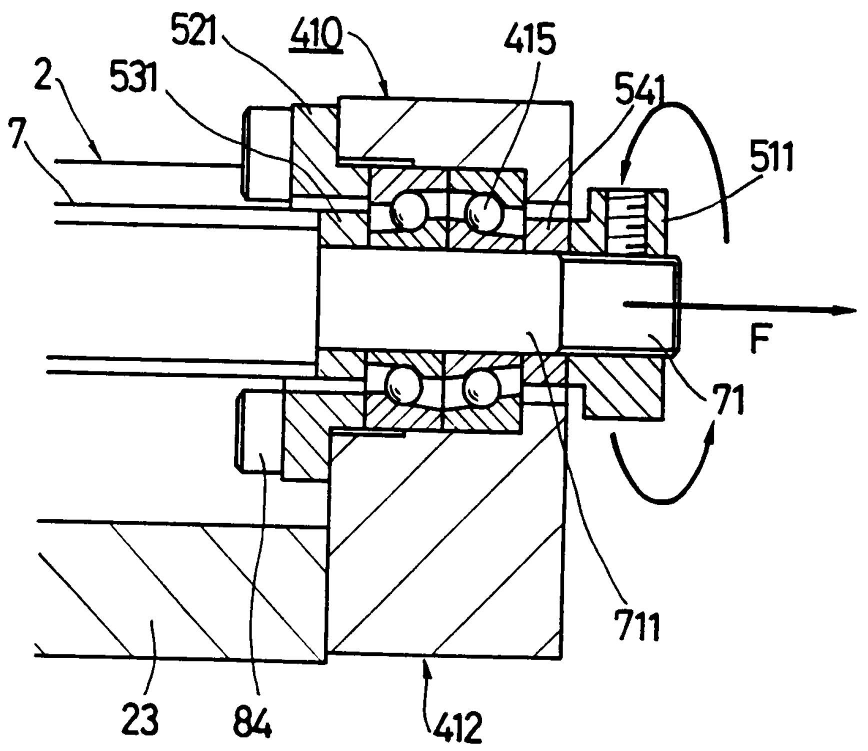
Hierzu 15 Seite(n) Zeichnungen

FIG. 1



Nummer: DE 41 35 167 A1
Int. Cl.5: F 16 H 25/22
Offenlegungstag: 21. Mai 1992

FIG. 2



Nummer: DE 41 35 167 A1
Int. Cl.5: F 16 H 25/22
Offenlegungstag: 21. Mai 1992

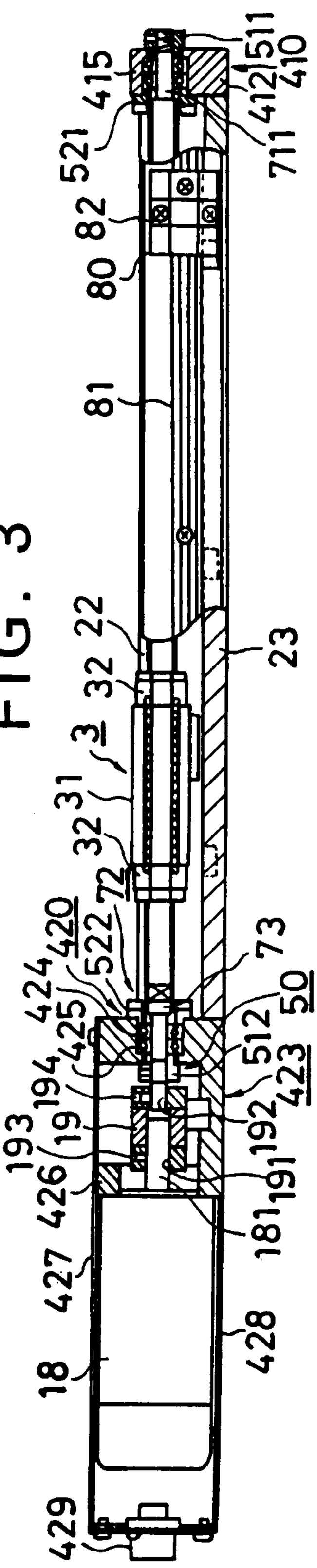


FIG. 3

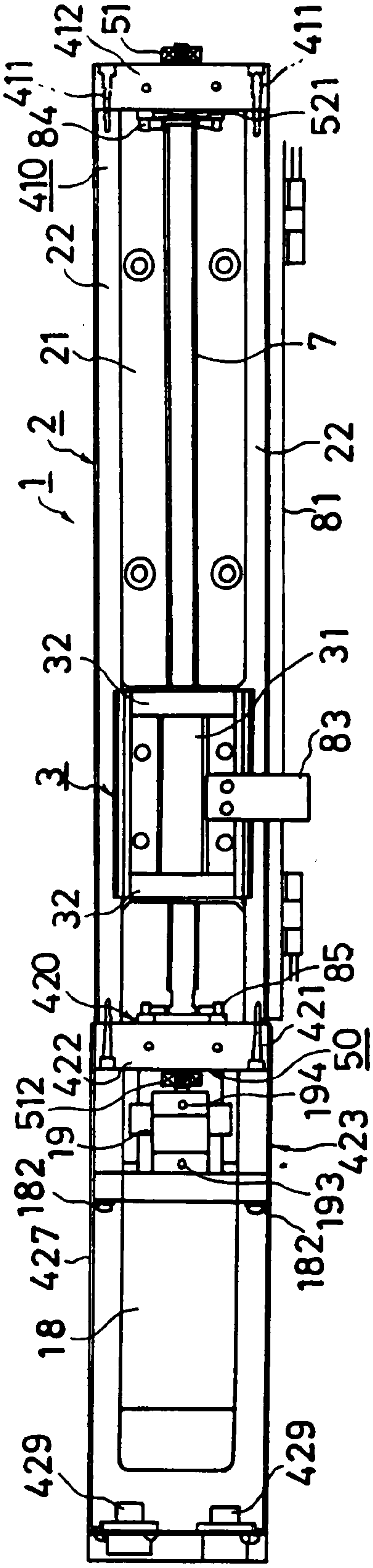
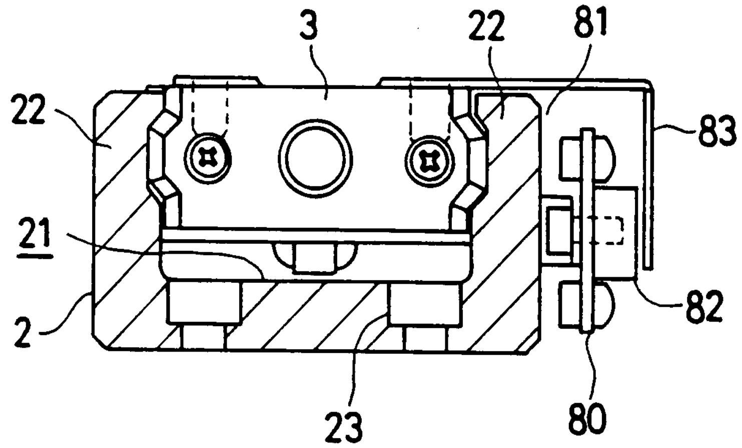


FIG. 4

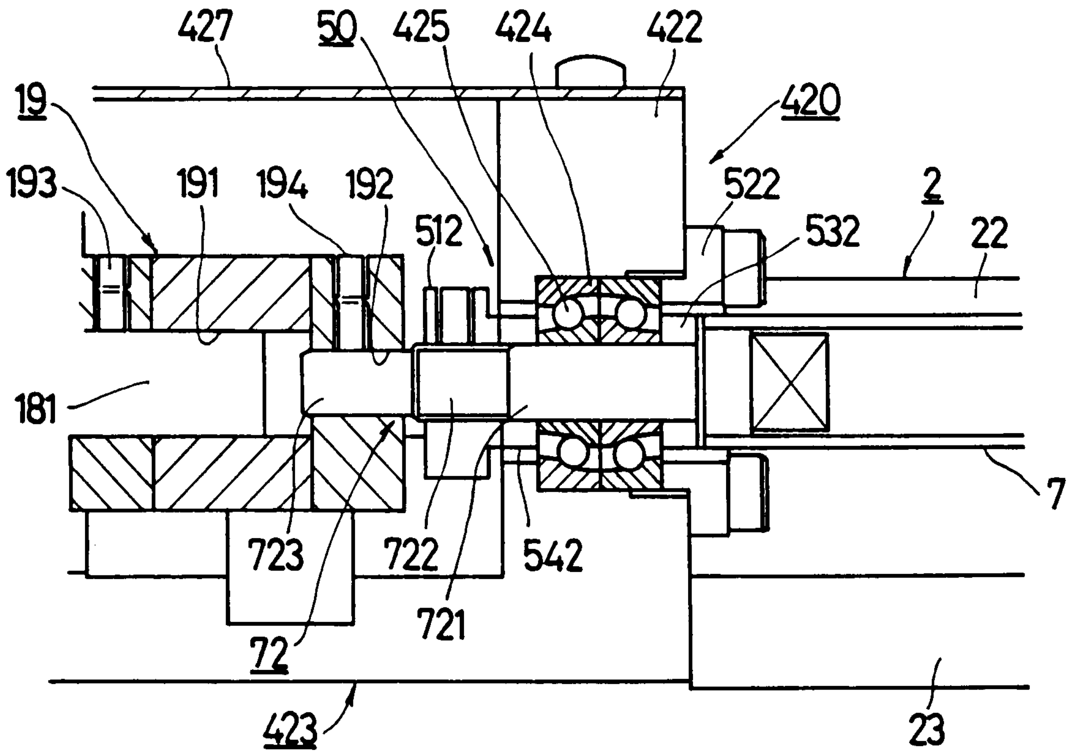
Nummer: DE 41 35 167 A1
Int. Cl.⁵: F 16 H 25/22
Offenlegungstag: 21. Mai 1992

FIG. 5



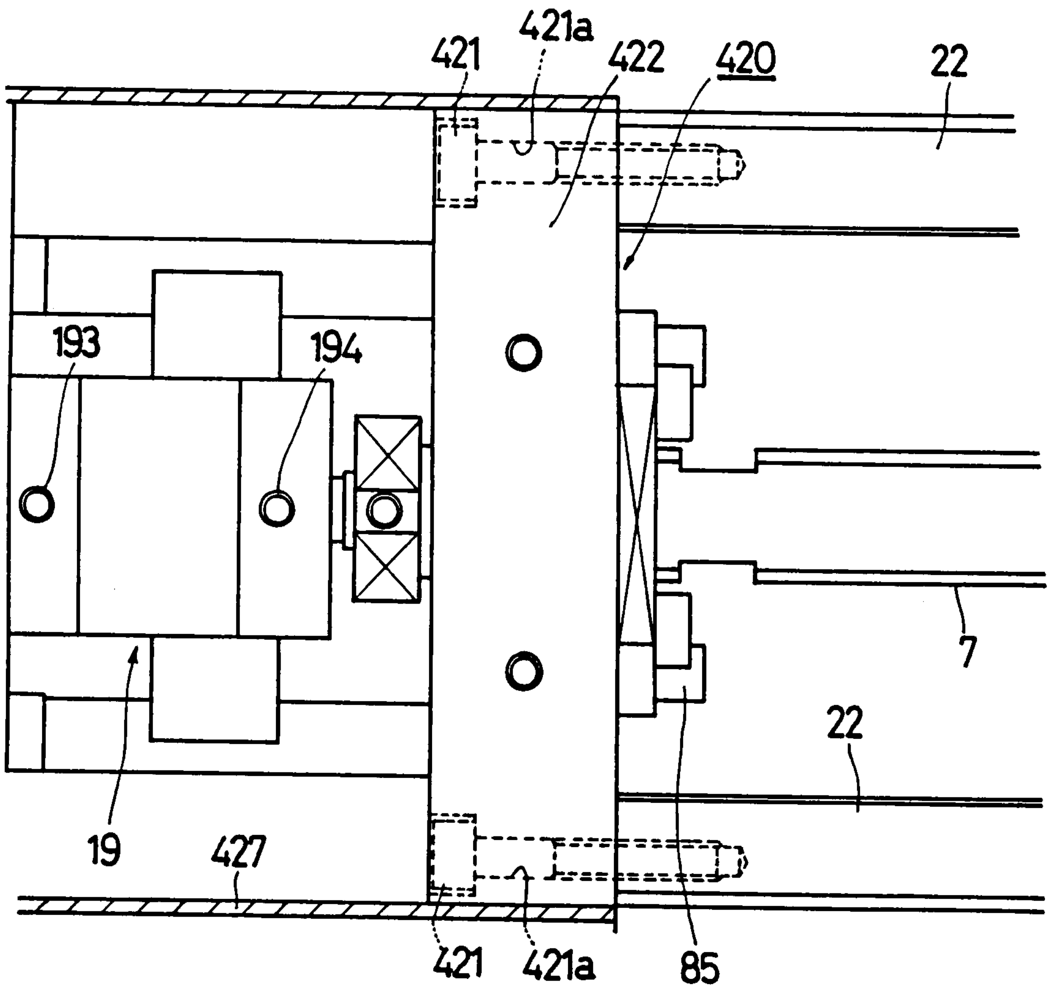
Nummer: DE 41 35 167 A1
Int. Cl.5: F 16 H 25/22
Offenlegungstag: 21. Mai 1992

FIG. 6



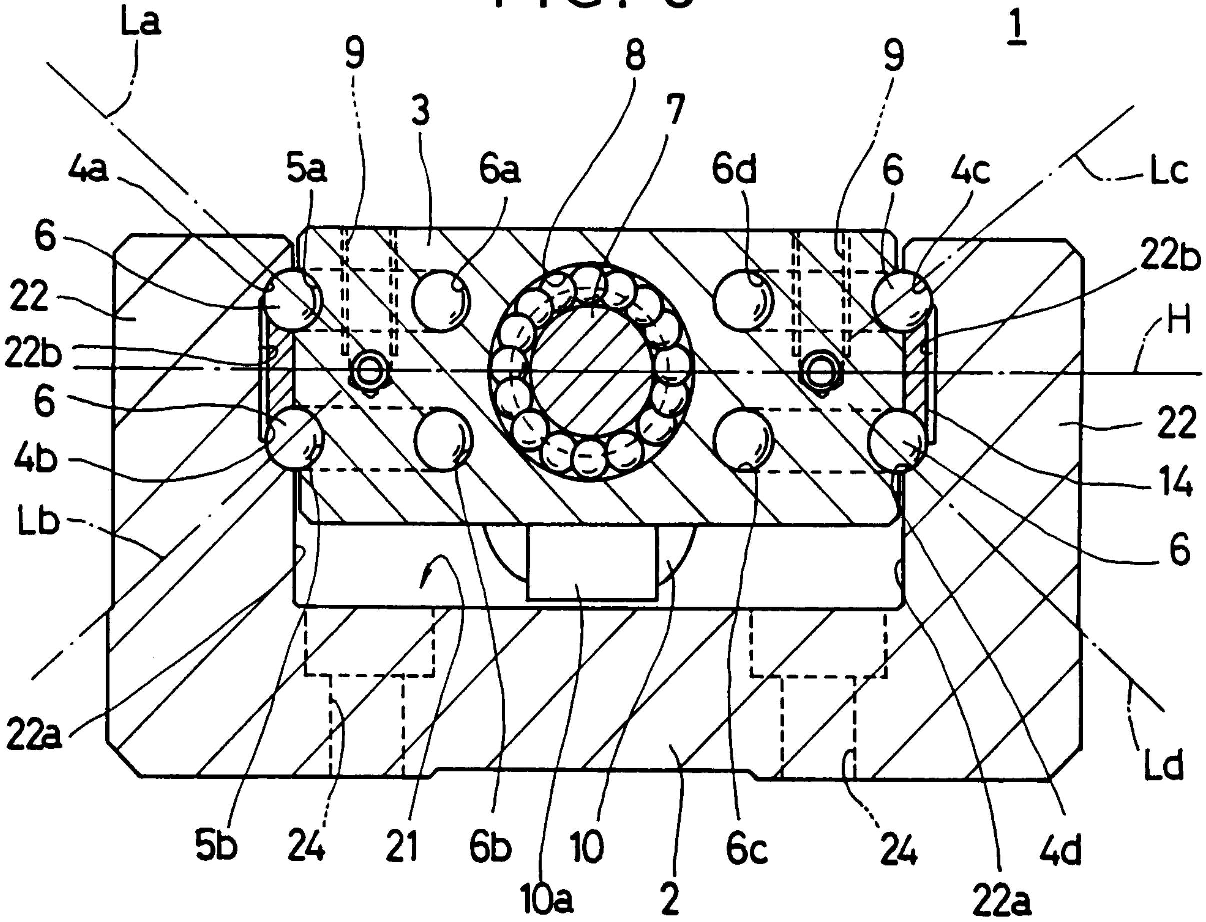
Nummer: DE 41 35 167 A1
Int. Cl.⁵: F 16 H 25/22
Offenlegungstag: 21. Mai 1992

FIG. 7



Nummer: DE 41 35 167 A1
Int. Cl.[5]: F 16 H 25/22
Offenlegungstag: 21. Mai 1992

FIG. 8



Nummer: DE 41 35 167 A1
Int. Cl.⁵: F 16 H 25/22
Offenlegungstag: 21. Mai 1992

FIG. 9

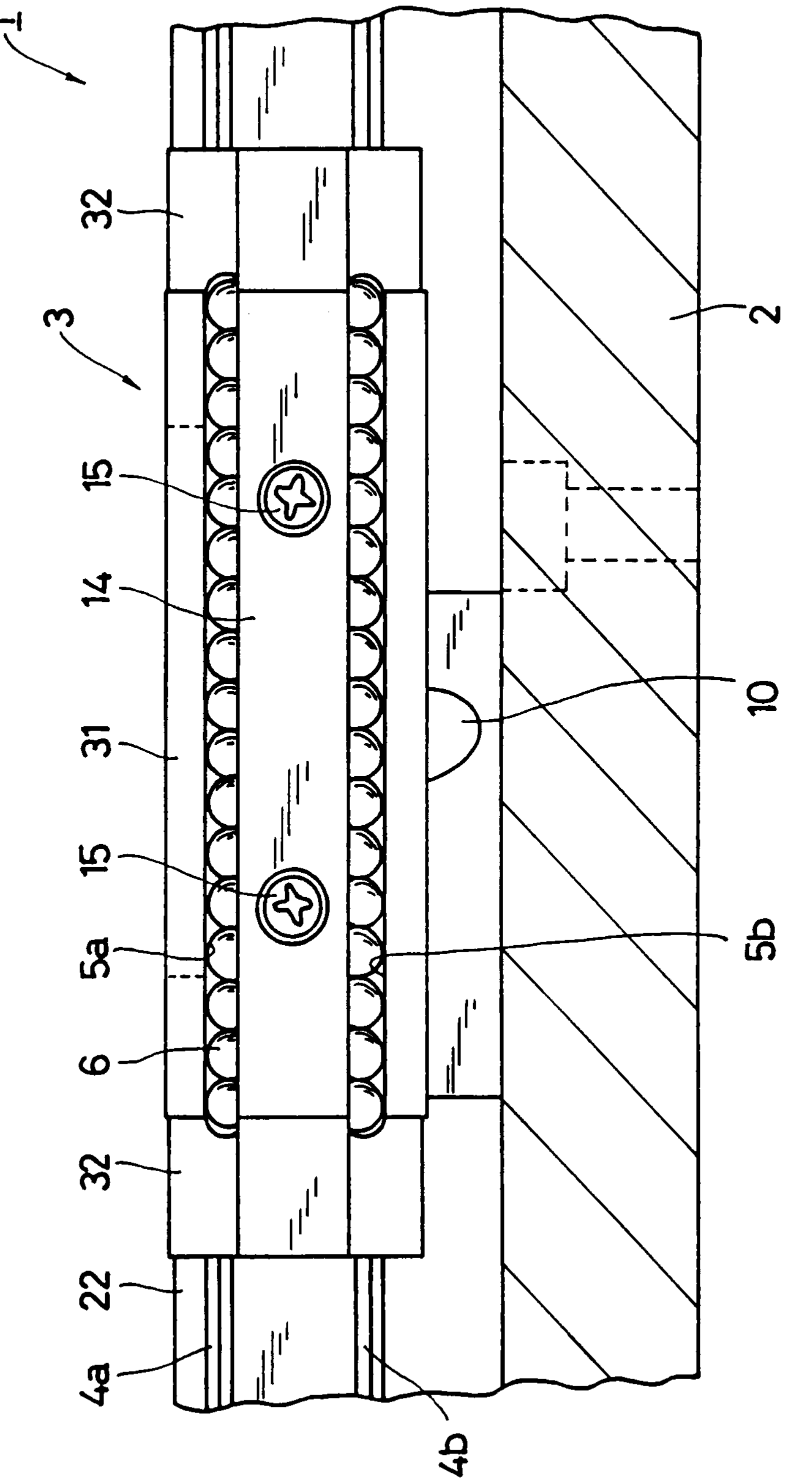


FIG. 10

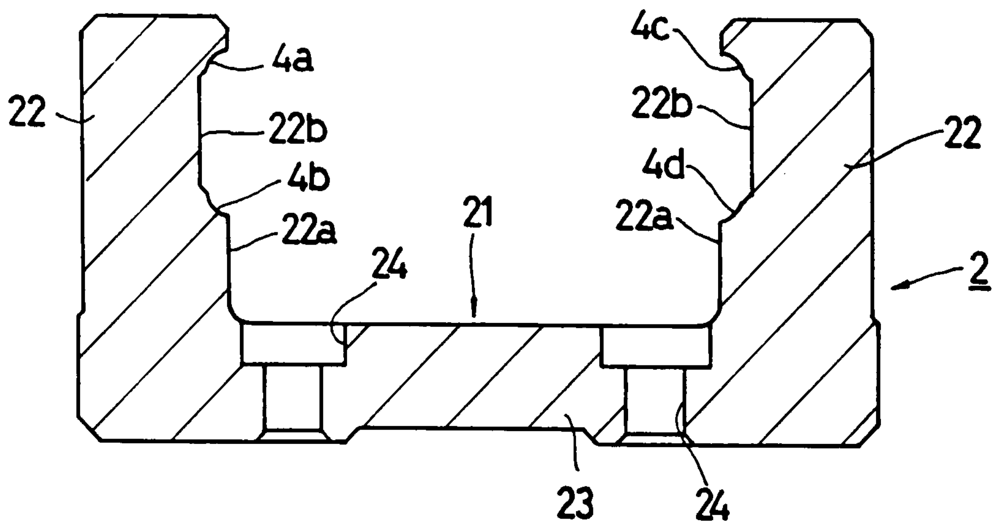


FIG. 11

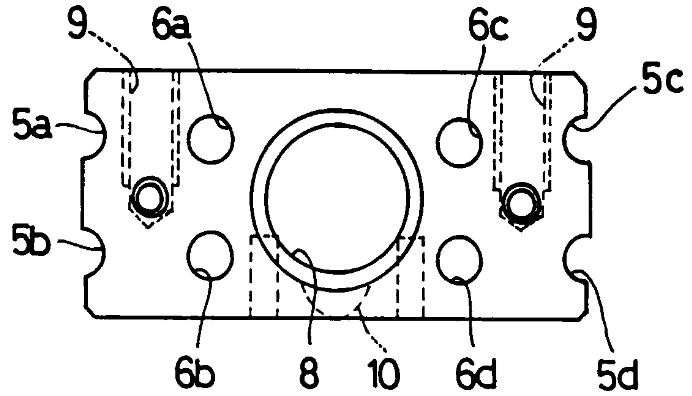
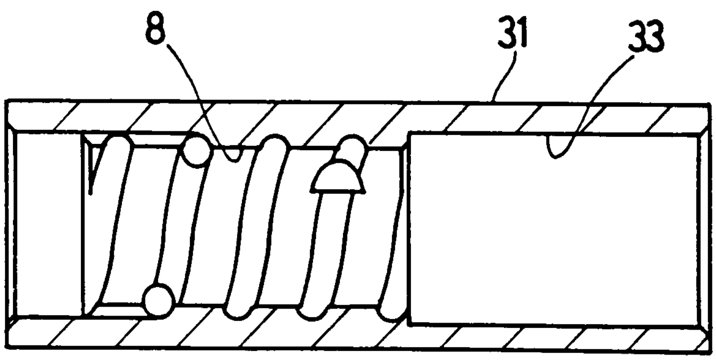


FIG. 12



Nummer: DE 41 35 167 A1
Int. Cl.5: F 16 H 25/22
Offenlegungstag: 21. Mai 1992

FIG. 13

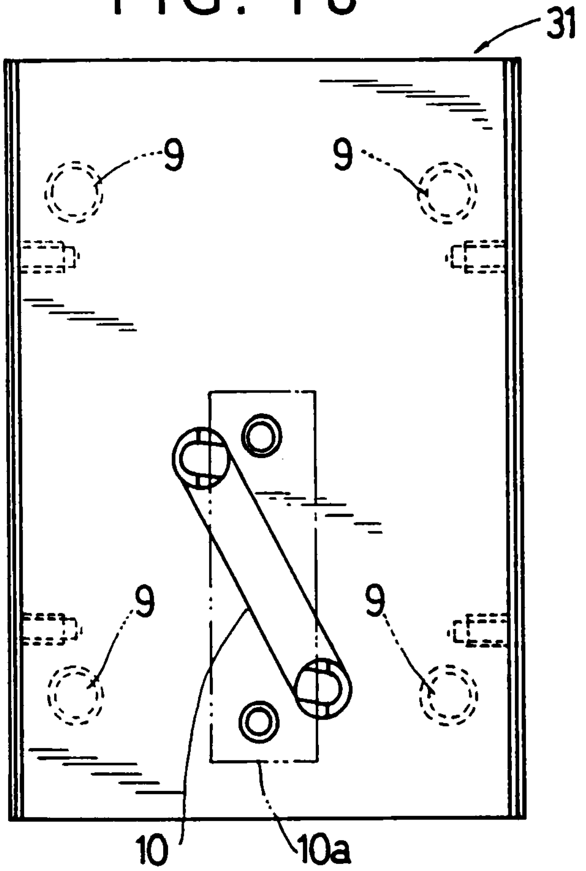


FIG. 14

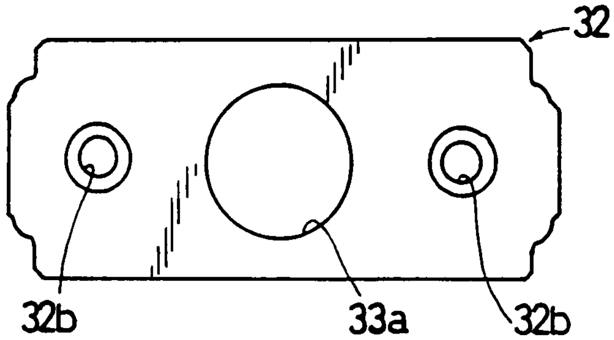
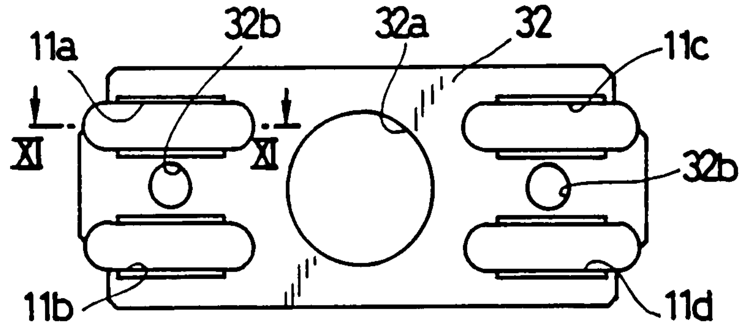


FIG. 15



Nummer: DE 41 35 167 A1
Int. Cl.[5]: F 16 H 25/22
Offenlegungstag: 21. Mai 1992

FIG. 16

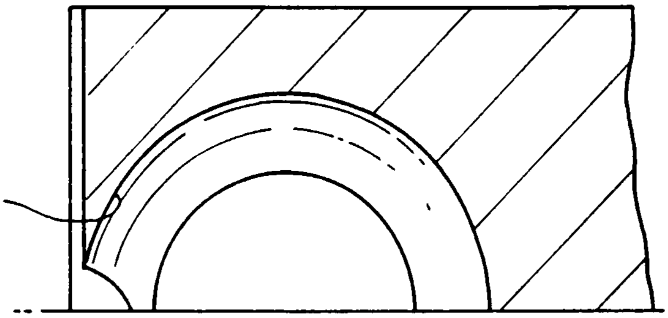


FIG. 17

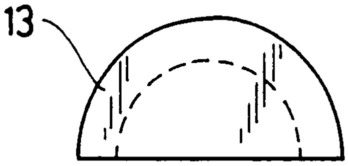
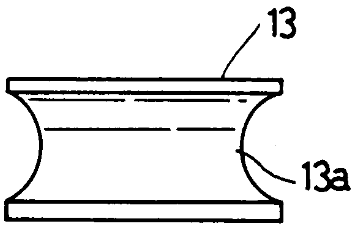


FIG. 18



Nummer: DE 41 35 167 A1
Int. Cl.[5]: F 16 H 25/22
Offenlegungstag: 21. Mai 1992

FIG. 20

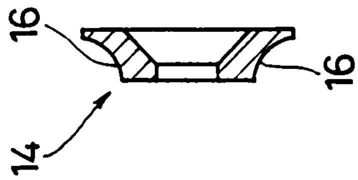
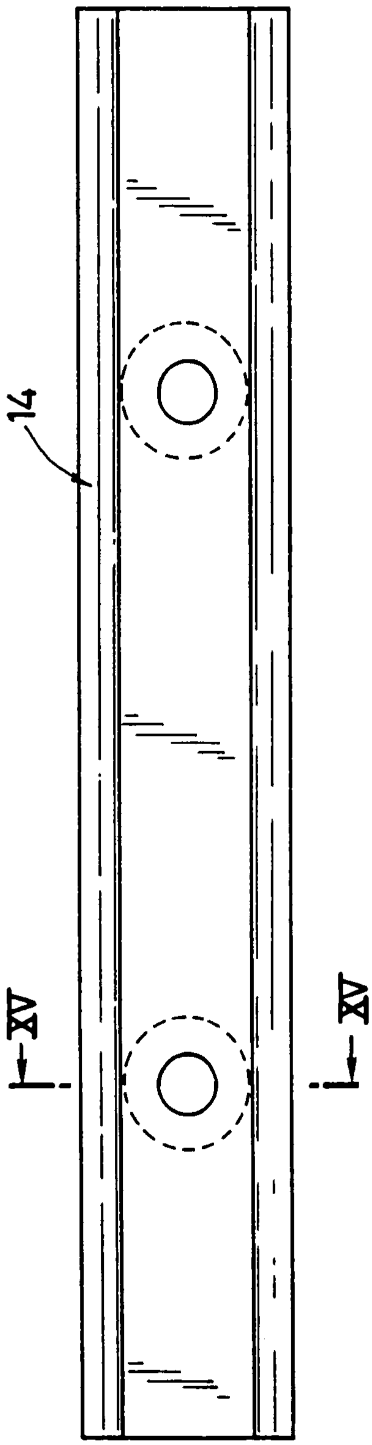


FIG. 19



Nummer: DE 41 35 167 A1
Int. Cl.^{5}: F 16 H 25/22
Offenlegungstag: 21. Mai 1992

FIG. 21

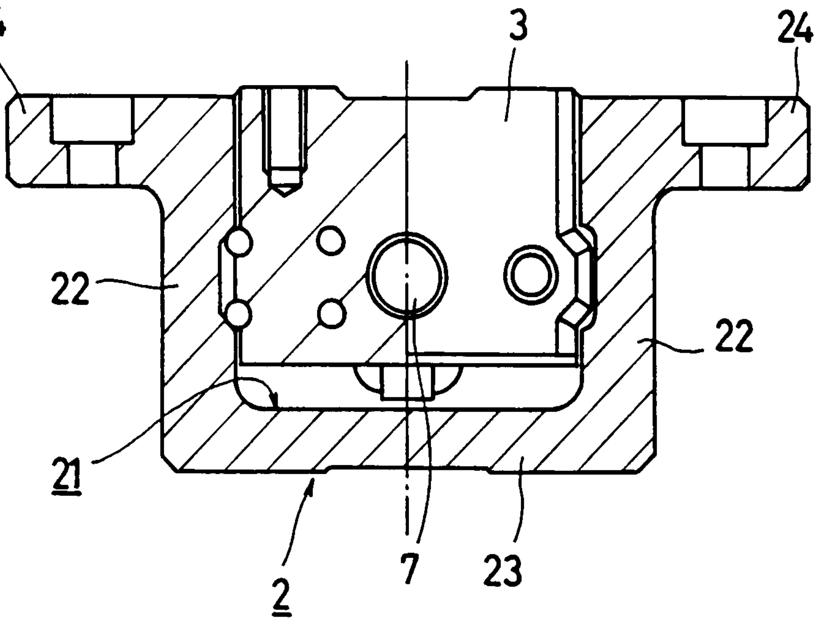
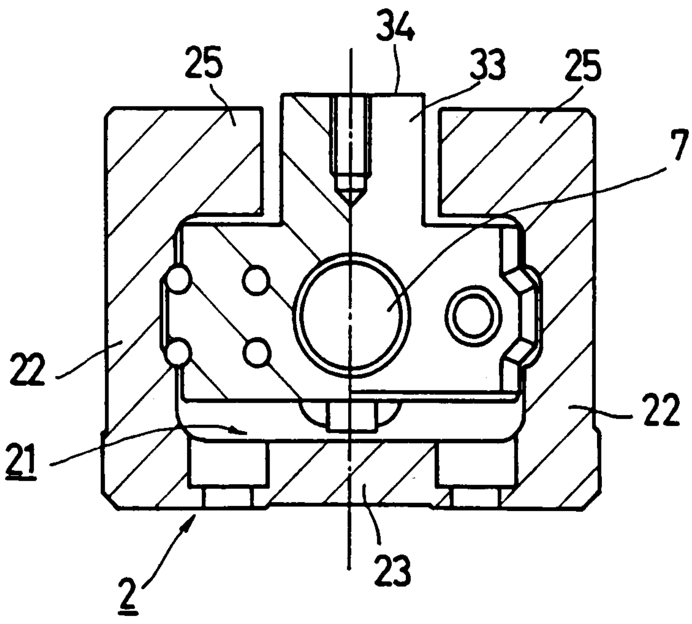
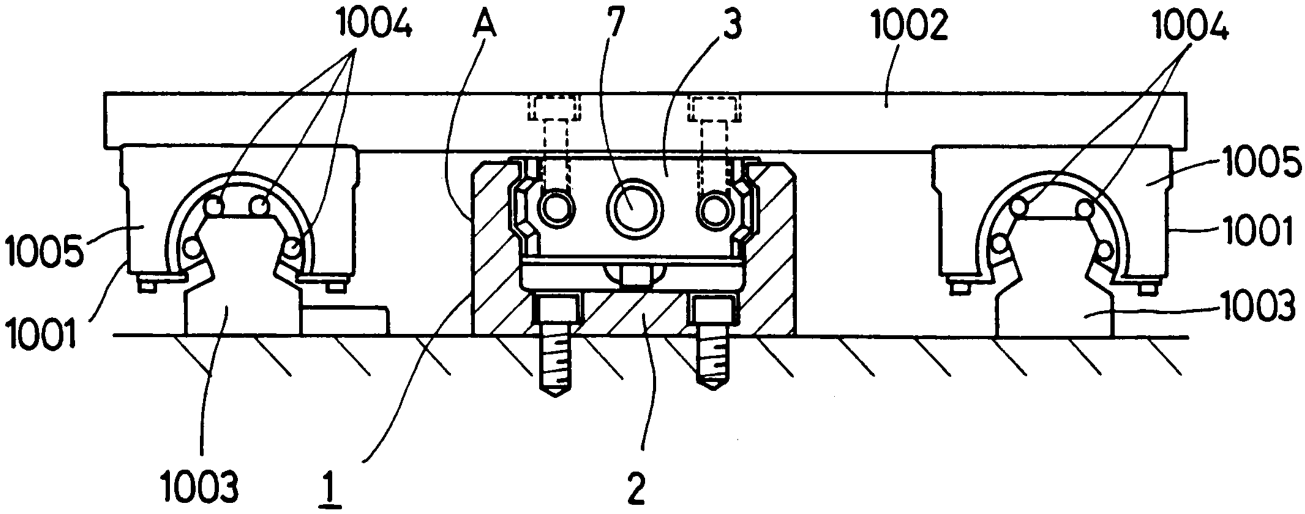


FIG. 22



Nummer: DE 41 35 167 A1
Int. Cl.5: F 16 H 25/22
Offenlegungstag: 21. Mai 1992

FIG. 23



Nummer: DE 41 35 167 A1
Int. Cl.^{6}: F 16 H 25/22
Offenlegungstag: 21. Mai 1992

FIG. 24